

LOUISIANA  
STANDARD  
SPECIFICATIONS  
FOR  
ROADS AND BRIDGES



DEPARTMENT OF HIGHWAYS  
BATON ROUGE

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JULY 1, 1947

Registry Number \_\_\_\_\_

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LOUISIANA  
STANDARD SPECIFICATIONS  
FOR  
ROADS AND BRIDGES

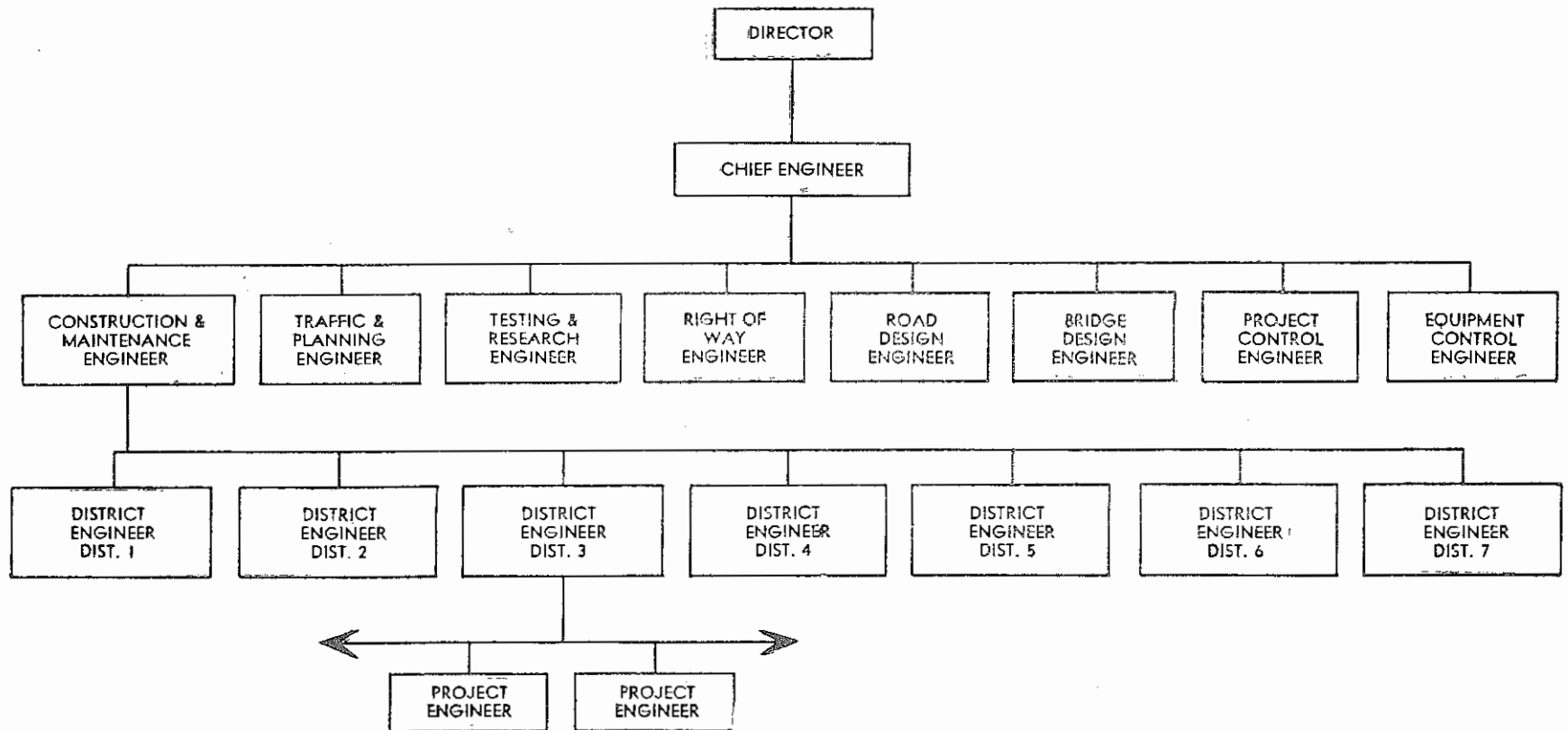


DEPARTMENT OF HIGHWAYS  
BATON ROUGE

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July 1, 1947

ORGANIZATION CHART  
OF  
LOUISIANA DEPARTMENT OF HIGHWAYS  
ENGINEERING DIVISION



## PREFACE

The general arrangement of the subject matter of this issue of the Standard Specifications differs from the arrangement of the previous issue (March, 1940) in that the specifications for construction procedure, for quality of materials and for methods and practices of design have been separated.

The general divisions of the subject matter are now:

Division I General provisions.

Division II Construction specifications.

Division III Material specifications.

Division IV Bridge design methods and standards.

Division V Legal contract and bond forms.

Division VI Movable bridges, design and construction.

The subject matter of Division II, Construction, has also been differently arranged and now appear as follows:

Capital Investment Code	Classification	Pay Item Numbers
74	(Engineering: not included in subject matter).	
75	Rights-of-way: demolition, rearrangement, rebuilding, etc., of fences, buildings, etc., (but not clearing or grubbing) .....	200-299
76	Earthwork, roadway, drainage, etc. ....	300-399
77 & 80	Structures .....	400-499 & 700-799
78	Surfaces and bases (but not subgrade treatments by the addition of selected earth) .....	500-599
79	Improved or stabilized shoulders and approach surfaces .....	600-699
81	Traffic and pedestrian facilities .....	800-899

82 Roadside development, parks, recreational areas, etc. ....900-999

The purpose of adopting this method of classifying the various items of work is to facilitate the keeping of capital accounts records in accordance with the classification established by the Public Roads Administration.

This arrangement will result in the apparent repetition of contract items, as for example: the item for concrete may appear under several classifications, but the price, if costs are correctly represented, may be different for each classification. In view of this apparent repetition, contractors should be careful that unit prices are submitted for every item for which quantities appear.

The contractor's attention is invited to these further specific revisions in the body of the specifications.

#### Division I—General Provisions

New and additional descriptions of the word engineer (See (C-5), C-6).

Relationship of contractors and engineers have been clarified as a result of recent litigation (See C-91). The purpose of this revision also is to provide the contractor a definite channel of appeal from the decisions of the Project Engineer. The revision is not expected to encourage minor complaints nor to alter the customary and traditional good will between engineers and contractors.

The relationship between the contractor and the Department will be more satisfactory if all matters are taken up directly with the Project Engineer who will, when the subject requires concurrence of higher authorities, forward the matter through channels. To assist the contractor to understand the channels through which reports and documents are processed, an outline of the Department of Highways Organization Chart is shown herein.

Although defaults seldom occur, the Contractor

should read this section (C-148) carefully so as to become familiar with his rights. Defaulted contracts will not be delivered to the surety for completion but will be completed by other means in the discretion of the Department.

The following sections of the Construction Specifications, Division II, should be carefully reviewed by the Contractor:

Piling, Cut-Off and Method of Measurement.  
Structural Excavation for Bridges and Culverts.  
Portland Cement Concrete Pavement.  
Shop Detail Drawings for Structures.

(Note): The Preface is included in this volume and is intended to be used only as a guide in reviewing the specifications, and is not an integral part of the specifications.

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DIVISION I  
GENERAL REQUIREMENTS  
AND COVENANTS

## DEFINITION OF TERMS

Whenever in these specifications, proposal, contract, and bond, the following terms, or pronouns in place of them, are used, the intent and meaning shall be interpreted as follows:

**C1 A. A. S. H. O.:** ✓

American Association of State Highway Officials.

**C2 A. S. T. M.:** ✓

American Society for Testing Materials.

**C3 Bidder:** ✓

Any individual, firm or corporation submitting a proposal for the work contemplated, acting directly or through a fully authorized representative.

**C4 Bridge Complete:** ✓

The entire structure, including both substructure and superstructure.

**C5 Bridges and Viaducts:**

Any structure, including multiple spans, of over twenty feet total length between bulkheads or end walls, carrying the roadway, measured under the copings, and parallel to the center of the road. The width of bridges is the distance between inside faces of the curb.

**C6 Chief Engineer:** ✓

The Chief Engineer of the Louisiana Department of Highways.

**C7 Construction and Maintenance Engineer:**

The direct representative of the Chief Engineer.

**C8 Contract:** ✓

The written agreement between the Department and the contractor covering the performance of the

work and the furnishing of labor, materials, tools, equipment, and incidentals necessary for the completion of the same. The contract shall be mutually understood to include "Plans," "Specifications," "Special Provisions," "Notice to Contractors," "Proposal," and "Contract Bond," also any and all "Supplemental Agreements" which are required to complete the construction of the work in a satisfactory and acceptable manner.

**C9 Contract Bond:** ✓

The approved form of security furnished by the contractor and his surety as a guarantee for the proper performance of the work and payment for all materials or other obligations contracted by him in the prosecution thereof.

**C10 Contract Day:** ✓

A contract day, for the purpose of this contract, is a calendar day (Sundays excepted) for the purpose of accounting contract time.

**C11 Contractor:** ✓

The individual, firm or corporation who enters into a contract awarded him by the Department. The contractor may act directly or through an authorized lawful agent or employee.

**C12 Culverts:** ✓

All waterway structures not defined as bridges.

**C13 Department:** ✓

Louisiana Department of Highways, as defined in Louisiana Statutes.

**C14 Director:** ✓

Director of Louisiana Department of Highways.

**C15 Equipment:** ✓

All machinery implements, power tools and live stock, together with the necessary supplies for the op-



eration, upkeep and maintenance of the same and also all other tools and apparatus necessary for the proper construction and acceptable completion of the work.

**C16 Extra Work Order:** ✓

A written agreement between the Department and the contractor, involving additional pay items to the contract, and when duly executed becomes a part of the contract.

**C17 Highway:** ✓

The entire right of way devoted to public travel and accessible to the public.

**C18 Inspector:** ✓

An authorized representative of the Project Engineer, assigned to make any and all inspections of the work performed and materials furnished by the contractor.

**C19 Laboratory:** ✓

The official testing laboratories of the Department or such other laboratories as may be designated by the Chief Engineer.

**C20 Materials:** ✓

Any substance used in connection with the construction of any structure or the roadway and its appurtenances, provided, however, that this term shall not include materials used in falsework or other temporary structures but not incorporated in the improvement.

**C21 Plans:** ✓

The official approved plans, profiles, typical cross sections, general sections, working drawings and supplemental drawings, or exact reproductions thereof, which show the location, character, dimensions and details of the work to be done, and which are to be considered as a part of the contract supplementary to these specifications.

**C22 Project Engineer:**

An engineer in charge of one or more specified projects.

**C23 Project Number:**

A number used for convenience to describe and delineate certain construction within definite geographical limits.

**C24 Proposal:**

The written offer of the bidder to perform the contemplated work and furnish the necessary materials, when made out and submitted on the prescribed proposal form, properly signed and guaranteed.

**C25 Proposal Guaranty:**

The security designated in the "proposal form" to be furnished by the bidder as a guaranty of good faith to enter into a contract with the Department if the contract is awarded to him.

**C26 Right of Way:**

The entire area of land which is acquired and reserved for use in constructing, maintaining and protecting the highway and its structures and appurtenances, safety areas and islands, roadside developments and parks.

**C27 Roadbed:**

The portion of the roadway included between the inside edges of slopes of ditches, in cuts and tops of fill slopes on embankments the "surfacing" plus the "shoulders."

**C28 Roadway:**

The portion of the right of way included between the outside lines of slopes, gutters, or side ditches including also the appertaining structures, and all slopes, ditches, channels, waterways, etc., necessary to proper drainage and protection.

✓  
**C29 Shoulders:**

That portion of the roadbed between the surfacing and the top of the side slopes of the roadbed.

✓  
**C30 Special Provisions:**

The specified clauses or provisions setting forth conditions or requirements, peculiar to the project under consideration and covering work, or materials, involved in the proposal and estimate but not thoroughly or satisfactorily stipulated or set forth by the Standard Specifications.

✓  
**C31 Specifications:**

The directions, provisions and requirements contained herein, which are designated as "Louisiana Standard Specifications for Roads and Bridges" as supplemented by such "Special Provisions" and "Supplemental Agreements" as may be necessary, pertaining to the method and manner of performing the work or to quantities and qualities of material to be furnished under the contract.

✓  
**C32 State:**

The State of Louisiana.

✓  
**C33 Structures:**

Bridges, culverts, headwalls, end walls and incidental construction such as catch basins, drop inlets, manholes, retaining walls, and other similar construction which may be encountered in the work and not otherwise classified herein.

✓  
**C34 Subcontractor:**

Any individual, firm, partnership, or corporation who contracts with the contractor to perform any part of the project covered by the contract.

✓  
**C35 Subgrade:**

That portion of the roadbed upon which the wearing course or base course is to be placed, except that for concrete pavement or pavements having a con-

crete base, the subgrade shall be interpreted to include an additional area extending one foot on each side of the concrete pavement or base.

**C36 Substructure:** ✓

All of that part of the structure below the bridge seats or below the spring lines of arches. Parapets, backwalls and wingwalls of abutments shall be considered as parts of the substructure.

**C37 Superstructure:** ✓

All of that part of the structure above the bridge seats or above the spring lines of arches and not included in the substructure.

**C38 Supplemental Agreement:** ✓

A written agreement between the Department and the contractor involving changes in the contract plans and/or specifications, and when duly executed becomes a part of the contract. ✓

**C39 Surety:**

The corporate body licensed to do business in Louisiana which is bound with and for the contractor, who is primarily liable, and which engages to be responsible for his payment of all obligations pertaining to and for his acceptable performance of the work for which he has contracted.

**C40 Surface:**

The combined base and wearing course, considered as a single unit.

**C41 Temporary Structures:** ✓

Any temporary structures or stream crossings required to maintain traffic while constructing or reconstructing structures or parts of structures covered by the contract. The temporary structures shall include the earth approaches thereto.

**C42 The Work:** ✓

All the work specified herein or indicated on the

plans as the contemplated improvement, covered by the contract.

**C43 Work Order:**

A written notice from the Chief Engineer notifying the contractor to begin the prosecution of the work.

## PROPOSAL REQUIREMENTS AND CONDITIONS

**C50 NOTICE TO CONTRACTORS:**

After the time and place have been fixed for the receipt of proposals, the Department shall publish an advertisement giving notice of request for bids. The advertisement shall contain a description of the project; a statement of the place where bids will be received and the time for opening same; and instructions to bidders as to access to plans, specifications and proposals.

**C51 CONTENTS OF PROPOSALS FORMS:**

Bidders shall be furnished with proposal forms which shall state the location and descriptions of the contemplated construction and shall show the approximate estimate of the various quantities of work to be performed and materials to be furnished, with a schedule of items for which unit prices are asked, and the date and time and place of the opening of the proposals. The "Notice to Contractors" and the "Special Provisions" shall be attached to the proposal form. All papers bound with or attached to the proposal forms are a necessary part thereof and shall not be detached or altered.

**C52 INTERPRETATION OF ESTIMATES:**

The quantities listed in the proposal form are to be considered as approximate and are to be used only for the comparison of bids. Payment to the contractor shall be made only for the actual quantities of work per-

formed and materials furnished in accordance with the contract, and if, upon completion of the construction, the actual quantities shall show either increase or decrease from the quantities given in the approximate estimate, the unit bid prices mentioned in the proposal shall still prevail, except as otherwise herein provided.

**C53 EXAMINATION OF PLANS, SPECIFICATIONS, SPECIAL PROVISIONS AND SITE OF WORK:**

The bidder is required to examine carefully the site of the proposed work, proposal, plans, specifications, special provisions, and contract and bond form for the work contemplated, and it shall be assumed that he has investigated and satisfied himself as to the conditions to be encountered, as to the character, quality and quantities of work to be performed and materials to be furnished, and as to the requirements of these specifications, special provisions and contract. Bidders are assumed to have made themselves familiar with all federal and state laws, local laws, ordinances and regulations which in any manner affect the work or its prosecution. The filing of a bid shall be presumptive evidence that the bidder has complied with these requirements.

**C54 PREPARATION OF PROPOSAL:**

The bidder shall submit his proposal on the prescribed form and the blank spaces in the proposal shall be filled in correctly, where indicated, for each and every item for which a quantity is given, and the bidder shall state the prices (written in ink, both in words and numerals), for which he proposes to do each item of the work contemplated. Bidders are required to examine carefully the proposal form before submitting same in order to see that a unit price is submitted on each and every item on which all bidders are required to submit a bid. The bidder shall be responsible for all errors or omissions in his proposal. In case of a conflict between the written unit price and the unit price in figures, the written unit price shall govern. Should the

written unit price be illegible, the unit price in figures shall govern. The bidder shall sign his proposal correctly. If the proposal is made by an individual, his name and post office address shall be shown. If made by a firm or partnership, the name and post office address of each member of the firm or partnership shall be shown. If made by a corporation, the person signing the proposal shall show the name of the state under the laws of which the corporation was chartered and the names, titles, and business address of the president, secretary and treasurer and, if required, the one signing the proposal as the agent of a firm or corporation shall furnish legal evidence that he has a rightful authority to such signature, and that the signature is binding upon the firm or corporation. Proposals shall be signed in ink.

Where the successful bidder is a person or group of persons carrying on, conducting or transacting any business in this State under an assumed name, or under any designation, name or style, corporate or otherwise, other than the real name or names of the individual or individuals conducting or transacting such business, the Department shall be furnished a certificate, (as provided by the law) from the Registrar of Conveyances in the City of New Orleans, or the Clerk of Court, as the case may be, of the parish or parishes in which such person or persons conduct, transact or intend to conduct or transact such business, setting forth the name under which said business is, or is to be conducted or transacted and the true or full name of the person or persons owning, conducting or transacting the same, with the post office address or addresses of said person or persons.

#### **C55 REJECTION OF PROPOSALS CONTAINING ALTERATIONS, ERASURES OR IRREGULARITIES:**

Proposals may be rejected if they show an alteration of form, additions not called for, conditional or alternate bids, incomplete bids, erasures, or irregulari-

ties of any kind. If not accompanied by a proposal guaranty, proposals shall be rejected.

**C56 PROPOSAL GUARANTY:**

Each bid shall be accompanied by a "Proposal Guaranty" not less than five per cent of the correct total amount of the highest combination for which a bid is submitted. Only certified checks shall be accepted as the bidders guaranty with his proposal; any deviation from this requirement shall be considered cause for rejection of the bid. The certified check shall be issued by a State or National bank in good standing and shall be made payable to the Louisiana Department of Highways for not less than the amount specified above. Cashier's checks or currency shall not be accepted as a substitute for certified checks. If cashier's check or currency is enclosed with the bid, the bid shall be considered informal and, with the cashier's check and/or currency and all other enclosures, shall be returned to the bidder without having been read.

**C57 DELIVERY OF PROPOSALS:**

Each proposal shall be submitted, together with the proposal guaranty in a special envelope furnished by the Department. The blank spaces on the envelope shall be filled in correctly so as to indicate clearly its contents, and the envelope shall be sealed. If submitted by mail, the envelope shall be enclosed in another addressed to the Department and should preferably be registered. If submitted otherwise than by mail, it shall be delivered to the proper place designated in the proposal. Proposals shall be received up to the time stated and shall be delivered to the Department at the designated place before the expiration of the time stipulated for the receipt of bids. Proposals received after the stipulated time shall be returned to the bidder unopened.

**C58 WITHDRAWAL OF PROPOSALS:**

A bidder may withdraw his proposal provided the request in writing is in the hands of the Chief Engineer



by the time set for opening proposals. The withdrawal of a bid shall not prejudice the right of a bidder to file a new bid.

**C59 PUBLIC OPENING OF PROPOSAL:**

Proposals shall be publicly opened and publicly read at the time and place indicated in the "Notice to Contractors." Bidders or their authorized agents are invited to be present.

**C60 DISQUALIFICATION OF BIDDERS:**

If more than one proposal is submitted by an individual, a firm or partnership, a corporation or association, under the same or different names, all proposals so submitted shall be considered irregular and shall be rejected. Evidence that any bidder is interested in more than one proposal for the work contemplated shall cause the rejection of all proposals in which such bidder is interested. Any or all proposals shall be rejected if there is any reason for believing that collusion exists among the bidders and all participants in such collusion shall not be considered in future proposals for the same work. Unbalanced proposals may be rejected. No contract shall be awarded except to responsible bidders capable of performing the class of work contemplated, and having sufficient equipment, financial resources and experience to properly perform the work.

**C61 QUALIFICATION OF BIDDERS:**

Bidders shall be capable of performing the various items of work bid upon. They shall be required to furnish a statement covering experience in similar work, a list of machinery, plant organization and other equipment available for the proposed work, and such statements of their financial resources as may be deemed necessary, and shall be required to show that they have not failed to carry out all previous contracts with the Department. Each prospective bidder shall file with the Department on forms furnished by the Department, a financial and experience statement as of the date on which his fiscal year ends. Bidders may

submit these statements either with their bid or prior to bidding.

In addition to the above, bidders shall submit a balance sheet showing their financial condition at the expiration of six months after the close of their fiscal year. The balance sheet shall be properly certified on forms furnished by the Department.

Financial statements previously filed with the Department shall remain in effect for a period not to exceed one year and forty-five days after the close of the bidder's fiscal year and balance sheet shall remain in effect not to exceed forty-five days after the close of the bidder's fiscal year.

All financial statements and balance sheets submitted to qualify for the performance of work in excess of forty-thousand dollars shall be prepared and certified to by a certified public accountant.

Bidders will also be required to submit a list of equipment that they propose to use on each project on which a bid is submitted.

#### **C62 MATERIAL GUARANTY:**

Before any contract is awarded, the bidder may be required to furnish a complete statement of the origin, composition and manufacture of any or all materials to be used in the construction of the work together with samples, which may be subjected to the tests provided for in these specifications to determine their quality and fitness for the work.

## **AWARD AND EXECUTION OF CONTRACT**

#### **C70 CONSIDERATION OF BIDS:**

For the purpose of award, the correct summation of the products of the approximate quantities shown in the proposal by their respective unit prices shall be considered the amount of the bid. Until the final award of the contract is made, the right is reserved to reject

any and all proposals and to waive technicalities when, in the opinion of the Chief Engineer, the best interest of the Department will be promoted thereby.

**C71 AWARD OF CONTRACT:**

The award of the contract, if it be awarded, shall be made only upon the recommendation of the Chief Engineer, to the lowest responsible bidder whose proposal shall comply with all requirements necessary to render it formal. The award, if made, shall be within thirty days after the opening of the proposals, but in no case shall an award be made until all necessary investigations are made into the responsibility of the bidder to whom it is proposed to award the contract. The successful bidder shall be notified, by letter mailed to the address shown on the proposal, that his bid has been accepted and that he has been awarded the contract. He shall execute the contract within ten days after the notice is issued.

**C72 RETURN OF PROPOSAL GUARANTIES:**

All proposal guaranties, except those of the two lowest bidders, shall be returned to the bidders immediately after the amount of the bids have been determined, compared and the results of such comparison have been considered by the Department; the others shall be retained until the execution of the contract and approval of the bond, after which they shall be immediately returned.

Should no award be made within thirty days, all proposals shall be rejected, and all guaranties returned, unless the successful bidder agrees to a longer delay.

**C73 REQUIREMENTS OF CONTRACT BOND:**

The successful bidder, at the time of the execution of the contract, shall deposit with the Department the bond of a surety company acceptable to the Department and authorized to do business in Louisiana, in the amount of the total bid, conditioned that such work shall be performed in accordance with the plans, specifications and terms of the contract and no surety com-

pany in which the bidder for the work is interested shall be accepted as surety on the bond. Bond shall be given on the form provided by the Department.

**C74 EXECUTION OF CONTRACT:**

The successful bidder shall be required to execute the contract and furnish bond satisfactory to the Department within ten days after notice of award. In the case of a corporation, the officer or agent to execute the contract shall be designated in a power of attorney executed by the Board of Directors, duly certified by the secretary and bearing the seal of the corporation. This power of attorney may be general, covering all contracts entered into with the Department until such time as it is revoked, or it may be specific authority for one contract. When the successful bidder is a partnership, a power of attorney designating one member of the firm to execute the contract shall be filed with the Department. This power of attorney shall bear the signatures of all members of the firm and shall be duly executed by a notary. Any officer or agent signing on behalf of the surety, bonding the contractor shall be required to file power of attorney with each bond executed and shall be required to affix the seal of the surety to all bonds executed.

**C75 FAILURE TO EXECUTE CONTRACT:**

In the event of failure or refusal on the part of the bidder to whom the award is made to execute the contract and furnish satisfactory bond within ten days after notice has been given the bidder by the Department of the award, the right is reserved by the Department to annul the award and to award the contract to the next lowest bidder or advertise for new proposals, or reject all bids. In the event the bidder to whom the award is made fails or refuses to execute the contract and furnish a satisfactory bond within the ten days above specified, the "Proposal Guaranty" accompanying his bid shall become the property of the Department.

## SCOPE OF WORK

### **C80 INTENT OF PLANS AND SPECIFICATIONS:**

The intent of the plans and specifications are to prescribe a complete work or improvement which the contractor undertakes to do in full compliance with the contract. The contractor shall perform all items of work covered and stipulated in the contract, and all extra or additional work required to complete the work in accordance with the plans and specifications. The contractor shall furnish all materials, equipment, tools, supplies, transportation and labor necessary to the prosecution of the work, unless otherwise specified in the contract.

### **C82 ALTERATION OF PLANS:**

The Chief Engineer may authorize or order changes made in the plans during the progress of the work if such changes appear necessary to complete the project as a whole and as originally conceived. Such changes in plans may increase or decrease the quantities of work specified in the contract or may take the form of extra work. The limits or the termini of the project shall not be extended.

### **C83 CHANGES IN QUANTITIES:**

If the quantities of work specified in the contract are increased or decreased more than 25% of the whole contract, measured in terms of the sum of the extension of quantities at the unit prices, a supplement to the contract shall be executed between the Department and the contractor and the consent of the contractors surety to such a supplement obtained.

### **C84 EXTRA WORK:**

Extra work shall be any work ordered by the Project Engineer and which is not covered by any item in the contract. Extra work shall be done in accordance with the plans and/or specifications. Extra work shall be measured and paid for at the price agreed on by the Project Engineer and contractor. The unit prices for

extra work shall be agreed on and an "Extra Work Order" executed before any extra work is prosecuted by the contractor. In the event that the Project Engineer and the contractor are unable to negotiate a unit price agreeable to both parties, the Project Engineer may direct that such extra work be prosecuted by the contractor on a force account basis.

#### **C85 TRAFFIC:**

Definition of Through and Local Traffic: Through traffic is that traffic emanating from without one limit of the project and having as its destination some point beyond the other limit of the project.

Local traffic is that traffic emanating from without the limits of the project and having as its destination some point or points within the limits of the project or emanating from within the limits of the project and having as its destination some point or points either within or without the limits of the project.

Handling Traffic: Satisfactory provisions for local traffic shall be made by the contractor, at his own expense, at all times during construction.

The plans and/or special provisions shall state how through traffic shall be handled. When stated in the plans and/or special provisions, the contractor shall be required to handle all traffic over the specified portion of the project at his own expense.

In the event that detours for through traffic are to be provided by the Department around the entire project or any major portion of the work during construction, the Department reserves the right, upon recommendation of the Project Engineer, to open for use by traffic any uncompleted portions of the project. When specifically provided by the contract that traffic shall be routed over the project during the construction, the contractor shall maintain the portion under traffic at his own expense. When not so provided, the Department may maintain such portions with its own forces or require the contractor to maintain them and reimburse him for such maintenance.

If the contractor hauls his materials or equipment over any road, culvert, or bridge provided by the State for the convenience of public travel, he shall so regulate his loads as not to exceed the capacity of the road and its structures as determined by the Project Engineer. The contractor shall be responsible for any specific damage that may result to the road or its structures from failure to observe the above requirements.

On concrete pavement contracts, pavement shall be opened to traffic as provided in the specifications for concrete pavement.

#### **C86 RIGHTS IN AND USE OF MATERIALS FOUND ON THE WORK:**

The contractor, with the written approval of the Project Engineer, may use in the proposed construction suitable stone, gravel, sand, or other material found in the "Excavation," which complies with the requirements of the specifications of the particular material and shall be paid for the excavation of such material at the contract unit price therefor, but he shall replace at his own expense with other suitable materials all of that portion of the material so removed and used as was contemplated for use in embankments, backfills, approaches or otherwise. Except for the replacement herein provided, no charge for materials so used shall be made against the contractor. Such material, suitable for special uses of the Department, when required by the Project Engineer, shall be reserved and deposited in convenient places on the right of way or as directed, and no special allowance shall be made to the contractor for so reserving and storing such materials, unless a pay item for this work is included in the contract. The contractor shall not excavate or remove any materials from within the highway right of way which is not within the excavation, as indicated by the slope and grade lines, without written authorization from the Project Engineer.

#### **C87 FINAL CLEARING UP:**

Upon completion of the work and before acceptance and final payment is made, the contractor shall clean

and remove from the roadway, footways and adjacent property all equipment, all surplus and discarded materials, weeds, bushes, rubbish, and temporary structures. He shall restore in an acceptable manner all property, both public and private, which has been damaged during the prosecution of the work, and shall leave the site of the work in a neat and presentable condition throughout.

Upon the completion of any structure, all superfluous material, cofferdams, unless otherwise ordered, construction buildings and other temporary structures and debris resulting from construction shall be removed. Falsework timber and piles are to be removed to the ground level. Upon completion of work in connection with drainage structures, the contractor shall be required to remove all debris, such as drift, weeds, dirt, scraps of building material, or any other obstructions to the flow of water, from inside all culverts, whether new or old.

All materials shall be deposited on the downstream side of the roadway or otherwise disposed of as directed by the Project Engineer, and stream channels, structures and roadway left in a neat and presentable condition.

No special payment shall be made for this work, its cost being included in the price paid for the construction work, unless an item is included in the contract for cleaning out old culverts.

#### **C88 REMOVAL AND DISPOSAL OF STRUCTURES AND OBSTRUCTIONS:**

All work indicated on the plans as necessary to the completion of the improvement shall be performed by the contractor, unless otherwise provided, and all fences, buildings, bridges and structures of any character not necessary to the construction of the roadway; or other encumbrances upon or within the limits of the highway right of way, where indicated on the plans to be removed, unless otherwise provided, shall be removed by the contractor and placed on the abutting



property or otherwise disposed of as directed by the Project Engineer. All unsightly material removed shall be disposed of in such a manner that same shall not be visible from the highway. This work shall be paid for as specifically provided for in the various pay items appearing in the proposal and contract but should no specific provision be made for the payment of this work, it shall be considered subsidiary work and as such shall be included by the contractor in the bid prices for pay items appearing in the proposal and contract.

All pipe, culverts and bridges to side roads and private drives shall be removed where required and immediately replaced after completion of the improvement at the site. No direct payment will be made for removing and replacing these structures unless specifically provided for by the contract.

Fences or pipe culverts which are to be re-used or salvaged, shall be removed with care and piled or disposed of in a manner acceptable to the Project Engineer.

## CONTROL OF WORK

### **C90 ENGINEERING:**

The Department shall furnish all personnel, equipment, supplies, tools, transportation and incidentals required by the Project Engineer for the proper engineering control and supervision of the work except as otherwise specified in the contract.

### **C91 AUTHORITY OF THE ENGINEERS:**

The work will be performed directly under the supervision of the Project Engineer, and in accordance with his interpretation of the plans, specifications and special provisions. Should the contractor consistently fail or refuse to comply with any directions of the Project Engineer, the Project Engineer will issue his directions in writing and forward a copy to the District Engineer. The contractor on receipt of such written instruction, will proceed to comply with the instructions

or may appeal through the District Engineer to the Construction and Maintenance Engineer in writing within forty-eight hours after the receipt of the written notice, delivered to the contractor in person, or his representative. Failure in making such an appeal within this period will constitute a waiver of the right of appeal. Should the contractor both fail to follow the directions of the Project Engineer and fail to make an appeal, the Project Engineer will certify the situation to the District Engineer in writing and notify the contractor to suspend all operations.

#### **C92 AUTHORITY AND DUTIES OF INSPECTORS:**

Inspectors employed by the Department shall be authorized to inspect all work done and all material furnished. Such inspection may extend to all or any part of the work and to the preparation or manufacture of the materials to be used. An inspector shall be stationed on the construction to report to the Project Engineer as to the progress of the work and the manner in which it is being performed; also to report whenever it appears that the materials furnished and the work performed by the contractor fail to fulfill the requirements of the contract, and to call to the attention of the contractor any such failure or other infringement; but such inspection shall not relieve the contractor from any obligation to perform all of the work, in accordance with the requirements of the contract. In case of any dispute arising between the contractor and the inspector as to materials furnished or the manner of performing the work, the inspector shall have the authority to reject materials or suspend the work until the question at issue can be referred to the Project Engineer. The inspector shall not, however, be authorized to revoke, alter, enlarge, relax or release any requirements of the contract, nor to approve or accept any portion of the work, nor to issue instructions contrary to the plans or specifications. He shall in no case act as foreman or perform other duties for the contractor, nor interfere with the management of the work. Any

advice which the inspector may give the contractor shall not be construed as binding the Project Engineer or the Department in any way, or as releasing the contractor from the fulfillment of the terms of the contract.

### **C93 INSPECTION:**

The Project Engineer and his inspectors shall have free access to all parts of the work, and to all materials intended for use in the work. The contractor shall furnish the Project Engineer with every reasonable facility for ascertaining whether or not the work as performed is in accordance with the requirements and intent of the specifications and contract. The work shall be inspected as it progresses, but failure to reject or condemn defective work or materials at the time it is done shall in no way prevent its rejection whenever it is discovered. If the Project Engineer requests it, the contractor shall at any time before the acceptance of the work, remove or uncover such portions of the finished work as may be directed. After examination, the contractor shall restore said portions of the work to the standard required by the specifications. Should the work thus exposed or examined prove acceptable, the uncovering, or removing, and the replacing of the covering or making good of the parts removed, shall be paid for as "Extra Work" but should the work so exposed or examined prove unacceptable, the uncovering or removing, and the replacing of the covering or making good of the parts removed, shall be at the contractor's expense. No work shall be done, nor materials used, without suitable supervision of the Department.

All highway construction on which Federal Aid of any kind is received shall be performed under the supervision of the Department, subject to the inspection and approval of the Federal Works Administrator or his duly accredited representative.

When specified in the contract, the contractor shall construct or otherwise make available an inspector's

house for the exclusive use of the Project Engineer. The house shall be a minimum in size of six feet wide by eight feet long by seven foot high walls and shall be reasonably weather tight. The house shall have at least two windows and one door and shall be floored and built on skids. The contractor shall move the house to locations along the site of the work as directed by the Project Engineer. The contractor shall not be paid for the house and after the completion of the work the house shall become the property of the contractor.

**C94 DEFECTIVE AND UNAUTHORIZED WORK:**

All work which has been rejected shall be remedied or removed, if necessary, and replaced in an acceptable manner by the contractor at his own expense, and no compensation shall be allowed him for such removal or replacement. Work done without lines or grades being given or beyond the lines and grades shown on the plans, except as herein provided, or any extra work done without written authority shall be considered as unauthorized and at the expense of the contractor, and shall not be measured or paid for. Work so done may be ordered removed at the contractor's expense. Upon failure on the part of the contractor to forthwith comply with any order of the Project Engineer made under the provisions of this article, the Project Engineer shall have authority to cause defective work to be remedied, or removed and replaced, and unauthorized work to be removed and such costs to be deduced from any monies due or to become due the contractor; or the Project Engineer, if he so elects, may withhold any money due or becoming due the contractor until such time as the work is satisfactorily corrected.

**C95 FINAL INSPECTION:**

Whenever the work provided for and contemplated by the contract shall have been satisfactorily completed and the final cleaning up performed, the Project Engineer shall notify the Construction and Maintenance Engineer in writing that said work is completed

and ready for final inspection. The Construction and Maintenance Engineer shall, unless otherwise provided, make the final inspection within a reasonable length of time after the receipt of such notification.

#### **C96 PLANS AND WORKING DRAWINGS:**

The Department shall furnish the contractor without charge two sets of plans and upon written request by the contractor additional sets of plans shall be supplied without charge to a maximum of five sets.

The plans shall consist of general drawings, showing such details as are necessary to give a comprehensive idea of the construction contemplated.

Roadway plans shall show alignment, profile, typical cross sections of improvements, and general cross sections.

Structure plans shall, in general, show in detail all dimensions of the work contemplated. When the structure plans do not show all dimensions in detail, they shall show general features and such details as are necessary to give a comprehensive idea of the structure.

The contractor shall submit to the Project Engineer for approval three sets of any required preliminary detailed shop or working drawings. These plans shall be submitted in sufficient time to allow discussion and correction prior to beginning the work they cover and any delay in the work occasioned by the non-approval of the plans shall not be cause for an extension of contract time. Prior to the approval of these drawings any work done or materials ordered for the structures involved shall be at the contractor's risk. One set of these drawings shall be returned to the contractor approved or marked with the corrections to be made; the other sets shall be retained by the Department.

Working drawings for steel structures shall consist of shop detail, erection, and other working plans showing details, dimensions, sizes of materials and other information necessary for the complete fabrication and erection of the metal work.

Working drawings for concrete structures shall consist of such detailed plans as may reasonably be required for the successful prosecution of the work and which are not included in the plans furnished by the Department. These shall include shop detail drawings for all steel and iron parts and may include plans for false-work, bracing, centering and form work, masonry, layout diagram and diagram for reinforcement.

It is expressly understood that the approval of the contractor's working drawings is general only, and such approval shall not relieve the contractor from any responsibility whatsoever.

Upon final approval of all working drawings, the contractor shall submit to the Project Engineer such copies of the approved, corrected detailed drawings as may be required, and upon completion of the work, the original corrected tracings, if so required, shall be surrendered to the Project Engineer.

The contract price shall include the cost of furnishing all working drawings and the contractor shall be allowed no extra compensation for such drawings.

#### **C97 CONFORMITY WITH PLANS AND ALLOWABLE DEVIATIONS:**

The location, details and dimensions of the finished work shall conform strictly to the approved plans. Any deviation from the plans as may be required, in all cases, shall be determined by the Project Engineer and authorized in writing.

#### **C98 COORDINATION OF PLANS, SPECIFICATIONS AND SPECIAL PROVISIONS:**

These specifications, the accompanying plans, special provisions and all supplementary documents are essential parts of the contract. They are intended to be complementary, to describe and provide for a complete work and a requirement occurring in one is as binding as though occurring in all. In case of discrepancy, figured dimensions, unless obviously incorrect, shall govern over scaled dimensions, plans shall govern over

specifications, and special provisions shall govern over both specifications and plans. The contractor shall take no advantage of any error or omission of dimensions in the plans, or of any discrepancy between the plans and specifications. The Project Engineer shall make such corrections and supply such omitted dimensions as may be necessary, and his interpretation shall be final.

#### **C99 CONSTRUCTION STAKES:**

The Project Engineer shall furnish and set construction stakes establishing lines and continuous profile grade in road work, and center line and bench mark for bridge work, and shall furnish the contractor with all necessary information relating to lines and grades. This work shall be performed well in advance of the contractor's requirements. The contractor shall furnish, free of charge, all additional stakes, all templates and other materials necessary for maintaining points and lines given. The contractor shall be held responsible for the preservation of all stakes and marks and if, in the opinion of the Project Engineer, any of the construction stakes or marks have been carelessly or willfully destroyed or disturbed by the contractor, the cost of replacing them shall be deducted from any money due or becoming due the contractor.

#### **C100 COOPERATION BY CONTRACTOR:**

The contractor shall give the work his constant attention to facilitate the progress thereof, and shall cooperate with the Project Engineer in every way possible. He shall have available on the work at all times one complete copy of the contract, including plans, specifications, special provisions and authorized alterations supplied to the contractor. He shall have at all times a reliable English speaking superintendent on the work authorized to receive orders and to act for him. The superintendent shall be qualified to superintend the performance of the particular type of work to be performed. Such a superintendent shall be furnished by the contractor regardless of how much work may be sublet. The superintendent shall accept service and citation. In the performance of the work under this

contract, the contractor shall so conduct his operations as to avoid interference with any other contractors.

**C101 AUTHORITY AND DUTIES  
OF PROJECT ENGINEER:**

The Project Engineer shall be in direct charge of the work and shall have full authority, under the Construction and Maintenance Engineer, in directing the proper performance thereof. He shall set such stakes as may be required for the proper direction of the contractor in establishing lines, grades or other details indicated by the plans. He shall also direct the sequence of the work, establish the priority of the several construction features, make or have made the necessary test of all materials used in the work, compile the data required in computing the estimates of the work actually done, and shall perform such other duties as may be assigned to him. In no case shall he act as an assistant to the contractor, as a foreman or in any similar capacity. In case of any dispute arising between the contractor and the Project Engineer as to materials furnished or the manner of performing the work, the Project Engineer shall have the authority to reject materials, or suspend the work until the question at issue can be referred to and decided by the Construction and Maintenance Engineer. He shall not be authorized to revoke, alter, enlarge, relax or release any requirements of these specifications, or to approve or accept any portion of work, or to issue instructions contrary to the plans and specifications. Any advice which the Project Engineer may give the contractor shall not be construed as binding the Construction and Maintenance Engineer or the Department in any way, or as releasing the contractor from the fulfillment of the terms of the contract.



## CONTROL OF MATERIALS

### **C110 SOURCE OF SUPPLY AND QUALITY OF MATERIALS:**

The source of supply of each of the materials shall be approved by the Project Engineer before the delivery is started. Representative preliminary samples of the character and quantity prescribed shall be submitted by the contractor or producer for examination and tested in accordance with the methods referred to under test of samples of materials. Only materials tested and found to conform to the requirements of these specifications and approved by the Project Engineer shall be used in the work. All materials proposed to be used may be inspected or tested at any time during their preparation and use. If, after trial, it is found that sources of supply which have been approved do not furnish a uniform product, or if the product from any source proves unacceptable at any time, the contractor shall furnish approved materials from other approved sources. No material which after approval has in any way become unfit for use shall be used in the work, and stored material, even though approved before being stored, shall be inspected prior to use in the work and shall meet the requirements of the specifications at the time of its use.

### **C111 PLANT INSPECTION:**

If the volume of the work, construction progress, and other considerations warrant, the Project Engineer may undertake the inspection of materials at the source, but it is understood that no obligation is assumed to inspect materials in this manner. Plant inspection shall be undertaken solely as a matter of convenience to the contractor and producers and only upon condition that:

The cooperation and assistance of the contractor and the producer with whom he has contracted for materials is assured.

When required by the Project Engineer, the ma-

terial producer shall furnish an approved weatherproof building for the use of the inspector, such building to be located conveniently near the plant.

It is understood that the Project Engineer reserves the right to retest all materials which have been tested and accepted at the source of supply after the same have been delivered and to reject all materials which when retested do not meet the requirements of these specifications.

#### **C112 SAMPLES AND TESTS:**

The contractor shall give sufficient notification of the placing of orders for materials to permit testing; shall afford such facilities as the Project Engineer may require for collecting and forwarding samples; shall not make use of, or incorporate in the work the materials represented by the samples until tests have been made and the materials found to be in accordance with the requirements of the specifications; and shall furnish without charge all samples required.

When required by the Project Engineer, representative preliminary samples of the character and quantity prescribed shall be submitted by the contractor or producer for examination and shall be tested in accordance with the methods referred to herein. The acceptance of a preliminary sample, however, shall not be construed as acceptance of materials from the same source delivered later. Only the materials actually delivered for the work shall be considered and their acceptance or rejection shall be based solely on the results of the tests prescribed in these specifications.

For the verification of weights or proportions and character of materials, and determinations of the temperatures used in the preparation of the materials and mixtures, the Project Engineer shall have access at all times to all parts of any plants connected with the work. The contractor shall facilitate and assist the verification of all scales, measures and other devices which he operates.

Unless otherwise specifically provided, all sampling and testing and laboratory methods required under

this contract shall be in accordance with the latest revision of the standard specifications of the American Society for Testing Materials, as amended to date of contract, and when not covered therein shall be sampled and tested in accordance with the "Standard Specifications for Highway Materials and Methods of Sampling and Testing" of the American Association of State Highway Officials, with subsequent revisions to date of contract. All tests not covered by the above shall be performed as specified by the Project Engineer.

**C113 STORAGE OF MATERIALS:**

Materials shall be stored so as to insure the preservation of their quality and fitness for the work, and in a manner that leaves the materials accessible to inspectors. With the approval of the Project Engineer, material may be stored on the right of way, provided such storage does not interfere with the prosecution of the work or with public travel.

**C114 DEFECTIVE MATERIALS:**

All materials not conforming to the requirements of these specifications shall be considered as defective, and all such materials, whether in place or not, shall be rejected and shall be removed immediately from the site of the work, unless otherwise permitted by the Project Engineer. No rejected material, the defects of which have been subsequently corrected, shall be used until approval has been given. Upon failure on the part of the contractor to forthwith comply with any order of the Project Engineer made under the provisions of this article, the Project Engineer shall have the authority to remove and replace defective material and to deduct the cost of removal and replacement from any monies due or to become due the contractor.

**C115 MATERIALS FURNISHED BY THE CONTRACTOR:**

Unless otherwise specifically stated in the contract,

all materials needed in the work shall be furnished by the contractor. The contractor shall assume full responsibility in ordering materials of the quality specified and required in the specifications. The contractor shall be responsible for the payment of all materials ordered by him in accordance with the contract, and this shall include payment of all freight and demurrage charges incurred in the shipment. The contractor shall be responsible for the proper storage and handling of the material to insure the required quality before and during incorporation into the work.

**C116 ADJUSTMENT FOR CHANGES IN COMMON CARRIER RATES:**

It shall be understood and agreed that the accepted proposal is based on common carrier rates current on the date of opening of the bids. In the event that such rates are increased thereafter on materials entering into and forming a part of the project, such increase, when properly shown by receipted common carrier bills, shall be paid by the Department to the contractor; likewise, should there be a reduction in the common carrier rates on said materials, the amount of such reduction shall be deducted by the Department from any monies due the contractor on said project.

**LEGAL RELATIONS AND RESPONSIBILITIES TO THE PUBLIC**

**C120 LAWS TO BE OBSERVED:**

The contractor is presumed to have made himself familiar with and at all times shall observe and comply with all Federal, State and local laws and bylaws, ordinances and regulations, in any manner affecting the conduct of the work, and shall indemnify and save harmless the Department and its representatives against any claim or liability arising from or based

on the violation of any such law, bylaw, ordinance, or regulation, whether by himself or by his employees.

**C121 PERMITS AND LICENSES:**

The contractor shall procure all permits and licenses, pay all charges and fees, and give all notices incident to the due and lawful prosecution of the work.

**C122 PATENTED DEVICES, MATERIALS AND PROCESSES:**

If the contractor is required or desires to use any design, device, material, or process covered by letters patent or copy-right, he shall provide for such use by suitable legal agreement with the patentee or owner, and a copy of this agreement shall be filed with the Department. The contractor and the surety shall indemnify and save harmless the Department from any and all suits, costs, penalties, or claims for infringement by reason of the use of any such patented design, device, material or process, or any trademark or copy-right in connection with the work agreed to be performed under this contract, and shall indemnify and save harmless the Department for cost, expenses, and damages which it may be obliged to pay by reason of any such infringement or alleged infringement at any time during the prosecution or after the completion of the work.

**C123 RESTORATION OF SURFACES OPENED BY PERMIT:**

Any individual or corporation wishing to make an opening in the highway shall secure a permit from the Chief Engineer and the contractor shall not allow any person to make an opening unless a duly authorized permit of the Chief Engineer is presented. Upon the presentation of a duly authorized and satisfactory permit, the contractor may allow parties bearing such permits to make openings in the highway. The contractor shall, if ordered by the Project Engineer in writing, make in an acceptable manner all necessary

repairs due to such openings, and such necessary work ordered by the Project Engineer shall be paid for on the basis of extra work or force account as provided for in these specifications.

**C124 FEDERAL PARTICIPATION:**

Bidders are advised that pursuant to the provisions of the Federal Highway Act and acts amendatory thereof and supplemental thereto, and other Federal laws or regulations, all highway construction on which Federal Aid or Federal Funds of any kind is received shall be performed under the supervision of the Department subject to the inspection and approval of the Federal Works Administrator or his duly accredited representative. Such inspection shall in no sense make the Federal Government a party to the contract and shall in no way interfere with the rights of either party hereunder.

**C125 SANITARY PROVISIONS:**

The contractor shall observe all rules and regulations of the State Board of Health, or any bodies having jurisdiction, and of all local health officials and shall take such precautions as are necessary to avoid unhealthful conditions.

**C126 PUBLIC CONVENIENCE AND SAFETY:**

The contractor shall at all times so conduct his work as to insure the least practicable obstruction to traffic. The convenience of the general public, the residents along and adjacent to the highway, and the protection of persons and property are of prime importance and shall be adequately provided for by the contractor. Fire hydrants on or adjacent to the highway shall be kept accessible to the fire apparatus at all times and no material or obstructions shall be placed within ten feet of any such hydrant. Materials stored upon the highway shall be placed so as to cause no unnecessary obstruction to the traveling public. No section of road shall be closed to the public except by express permission of the Project

Engineer, which permission may be revoked by the Project Engineer at any time. When the highway under construction is open to the traveling public, the contractor shall maintain both the subgrade and surfacing in such condition that the public can travel over the same in comfort and safety and shall at his own expense blade and drag the subgrades and all courses adapted to such treatment, when and as directed by the Project Engineer. To accommodate traffic on the roadway under construction, the contractor shall provide and maintain in a passable condition all necessary by-passes around structures or suitable and adequate temporary bridges over the structures to be rebuilt or extended. If the maintenance of traffic over detours for which the contractor is responsible make necessary the construction of bridges or temporary stream crossings, his responsibility for accidents shall include the roadway approaches as well as the structures of such crossings. During the progress of the work, the contractor shall provide for local traffic to private property within the closed portion of the work.

The contractor shall provide and maintain in a safe condition temporary approaches to and crossings of, railways and intersecting highways. When so provided in the contract or directed by the Project Engineer, concrete base courses, concrete pavements, and other pavements shall be constructed one-half width at a time, opened to traffic in accordance with the contract and satisfactorily maintained. Unless specifically otherwise provided for by the plans and/or special provisions, the cost of all necessary materials and all other costs incidental to the public's convenience and safety shall be borne by the contractor and shall be included by him in his bid prices for the various pay items appearing in the proposal and contract. The contractor shall cooperate with the Project Engineer in the regulation of traffic. If, in the opinion of the Project Engineer, the above requirements are not complied with, the Project Engineer may have such work done as he considers necessary and

charge the cost to the contractor. The contractor shall not be responsible for the maintenance of traffic on independent detours provided by the Department.

**C127 BARRICADES, DANGER, WARNING, AND  
DETOUR SIGNS:**

The contractor shall provide, erect and maintain all necessary barricades, suitable and sufficient red lights, danger signals and signs, provide a sufficient number of watchmen and take all necessary precautions for the protection of the work and workmen and safety of the public. Highways closed to traffic shall be protected by effective barricades on which shall be placed acceptable warning signs. The contractor shall provide and maintain acceptable warning and detour signs at all closures, intersections and along the detour routes, directing the traffic around the closed portion or portions of the highway, so that the temporary detour route or routes shall be indicated clearly throughout its or their entire length. All barricades and obstructions shall be illuminated at night and all lights shall be kept burning from sunset until sunrise. The contractor shall be held responsible for all damage to the project due to failure of the signs and/or barricades to properly protect work from traffic, pedestrians, animals, and from all other sources, and whenever evidence of any such traffic is found upon the unaccepted work, the Project Engineer shall order that work, if in his opinion it is damaged, to be immediately removed and replaced by the contractor without cost to the Department. y Except where special signs are required, the contractor shall provide signs as near as practical to conform with the Department's standard signs. The method of placing and position of their locations will generally follow the Department's standards for marking highways. The designation of such signs or the term "acceptable" where applicable to signs or barricades, shall not be interpreted as relieving the contractor of any responsibility of any nature as is expressly stated herein or under any other terms of the contract. The contractor's responsibility for the main-



tenance of barricades, signs, lights and any other necessary precautions, shall not cease until the project shall have been completed and accepted. Upon completion of the project, barricades and signs shall be removed and will remain the property of the contractor unless such signs or barricades are indicated on the plans to remain in place. This cost shall be included in other pay items unless otherwise specifically provided for.

**C128 USE OF EXPLOSIVES:**

When the use of explosives is necessary for the prosecution of the work, the contractor shall use the utmost care not to endanger life or property. Only light shooting will be permitted without specific authority of the Project Engineer, and whenever directed, the number and sizes of the charges shall be reduced. All explosives shall be stored in a secure manner and all such storage places shall be marked clearly "DANGEROUS—EXPLOSIVES." The methods of hauling, storing and handling explosives and highly inflammable materials shall conform to Federal and State laws and regulations.

**C129 PRESERVATION AND RESTORATION OF PROPERTY, TREES, MONUMENTS, ETC.:**

The contractor shall be responsible for the preservation of all public and private property, trees, monuments, etc., along and adjacent to the roadway and shall use every precaution necessary to prevent damage or injury thereto. He shall use suitable precaution necessary to prevent damage to pipes, conduits, and other underground structures and shall protect carefully from disturbance or damage all land monuments, State and United States bench marks, geodetic and geological survey monuments, and property marks until an authorized agent has witnessed or otherwise referenced their location and shall not remove them until directed. Any utility lines injured by the contractor shall be repaired at once at his own expense in accordance with the requirements of Article C143. The contractor shall not injure or destroy trees or

shrubs nor remove or cut them without proper authority.

The contractor shall be responsible for any damage done to public or private property by or on account of any act, omission, neglect, or misconduct in the execution of the work, or on account of defective work or material and he shall restore at his expense, such property to a condition similar or equal to that existing before such damage was done, by repairing, rebuilding, or otherwise restoring same, or he shall make good such damage or injury in an acceptable manner. In case of failure on the part of the contractor to restore such property or make good such damages or injury, the Project Engineer may, after forty-eight hours' written notice, proceed to repair, rebuild, or otherwise restore such property as may be deemed necessary and the cost thereof will be deducted from any monies due or which may become due the contractor under this contract. In case no money is due or to become due, his surety shall be held until such time as all suits, claims or damages shall have been settled and suitable evidence to that effect furnished the Project Engineer.

#### **C130 RESPONSIBILITY FOR DAMAGE CLAIMS:**

The contractor shall save harmless the Department and all its representatives from all suits, actions, or claims of any character brought on account of any damages sustained by any person or property in consequence of any neglect in safeguarding the work, or through the use of unacceptable material in the construction of the improvement, or on account of any act or omission by the said contractor or by or on account of any claims or amounts recovered for any infringement of patent, trademark, or copyright, or from any claims or amounts arising or recovered under the "Workman's Compensation Laws," or any other law, bylaw, ordinance, order or decree. The contractor shall carry at his expense, Workman's Compensation Insurance as, and to the extent, provided by law. He shall not be released from said re-

sponsibility until the contract shall have been completed and the work accepted and so much of the money due the said contractor under and by virtue of his contract as shall be considered necessary by the Department, may be held until such aforesaid claims have been settled and suitable evidence to that effect furnished to the Department. In case no money is due the contractor, his surety shall be held until any suit, claims, or actions, for injuries or damages shall have been settled.

**C131 OPENING OF SECTION OF HIGHWAY TO TRAFFIC:**

The contractor shall be required to maintain the highway in first class condition until final acceptance. Whenever, in the opinion of the Project Engineer, any roadway, or portion thereof, is in an acceptable condition for travel, it shall be opened to traffic as may be directed and such opening shall not be held to be in any way an acceptance of the roadway or any part of it, or as a waiver of any of the provisions of these specifications and contract. Necessary repairs or renewals made on any section of the roadway, due to its being opened to travel under instructions from the Project Engineer, to defective materials or work, natural causes, to ordinary wear and tear or otherwise pending completion and acceptance of the roadway, shall be performed at the expense of the contractor. The contractor shall harrow, drag or otherwise maintain the completed sections of the roadway until final acceptance of such section, in a manner approved by the Project Engineer.

**C132 CONTRACTOR'S RESPONSIBILITY FOR WORK:**

Until the acceptance of the work by the Construction and Maintenance Engineer as evidenced in writing, it shall be under the charge and care of the contractor. He shall take every necessary precaution against damages to any part thereof by the action of the elements or from any other cause, whether arising from the execution or from the non-execution

of the work. The contractor shall rebuild, restore, repair, and make good, at his own expense, all injuries or damages to any portion of the work occasioned by any of the above causes before its completion and acceptance. No work under this contract shall be accepted in sections unless specifically provided for by the plans and/or special provisions and in no case shall the retained percentage amount be paid the contractor until completion and acceptance of the entire project. In case of the suspension of work from any cause whatever, the contractor shall be responsible for all materials, shall properly store them, if necessary, and shall provide suitable drainage of the roadway and erect temporary structures where necessary. When final inspection has been made as provided in Article C95, and the work accepted in writing by the Chief Engineer, the contractor shall be relieved of any construction responsibility subject to the provisions of Articles C130, C149 and C154.

**C133 PERSONAL LIABILITY OF PUBLIC OFFICIALS:**

In carrying out any of the above provisions or in exercising any power or authority granted to him by this contract, there shall be no liability upon the Chief Engineer or his authorized assistants, either personally or as an official of the State, it being understood that in such matters he acts as the representative of the State.

**C134 NO WAIVER OF LEGAL RIGHTS:**

Inspection by the Project Engineer or by any of his duly authorized representatives; any order, measurement, or certificate by the Project Engineer; any order by the Department for the payment of money; any payment for or acceptance of any work or any extension of time; or any possession taken by the Department shall not operate as a waiver of any provision of the contract, or any power therein preserved to the Department, or of any right to damages therein provided. Any waiver of any breach of

the contract shall not be held to be a waiver of any other or subsequent breach.

The Department reserves the right to correct any error that may be discovered in any estimate that may have been paid, and to adjust the same to meet the requirements of the contract and specifications. Upon conclusive proof of collusion or dishonesty between the contractor and his agents and the Project Engineer or his assistants being discovered in the work after final payment has been made, the Department reserves the right to claim and recover by process of law, sums as may be sufficient to correct the error or make good the defects in the work resulting from such error, dishonesty or collusion.

**C135 FURNISHING RIGHT OF WAY:**

All necessary right of way for the proper completion of the work will be secured by the Department without cost to the contractor, unless otherwise specifically provided.

**PROSECUTION AND PROGRESS  
OF WORK**

**C140 SUBLETTING OR ASSIGNING OF CONTRACT:**

The contractor shall not assign, sell, transfer, or otherwise dispose of the contract, or any portion thereof, or his rights, title or interest therein, without the previous written approval of the Chief Engineer. The contractor shall not be permitted to sublet any portion of the contract, except for the delivery of materials, without the written approval of the Project Engineer.

Roadside production of materials, unless performed by the contractor, shall be considered as subcontracting. Roadside production of materials is construed to be production of crushed stone, gravel and/or other materials with portable or semiportable crushing, screening or washing plants established or re-

opened in the vicinity of the work for the purpose of supplying materials to be incorporated into the work on a designated project or projects.

The purchase of sand, gravel, crushed stone, crushed slag, batched concrete aggregates, ready mixed concrete and/or any other materials produced at and furnished from established and recognized commercial plants, together with the delivery of such materials to the site of the work by means of vehicles owned or operated by such plants or by recognized commercial hauling companies, shall not be considered as subcontracting under these provisions.

Except as hereinafter stated all hauling of materials from roadside production sources, or from railroad or water delivery points, to batching plants, mixing plants or directly to their place of use in the road, and all hauling of materials from batching plants and mixing plants to their place of use in the road, unless done by the contractor's own equipment or by recognized commercial hauling companies shall be considered as subcontracting under these provisions.

If batching plants or mixing plants are set up at rail or water delivery points and materials in part supplied to such plants by rail or water transportation companies, the remaining materials required at such batching or mixing plants may be hauled to such plants without such hauling being considered as subcontracting.

No subcontract shall in any case relieve the contractor of his responsibility under the contract and bond.

#### **C141 PROSECUTION OF WORK:**

The contractor shall begin the work to be performed under the contract within ten calendar days after the date of the work order. The contract days shall start on the eleventh day after the date of the work order. The contractor shall notify the Project Engineer at least forty-eight hours before beginning work. He shall start the work at the point designated

by the Project Engineer, shall prosecute the work at as many different points as the Project Engineer may direct, shall complete any portion of the work in such order of time as the Project Engineer may require and shall provide an adequate force of labor and equipment to insure the completion of the contract within the time limit for completion as set forth in the contract. The contractor shall notify the Project Engineer at least forty-eight hours before beginning work after suspension of work.

The Department reserves the right to issue a conditional work order prior to the acquisition of all rights of way included within the project. When a conditional work order is issued to the contractor authorizing the contractor to begin construction before all rights of way have been secured, the act of beginning construction shall constitute and be a waiver by the contractor of any claim for loss or damage that may be attributed to or may arise from lack of any part of the rights of way shown on the plans. Such conditional work order, or orders, to begin construction shall state the stations on the plans between which rights of way have been acquired. The contractor shall have the right to refuse to proceed under the authority of such conditional work order without prejudice and without penalty. The issuance of a conditional work order shall not operate to change the method of counting time as specified under Paragraph C146, these specifications.

#### **C142 LIMITATIONS OF OPERATIONS:**

The contractor shall at all times conduct the work in such manner and such sequence as will insure the least practicable interference with traffic and he shall have due regard to convenient detours. He shall not open up work to the prejudice of work already started and this feature of the prosecution of the work shall be governed by the order of the Project Engineer.

The contractor shall arrange his work and dispose of his material so as not to interfere with the opera-

tions of other contractors engaged upon adjacent work and to join his work to that of others in a proper manner, and to perform his work in the proper sequence in relation to that of other contractors, all as may be directed by the Project Engineer. Each contractor shall be held responsible for any damage done by him or his agents to the work performed by another contractor and the Department shall not be liable therefor.

#### **C143 COOPERATION WITH PUBLIC UTILITIES:**

It shall be the contractor's responsibility to notify all public utilities or other parties interested to make all necessary adjustments of public utility fixtures and appurtenances within or adjacent to the limits of construction. Unless otherwise specified, these adjustments are to be made by the owners of the utility.

The contractor shall be responsible for any damage done by him to any telephone, telegraph, power poles or lines, water or fire hydrants, water mains and pipe lines, sewers, conduits and other accessories and appurtenances of a similar nature which are owned or controlled by a city, public utility company or corporation. He shall perform and carry on his work in such a manner as not to interfere with or damage fixtures mentioned herein, or as shown on the plans, or discovered during construction which are to be left within the limits of the project. The Department shall not be liable for any delay or damage incurred by the contractor due to working around or joining his work to fixtures left in place.

The Department shall not be responsible for any delays or inconveniences to the contractor in carrying on his work in the above mentioned manner and/or while the public utilities companies or city are making necessary adjustments of their fixtures or appurtenances. Any additional cost incurred shall be the expense of the contractor and shall be considered as completely covered by the contract unit prices for the various pay items provided for in the proposal and contract.



#### **C144 CHARACTER OF WORKMEN AND EQUIPMENT:**

The contractor shall at all times employ sufficient labor and equipment for prosecuting the several classes of work to full completion in the manner and time specified. Failure by the contractor to provide adequate equipment or labor may result in the annulment of the contract as hereinafter provided. Any foreman or workman employed by the contractor or by any subcontractor who, in the opinion of the Project Engineer or his authorized representative, disobeys orders, does not perform his work in a proper and skillful manner, or is disrespectful, intemperate, disorderly or otherwise objectionable, shall at the written request of the Project Engineer be forthwith discharged by contractor, or subcontractor, employing such foreman or workman, and shall not be employed again on any portion of the work without the written consent of the Project Engineer. Should the contractor fail to remove such person or persons, or fail to furnish suitable and sufficient machinery, equipment, or force for the proper prosecution of the work, the Project Engineer may withhold all estimates which are or may become due, or may suspend the work until such orders are complied with.

All workmen shall have sufficient skill and experience to properly perform the work assigned them. All workmen engaged on special work or skilled work, such as bituminous courses or mixtures, concrete base courses, pavements or structures, or in any trade, shall have had sufficient experience in such work to properly and satisfactorily perform it and operate the equipment involved, and shall make due and proper effort to execute the work in the manner prescribed in these specifications, otherwise the Project Engineer may take action as above prescribed.

All machinery and equipment owned or controlled by the contractor which is proposed to be employed by him on the work, shall be of sufficient size to meet the requirements of the work and shall be

such as to produce a satisfactory quality of work; all to be subject to the inspection and approval of the Project Engineer. No change in machinery and equipment employed on the work, which shall have the effect of decreasing its capacity, shall be made except by written permission of the Project Engineer. The measure of the capacity shall be its actual performance on the work. No item of equipment or machinery after once being placed on the work shall be removed without the consent of the Project Engineer.

#### **C145 TEMPORARY SUSPENSION OF WORK:**

The Project Engineer shall have the authority to suspend the work wholly or in part. The order to suspend the work for periods exceeding one calendar day shall be in writing and shall include the specific reasons for the suspension.

If the work is suspended by the Project Engineer in the interest of the Department, allowances shall be made for the time elapsed during the period of suspension as hereinafter provided.

If the work is suspended by the Project Engineer because of the failure or refusal of the contractor to comply with the order of the Project Engineer or with the plans and specifications, the time elapsed during such suspension shall remain charged against the contractor.

When the work is suspended, the contractor shall store all materials in such manner that they shall not obstruct or impede the traveling public unnecessarily nor become damaged in any way, and he shall take every precaution to prevent damage or deterioration of the work performed; provide suitable drainage of the roadway by opening ditches, shoulder drains, etc., and erect temporary structures where necessary. The work shall be resumed when conditions are favorable and methods are corrected, as ordered or approved in writing by the Project Engineer. Liquidated damages shall not accrue during the period in which work is suspended by approval of the Project

Engineer unless suspension is due to the failure of the contractor to perform any of the provisions of the contract.

**C146 DETERMINATION AND EXTENSION OF CONTRACT TIME:**

The time within which the work is required to be completed is of the essence of the contract. The contract time shall consist of the calendar days (Sundays excepted) elapsed during the period beginning on the eleventh day after the date of the work order as provided in Article C141, and ending with the Construction and Maintenance Engineer's acceptance of the work as provided in Article C149.

The contract time shall automatically be extended by a period proportional to the positive difference in dollars obtained by subtracting the amount of the contract from the total amount of the final estimate.

The contract time shall automatically be extended by the period during which the whole work, or a controlling part thereof, was suspended by the Project Engineer in the interest of the Department as provided in C145.

At any time before the payment of the final estimate, the contractor may submit to the Project Engineer an application for an extension of the contract time. In support of the application the contractor shall allege delay in the performance of the work only by either or both of the following causes:

(a) An act of the State.

(b) "Fortuitous events" or "events beyond the control" as defined in Louisiana jurisprudence.

The application shall show in detail the cause of delay, the terminal dates influenced by the causes recited and clearly indicate how the progress of the work as a whole was retarded. The application shall be accompanied by ample evidence which can be verified by the Project Engineer.

The Project Engineer shall promptly make a written report and recommendation on the project or

application presented by the contractor. The documents shall be reviewed by the Chief Engineer and the contractor notified of the decision reached. If an extension of the time is approved, the contractor shall secure the assent of his surety thereto.

**C147 FAILURE TO COMPLETE WORK ON TIME:**

Should the contractor fail to complete the work in the time specified in the contract, or within such extra time as may have been allowed for delays by formal extensions, a deduction of an amount equal to the actual cost incurred by the Department will be made for each and every day that such contract remains uncompleted after the time above designated for the completion. The said amount is hereby agreed upon as liquidated damages for the loss to the Department on account of the expenses due to the employment of engineers, inspectors and other employees and the maintenance of any detours which are required to maintain traffic after the expiration of the number of contract days agreed upon, and shall be deducted from any money due the contractor under this contract, and the contractor and his sureties shall be liable for any liquidated damages in excess of the amount due the contractor. Permitting the contractor to continue and finish the work or any part of it after the time affixed for its completion, or after the date to which the time of completion may have been extended shall in no way operate as a waiver on the part of the Department of any of its rights under this contract.

**C148 DEFAULT OF CONTRACT:**

If this contract, or any part thereof, shall be sublet, without the previous written consent of the Project Engineer, or if the contract shall be assigned by the contractor otherwise than as herein specified, or if the contractor shall become insolvent or be declared bankrupt, or shall commit any act of bankruptcy, or insolvency, the contractor shall, ipso facto and without any demand or putting into default, be in default.

If the contractor fails to begin the work within

the time specified or if the construction or work to be done under this contract shall be abandoned, or if at any time the Chief Engineer shall be of the opinion that the work or any part thereof is unnecessarily or unreasonably delayed or that the contractor has violated any provision of this contract, or if the contractor shall discontinue the prosecution of the work without authority, the Chief Engineer shall so certify to the Director and the Director may give notice in writing to the contractor and his Surety of such delay, neglect, or default specifying the same, together with a demand that the contractor begin and/or prosecute said work with all due dispatch, or remedy such violation, as the case may be. If the contractor within a period of ten days after receipt of such notice and demand shall not proceed in accordance therewith, then the contractor shall, ipso facto and without any further demand or putting in default, be in default.

Whenever the contractor shall be in default, the party of the first part shall, upon written certificate from the Chief Engineer of the fact of default, have full power and authority without violating the contract to take the prosecution of the work out of the hands of the contractor and to appropriate or use any or all materials and equipment on the ground as may be suitable and acceptable, and enter into an agreement for the completion of the contract according to the terms and provisions thereof or use such other methods as in his opinion may be required for the completion of the contract in an acceptable manner.

All cost and charges that may be incurred under this article or any damages that should be borne by the contractor, shall be withheld or deducted from any monies then due, or to become due the contractor, under this contract, or any part thereof; and in such accounting the Department shall not be held to obtain the lowest cost of the work of completing the contract or any part thereof, but all sums actually paid therefor shall be charged to the contractor.

In case the costs and charges incurred are less than the sum which would have been payable under the contract, if the same had been completed by the contractor, the contractor or his Surety shall be entitled to receive the difference and in case such costs and charges exceed the said sum, the contractor or his Surety shall pay the amount of excess to the Department for the completion of the work.

The Department expressly reserves the right to waive any default or defaults of the contractor.

Nothing contained in this section shall obligate the Department in any way to avail itself of any of the rights conferred upon the Department by this section, and no person shall have any right to complain of any failure of the Department to avail itself of any of its said rights.

The remedies accorded the Department by this section shall not be exclusive and the Department shall at any and all times have the right to avail itself of any other remedy accorded it by law.

No indulgence or waiver by the Department of any default of the contractor or any breach by the contractor of any of the contractor's obligations shall ever be construed to be a waiver of any other default of the contractor or any other breach by the contractor of his obligations, nor as a waiver of the right of the Department to insist thereafter upon strict compliance with the terms of the contract.

#### **C149 TERMINATION OF CONTRACTOR'S RESPONSIBILITY:**

The contract will be considered complete when all work has been satisfactorily completed, the final inspection made, the work accepted by the Chief Engineer, and the final estimate paid. The contractor will then be released from further obligation except as set forth in his contract bond, and except as provided in Article C134.

## MEASUREMENT AND PAYMENT

### C150 MEASUREMENT OF QUANTITIES:

The measurements necessary to determine the quantities of work actually performed under this contract shall be taken by the Project Engineer. The units used, unless otherwise specified, shall be United States Standard.

Earthwork shall be computed by the average end area method, using lengths measured on center line as the distance between cross sections.

The prismoidal formula shall be used in computing the volume of masonry.

All longitudinal measurements for area shall be made along the actual surface of the roadway and not horizontally.

For all transverse measurements for area of base courses, surface courses and pavements, the dimensions to be used in calculating the pay area shall be the net dimensions shown on the plans or ordered in writing by the Project Engineer.

No deductions shall be made for fixtures in the roadway having an area of nine square feet or less.

All materials which are specified for measurement by the cubic yard in vehicles shall be hauled in approved vehicles and measured therein at the point of delivery. Allowance shall not be made for wastage or shrinkage of materials during its transportation from the pit, barge, car, or other point of loading to the unloading point. The contractor shall strike off and level the load, and the checker or inspector shall inspect each load and check its yardage. Approved vehicles for this purpose may be of any size or type acceptable to the Project Engineer, provided the body is of such shape that the actual delivered contents may be readily and accurately determined and shall remain constant. Unless all approved vehicles on the work are of uniform capacity, each vehicle shall bear a plainly legible identification mark, indicating its specific approved

capacity. The inspector may reject all loads not hauled in approved vehicles.

The Project Engineer shall be the final judge as to the accuracy of any measurements or quantities, and the reasonableness of any approximations made in lieu of accurate determinations, and his decisions shall be binding upon both parties.

**C151 SCOPE OF PAYMENT:**

The contractor shall receive and accept the compensation provided for in the contract as full payment for furnishing all materials, labor, tools, and equipment, and for performing all work contemplated and embraced under the contract, in a complete and acceptable manner in accordance with the contract; for all loss or damage arising out of the nature of the work or from the action of the elements; for all expenses incurred by, or in consequence of, the suspension or discontinuance of the said prosecution of the work as herein specified, or from any unforeseen difficulties or obstructions which may arise or be encountered during the prosecution of the work; and for all risks of every description connected with the prosecution of the work until its final acceptance by the Chief Engineer. The payment of any current or final estimate or the acceptance of any portion of the work as provided in the contract shall in no way or in no degree affect the obligation of the contractor, who, at his own cost and expense, shall repair, correct, renew, or replace any defects or imperfections in the construction, strength, or quality of materials used in or about the construction of the work under the contract, and this payment shall in no way affect his responsibility for all damages due or attributed to such defects or imperfections which may be discovered before the final acceptance of the whole work and the Project Engineer shall be the judge of such defects or imperfections. No monies payable under the contract, except the estimate for the first month or period, shall become due, if the Project Engineer so elects, until the contractor shall satisfy the Project Engineer that he



has fully settled for materials and equipment used in or upon the work and labor done in connection therewith.

#### **C152 PAYMENT BY FORCE ACCOUNT:**

All extra work done on a force account basis shall be performed by such labor, teams, tools, and equipment as may be specified by the Project Engineer.

When work to be performed is to be paid for on a force account basis, the contractor shall furnish itemized weekly statements to the Project Engineer of the cost of all force account work, together with original receipted bills for all materials used and freight charges paid on same. These weekly statements shall show the following information:

a. Nature of work performed.

b. Name, class, dates, number of hours worked each day, total hours, rate and extension, for each laborer, foreman, and team engaged. (Teams and drivers shall be carried separately on the statement and likewise shall all operators of equipment be carried separately, in order that the amount paid for labor may be determined.)

c. Designation, number of hours worked each day, total hours, rental rate and extension for each truck, and unit of machinery engaged.

d. Quantity of materials used, prices and extensions.

e. Freight on materials.

For all labor, teams, and foremen in direct charge of the specific operation, the contractor shall receive the wage required by the contract in each case or, if not specified, then the current local rate of wage to be agreed upon in writing before starting the work, to which shall be added an amount equal to

15 per cent of the sum thereof. In addition to the payments above mentioned, the contractor shall be reimbursed in the amount of the actual payments made by him for labor, taxes and insurance. No allowance shall be made for general superintendence and the use of small tools and manual equipment.

For all materials accepted by the Project Engineer and used, the contractor shall receive the actual cost of such material, including transportation charges, to which cost shall be added a sum equal to ten per cent thereof.

For any machine-power tools, or special equipment, including pertinent fuel and lubricants, which it may be deemed necessary or desirable to use, the Project Engineer shall allow the contractor a reasonable rental price to be agreed upon in writing before such work is begun for the time that such tools or equipment are in use on the work and to which sum no percentage shall be added.

The compensation as herein provided shall be received by the contractor as payment in full for extra work done on a force account basis, and shall include superintendence, use of equipment for which no rental is allowed, and profit. The contractor's representative and the inspector shall compare records of extra work done on a force account basis at the end of each day. Copies of these records shall be made upon suitable forms provided for this purpose by the inspector and signed by both the inspector and the contractor's representative, one copy being forwarded, respectively, with the monthly estimate and one to the contractor. All claims for extra work done on a force account basis shall be submitted to the Project Engineer by the contractor upon certified statements to which shall be attached original receipted bills covering the cost of, and the freight charges on, all materials used in such work, in order that said statements shall be forwarded with the monthly estimate not later than the twentieth day of the estimate month in which the work was actually performed, and shall include all labor charges, etc., and material charges.

### **C153 PARTIAL PAYMENTS:**

So long as the work herein contracted for is prosecuted in accordance with the provision of the contract, and with such progress as may be satisfactory to the Project Engineer, the Project Engineer shall, on or about the twentieth day of each month, make or have made an approximate estimate of the proportionate value of the work done, up to and including that day. Progress estimates shall be based on material in place and labor expended thereon, but no more than ninety per cent of the contract price of the work shall be paid in advance of the full completion of the contract and its acceptance by the Department.

The amount of said estimate, after deducting ten per cent and all previous payments, shall be due and payable to the contractor at the office of the Treasurer of the State of Louisiana.

The monthly estimates shall be approximate only, and all partial or monthly estimates and payments shall be subject to corrections in the estimate rendered following discovery of any error in any previous estimates.

Should any defective work or material be discovered, or should a reasonable doubt arise as to the integrity of any part of the work completed previous to the final acceptance and payment, there shall be deducted from the first estimate rendered after the discovery of such defective or questioned work an amount equal in value to the defective or questioned work, and this work shall not be included in a subsequent estimate until the defects have been remedied or the causes for doubt removed.

The payment of the monthly estimate shall not in any respect be taken as an admission that the work is done or that its quality is satisfactory, nor as a release of the contractor from the responsibility for any portion thereof, but the whole work and all particulars relating thereto shall be subject to revision and adjustment by the Project Engineer at the time of

final acceptance and the payment of the final estimate.

#### **C154 ACCEPTANCE AND FINAL PAYMENT:**

Upon the completion and acceptance of the work, the Chief Engineer shall execute a certificate that the whole work provided for in this contract has been completed and accepted under the terms and conditions of the contract, and said certificates of acceptance shall be recorded in the office of the Recorder of Mortgages of the Parish in which the work has been done, and the entire balance found to be due the said contractor, including all retained percentages (all prior certificates or estimates upon which payments have been made being approximate only and subject to correction in the final payment) shall be paid to the contractor at the office of the Treasurer of the State after the Department has satisfied itself that the quantities shown on the final estimate are correct; provided, however, that before the payment of said final estimate shall be made, the contractor shall submit to the Department a certificate from the Recorder of Mortgages of the Parish in which the said work has been done, to the effect that there are no claims or liens recorded against the said contract. The date of said certificate shall be not prior to the expiration of forty-five days after the certificate of acceptance was recorded by the Department in the Mortgage office.

It is expressly stipulated and understood that payment of the final estimate shall not operate to release the contractor or his sureties from liability for any fraud in construction, or in obtaining progress payments, or in payment for materials, labor, or other supplies or services incidental to the work, or for any and all claims for damages, loss or injury sustained by any person or persons whomsoever, through the fault, negligence or conduct of said contractor or any of his employees.

DIVISION II  
CONSTRUCTION DETAILS

## RIGHT OF WAY

Right of way land costs; cost of considerations when in lieu of price of land; prosecution and fulfillment of right of way considerations and agreements, such as: building gates and fences, removal and relocation of buildings and appurtenances; removal and relocation of shrubs, flowers, trees, etc., compensation for standing crops; right of way markers; public utility adjustments; other costs in connection.

## FENCE

New Barbed Wire Fence	Item 201
New Combination Mesh and Barbed Wire Fence	Item 202
Rebuilt Fence	Item 203
New Fence Posts	Item 204

### DESCRIPTION:

This item shall consist of furnishing and constructing or rebuilding fence in accordance with the plans and these specifications.

### MATERIALS:

Barbed wire shall conform to the requirements specified in M-105.

Mesh wire shall conform to the requirements specified in M-106.

Staples shall conform to the requirements specified in M-100.

Posts shall conform to the requirements specified in M-40.

Braces shall be of sound timber of the sizes shown on the plans.

### CONSTRUCTION METHODS:

#### New Fence:

The fence shall be constructed at the location indicated on the plans or as directed by the Project Engineer. Posts shall be set vertically to the full depth shown on the plans and accurately spaced and aligned. The postholes shall be backfilled, with carefully selected material for the backfill, and thoroughly compacted by tamping. Braces shall be placed at angles, corners, gates, and at the beginning and end

of fence and on straight sections shall not be more than 1,000 feet apart. The wire shall be stretched and nailed to the posts with at least one staple for each horizontal strand and as many additional staples as required to make a secure and workmanlike fence.

**Rebuilt Fence:**

Where indicated on the plans or directed by the Project Engineer, the contractor will be required to take down, move back and rebuild existing fence. The fence shall be rebuilt in the same manner as specified for new fence. The contractor shall take every possible precaution and care against damage in removing the fence and he shall be responsible for any damage to crops or property occasioned by allowing cattle, horses, mules, and other animals to roam through gaps left by workmen.

**Fence Posts in Rebuilt Fence:**

New posts shall be used in rebuilding fence where indicated on the plans or directed by the Project Engineer. The posts shall be installed in the rebuilt fence in the same manner as specified for new fence.

**METHOD OF MEASUREMENT:**

Fence shall be measured by the station (one-hundred linear feet) and the quantity determined by measurement of length of fence actually completed.

New posts shall be measured by the post and the number of new posts installed in rebuilt fence shall be counted.

**BASIS OF PAYMENT:**

The number of stations of fence and number of posts completed and accepted, measured as provided above, shall be paid for at the contract unit price per unit for "Fence" and "Fence Posts," complete in place, which price and payment shall constitute full compensation for furnishing all materials, tools, equipment, labor and incidentals and the performance of all work necessary to complete the item.



The unit price bid for "New Fence" shall include the furnishing and installing of posts. The unit price bid for "Rebuilt Fence" shall not include furnishing and installing new posts, the cost of same will be paid for at the contract unit price bid for "New Fence Posts."

Payment will be made under:

Item 201, New Barbed Wire Fence, per station.

Item 202, New Combination Mesh and Barbed Wire Fence, per station.

Item 203, Rebuilt Fence, per station.

Item 204, New Fence Posts, per post.

## GATES

Walk Gates

Item 205

Driveway Gates

Item 206

### DESCRIPTION:

This item shall consist of the furnishing and construction of gates of the design and dimensions shown on the plans and constructed in accordance with these specifications.

### MATERIALS:

#### Lumber and Posts:

All lumber and posts shall be No. 2 common cypress rough and shall be of the size and dimensions shown on the plans. No. 2 common will admit unsound knots and slight peck on both sides, shakes and other defects that will not prevent the use of the piece in its full length and width for common dimension use.

The bottom three feet of posts shall be dipped in hot tar pitch.

#### Hardware:

Strap hinges, carriage bolts, washers, nails, staples, and well chain shall be standard quality of the size and dimensions shown on the plans and acceptable to the Project Engineer.

## **CONSTRUCTION METHODS:**

### **General:**

The gates shall be constructed at the places indicated on the plans or as directed by the Project Engineer.

Posts shall be set vertically to the full depth shown on the plans and accurately spaced and aligned. The post holes shall be backfilled, great care used to select suitable material for the backfill, and thoroughly compacted by tamping. The bottom edge of the gate shall be elevated above ground line as shown on the plans. The finished gate shall swing free and shall be constructed in a workmanlike manner acceptable to the Project Engineer.

### **METHOD OF MEASUREMENT:**

Gates shall be measured, complete in place, and each completed gate shall be counted.

### **BASIS OF PAYMENT:**

The number of gates completed and accepted, measured as provided above, shall be paid for at the contract unit price each for "Gates," complete in place, which price and payment shall constitute full compensation for furnishing all materials, including posts, equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

Payment will be made under:

- Item 205a, Single Swinging Walk Gates, per each.
- Item 205b, Double Swinging Walk Gates, per each.
- Item 206a, Single Swinging Driveway Gates, per each.
- Item 206b, Double Swinging Driveway Gates, per each.

# PROJECT MARKERS AND RIGHT OF WAY MARKERS

Project Markers (Cast Iron)	Item 207
Project Markers (Bronze)	Item 208
Right of Way Markers (Concrete)	Item 209
Right of Way Markers (Bronze)	Item 210

## DESCRIPTION:

This item shall consist of furnishing and erecting project markers, and right of way markers in conformity with the design, dimensions, and elevations shown on the plans.

## PROPORTIONING AND MIXING:

All concrete for this item shall be class "A," proportioned and mixed as specified under "Concrete."

## MATERIALS:

Cement, sand, coarse aggregate and water shall meet the requirements specified under "Class A Concrete."

Reinforcing steel shall consist of deformed bars and shall conform to the requirements specified in M-110 or M-111.

Cast Iron Marker plates shall conform to the requirements specified in M-21.

Bronze marker plates shall conform to the requirements specified in M-20.

Paint shall conform to the requirements specified in "Painting."

## CONSTRUCTION METHODS:

### Project Markers:

The markers shall consist of either cast iron or bronze plates as indicated on the plans.

(a) Cast Iron Markers: The required number of cast iron marker plates shall be furnished and in-

stalled on the reinforced concrete posts at the location indicated on the plans or as directed by the Project Engineer. The concrete posts shall be cast, finished and cured in accordance with specifications for "Precast Concrete Posts and Braces." The plate shall be painted with two coats of black graphite paint and the faces of the raised letters shall be painted with two coats of white lead and oil, as specified under "Painting."

(b) Bronze Markers: Bronze markers shall be furnished and installed in concrete at the locations indicated on the plans in a neat and workmanlike manner as directed by the Project Engineer.

#### **Right of Way Markers:**

These markers shall consist of either reinforced concrete posts or bronze plates as indicated on the plans. The markers shall be installed on right of way lines at points designated on the plans or directed by the Project Engineer.

(a) Marker Posts: The posts shall be cast, finished, and cured in accordance with specifications for "Precast Concrete Posts and Braces."

(b) Bronze Markers: These markers shall be constructed in accordance with the requirements for "Bronze Project Markers."

#### **Backfilling:**

All posts shall be set to the depth indicated on the plans or as directed by the Project Engineer and post holes shall be backfilled with selected suitable material. The backfill shall be placed in layers, watered and tamped as directed by the Project Engineer.

#### **METHOD OF MEASUREMENT:**

Project and right of way markers shall be measured by the marker and the number placed and accepted shall be counted.

**BASIS OF PAYMENT:**

The number of markers placed and accepted, measured as provided above, shall be paid for at the contract unit price per "Marker," complete in place, which price and payment shall constitute full compensation for furnishing all equipment, tools, labor, materials, and incidentals and the performance of all work necessary to complete the item.

Payment will be made under:

Item 207, Project Markers (Cast Iron), per marker.

Item 208, Project Markers (Bronze), per marker.

Item 209, Right of Way Markers (Concrete), per marker.

Item 210, Right of Way Markers (Bronze), per marker.

**PLAIN PORTLAND CEMENT  
CONCRETE STEPS  
ITEM 211**

**DESCRIPTION:**

This item shall consist of the construction of concrete steps at designated locations and in conformity to the lines and grades shown on the plans.

**PROPORTIONING AND MIXING:**

All concrete for this item shall be class "A," proportioned and mixed as set out under "Concrete."

**MATERIALS:**

**CEMENT, SAND, COARSE AGGREGATE, WATER  
AND PREMOULDED FILLER:**

These materials shall meet the requirements specified under "Class A Concrete."

## **CONSTRUCTION METHODS:**

### **Forms:**

The forms shall be either metal or wood and shall be straight, free from warp, of sufficient strength to resist springing during construction, and of a height equal to the full depth of the steps to be constructed. Wood forms shall have a minimum thickness of two inches. Metal forms shall be of a type approved by the Project Engineer. The forms shall be thoroughly cleaned, well oiled, securely staked, braced, and held to the required line and grade before any concrete is deposited.

### **Depositing and Finishing Concrete:**

The concrete shall be deposited between the forms and shall be struck off and compacted to the required thickness. It shall be tamped sufficiently to bring the mortar to the top surface. The surface shall be finished with a wood float or steel trowel, provided that the surface is finally brushed in order to leave a slightly rough finish. All joints and edges shall be rounded with an edging tool having a one-quarter inch radius. Concrete steps shall be cured as specified for concrete pavement.

### **Backfilling:**

After the concrete has set sufficiently, the forms shall be removed and the space adjacent to the steps shall be backfilled with suitable material, thoroughly compacted and neatly graded.

## **METHOD OF MEASUREMENT:**

Concrete steps shall be measured by the square yard. The area to be measured shall be the surface of the treads only.

## **BASIS OF PAYMENT:**

The number of square yards completed and accepted, measured as specified, shall be paid for at the contract unit price per square yard for "Port-

land Cement Concrete Steps," complete in place, which price and payment shall constitute full compensation for finishing the subgrade; furnishing all materials, forms, equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

Payment will be made under:

Item 211, Portland Cement Concrete Steps, per square yard.

## PULLING AND REDRIVING WELLS ITEM 212

### **DESCRIPTION:**

This item shall consist of pulling pipe wells and redriving them at the location shown on the plans or as directed by the Project Engineer and shall be done in conformity with the plans and in accordance with these specifications. Work under this item shall be limited to the type of wells which have been installed by driving.

### **CONSTRUCTION METHODS:**

#### **General:**

The pumps and fittings shall be disconnected, the pipe pulled, moved to the new location and redriven, the pumps and fittings replaced and reconnected and the wells left in as good condition in all respects as they were before they were moved. Any new pipe, pipe fittings and pump parts that may be necessary for the proper functioning of the pump in its new location shall be furnished by the contractor without additional compensation.

The contractor will be required to furnish a certificate of release from the property owner as specified in Item 215.

**METHOD OF MEASUREMENT:**

Pulling and re-driving wells shall be measured by the well and each well pulled and re-driven shall be counted.

**BASIS OF PAYMENT:**

The number of wells pulled, re-driven and accepted, measured as provided above, shall be paid for at the contract unit price per well for "Pulling and Redriving Wells," complete in place, which price and payment shall constitute full compensation for pulling the pipes, moving to new locations and re-driving, for all disconnecting and reconnecting pipe, pipe fittings and pump, for any necessary new parts and for the furnishing of all equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

Payment will be made under:

Item 212, Pulling and Redriving Wells, per well.

**CONSTRUCTING WELLS  
ITEM 213**

**DESCRIPTION:**

This item shall consist of the construction of new wells at the location shown on the plans or as directed by the Project Engineer to replace existing wells and the filling of the old wells, and shall be done in conformity with the plans and in accordance with these specifications.

**CONSTRUCTION METHODS:**

**General:**

Wells shall be constructed the same size as the ones they replace and shall be lined or cased with material of the same type or character as the lining or casings in the existing wells. Material salvaged from the old



wells may be used in the new wells, provided this material is salvaged in a usable condition, but any new material required shall be furnished by the contractor without additional compensation.

The new well shall be dug to such a depth that its supply of water will be equal in quantity to that of the well which it replaces and the new well shall be equal in all respects to the well which it replaces. The old wells shall be filled with material secured as "Excavation." The contractor will be required to furnish a certificate of release from the property owner as specified in Item 215.

#### **METHOD OF MEASUREMENT:**

Constructing wells shall be measured by the well and the number of wells constructed shall be counted.

#### **BASIS OF PAYMENT:**

The number of wells constructed and accepted, measured as provided above, shall be paid for at the contract unit price per well for "Constructing Wells," complete in place, which price and payment shall constitute full compensation for all drilling and excavation, for lining and casing the new wells, for the furnishing of all new materials, equipment, tools, labor and incidentals, and the performance of all work necessary to complete the item. The filling of the old wells shall be paid for as "Excavation."

Payment will be made under:

Item 213, Constructing Wells, per well.

## **REMOVING OLD WALK ITEM 214**

#### **DESCRIPTION:**

This item shall consist of removing old walk and disposing of same in accordance with the plans and specifications.

### **CONSTRUCTION METHODS:**

Where old walk to be removed is of concrete, the concrete shall be broken into pieces of a size easily handled by one man and placed around the ends of drainage structures as indicated on the plans or otherwise disposed of as directed by the Project Engineer. Walks other than of concrete shall be removed in a satisfactory manner and the materials salvaged or disposed of as directed by the Project Engineer. Where a portion of the old walk is to be left in place, the removed portion shall extend to an existing joint or shall be cut to a true line with a vertical face. Sufficient removal shall be made to provide for proper grades and connections with the new work.

### **METHOD OF MEASUREMENT:**

Removing old walk shall be measured by the square yard.

### **BASIS OF PAYMENT:**

The number of square yards of old walk removed, measured as specified, shall be paid for at the contract unit price for "Removing Old Walk," which price and payment shall constitute full compensation for removing the old walk, breaking up concrete and placing same as rip rap, salvaging or disposing of all resulting materials, and all hauling and other work in connection therewith; the furnishing of all equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

Payment will be made under:

Item 214, Removing Old Walk, per square yard.

# REMOVAL AND RELOCATION OF BUILDINGS AND MISCELLA- NEOUS STRUCTURES ITEM 215

## **DESCRIPTION:**

This item shall consist of the removal, preparation for moving and relocation of buildings or structures of all types, together with all service connections, appurtenances, and accessories; reconstructing all foundations and appurtenances, all in accordance with the plans and these specifications. Any moving of buildings and miscellaneous structures shall be done under Item 216.

## **CONSTRUCTION METHODS:**

### **General:**

Buildings or structures shall be removed and prepared for moving and shall be placed in their new locations, as shown on the plans or as designated by the Project Engineer, left plumb and level and in as good condition in all respects as originally. All units removed and relocated shall be placed on foundations of the same type and character as the original foundation.

Steps, outside stairways, canopies, porches, block or post supports, sills, chimneys on brackets and other appurtenances forming an integral part of the building are to be considered as part of the building and removed and relocated accordingly. Cellars, cellar steps, concrete or masonry porches, concrete floors, solid or semi-solid concrete and masonry foundations and supports; septic tanks, fireplaces and chimneys standing on the ground and other appurtenances attached or connected to the building but not movable as an integral part of the building shall be removed, relocated and replaced with foundations or appurtenances of the same size, type and character as existed before the building was removed.

Wherever sanitary sewers, water, gas, electric, or telephone service lines are connected to the buildings being removed and relocated, the same shall be disconnected and reconnected without unnecessarily discommoding the occupants of the building being moved. The contractor shall be responsible for all notices to the public utility companies and for all fees charged by them.

All privies, wash houses, garages, and other out-buildings, cisterns, wells, septic tanks and other appurtenances used in conjunction with a building or structure shall be removed and relocated. The contractor shall also remove and rebuild existing yard fences, driveways and walks and extend same as necessary. Existing shrubbery shall be removed and replanted at the new location designated by the Project Engineer. All of the above shall be considered as appurtenances and appliances to the buildings or structures indicated on the plans to be removed and relocated.

The removal and relocation of a building, any part of which is used as a filling station, unless otherwise noted on the plans, shall include the removal and relocation of all gasoline pumps, tanks, pipes, signs, and other accessories appurtenant to the filling station. Tanks shall be placed the same depth below the ground as existed before moving.

Material in the existing foundations, concrete or masonry floors, chimneys and other appurtenances, where not used in the reconstruction of the appurtenances, shall be removed and disposed of as directed by the Project Engineer.

All new material required by the contractor in performing any of the above operations shall be furnished by the contractor at his expense.

The contents of all buildings or structures shall be removed and relocated along with the building or structure to its new site. In the event that it is not feasible or possible to remove the building or structure together with the contents therein, the contents shall be removed from the building or structure at

its original location and same replaced in the relocated building or structure. Such precautions as necessary shall be taken to prevent damage or loss of any kind to the contents thereof.

The contractor shall furnish the Department with a certificate of release from each property owner, and in the event of separate ownership of building and property, a certificate of release from each owner shall be furnished. This certificate shall state that the buildings or structures removed and relocated are in an acceptable condition and that said owner waives all claims for damages to his property and buildings or structures removed.

**METHOD OF MEASUREMENT:**

Removal and relocation of buildings and structures will be measured by the building or structure designated on the plans and each principle building or structure will be designated on the plans and in the contract by its station number and for the purpose of measurement each principle building or structure together with its appurtenances and appliances will be considered a complete and separate unit.

**BASIS OF PAYMENT:**

The number of buildings or structures removed, relocated and accepted, measured as provided above, shall be paid for at the contract price per unit for "Removal and Relocation of Buildings and Miscellaneous Structures," which price and payment shall constitute full compensation for furnishing all materials, tools, equipment, labor and incidentals and the performance of all work necessary to complete the item.

Payment will be made under:

Item 215, Removal and Relocation of Buildings and Miscellaneous Structures, per unit.

# MOVING OF BUILDINGS AND MISCELLANEOUS STRUCTURES ITEM 216

## **DESCRIPTION:**

This item shall consist of moving units specified under item "Removal and Relocation of Buildings and Miscellaneous Structures" from the original location to the final location. (Removal, preparation for moving, rebuilding and relocation of buildings and miscellaneous structures shall be done under item 215). This item shall include the extension of water, gas, sewer and other service lines and utilities.

## **CONSTRUCTION METHODS:**

Each building or structure shall be designated on the plans and in the contract by its station number and for the purpose of measurement, each principle building or structure together with its appurtenances and appliances shall be considered a complete and separate unit.

No payment will be made under this item for the materials, labor, tools, equipment and work required in the preparation for moving the unit and the relocation of the unit; including all reconstruction necessary, at its new location.

The limits of moving of a building unit shall be the distance from the center of the principal building or structure in its original location, measured along the shortest practical route of moving to the center of the principle building or structure in its new location. Appurtenances to the principle building or structure will not be considered in the measurement, but shall be moved with the principle building or structure as a unit and reestablished at the new location.

## **METHOD OF MEASUREMENT:**

The moving of a building unit shall be measured in

units of principle building or structure moved one foot which shall be designated as "building foot."

**BASIS OF PAYMENT:**

Moving of buildings and miscellaneous structures listed under this item shall be paid for at the contract unit price per building foot, which price and payment shall constitute full compensation for furnishing all materials, equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

Payment will be made under:

Item 216, Moving of Buildings and Miscellaneous Structures, per building foot.

**SINGLE LINE RICE LEVEE  
ITEM 217**

**DESCRIPTION:**

This item shall consist of the complete construction of a single line rice levee conforming to the dimensions as shown on the plans.

**CONSTRUCTION METHODS:**

The contractor shall be required to construct a single line rice levee with soil to the grade and lines shown on the plans. Before the levee is constructed, the contractor shall remove all roots and vegetation from the surface of the ground under the proposed levee and shall be required to plow this portion of the original ground. Due to irregularities in the contours of the ground the height of the levee may vary from the height shown on the plans, and such variations shall not be considered cause for a claim for additional compensation by the contractor. The levee shall be constructed uniformly as to slope and compaction.

**METHOD OF MEASUREMENT:**

Single line rice levee shall be measured in one-hundred foot stations and the number of linear feet of levee to be measured shall be the actual length constructed and accepted.

**BASIS OF PAYMENT:**

The number of stations of single line rice levee measured as specified shall be paid for at the contract unit price per station for "Single Line Rice Levee," which price and payment shall be full compensation for the removal and placing of all material in its final position in the levee, the necessary clearing and grubbing, the use of all equipment, tools, labor and work incidental to the completion of the item.

**Payment will be made under:**

Item 217, Single Line Rice Levee, per station.

**DOUBLE LINE RICE LEVEE  
ITEM 218**

**DESCRIPTION:**

This item shall consist of the complete construction of a double line rice levee conforming to the dimensions as shown on the plans.

**CONSTRUCTION METHODS:**

The contractor shall be required to construct a double line rice levee with soil to the grade and lines shown on the plans. Before the levee is constructed, the contractor shall remove all roots and vegetation from the surface of the ground under the proposed levee and shall be required to plow this portion of the original ground. Due to irregularities in the contours of the ground the height of the levee may vary from the height shown on the plans, and such variations shall



not be considered cause for a claim for additional compensation by the contractor. The levee shall be constructed uniformly as to slope and compaction.

Where rice canals are flumed across low areas and drainage ditches, the contractor shall be required to build new flumes and rebuild flumes in place as are necessary, replacing any unsatisfactory members.

**METHOD OF MEASUREMENT:**

Double line rice levee shall be measured in one-hundred foot stations and the number of linear feet of levee to be measured shall be the actual length of double line rice levee and flumes constructed and accepted.

**BASIS OF PAYMENT:**

The number of stations of double line rice levee measured as specified shall be paid for at the contract unit price per station for "Double Line Rice Levee," which price and payment shall be full compensation for the removal and placing of all material in its final position in the levees, the necessary clearing and grubbing, the use of all equipment, tools, labor and work incidental to the completion of the item.

Payment will be made under:

Item 218, Double Line Rice Levee, per station.

## EARTHWORK ROADWAY AND DRAINAGE GRADING

Clearing and grubbing; excavation of earth and construction of fills, slopes; fine grading; overhaul on excavation and borrow; rolling and compacting fills and cuts; purchase cost of earth when title remains with seller; approaches and driveway entrances; drainage ditches, channel changes, and sub-drains; dikes and levees; moving structures, fences and buildings when not a right of way consideration; grading for bridges, overpasses, and underpasses.

# CLEARING

## ITEM 302

### **DESCRIPTION:**

This item shall consist of cutting, removing, burning and cleaning up the timber, logs, brush, stumps and debris from within the limits of the entire right of way; also from such areas as may be required for offtake ditches, channel changes and borrow pits, etc., furnished by the Department, as directed. All work under this item shall be done in accordance with these specifications and in conformity with the plans.

### **CONSTRUCTION METHODS:**

All of the surface of the right of way, or so much thereof as the Project Engineer may direct, shall be completely cleared of all trees, logs, stumps, brush, vegetation, rubbish and other perishable or objectionable matter. Such individual trees as the Project Engineer may designate and mark within the areas staked for clearing shall be left standing uninjured. Living trees outside of the roadway lines shall be cut only as directed by the Project Engineer. All trees not required to be moved shall be carefully protected.

Trees, brush, stumps, etc., shall not be deposited on adjacent lands, but shall be disposed of within the limits of the clearing. Trees unavoidably falling outside of the specified limits shall be cut up, removed to within the clearing, and disposed of. Timber of any value which it may be necessary to cut shall be cut in logs of commercial lengths and shall be piled neatly along the right of way on the downstream side, or on abutting property, if directed by the Project Engineer. Cleared material shall not become the property of the contractor. All

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branches of trees extending within the right <sup>(if)</sup> way shall be trimmed when and as directed by the Project Engineer, and branches extending over the roadway shall be trimmed carefully to give a clear height of 15' over the finished roadway.

Material without value shall be piled in the right of way and burned or otherwise disposed of in such a manner as not to injure any trees or merchantable timber or other property on the right of way or abutting property.

Isolated trees, and stumps projecting more than six inches above the ground, shall be cleared. Trees and stumps will be considered isolated when they are fifty feet or more apart.

In clearing, all trees, stumps, brush, etc., shall be cut flush with the ground surface if practicable and in no case shall remain higher than six inches above the ground.

#### **METHOD OF MEASUREMENT:**

Clearing will be measured by the acre and the number of acres shall be determined by measurement of the area actually cleared. Isolated trees or stumps will not be measured or paid for unless a price is included in the contract under Item 304.

#### **BASIS OF PAYMENT:**

The number of acres cleared and accepted, measured as provided above, shall be paid for at the contract unit price per acre for "Clearing," which price and payment shall constitute full compensation for furnishing all materials, tools, equipment, labor and incidentals and the performance of all work necessary to complete the item.

**Payment will be made under:**

Item 302, Clearing, per acre.

# GRUBBING

## ITEM 303

### DESCRIPTION:

This item shall consist of the excavation and removal of all stumps, roots, submerged logs, corduroy and other perishable and objectionable materials from within the limits of the slopes; also from such areas as may be required for offtake ditches, channel changes, borrow pits furnished by the Department, as directed by the Project Engineer. All work under this item shall be done in accordance with these specifications and in conformity with the plans.

### CONSTRUCTION METHODS:

All stumps, roots and other objectionable materials between slope stakes in cuts and between slope stakes of embankment two feet or less in height, shall be removed to a depth of two feet below the finished surface of the section. In embankments of two feet or more in height, all stumps shall be removed flush with the ground surface if practicable and in no case shall remain higher than six inches above the ground and shall be paid for as provided in Item 302. All stumps and roots in borrow pits shall be removed if and as directed by the Project Engineer.

All removed material shall be burned or otherwise disposed of as directed by the Project Engineer. Removed materials shall not be deposited on adjacent lands. Grubbing with explosives shall not be permitted in swampy sections or elsewhere, unless permitted by the Project Engineer.

The grubbing and removal of sod, grass, weeds, crops and other similar objectionable matter shall not be paid for as grubbing, but as provided for in the specifications under the various classes of excavation. Stumps shall be considered isolated when they are fifty feet or more apart.

All excavations or grubbing done below the sub-

grade surface by the removal of stumps, roots, etc., shall be refilled with suitable soil immediately after grubbing, and compacted thoroughly so as to make the surface at these points conform to the same degree of compaction as the surrounding subgrade.

All grubbing shall be done at least fifteen hundred feet ahead of the grading operations.

**METHOD OF MEASUREMENT:**

Grubbing will be measured by the acre and the number of acres shall be determined by the measurement of the area actually grubbed. Isolated stumps shall not be measured or paid for unless a price is included in the contract under Item 304.

**BASIS OF PAYMENT:**

The number of acres grubbed and accepted, measured as provided above, shall be paid for at the contract unit price per acre for "Grubbing," which price and payment shall constitute full compensation for furnishing all materials, tools, equipment, labor and incidentals and the performance of all work necessary to complete the item.

Payment will be made under:

Item 303, Grubbing, per acre.

**SPECIAL CLEARING AND  
GRUBBING  
ITEM 304**

**DESCRIPTION:**

This item shall consist of the clearing and grubbing of specifically designated trees or stumps from within the limits of the right of way in accordance with these specifications and in conformity with the plans. This item shall apply where specifically indicated on the plans, or ordered by the Project Engineer.

**CONSTRUCTION METHODS:**

The methods of construction shall be as provided in Items 302 and 303, insofar as applicable hereto.

**METHOD OF MEASUREMENT**

Special Clearing and Grubbing shall be measured by the tree or stump having a diameter of six inches or over. Diameter shall be measured at a point one foot above the ground. The number of trees or stumps cleared and grubbed shall be counted.

**BASIS OF PAYMENT:**

The number of trees or stumps cleared, grubbed and accepted, measured as provided above, shall be paid for at the contract unit price per tree or stump for "Special Clearing and Grubbing," which price and payment shall constitute full compensation for furnishing all materials, tools, equipment, labor and incidentals and the performance of all work necessary to complete the item.

No payment will be made under this item for any trees or stumps removed from the area covered by payment under Items 302 and 303.

**Payment will be made under:**

Item 304, Special Clearing and Grubbing, per tree or stump.

**EXCAVATION AND EMBANKMENT**

- Common Excavation .....Item 305
- Borrow Excavation .....Item 306
- Special Borrow Excavation .....Item 307
- Drainage Excavation .....Item 308
- Muck Excavation .....Item 309

**DESCRIPTION:**

These items shall consist of excavating, removing

and satisfactorily disposing of all materials of every character within the limits of the work, except structural excavation and such other work as may be covered by pay items. It shall include excavation for the roadway, inlet and outlet ditches, and for the changing and completion of all channels and all operations necessary for the formation and compaction of embankments, subgrades, shoulders, ditches, slopes, intersections and all other appurtenances necessary for the completion of the work, all in accordance with these specifications and in conformity with the grades, alignment and cross sections shown on the plans.

Unless otherwise provided, this item shall also include removal and disposal of old surfacing materials, curb, gutter, fences, hedgerows, crops, sidewalks, timber bridges and culverts, pipe culverts, etc.

**Borrow Excavation:** Borrow Excavation shall include all excavation obtained from borrow pits furnished by the Department, as shown on the plans or designated by the Project Engineer, as special pits to supplement material obtained from within the highway right of way.

**Special Borrow Excavation:** Special Borrow Excavation shall include all acceptable excavation obtained from borrow pits furnished by the contractor as special pits to supplement material obtained from within the highway right of way. The site of the borrow pits shall be approved by the Project Engineer and shall be located a minimum distance of three hundred feet from the right of way except on written approval of the Chief Engineer. The borrow material shall be approved by the Project Engineer.

#### **CLASSIFICATION:**

All materials excavated except Borrow Excavation and Special Borrow Excavation shall be unclassified and paid for as Common Excavation regardless of the material encountered, unless a classification is indicated on the plans and separate items shown in the contract.



When such classification is indicated in the contract, excavation shall be classified as follows:

Common Excavation.

Drainage Excavation.

Muck Excavation.

**Common Excavation:** Common Excavation shall include all excavation under this item, except Borrow Excavation and Special Borrow Excavation, when no Drainage Excavation or Muck Excavation is shown on the plans or indicated in the contract. When either or both Drainage Excavation or Muck Excavation is indicated, Common Excavation shall include all excavating except Borrow Excavation and Special Borrow Excavation and the indicated classified material.

**Drainage Excavation:** Drainage Excavation shall include all required excavation under this item beyond the limits of the roadway section for inlet and outlet ditches to structures and roadway; changes in or deepening of channels or streams, berm ditches, ditches parallel to or adjacent to roadway, and ditches draining borrow pits. Material excavated from under existing bridges will also be classified as Drainage Excavation.

**Muck Excavation:** Muck Excavation shall include the excavation of unsatisfactory overburden, covering clay or other suitable material, in swamp or marsh areas. Muck shall include such materials as will decay or produce unsatisfactory subsidence in the embankment and may be made up of decaying stumps, roots, logs, humus and other material not satisfactory for incorporation in the embankment or to remain under the embankment. The Project Engineer shall determine the material to be classified as muck and wasted and the material that is satisfactory for use in the embankment or under the embankment in accordance with these specifications.

## **CONSTRUCTION METHODS:**

### **General:**

While the excavation is being done and until the

work is finally accepted, the contractor shall take the necessary steps to protect the work to prevent loss of material from the roadway. During construction of the roadway, the roadbed shall be maintained in such condition that it will be well drained at all times.

**Common Excavation:**

All suitable materials removed from the excavation shall be used as far as practicable in the formation of the embankment, subgrade, shoulders and at such other places as directed. No excavated material shall be wasted without written permission from the Project Engineer and when such material is to be wasted, it shall be disposed of as directed by the Project Engineer. When more material is required, the Project Engineer, in locating same, shall give preference to the widening of cuts on the inside of curves. No payment will be made for any excavated material which is used for purposes other than those designated. Side ditches or gutters emptying from cuts to embankments shall be constructed so as to avoid damage to embankments by erosion. Under no conditions shall holes be gouged or dug in back slopes or in embankment to obtain material for curing concrete pavements, for constructing shoulders or for any other purposes.

All common excavation shall be unclassified and the contractor will not be allowed any additional compensation for excavating existing surfacing material or rock excavation that may be encountered in performing the work unless specifically provided for.

Any material excavated by the contractor beyond the limits of the typical cross section of the roadway, where such material is not needed for constructing the embankment, shall be at the contractor's expense and will not be paid for. The Project Engineer may require such material to be satisfactorily replaced.

**Drainage Excavation:**

The contractor shall perform the drainage excavation at the time the rough grading is done unless otherwise directed by the Project Engineer. The contractor

shall dispose of the excavated material as shown on the plans or directed by the Project Engineer, and suitable material shall be placed in the embankment and berm or used for widening same when shown on the plans or directed by the Project Engineer. All roots, stumps and other obstructions in the sides and bottoms of ditches shall be cut to conform to the required cross section and grade. No excavated material from ditches shall be deposited or left within three(3) feet of the edge of the ditch. All ditches excavated by the contractor shall be maintained free from earth, sticks or other debris until final acceptance.

**Muck Excavation:**

Material excavated as Muck Excavation shall be disposed of as indicated on the plans or as directed by the Project Engineer.

**Borrow Excavation and Special Borrow Excavation:**

Borrow shall only be used when sufficient quantities of suitable material are not available, as herein prescribed, from common and drainage excavation to properly construct the embankments, subgrade, and shoulders, and to complete the backfilling of structures. No material shall be removed from the borrow pits until they have been cross sectioned and measured by the Project Engineer and the contractor shall notify the Project Engineer of the opening of any borrow pit sufficiently in advance to permit such cross sections and measurements to be taken. Borrow pits which are visible from the highway shall be neatly trimmed and unsightly stumps removed to the satisfaction of the Project Engineer. All borrow pits shall be left in a neat and suitable condition to facilitate the accurate measurement of the materials used and shall be properly drained to the satisfaction of the Project Engineer.

**Embankments, Other Than Dredged and Hydraulic:**

Embankments shall be formed of approved material obtained from the excavation and placed in successive horizontal layers not exceeding eight inches loose

depth, deposited uniformly over the full width of the cross section and thoroughly compacted.

Sod, grass, weeds, and other objectionable matter shall be removed from within the limits of slope stakes.

When embankments are made on a hillside, sloping more than  $20^{\circ}$  from horizontal, the slope of the ground on which the embankment is to be placed shall be plowed deeply or cut into steps before the filling is commenced. Where a new road is to be constructed on an old one, the surface and slopes of the old road shall be plowed or scarified and broken up full width, unless otherwise shown on the plans.

Fills shall be constructed in lengths of not less than three hundred feet or for the full length of the fill if less than three hundred feet. Stumps, roots, brush, sod, rubbish, or any other unsuitable material shall not be placed in the embankment.

Where the material from which embankments are being constructed is of variable quality, the contractor shall so arrange his operations that the top one foot of embankment may be constructed of selected material as directed by the Project Engineer.

Draglines will not be permitted to operate with any part of the weight of same resting on existing pavement. This does not prohibit moving a dragline over the pavement provided permission is first obtained from the Project Engineer and proper precautions are taken to protect the slab.

Except when specifically provided for by the plans and special provisions, dumping trestles will not be allowed in the construction of embankments without the written permission of the Project Engineer and when permitted the construction of the embankment shall be subject to such additional requirements as the Project Engineer may deem advisable.

In backfilling around and over culverts, abutments and retaining walls, the embankment end of weep holes shall be covered with at least two cubic feet of clean, broken stone or gravel, so placed as to allow free drainage. From approximately six inches below the bottom

of the outside ends of weep holes, a column of clean, broken stone or gravel, at least one foot square, shall be carried up against the back of the wall to the elevation of the subgrade.

No backfilling shall be placed against any masonry abutment, wing wall or culvert until permission shall have been given by the Project Engineer and in no case until the masonry has attained the minimum specified strength.

Embankments that are placed against bridge abutments, retaining walls or other structures and open end bents must be built in horizontal layers not exceeding six inches loose and for a distance, measured from the end of the structure along the center line of the road, equal to one and one-half times the height of the structure above the existing ground line and must be thoroughly compacted by hand or mechanical tamping and jetting will not be permitted. This method of building the embankment shall extend to such height above the structures as the Project Engineer may direct. If necessary, each layer of fill material shall be dampened to insure desired compaction and density.

All of the operations necessary to placing of embankment as herein described, shall be considered as incidental to the work of excavation, and additional compensation will not be made for performing the work in the manner hereinbefore described.

**Compaction of Embankments:**

Compaction of embankments shall be accomplished by the following method. The density of compacted material in an embankment shall not be less than the percentage of the maximum density (A. A. S. H. O. Method T-99) shown in the following table:

Type of Pavement	Minimum Compaction Permitted Percentage of Maximum Density Obtained by A. A. S. H. O. Method T-99
Aggregate Type of Surfacing.....	90
Asphalt Type of Surfacing.....	95
Portland cement concrete.....	95

The wetting of each layer may be done with a water wagon or other approved sprinkling device but the device used shall be capable of delivering not less than sixty gallons per minute at the discharge end.

All embankment compaction operations shall be under the direct supervision of the Project Engineer, and these operations shall proceed in such sequence as he may direct. The Project Engineer shall determine by approved methods and standard tests the amount of water which will uniformly and sufficiently moisten the soil, and in addition and at the same time provide for the proper total moisture content in the embankment material which will obtain the specified degree of compaction in the embankment when compacted by methods and in amounts directed in these specifications. Embankment material containing excess moisture shall be permitted to dry to the proper consistency before being compacted. The contractor shall be responsible for correctly applying the water to the soil, for correctly mixing the water with the soil, manipulating the soil and the water to the proper uniform moisture content before beginning compaction, and finally compacting the properly moistened embankment material uniformly to the degree of compaction required in these specifications. The contractor shall be responsible for the stability of all embankments made under the contract until final acceptance of the work and shall bear the expense of replacing any portions which have become displaced due to carelessness or negligent work on the part of the contractor or to damage resulting from natural causes, such as storms, etc., and not attributable, in the opinion of the Project Engineer, to unavoidable movements of the ground upon which the embankment is made.

#### **Compaction of Embankment by Use of Sheeps Foot Roller:**

Each layer of embankment shall be compacted with a sheeps foot roller until specified compaction has been secured. The sheeps foot roller used shall be a multiple unit oscillating type and shall be drawn with a crawler

type tractor. Each unit of the roller shall consist of a water tight drum provided with tamping feet, and teeth cleaning devices. Tamping feet shall be projected from the drum not less than seven inches. The roller unit shall weigh a minimum of fifty pounds per linear inch of drum length without ballast. With the drum filled with ballast, the unit shall weigh a minimum of fifty per cent more than when empty. The pressure per square inch of tamping foot area with one row of tamping feet supporting the roller and without ballast, shall be a minimum of one hundred ten pounds.

**Subgrade:**

The subgrade is that portion of the roadbed upon which the wearing course or base course is to be placed, except that for concrete pavement or pavements having a concrete base, the subgrade shall be interpreted to include an additional area extending one foot on each side of the concrete pavement or base. No payment for excavation will be allowed for this additional width.

All soft and yielding material, boulders and loose stones, and other portions of the subgrade which will not compact readily shall be removed and replaced with selected material, tamped if required, and the whole subgrade brought to line and grade and to a foundation of uniform compaction and supporting power. All stratified rock or boulders extending close to the surface of the subgrade shall be broken off twelve inches below the surface of the subgrade and removed. Where specified, a mechanical or chemical admixture shall be mixed with and incorporated into the subgrade materials to the lines and grades shown on the plans.

All submerged roots, stumps or other perishable matter encountered in the preparation of the subgrade shall be removed to a depth of not less than two feet below the finished surface of roadway.

The subgrade shall be properly shaped, rolled and uniformly compacted so that it conforms to the lines and grades as shown, before any roadway material is placed thereon, and shall be brought to a firm unyielding surface by rolling the entire area with a power

driven roller weighing from eight to ten tons or a power driven roller weighting not less than one hundred seventy pounds per inch width of tread unless otherwise specifically provided. Any portion of the subgrade that is inaccessible to the roller shall be compacted thoroughly with hand or mechanical tamps weighing not less than fifty pounds, the bearing or tamping face of which shall not exceed one hundred square inches in area. Any frozen material shall be removed, if required, before placing any surfacing material on the subgrade, and shall be replaced with suitable material. In preparing the subgrade, the material excavated shall not be piled outside and along the forms in such a manner as to interfere with the proper operation of all the finishing tools.

After the subgrade has been prepared as specified above, the contractor shall maintain it free from ruts and depressions and all damage resulting from the hauling or handling of any materials, equipment, tools, etc., and if ruts are formed, the subgrade shall be scarified and rolled, or thoroughly tamped. The subgrade shall be planked to prevent further rutting, if necessary in the opinion of the Project Engineer. Ditches and drains shall be finished and maintained along the completed subgrade section. The subgrade shall be in final condition for receiving the surface or base course for a distance of at least five hundred feet in advance of the placing of the surfacing materials, forms, etc. No surfacing materials, forms, etc., shall be placed until the subgrade has been approved by the Project Engineer.

#### **Shoulders. Ditches and Slopes:**

Before any subgrade shall be approved, the adjacent shoulders shall be constructed to the full width and at least, to the level of the finished subgrade, but not necessarily to the final height and shape. At all times construction shall be so carried on that the subgrade, shoulders, and adjacent slopes and ditches will be effectively and completely drained. This work shall be done in proper sequence with any base or surface course construction, as directed.



Progress on shoulder and ditch work shall not be more than four thousand feet behind the last laid pavement or surfacing, except in the case of concrete pavements where the curing periods has not elapsed or where an industrial system is used. All shoulders shall be compacted to the density required for subgrade by the use of rubber tired rollers, except that when the plans indicate that shoulders are to be sodded, the surface soil on the shoulders to a depth of 4 or 5 inches shall be left loose.

#### **METHOD OF MEASUREMENT:**

Excavation will be measured by the cubic yard and the number of cubic yards shall be determined by measurement in its original position by the method of average end areas.

Structural Excavation for new or reconstructed structures will not be measured or paid for under this item.

Excavation incidental to the removal of all existing drainage structures, except where a pay item is specifically provided for the removal of the structure, will be measured. The quantity of excavation to be paid for will be that determined by vertical planes one foot outside and parallel to the outside lines of the portions of the structure actually removed and the actual depth of the material removed.

The measurement of Muck Excavation shall include only such material as is excavated within the lines and grades indicated on the plans or as directed by the Project Engineer.

Materials excavated which are used for purposes other than shown on the plans or designated by the Project Engineer will not be measured or paid for. Materials excavated outside the lines and grades given by the Project Engineer, unless specifically authorized by the Project Engineer, shall not be measured or paid for. Slides and falls or insecure masses of material beyond the regular slopes not due to carelessness or lack of precaution on the part of the contractor, when ordered

by the Project Engineer to be utilized or disposed of, will be measured and paid for.

Rolling shall be measured by the hour and pay quantities will be determined as follows:

The number of hours that the roller actually works, shall be divided by five (5), and the quotient thus obtained, multiplied by the actual outside rolling width of the roller in feet, shall be the number of hours for which payment will be made. In case of sheepsfoot roller, the width to be used shall be the sum of the widths of the individual drums composing the roller. No time shall be allowed for moving the roller to and from the site of the work to be rolled.

Sprinkling will be measured for payment by the one thousand (1000) gallons of water actually used and shall be measured as delivered in calibrated tank wagons or if water is obtained by pipe line, the contractor shall supply an accurate water meter for measuring the water.

#### **BASIS OF PAYMENT:**

When no classification of material is indicated on the plans, the total quantity of accepted excavation, except Borrow Excavation and Special Borrow Excavation, determined as provided above, shall be paid for at the contract unit price per cubic yard for Common Excavation. When a classification of materials is indicated on the plans, the quantities of the various classes of materials, determined as provided above, shall be paid for at the contract unit price per cubic yard for Common Excavation, Drainage Excavation or Muck Excavation. The quantity of Borrow Excavation and Special Borrow Excavation determined as provided above, shall be paid for at the contract unit prices per cubic yard for "Borrow Excavation" or "Special Borrow Excavation." The quantity of "Rolling" shall be paid for at the contract unit price per hour and the quantity of "Sprinkling" shall be paid for at the contract unit price per M gallons.

The contract unit prices and payment for any of the

above items shall constitute full compensation for all work described under this section and shall include the removal of all obstructions as specified herein; the formation of embankments; back-filling around structures; preparation of subgrade; dressing shoulders, ditches, slopes, borrow pits; all hauling (unless an item for "Overhaul" is included in the contract); disposal of all surplus materials; the removal of vegetation where an item of clearing or grubbing is not provided; wetting and compacting by rolling or otherwise, and shall also include the furnishing of all materials, equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

**Payment will be made under:**

Item 305, Common Excavation, per cubic yard.

Item 305a, Rolling, per hour.

Item 305b, Sprinkling, per M Gallons.

Item 306, Borrow Excavation, per cubic yard.

Item 307, Special Borrow Excavation, per cubic yard.

Item 308, Drainage Excavation, per cubic yard.

Item 309, Muck Excavation, per cubic yard.

## OVERHAUL ON EXCAVATION ITEM 310

**DESCRIPTION:**

This item shall consist of such hauling in excess of one thousand feet as required by the contract or as directed by the Project Engineer, of material paid for under "Excavation," and placed on the highway.

**METHOD OF MEASUREMENT:**

The limits of free haul for excavation shall be determined from a mass diagram of actual construction quantities by fixing on the volume curve two points

such that the distance between them, measured along the center line of the highway equals one thousand feet, and the included quantities of excavation and embankment balance. All material within this free haul limit shall be eliminated from further consideration.

Overhaul will be measured by the station yard and the quantity of overhaul shall be determined by multiplying the volume of the overhauled material, measured in its original position in cubic yards, by the overhaul distance in feet, divided by one hundred. The overhaul distance shall be the distance, measured along the center line of the highway between the centers of volume of the overhauled material in its original position and after placing, less one thousand feet.

Where material is secured from borrow pits furnished by the Department, outside the limits of the highway right of way, the hauling shall be performed over the shortest practical route as determined by the Project Engineer and the overhauled distance shall be the distance thus determined less one thousand feet.

#### **BASIS OF PAYMENT:**

The quantity of overhaul, measured as provided above, shall be paid for at the contract unit price per station yard for "Overhaul on Excavation," which price and payment shall constitute full compensation for all hauling and the furnishing of all equipment, tools, labor, and incidentals and the performance of all work necessary to complete the item.

No payment shall be made under this item for overhaul on "Special Borrow Excavation," Item 307, and "Structural Excavation," Item 415, or 709.

#### **Payment will be made under:**

Item 310, Overhaul on Excavation, per station yard.

**DREDGED EMBANKMENT  
(BUCKET)  
ITEM 311**

**DESCRIPTION:**

This item shall consist of dredging acceptable material from designated canals, placing the material in embankments and dressing and completing the embankment, all in accordance with the specifications and in conformity with the lines, grades and typical cross sections shown on the plans.

**PERMITS:**

Unless otherwise provided in the contract, the contractor shall, at his own expense, procure all necessary permits from proper authorities, to operate dredges and other floating equipment in waters under their control. Failure to procure any such permits will not operate to release the contractor or his bonding company from responsibility for completion of the work within the time limit.

**EQUIPMENT:**

The dredge to be used shall be approved by the Project Engineer. The length of boom shall be such as to reach to or above the shoulder farthest from the canal in order that the material may be dropped into place directly from the dipper. Bank Spud type dredges shall not be used.

**MATERIAL:**

Material used in the embankment shall be free from all decayed matter, roots, stumps, logs, or other material considered by the Project Engineer to be unfit for incorporation in the embankment.

**CONSTRUCTION METHODS:**

**General:**

In placing material excavated by the dredge, the

bucket or dipper shall be swung into place and shall be lowered to within two feet of the original ground or the previously placed material before being opened. In no case shall excavated material be dumped in a pile on the berm or within the area to be occupied by the completed embankment. Successive buckets of material shall be deposited uniformly across the width of the embankment so that uneven loading of the embankment shall not occur. Material considered unfit for incorporation in the embankment shall be placed on the side of the canal farthest from the roadway at such a distance from the edge of the canal as shall preclude sloughing.

The embankment shall be constructed in two or more layers, the thickness of the first layer being determined by the depth of canal necessary to float the dredge. Each layer shall be bladed with a bulldozer, tractor and blade, or other approved equipment.

#### **Cross Section of Canal:**

The depth of canal on the embankment side shall be only sufficient to float the dredge. The depth shall increase in the direction away from the embankment to a point four-fifths the width of the canal, at which point the depth shall be maximum allowable by the conformation of the dredge. From the four-fifths point, the bottom of the canal shall slope up to the canal bank. In no case shall the construction of a canal having vertical sides and flat bottom be allowed.

The undercutting of slopes shown on the plans is expressly prohibited.

#### **Berm:**

The width of berm shall be as shown on the plans.

#### **Dressing Embankment:**

When the embankment is completed the top and side slopes shall be carefully dressed to the satisfaction of the Project Engineer.

#### **METHOD OF MEASUREMENT:**

Dredged embankment shall be measured by the

cubic yard and the yardage shall be determined by measurement of the original space occupied by the material, computed by the method of average end areas. Cross sections shall be taken along the center line at intervals not exceeding fifty feet. Measurement shall be made within forty-eight hours after excavation and on progress estimates, the payment shall not cover yardage closer than two hundred feet in the rear of the dredge.

**BASIS OF PAYMENT:**

The number of cubic yards of material placed and accepted, measured as provided above, shall be paid for at the contract unit price per cubic yard for "Dredged Embankment," complete in place, which price and payment shall constitute full compensation for furnishing all materials, equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

**Payment will be made under:**

Item 311, Dredged Embankment (Bucket), per cubic yard.

## HYDRAULIC EMBANKMENT ITEM 312

**DESCRIPTION:**

This item shall consist of dredging and pumping acceptable materials from lakes, canals or other designated places, placing this material in embankments, and dressing and completing the embankment all in accordance with the specifications and in conformity with lines, grades and typical cross sections as shown on the plans.

**PERMITS:**

Unless otherwise provided in the contract, the con-

tractor shall, at his own expense, procure all necessary permits from proper authorities to operate dredges and other floating equipment in waters under their control. The contractor shall also obtain all necessary permits for the passage of the discharge pipe over private property. Failure to procure any such permits shall not operate to release the contractor or his bonding company from responsibility for completion of the work within the time limit.

#### **EQUIPMENT:**

The contractor shall furnish dredging and hydraulic equipment adequate to insure completion of the work within the time specified in the contract. All equipment shall be subject to approval by the Project Engineer.

#### **MATERIAL:**

The Project Engineer shall decide what materials may be used for construction purposes. In the event information is shown on the plans as to availability of material suitable for hydraulic embankment, it is understood that these data are for the information and guidance of the contractor but the Department does not guarantee the depth, extent and character of the material so indicated. No additional compensation shall be allowed the contractor should it develop during construction that the material is of a different nature from that indicated on the plans.

It is the responsibility of the contractor to make such examination of the site of the work and all sources of material as may be necessary to inform himself of the conditions under which the work is to be performed.

There shall be no classification of material for purposes of payment.

#### **CONSTRUCTION METHODS**

##### **General:**

No material for the embankment shall be obtained



from sources closer than five hundred feet from the toe of the slope of the embankment shown on the plans, unless otherwise specifically provided. The Project Engineer shall have authority to reject materials considered by him to be unsatisfactory for use in the embankment and such materials shall be stripped before the embankment is built. The contractor shall remove from the surface of the ground all muck and unsuitable material to a line and grade as shown on the plans. Any muck or other unsatisfactory material brought to the top of the embankment shall be removed by the contractor, at his own expense, and satisfactory material substituted therefor. In placing the material in the embankment, the contractor shall begin at the center line and deposit the material in either or both directions towards the toes of the slopes and the discharge shall always be in the direction of, and along or parallel to, the center line, unless otherwise permitted by the Project Engineer. If the discharge of the material from the pipe line shall cause erosion or damage to existing work or property to an extent considered dangerous to the Project Engineer, the work shall be stopped until such method of discharge is effected to prevent such damage. Material shall be deposited in such manner as to maintain at all times a higher elevation at the center of the roadway than on either side. The contractor shall not be permitted to construct the retaining levees along the highway of such dimensions as to cause subsidence and upheaval in the roadway. The contractor shall so conduct his operations as to insure the completion of embankment which shall conform to the cross sections shown on the plans, except that he shall be permitted to flatten side slopes. If material is deposited on private property, the contractor shall obtain permission from the property owners affected. The contractor shall take all necessary precautions to prevent the filling of streams. The contractor shall be required to assume all responsibility for compression, subsidence, displacement or slides that may take place in the hydraulic fill and no payment shall be made for materials that may, by displacement, or by the filling of subsur-

face channels or voids, find its way beyond the limits of the net pay section. The contractor shall provide sufficient material to maintain the embankment in accordance with the typical section as shown on the plans, until the project is accepted. The contractor shall hold the State harmless against any and all claims for damages occasioned by his operations.

Where pipe lines used in the dredging operation cross the surface of an existing traveled highway, they shall be satisfactorily bridged, and traffic protected by the display of warning signals both day and night. If, in the opinion of the Project Engineer, it is evident the operations and activities of the contractor will cause such damage to an existing traveled highway that traffic would be stopped, the Project Engineer shall require the contractor to stop operation of the dredge until proper precautions are made to prevent such damage.

#### **METHOD OF MEASUREMENT:**

Hydraulic embankment shall be measured by the cubic yard and quantities shall be computed by the average end area method. The following method shall be used for measurement:

Cross sections of the area to be covered by the embankment shall be taken before the ground is disturbed or any material placed thereon. These cross sections shall extend laterally from the center line to the toes of the slopes as indicated on the typical section and the elevations as determined by these sections shall be considered the original ground line. The pay quantity of hydraulic embankment to be measured shall be the volume of material included in the section above the original ground line and below the upper limits of the typical cross section, plus the quantity of material required for filling the muck ditch. The quantity of material allowed for filling the muck ditch shall be determined by the fixed width of the muck ditch indicated on the typical cross sections of the plans and the actual depth of muck or other unsuitable material removed

therefrom. The actual depth shall be construed to mean the depth below the original ground line. No measurement will be made under this item for payment for excavation of muck ditch but will be classified and paid for as "Muck Excavation." Material outside of the typical cross sections, as shown on the plans, will not be measured or paid for.

**BASIS OF PAYMENT:**

The number of cubic yards of material placed and accepted, measured as provided above, shall be paid for at the contract unit price per cubic yard for "Hydraulic Embankment," complete in place, which price and payment shall constitute full compensation for placing all material and for dressing the top and side slopes of the embankment, either to the slopes shown or to a flatter slope, if allowed by the Project Engineer, together with the furnishing of all materials, equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

**Payment will be made under:**

Item 312, Hydraulic Embankment, per cubic yard.

**UNDERDRAINS**

- Perforated Corrugated Metal Pipe....Item 313
- Perforated Corrugated Metal Pipe  
(Bituminous Coated).....Item 314
- Perforated Helical Metal Pipe .....Item 319
- Perforated Helical Metal Pipe  
(Bituminous Coated).....Item 320

**DESCRIPTION:**

This item shall consist of underdrains of the kinds and sizes designated on the plans or by the Project Engineer, constructed in accordance with these specifications and conforming to the lines, grades, dimensions

and designs shown on the plans or directed by the Project Engineer.

**MATERIALS:**

Perforated corrugated metal culvert pipe shall conform to the requirements specified in M-81.

Perforated helical metal pipe shall conform to the requirements specified in M-81.

**AGGREGATE BACKFILL MATERIAL:**

Unless otherwise shown on the plans the backfill material shall consist of gravel, stone or slag meeting the following gradation requirements on square mesh laboratory screens:

Passing	Percent
1-1/2" .....	100
3/4" .....	80-95
3/8" .....	50-70
No. 8 .....	35-55
No. 50 .....	5-15
No. 100 .....	0- 5

**CONSTRUCTION METHODS:**

**Installation:**

Trenches shall be carefully excavated to the depth required to permit the pipe to be laid to the grade specified. After the trench is excavated to the grade, the backfill material specified shall be placed to a depth of 4 inches compacted, and shall be shaped to form a bed for the pipe. The pipe shall be laid in this bed and closely joined and set to true alignment and grade. All perforated pipe shall be laid with the perforated side down. After the pipe has been laid and inspected, the backfill material shall be carefully placed and worked into position in such a manner as to insure compaction sufficient to support the pipe. The backfill of the trench shall be completed to the specified depth by placing material in 4-inch layers. Each layer of backfilling shall be

tamped firmly in a manner that will not injure or disturb the pipe. The upper portion of the trench shall be filled with approved soil to the depth specified in layers not to exceed 6 inches. Lateral connections, headers or caps for the pipe shall be furnished and installed by the contractor as indicated on the plans.

**METHOD OF MEASUREMENT:**

Underdrains shall be measured by the linear foot and the number of linear feet of underdrains actually completed will be measured.

**BASIS OF PAYMENT:**

The number of linear feet of underdrains completed and accepted, measured as provided above, shall be paid for at the contract unit price per linear foot of "Underdrains," which price and payment shall constitute full compensation for all necessary excavation and backfilling; for furnishing all materials or pipe, including stone or gravel backfill, equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

**Payment will be made under:**

Item 313a, Eight-Inch Perforated Corrugated Metal Pipe Underdrains, per linear foot.

Item 313b, Ten-Inch Perforated Corrugated Metal Pipe Underdrains, per linear foot.

Item 313c, Twelve-Inch Perforated Corrugated Metal Pipe Underdrains, per linear foot.

Item 314a, Eight-inch Perforated Corrugated Metal Pipe Underdrains, (Bituminous Coated), per linear foot.

Item 314b, Ten-Inch Perforated Corrugated Metal Pipe Underdrains, (Bituminous Coated), per linear foot.

Item 314c, Twelve-Inch Perforated Corrugated Metal Pipe Underdrains, (Bituminous Coated), per linear foot.

Item 319a, Six-Inch Perforated Helical Metal Pipe Underdrains, per linear foot

Item 319b, Eight-Inch Perforated Helical Metal Pipe Underdrains, per linear foot.

Item 319c, Ten-Inch Perforated Helical Metal Pipe Underdrains, per linear foot.

Item 319d, Twelve-Inch Perforated Helical Metal Pipe Underdrains, per linear foot.

Item 320a, Six-Inch Perforated Helical Metal Pipe Underdrains (Bituminous Coated), per linear foot.

Item 320b, Eight-Inch Perforated Helical Metal Pipe Underdrains (Bituminous Coated), per linear foot.

Item 320c, Ten-Inch Perforated Helical Metal Pipe Underdrains (Bituminous Coated), per linear foot.

Item 320d, Twelve-Inch Perforated Helical Metal Pipe Underdrains (Bituminous Coated), per linear foot.

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# STRUCTURES

# CULVERTS AND RETAINING WALLS

## **DESCRIPTION:**

This item shall consist of reinforced concrete culverts, retaining walls and pipe headwalls, all of which shall be built and completed as indicated on the plans in true conformity with the lines, profile grades, dimensions and designs shown, in accordance with these specifications and in full compliance with the specifications for "Concrete" and with any other specifications or contract items which are to contribute to and constitute the complete structure in each case.

## **MATERIALS:**

### **General:**

The materials to be furnished and used shall be those prescribed for the several specifications and contract items which are to constitute the completed structure. The materials and the composition and proportions for the concrete used in this item shall meet all the requirements specified under "Concrete" for the particular class or classes of concrete shown on the plans.

## **CONSTRUCTION METHODS:**

### **Excavation:**

All excavation involved shall be performed and all foundations and beddings shall be prepared as specified under "Structural Excavation."

### **Backfilling:**

Backfilling for all retaining walls shall be as prescribed under "Structural Excavation."



Backfilling for pipe headwalls and culverts shall be as prescribed under "Excavation and Embankment."

**Foundation Fill:**

If suitable foundation material is not encountered upon excavating to the required depth for a culvert, special backfill shall be furnished to replace the unsatisfactory material. The amount of foundation fill required shall be determined by the Project Engineer. It shall be placed and built up in uniform layers, not to exceed six inches, to the foundation elevation and thoroughly compacted. The cost of furnishing and placing foundation fill shall be paid for under Item 415 when this item is covered by a unit price in the contract, otherwise it shall be paid for as extra work.

**Concrete:**

(a) Class: All concrete used in culverts, retaining walls and pipe headwalls shall be class "A," unless otherwise shown on the plans.

(b) Mixing, Placing and Finishing: Concrete used in this item shall be batched, mixed, placed, and finished in accordance with the requirements of "Concrete." In addition, the following requirements for the placing of concrete in culverts shall be as follows:

In general, the base slab or footings of box culverts and 6 inches of the sidewalls shall be placed and allowed to set before the remainder of the culvert is constructed. In this case suitable provision shall be made for bonding the sidewalls to the culvert base, preferably by means of raised longitudinal keys so constructed as to prevent, as far as possible, the percolation of water through the construction joint.

Before concrete is placed in the sidewalls, the culvert footings shall be thoroughly cleaned of all shavings, sticks, sawdust, or other extraneous material and the surface carefully prepared in accordance with the method of bonding construction joints as specified under "Concrete."

In the construction of box culverts 4 feet or less in height, the sidewalls and top slab may be constructed as a monolith . When this method of construction is used, any necessary construction joints shall be vertical and at right angles to the axis of the culvert.

In the construction of box culverts more than 4 feet in height, the concrete in the walls shall be placed and allowed to set before the top slab is placed. In this case, appropriate keys shall be left in the sidewalls for anchoring the cover slab.

Each wing wall shall be constructed, if possible, as a monolith. Construction joints, where unavoidable, shall be horizontal and so located that no joint will be visible in the exposed face of the wing wall above the ground line. Wing walls for culverts shall fill all the requirements for wing walls for abutments.

#### **METHOD OF MEASUREMENT:**

The quantities of the various contract pay items which constitute the completed and accepted structures shall be measured for payment according to the specifications for the several individual contract items. Only accepted work shall be included and the dimensions used shall be those shown on the plans or ordered in writing.

#### **BASIS OF PAYMENT:**

The quantities, measured as provided above, shall be paid for at the contract unit price for the several contract pay items, which prices and payments shall constitute full compensation for furnishing, hauling and incorporating all prescribed and necessary material in the structures, and for all labor, equipment, tools and incidentals necessary to complete the work. Such payment shall constitute full compensation for the completed structures, ready for use and shall include all excavation necessary to construct the structures. No additional allowance will be made for cofferdam construction, falsework, lumber or other erection expense.

# DITCH CHECKS

## ITEM 401

### **DESCRIPTION:**

This item shall consist of the construction of ditch checks in conformity with the plans and these specifications at the locations indicated on the plans or as directed by the Project Engineer.

### **MATERIALS:**

Pecky cypress shall conform to the requirements specified in M-116.

Treated structural timber shall conform to the requirements specified in M-117.

### **CONSTRUCTION METHODS:**

#### **Erection:**

Timber ditch checks shall be carefully framed and erected as designated on the plans. Vertical timbers may be driven where it is possible to do so without damage to the timber. Where this procedure is not possible, the contractor will be required to set ditch checks and all material used for backfilling shall be thoroughly tamped.

### **METHOD OF MEASUREMENT:**

Ditch checks shall be measured by the thousand feet board measure.

### **BASIS OF PAYMENT:**

The number of thousand feet board measure placed and accepted, measured as provided above, shall be paid for at the contract unit price per thousand feet board measure, for "Ditch Checks," complete in place, which price and payment shall constitute full compensation for all excavation and backfilling; for all materials, including hardware, equipment, tools, labor and incident-

tals and the performance of all work necessary to complete the item.

**Payment will be made under:**

Item 401, Ditch Checks, per thousand feet board measure.

## RIPRAP

Random Riprap	Item 403 or Item 701
Hand-Placed Riprap	Item 404 or Item 702
Grouted Riprap	Item 405 or Item 703

**DESCRIPTION:**

This item shall consist of a protective covering of approved stone or waste concrete, placed over such areas as are shown on the plans or as directed by the Project Engineer and in conformity with the plans and specifications.

**MATERIALS:**

Riprap stone shall conform to the requirements specified in M-92.

**CEMENT, SAND AND WATER:**

These materials shall meet the requirements specified under "Concrete."

**CONSTRUCTION METHODS:**

**Random Riprap:**

Random riprap shall be dumped or rolled into place in such a manner that the smaller stones will be uniformly distributed throughout the mass. Sufficient hand work shall be done to procure a neat and uniform surface, and to the depth shown on the plans or specified by the Project Engineer.

**Hand-Placed Riprap:**

The area over which the hand-placed riprap is to be placed shall be shaped to conform to the cross section shown on the plans or designated by the Project Engineer. All trees, brush, or stumps shall be removed to the elevation of the bed of the riprap and all loose material shall be thoroughly compacted by hand tamping or other approved methods. When the riprap is to be laid on a slope, a trench of the required dimension shall be excavated at the toe of the slope and the stone firmly embedded in the trench at the toe thereof, with the axis of each stone most nearly approximating the specified thickness of the riprap, laid perpendicular to the slope. All stones shall be laid in such a manner as to break joints with adjacent stones and shall be laid with the minimum practicable amount of space between them. After the stones have been laid, all spaces between them shall be chinked with small stones or spalls rammed firmly into place. The finished face of the riprap shall be as smooth and true to line, grade, and section as the material will permit. Unless otherwise specified the riprap in place shall have a minimum thickness of six inches, measured at right angles to the face of the riprap.

**Grouted Riprap:**

Grouted riprap shall conform to the requirements of "Hand-Placed Riprap" and in addition all interstices in the stone shall be completely filled with grout throughout the entire thickness of the riprap, after which the surface shall be swept with a stiff broom. The grout shall consist of one part by volume of Portland cement, three parts by volume of dry sand and sufficient water to produce the desired consistency.

**METHOD OF MEASUREMENT:**

Random riprap will be measured by the cubic yard of stone in vehicles at the point of dumping on the project as specified under C-150.

Hand-placed riprap will be measured by the square yard in place.

Grouted riprap will be measured by the square yard in place.

#### **BASIS OF PAYMENT:**

The quantity of riprap placed and accepted, measured as provided above, shall be paid for at the contract price per unit for "Random Riprap," "Hand-Placed Riprap" or "Grouted Riprap," as the case may be, which price and payment shall constitute full compensation for furnishing all materials, unless otherwise specified, and for placing the riprap in accordance with the plans or as directed by the Project Engineer; for all excavation and backfilling; for furnishing all equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

Payment will be made under:

- Item 403, Random Riprap, per cubic yard.
- Item 404, Hand-Placed Riprap, per square yard.
- Item 405, Grouted Riprap, per square yard. or,
- Item 701, Random Riprap, per cubic yard.
- Item 702, Hand-Placed Riprap, per square yard.
- Item 703, Grouted Riprap, per square yard.

## **REVETMENTS**

Concrete Block Revetments, Item 406, or Item 704.

Grouted Concrete Block Revetments, Item 407, or Item 705.

Sand Cement Revetments, Item 408, or item 706.

Sacked Concrete Revetments, Item 409, or Item 707.

### **DESCRIPTION:**

This item shall consist of the construction of revetments composed of 4" x 12" x 24" precast concrete blocks, or of sacked sand and cement or sacked concrete which shall be placed on embankments or slopes to be protected in accordance with the plans and specifications or as directed by the Project Engineer.

### **PROPORTIONING AND MIXING:**

Concrete Block: All concrete for this item shall be class "D," proportioned and mixed as set out under "Concrete."

Sand Cement: The sand and cement shall be mixed dry, in proportions of one part cement to five parts sand, until the mixture is of uniform color.

Grout: The grout shall consist of one part by volume of Portland cement, three parts by volume of dry sand and sufficient water to produce the desired consistency.

Concrete: The concrete for sacked concrete revetment shall be composed of one part Portland cement, three and six-tenths parts of fine aggregate and five and four-tenths parts of Grade "A" coarse aggregate by weight, measured separately. If the contractor desires to measure the materials by volume, the proportion by volume of the mix for each respective ingredient shall be determined by the Laboratory to obtain the same yield of concrete. The mixing equipment and mixing shall comply with the requirements specified under "Concrete."

### **MATERIALS:**

Cement shall conform to the requirements specified in M-24.

Sand shall conform to the requirements specified in M-14, Type A.

Coarse aggregate shall conform to the requirements specified in M-13, Type D.

Water shall conform to the requirements specified in M-121.

## **CONSTRUCTION METHODS:**

### **Placing:**

Concrete Block Revetment: Unless otherwise directed, the slopes upon which concrete block is to be placed shall conform to the slope of the cross section of the embankment as shown on the plans. The placing of concrete blocks shall commence in a trench below the toe of the slope and shall progress upward.

Each block shall be laid by hand perpendicular to the slope, shall be firmly bedded against the slope and against adjoining blocks, and shall be laid with the joints staggered.

Grouted Concrete Block Revetment: When designated on the plans or in the contract, revetment constructed of concrete blocks shall be grouted into place. Grout shall be applied in such a manner as to insure filling all joints and crevices.

Sand Cement Revetment: Unless otherwise directed, the slopes upon which sand cement sacks are to be placed shall conform to the slope of the cross section of the embankment as shown on the plans.

The sacks shall be filled approximately two-thirds full with sand cement and shall be securely and substantially tied. The placing of sacks shall commence in a trench below the toe of the slope and shall progress upward. The tied ends of sacks shall all be pointed downward toward the toe of the slope. The sacks shall be rammed or packed against each other so as to form a close and moulded contact after the cement and sand mixture has set up. Sacks ripped or otherwise damaged in placing shall be removed and replaced with sound, unbroken sacks. All sacks shall be thoroughly wetted by sprinkling with water as soon as practicable after placing.

Sacked Concrete Revetment: After the earth bed on which the revetment is to be placed has been dressed and compacted to a true surface and approved by the Project Engineer, the sacked concrete shall be placed by hand and rammed or tamped into final location, while the concrete is still green, in such a manner as



to close all crevices between bags, and cause the mortar oozing through the open mesh to form a moderate bond. On slopes, construction shall begin at the bottom of the section to be covered, against a toe wall, which shall be constructed as hereinafter described. The bags of concrete shall be placed end to end, side to side, or end to side as necessary to stagger in such a manner as to provide a locked construction. They shall be so laid as to give a fairly uniform construction of the thickness specified on the plans.

The toe of the revetment at the bottom of slopes, stream channels and also the outer edges along the channel sides or slopes shall be laid against a toe wall extending two feet below the ground surface. This wall shall be composed of bags of concrete placed in such a manner as to form a wall eight inches thick where a four-inch thickness of revetment is used and twelve inches thick where a six-inch thickness of revetment is used. Outer edges and top of the revetment not requiring heavy toe wall protection shall be formed by placing a single header row of bags of concrete on end and extending below the bottom surface of the revetment at least six inches. Unless otherwise provided by the plans, or directed by the Project Engineer, the surface of the revetment where the construction terminates shall be embedded even with the surface of the slope or ground adjoining the revetment.

#### **METHOD OF MEASUREMENT:**

**Concrete Block and Grouted Concrete Block Revetment:** Concrete Block Revetment shall be measured by the square yard and the number of square yards determined by measurement of the net area of the blocks. Four and one-half blocks will equal one square yard of block revetment in place.

**Sand Cement Revetment:** Sand cement revetment shall be measured by the cubic yard and the number of cubic yards determined by counting the number of sacks placed and accepted. Forty sacks will be considered to equal one cubic yard of revetment.

Sacked concrete revetment shall be measured by the cubic yard as determined from theoretical yield and actual number of batches used.

**BASIS OF PAYMENT:**

The number of units placed and accepted, measured as provided above, shall be paid for at the contract price per unit for "Revetment," which price and payment shall constitute full compensation for preparation of embankment slopes, excavation and backfilling; for furnishing all materials, equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

**Payment will be made under:**

Item 406, Concrete Block Revetments, per square yard.

Item 407, Grouted Concrete Block Revetments, per square yard.

Item 408, Sand Cement Revetments, per cubic yard.

Item 409, Sacked Concrete Revetments, per cubic yard. or,

Item 704, Concrete Block Revetments, per square yard.

Item 705, Grouted Concrete Block Revetments, per square yard.

Item 706, Sand Cement Revetments, per cubic yard.

Item 707, Sacked Concrete Revetments, per cubic yard.

## REMOVAL OF BRIDGES AND CULVERTS

Removal of Culverts

Item 410.

Removal of Bridges

Item 708.

**DESCRIPTION:**

This item shall consist of dismantling and removing each old structure designated on the plans and in the proposal, and hauling and piling or disposing of all

parts and materials from the old structure, all in accordance with the plans and these specifications.

## **CONSTRUCTION METHODS:**

### **General:**

The old structure shall not be removed or closed to traffic until the passage of traffic has been satisfactorily provided for, either by the construction of a temporary crossing and detour, by detouring traffic over another convenient route, or by the completion and opening of the new structure. When existing structures are to be used for traffic during construction, their removal shall not be undertaken until the new structures replacing them are opened to traffic.

Steel superstructures shall be dismantled and removed in a condition suitable for re-erection. The work of disconnecting, removing, handling, hauling and piling of the members and parts shall be done by such methods and equipment that the steel will not be bent, distorted, or injured in any way. Small parts, such as pins, bolts, loose plates, fillers, packing, etc., shall be securely fastened to one of the members to which they belong or connect. When required, all members and parts shall be marked and all joints match-marked and a diagram showing this marking shall be furnished to the Project Engineer.

Substructures and fenders shall be removed to such an extent that no portions of them will remain above the stream bed or ground surface or interfere in any way with the new work. Blasting or other removal operations shall be so conducted that the new work will not be endangered or harmed in any way.

Timber which is salvageable shall be removed without undue splitting or breakage. All rotten or unsalvageable timber shall be burned or otherwise disposed of.

All steel and all salvageable timber or other materials removed from old structures shall be stored above the ground on skids or other supports in a neat and presentable manner, in locations designated by the Project Engineer, within the right of way and adjacent to the site of the work.

All concrete and masonry removed from old structures shall be placed in backfills or approach embankments or used to riprap the slopes of the embankments or the channel if so specified on the plans, or as directed by the Project Engineer. Any concrete or masonry which cannot be placed in the backfills or embankments or used as riprap shall be disposed of in such manner as to avoid damage to property or the creation of unsightly conditions.

The contractor shall not make use of any materials or parts from old structures without the written permission of the Project Engineer, and any materials and parts so used shall be left in substantially the same condition in which they were removed from the old structure.

#### **METHOD OF MEASUREMENT:**

Measurement of Each Structure as a Separate Unit: Each old structure to be removed shall be designated on the plans and in the contract by its station number and for the purpose of measurement shall be considered a complete and separate unit.

Measurement of Structures Collectively: The unit of measure shall be the structure and each structure actually removed shall be counted.

#### **BASIS OF PAYMENT:**

The number of old structures removed, measured as provided above, shall be paid for at the contract unit price for each structure removed, which price and payment shall constitute full compensation for the furnishing of all equipment, tools, falsework, labor and incidentals, and the performance of all work necessary to complete the item.

#### **Payment will be made under:**

- Item 410a, Removal of Culverts, per structure.
- Item 410b, Removal of Culverts, per each.
- Item 708a, Removal of Bridges, per structure.
- Item 708b, Removal of Bridges, per each.

# CLEANING OLD DRAINAGE STRUCTURES ITEM 411

## **DESCRIPTION:**

This item shall consist of cleaning deposits of soils and debris of any description from old drainage structures, in accordance with the specifications.

## **CONSTRUCTION METHODS:**

### **General:**

Where designated on the plans, old drainage structures shall be cleaned free of any foreign matter that interferes with or impedes the flow of drainage waters through the structure. This work shall be done in such a manner as not to damage the structure in place.

## **METHOD OF MEASUREMENT:**

Each old structure to be cleaned shall be designated on the plans by its station number and for the purpose of measurement shall be considered as a complete and separate unit.

## **BASIS OF PAYMENT:**

The number of old structures cleaned out, measured as provided, shall be paid for at the contract unit price for "Cleaning Old Drainage Structures," which price and payment shall constitute full compensation for the furnishing of all equipment, tools, labor and incidentals, and the performance of all work necessary to complete the item.

### **Payment will be made under:**

Item 411, Cleaning Old Drainage Structures, per structure.

## REMOVING OLD GUTTER, CURB AND CURB AND GUTTER

Removing Old Gutter	Item 412
Removing Old Curb	Item 413
Removing Old Curb and Gutter	Item 414

### DESCRIPTION:

These items shall consist of removing old curb, gutter, curb and gutter and disposing of same in accordance with the plans and these specifications.

### CONSTRUCTION METHODS:

Where old gutter to be removed is of concrete, and where the old curb and combination curb and gutter is of concrete and is not to be salvaged, the concrete shall be broken into pieces of a size easily handled by one man and placed around the ends of drainage structures as indicated on the plans or otherwise disposed of, as directed by the Project Engineer. Curb, combination curb and gutter, and gutter other than of concrete shall be removed in a satisfactory manner and the materials salvaged or disposed of, as directed by the Project Engineer. Where a portion of the old curb, combination curb and gutter, or gutter, is to be left in place, the removed portion shall extend to an existing joint or shall be cut to a true line with a vertical face. Sufficient removal shall be made to provide for proper grades and connections with the new work.

If the existing curb or combination curb and gutter is in sections and is to be salvaged, it shall be taken up in sections without unnecessary breakage, stored beyond the limits of construction or reset in the new location as required.

### METHOD OF MEASUREMENT:

Removing old gutter shall be measured by the square yard.

Removing old curb, and old combination curb and gutter shall be measured by the linear foot along the face of the curb.

**BASIS OF PAYMENT:**

The number of square yards of gutter removed, and the number of linear feet of curb and combination curb and gutter removed, measured as specified, shall be paid for at the contract unit price for the item applying thereto, which price and payment shall constitute full compensation for removing the curb, gutter or combination curb and gutter, breaking up concrete and placing same as riprap, salvaging or disposing of all resulting materials, and all hauling and other work in connection therewith; the furnishing of all equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

**Payment will be made under:**

- Item 412, Removing Old Gutter, per square yard.
- Item 413, Removing Old Curb, per linear foot,
- Item 414, Removing Old Curb and Gutter, per linear foot.

## STRUCTURAL EXCAVATION ITEM 415

**DESCRIPTION:**

This item shall consist of the excavation for all types of "Small Drainage Structures (Under 20 Ft.)," and the satisfactory disposal of the excavated materials.

**CONSTRUCTION METHODS:**

Construction methods shall be as specified under Item 709.

**METHOD OF MEASUREMENT:**

Structural excavation shall be measured as specified under Item 709 except as follows:

No measurement shall be made under this item for

structural excavation for "Small Drainage Structures (Under 20 Ft.)," except under the following conditions: When the flow line elevation shown on the plans is lowered in relation to the natural ground elevation more than one foot on either or both ends of the structure or when unstable foundation is encountered at foundation grade and it is necessary to remove unsuitable material and backfill with selected material to insure a suitable foundation for the structure, under either of the above conditions, the actual number of cubic yards of excess excavation removed shall be measured as structural excavation, and the number of cubic yards of selected backfill material shall be measured as selected backfill material.

**BASIS OF PAYMENT:**

The number of cubic yards of structural excavation measured as specified, shall be paid for at the contract unit price per cubic yard for "Structural Excavation," which price and payment shall constitute full compensation for all excavation, for disposing of surplus material, for all bailing, draining and sheeting, for the construction of cribs or cofferdams. The number of cubic yards of selected backfill material, measures as specified, shall be paid for at the contract unit price per cubic yard for "Selected Backfill Material," which price and payment shall constitute full compensation for furnishing, placing, moistening, and compacting backfill material as required.

**Payment will be made under:**

Item 415a, Structural Excavation, per cubic yard.

Item 415b, Selected Backfill Material, per cubic yard.

**CULVERT PIPE  
SEWER PIPE**

**DESCRIPTION:**

This item shall consist of furnishing sections of corrugated metal or concrete pipe, of the dimensions



shown on the plans, and installing such pipe at the locations indicated on the plans, or ordered by the Project Engineer, in conformity with the lines and grades given.

#### **MATERIALS:**

Reinforced concrete sewer pipe shall conform to the requirements specified in M-85.

Plain concrete culvert pipe shall conform to the requirements specified in M-82.

Reinforced concrete culvert pipe shall conform to the requirements specified in M-84.

Corrugated metal culvert pipe shall conform to the requirements specified in M-79.

Bituminous coated corrugated metal culvert pipe shall conform to the requirements specified in M-76.

Metal pipe ends shall conform to the requirements specified in M-77.

#### **CONSTRUCTION METHODS:**

##### **Forming Bed for Pipe:**

The width of trench (if required) shall be sufficient to permit thorough tamping of the backfill under the haunches and around the pipe but not exceeding the external diameter of the pipe by more than two feet except in unstable material.

The pipe shall be bedded in an earth foundation of uniform density carefully shaped, by means of a template supported at the desired grade, to fit the lower part of the pipe exterior for at least ten per cent of its overall height. Where rock, in either ledge or boulder formation, is encountered, it shall be removed below grade and replaced with suitable material in such a manner as to provide a compacted earth cushion having a thickness under the pipe of not less than one-half inch per foot height of fill over the top of the pipe, with a minimum allowable thickness of eight inches. Where a firm foundation is not encountered at the grade established, due to soft spongy or other unstable soil, unless other special construction methods are called for on the

plans or in the special provisions, all such unstable soil under the pipe shall be removed and replaced with a foundation fill consisting of gravel or other suitable approved material properly compacted to provide adequate support for the pipe line. When foundation fill is required, in the opinion of the Project Engineer, it shall be paid for by "Extra Work Order."

If pipe is not laid in a trench, a uniformly firm bed shall be made in the same manner as above specified for the preparation of the bottom of the trench.

#### **Laying Pipe:**

The pipe shall be carefully laid true to lines and grade given. Bell and spigot pipe shall be laid with the bell end up grade. All joints in bell and spigot pipe shall be sealed with cement mortar. The mortar shall consist of one part Portland cement, two parts sand and sufficient water to give the proper consistency. After each section of pipe has been laid the lower portion of the bell shall be filled with mortar and the succeeding section laid in place so that the inner surface of the two sections are flush. The remainder of the joint shall be solidly filled with mortar and neatly troweled and finished to a forty-five degree bevel beyond the edge of the bell, forming a continuous ring around the pipe. The inside of the joint shall be wiped clean and smooth.

All tongue and groove joints shall be sealed with cement mortar consisting of one part Portland cement, two parts sand, one-tenth part of hydrated lime or its equivalent and sufficient water to give the desired consistency. Special care shall be taken to force the mortar thoroughly into the joint.

Bells and spigots and tongues and grooves of concrete pipe shall be thoroughly wetted before the mortar is placed. After the initial set, mortar on the outside of joints shall be protected from the elements with earth or other covering.

Under high fills or where fill or pipe settlement can be anticipated, the Project Engineer may direct the contractor to use an Asphaltic Mastic filler in lieu of cement mortar which work shall be done at no addi-

tional cost. The Mastic shall be used according to manufacturers instructions.

Corrugated metal pipe shall be laid with the outside laps on the circumferential joints upgrade, with the longitudinal joints on the sides, and with the ends of sections butted together and connected with bands bolted firmly into place.

Corrugated metal pipe shall be furnished and installed complete with metal pipe ends where specified on the plans. The metal pipe ends shall be installed in accordance with the requirements shown on the plans.

The interior of culvert and sewer pipe shall be cleared of debris as the work progresses. Where practicable, a swab or drag shall be kept in the pipe line and pulled forward past each joint immediately after its completion.

Branch openings or service connections provided for future extension shall be plugged as directed by the Project Engineer.

Any pipe which is not true in alignment or which shows settlement after laying, shall be taken up and relaid at the contractor's expense.

**Backfilling:**

Selected embankment material, free from large lumps, clods, or rock shall be placed alongside the pipe in layers not exceeding six inches in depth and thoroughly compacted so that on each side of the pipe there shall be a berm of thoroughly compacted or undisturbed earth at least as wide as the external diameter of the pipe. Each layer, if dry, shall be moistened and then compacted by rolling or tamping with mechanical rammers or by hand tamping with heavy iron tampers having a tamping face not exceeding twenty-five square inches in area, special care being taken to thoroughly compact the fill under the haunches of the pipe. This method of filling and compacting shall be continued until the embankment is level with the top of the pipe, if the top of the pipe is below the original surface; otherwise, it shall be continued until the embankment is level with the original surface.

**Relaying Pipe:**

If indicated or directed, old pipe culverts shall be removed and all suitable sections shall be relaid, extended, or renewed in the same manner as specified for new pipe culverts.

**METHOD OF MEASUREMENT:**

Culvert and sewer pipe shall be measured by the linear foot. The length of measurement shall be the total number of joints placed and accepted, multiplied by the nominal length of joint. When it is necessary to use cut joints of pipe they shall be counted as full joints. Excavation for removal of existing pipe culverts shall be measured as provided under Item 305.

Metal pipe ends shall be measured per each and the number to be measured shall be the number of pipe ends installed measured separately for each size of culvert pipe.

**BASIS OF PAYMENT:**

Pipe placed and accepted, measured as provided above, shall be paid for at the contract unit price for "Culvert Pipe," "Sewer Pipe" and "Metal Pipe Ends," which price and payment shall constitute full compensation for furnishing, hauling and installing the pipe and metal pipe ends; for all excavation, except as provided under Item 305, preparation of bed and backfilling; and for furnishing of all equipment, tools, labor and incidentals and the performance of all work necessary to complete the item, but shall not be payment for headwalls.

**Payment for pipe will be made under:**

Item 402, Relaying Culvert Pipe, per linear foot.

Item 416a, Twelve Inch Reinforced Concrete Culvert Pipe (Standard Strength), per linear foot.

Item 416b, Fifteen Inch Reinforced Concrete Culvert Pipe (Standard Strength), per linear foot.

Item 416c, Eighteen Inch Reinforced Concrete Culvert Pipe (Standard Strength), per linear foot.

Item 416d, Twenty-four Inch Reinforced Concrete Culvert Pipe ( Standard Strength), per linear foot.

Item 416e, Thirty Inch Reinforced Concrete Culvert Pipe (Standard Strength), per linear foot.

Item 416f, Thirty-six Inch Reinforced Concrete Culvert Pipe (Standard Strength), per linear foot.

Item 416g, Forty-two Inch Reinforced Concrete Culvert Pipe ( Standard Strength), per linear foot.

Item 416h, Forty-eight Inch Reinforced Concrete Culvert Pipe (Standard Strength), per linear foot.

Item 416j, Fifty-four Inch Reinforced Concrete Culvert Pipe (Standard Strength), per linear foot.

Item 416k, Sixty Inch Reinforced Concrete Culvert Pipe (Standard Strength), per linear foot.

Item 416m, Seventy-two Inch Reinforced Concrete Culvert Pipe (Standard Strength), per linear foot.

Item 416n, Eighty-four Inch Reinforced Concrete Culvert Pipe (Standard Strength), per linear foot.

Item 417a, Twenty-four Inch Reinforced Concrete Culvert Pipe (Extra Strength), per linear foot.

Item 417b, Thirty Inch Reinforced Concrete Culvert Pipe (Extra Strength), per linear foot.

Item 417c, Thirty-six Inch Reinforced Concrete Culvert Pipe (Extra Strength), per linear foot.

Item 417d, Forty-two Inch Reinforced Concrete Culvert Pipe (Extra Strength), per linear foot.

Item 417e, Forty-eight Inch Reinforced Concrete Culvert Pipe (Extra Strength), per linear foot.

Item 417f, Fifty-four Inch Reinforced Concrete Culvert Pipe (Extra Strength), per linear foot.

Item 417g, Sixty Inch Reinforced Concrete Culvert Pipe (Extra Strength), per linear foot.

Item 417h, Seventy-two Inch Reinforced Concrete Culvert Pipe (Extra Strength), per linear foot.

Item 417j, Eighty-four Inch Reinforced Concrete Culvert Pipe (Extra Strength), per linear foot.

Item 418a, Eight Inch Corrugated Metal Culvert Pipe, per linear foot.

Item 418b, Ten Inch Corrugated Metal Culvert Pipe, per linear foot.

Item 418c, Twelve Inch Corrugated Metal Culvert Pipe, per linear foot.

Item 418d, Fifteen Inch Corrugated Metal Culvert Pipe, per linear foot.

Item 418e, Eighteen Inch Corrugated Metal Culvert Pipe, per linear foot.

Item 418f, Twenty-one Inch Corrugated Metal Culvert Pipe, per linear foot.

Item 418g, Twenty-four Inch Corrugated Metal Culvert Pipe, per linear foot.

Item 418h, Thirty Inch Corrugated Metal Culvert Pipe, per linear foot.

Item 418j, Thirty-six Inch Corrugated Metal Culvert Pipe, per linear foot.

Item 418k, Forty-two Inch Corrugated Metal Culvert Pipe, per linear foot.

Item 418m, Forty-eight Inch Corrugated Metal Culvert Pipe, per linear foot.

Item 418n, Fifty-four Inch Corrugated Metal Culvert Pipe, per linear foot.

Item 418p, Sixty Inch Corrugated Metal Culvert Pipe, per linear foot.

Item 419a, Eight Inch Corrugated Metal Culvert Pipe (Bituminous Coated), per linear foot.

Item 419b, Ten Inch Corrugated Metal Culvert Pipe (Bituminous Coated), per linear foot.

Item 419c, Twelve Inch Corrugated Metal Culvert Pipe (Bituminous Coated), per linear foot.

Item 419d, Fifteen Inch Corrugated Metal Culvert Pipe (Bituminous Coated), per linear foot.

Item 419e, Eighteen Inch Corrugated Metal Culvert Pipe (Bituminous Coated), per linear foot.

Item 419f, Twenty-one Inch Corrugated Metal Culvert Pipe (Bituminous Coated), per linear foot.

Item 419g, Twenty-four Inch Corrugated Metal Culvert Pipe (Bituminous Coated), per linear foot.

Item 419h, Thirty Inch Corrugated Metal Culvert Pipe (Bituminous Coated), per linear foot.

Item 419j, Thirty-six Inch Corrugated Metal Culvert Pipe (Bituminous Coated), per linear foot.

Item 419k, Forty-two Inch Corrugated Metal Culvert Pipe (Bituminous Coated), per linear foot.

Item 419m, Forty-eight Inch Corrugated Metal Culvert Pipe (Bituminous Coated), per linear foot.

Item 419n, Fifty-four Inch Corrugated Metal Culvert Pipe (Bituminous Coated), per linear foot.

Item 419p, Sixty Inch Corrugated Metal Culvert Pipe (Bituminous Coated), per linear foot.

Item 420a, Metal Pipe End for Eight Inch Pipe, per each.

Item 420b, Metal Pipe End for Ten Inch Pipe, per each.

Item 420c, Metal Pipe End for Twelve Inch Pipe, per each.

Item 420d, Metal Pipe End for Fifteen Inch Pipe, per each.

Item 420e, Metal Pipe End for Eighteen Inch Pipe, per each.

Item 420f, Metal Pipe End for Twenty-one Inch Pipe, per each.

Item 420g, Metal Pipe End for Twenty-four Inch Pipe, per each.

Item 420h, Metal Pipe End for Thirty Inch Pipe, per each.

Item 420j, Metal Pipe End for Thirty-six Inch Pipe, per each.

Item 420k, Metal Pipe End for Forty-two Inch Pipe, per each.

Item 420m, Metal Pipe End for Forty-eight Inch Pipe, per each.

Item 420n, Metal Pipe End for Fifty-four Inch Pipe, per each.

Item 420p, Metal Pipe End for Sixty Inch Pipe, per each.

Item 420q, Metal Pipe End for 18" x 11" Pipe-arch, per each.

Item 420r, Metal Pipe End for 22" x 13" Pipe-arch, per each.

Item 420s, Metal Pipe End for 25" x 16" Pipe-arch, per each.

Item 420t, Metal Pipe End for 29" x 18" Pipe-arch, per each.

Item 420u, Metal Pipe End for 36" x 22" Pipe-arch, per each.

Item 420v, Metal Pipe End for 43" x 27" Pipe-arch, per each.

Item 420w, Metal Pipe End for 50" x 31" Pipe-arch, per each.

Item 420x, Metal Pipe End for 58" x 36" Pipe-arch, per each.

Item 420y, Metal Pipe End for 65" x 40" Pipe-arch, per each.

Item 420z, Metal Pipe End for 72" x 44" Pipe-arch, per each.

Item 421a, Bituminous Coated Pipe End for Eight-Inch Pipe, per each.

Item 421b, Bituminous Coated Pipe End for Ten-Inch Pipe, per each.

Item 421c, Bituminous Coated Pipe End for Twelve-Inch Pipe, per each.

Item 421d, Bituminous Coated Pipe End for Fifteen-Inch Pipe, per each.

Item 421e, Bituminous Coated Pipe End for Eighteen-Inch Pipe, per each.

Item 421f, Bituminous Coated Pipe End for Twenty-one-Inch Pipe, per each.

Item 421g, Bituminous Coated Pipe End for Twenty-four-Inch Pipe, per each.

Item 421h, Bituminous Coated Pipe End for Thirty-Inch Pipe, per each.

Item 421j, Bituminous Coated Pipe End for Thirty-six-inch Pipe, per each.

Item 421k, Bituminous Coated Pipe End for Forty-two-Inch Pipe, per each.

Item 421m, Bituminous Coated Pipe End for Forty-eight-Inch Pipe, per each.

Item 421n, Bituminous Coated Pipe End for Fifty-four-Inch Pipe, per each.

Item 421p, Bituminous Coated Pipe End for Sixty-Inch Pipe, per each.

Item 421q, Bituminous Coated Pipe End for 18" x 11" Pipe-arch, per each.

Item 421r, Bituminous Coated Pipe End for 22" x 13" Pipe-arch, per each.



Item 421s, Bituminous Coated Pipe End for 25" x 16" Pipe-arch, per each.

Item 421t, Bituminous Coated Pipe End for 29" x 18" Pipe-arch, per each.

Item 421u, Bituminous Coated Pipe End for 36" x 22" Pipe-arch, per each.

Item 421v, Bituminous Coated Pipe End for 43" x 27" Pipe-arch, per each.

Item 421w, Bituminous Coated Pipe End for 50" x 31" Pipe-arch, per each.

Item 421x, Bituminous Coated Pipe End for 58" x 36" Pipe-arch, per each.

Item 421y, Bituminous Coated Pipe End for 65" x 40" Pipe-arch, per each.

Item 421z, Bituminous Coated Pipe End for 72" x 44" Pipe-arch, per each.

Item 422a, Twelve Inch Plain Concrete Culvert Pipe, per linear foot.

Item 422b, Fifteen Inch Plain Concrete Culvert Pipe, per linear foot.

Item 422c, Eighteen Inch Plain Concrete Culvert Pipe, per linear foot.

Item 422d, Twenty-four Inch Plain Concrete Culvert Pipe, per linear foot.

Item 423a 18" x 11" Corrugated Metal Pipe-arch, per linear foot.

Item 423b, 22" x 13" Corrugated Metal Pipe-arch per linear foot.

Item 423c, 25" x 16" Corrugated Metal Pipe-arch, per linear foot.

Item 423d, 29" x 18" Corrugated Metal Pipe-arch, per linear foot.

Item 423e, 36" x 22" Corrugated Metal Pipe-arch, per linear foot.

Item 423f, 43" x 27" Corrugated Metal Pipe-arch, per linear foot.

Item 423g, 50" x 31" Corrugated Metal Pipe-arch, per linear foot.

Item 423h, 58" x 36" Corrugated Metal Pipe-arch, per linear foot.

Item 423j, 65" x 40" Corrugated Metal Pipe-arch, per linear foot.

Item 423k, 72" x 44" Corrugated Metal Pipe-arch, per linear foot.

Item 424a, 18" x 11" Corrugated Metal Pipe-arch, (Bituminous Coated), per linear foot.

Item 424b, 22" x 13" Corrugated Metal Pipe-arch, (Bituminous Coated), per linear foot.

Item 424c, 25" x 16" Corrugated Metal Pipe-arch (Bituminous Coated), per linear foot.

Item 424d, 29" x 18" Corrugated Metal Pipe-arch, (Bituminous Coated), per linear foot.

Item 424e, 36" x 22" Corrugated Metal Pipe-arch, (Bituminous Coated), per linear foot.

Item 424f, 43" x 27" Corrugated Metal Pipe-arch, (Bituminous Coated), per linear foot.

Item 424g, 50" x 31" Corrugated Metal Pipe-arch, (Bituminous Coated), per linear foot.

Item 424h, 58" x 36" Corrugated Metal Pipe-arch, (Bituminous Coated), per linear foot.

Item 424j, 65" x 40" Corrugated Metal Pipe-arch, (Bituminous Coated), per linear foot.

Item 424k, 72" x 44" Corrugated Metal Pipe-arch (Bituminous Coated), per linear foot.

Item 425a, Twenty-four Inch Reinforced Concrete Sewer Pipe, per linear foot.

Item 425b, Twenty-seven Inch Reinforced Concrete Sewer Pipe, per linear foot.

Item 425c, Thirty Inch Reinforced Concrete Sewer Pipe, per linear foot.

Item 425d, Thirty-three Inch Reinforced Concrete Sewer Pipe, per linear foot.

Item 425e, Thirty-six Inch Reinforced Concrete Sewer Pipe, per linear foot.

Item 425f, Forty-two Inch Reinforced Concrete Sewer Pipe, per linear foot.

Item 425g, Forty-eight Inch Reinforced Concrete Sewer Pipe, per linear foot.

Item 425h, Fifty-four Inch Reinforced Concrete Sewer Pipe, per linear foot.

Item 425j, Sixty Inch Reinforced Concrete Sewer Pipe, per linear foot.

Item 425k, Sixty-six Inch Reinforced Concrete Sewer Pipe, per linear foot.

Item 425m, Seventy-two Inch Reinforced Concrete Sewer Pipe, per linear foot.

Item 425n, Seventy-eight Inch Reinforced Concrete Sewer Pipe, per linear foot.

Item 425p, Eighty-four Inch Reinforced Concrete Sewer Pipe, per linear foot.

Item 425r, Ninety Inch Reinforced Concrete Sewer Pipe, per linear foot.

Item 425s, Ninety-six Inch Reinforced Concrete Sewer Pipe, per linear foot.

Item 425t, One Hundred-eight Inch Reinforced Concrete Sewer Pipe, per linear foot.

## CONCRETE

### DESCRIPTION:

This item shall consist of concrete masonry composed of approved Portland cement, fine aggregate, coarse aggregate and water, prepared and constructed in accordance with these specifications at the locations and of the form, dimensions and class shown on the plans or directed in writing by the Project Engineer. The use of High-Early-Strength cement will not be permitted without the written consent of the Construction and Maintenance Engineer.

### EQUIPMENT:

Concrete shall be mixed thoroughly in a batch mixer of approved type and capacity with accurate timing and water measuring devices. The timing device shall be of the type which will automatically lock the discharging apparatus so as to prevent the emptying of the mixer until the materials have been mixed the minimum specified time.

Minimum Size of Mixer: No mixer shall be operated above its rated capacity and no mixer shall be used which has a rated capacity of less than a one bag batch, except in the construction of pipe headwalls where a three and one-half cubic foot mixer may be used.

In determining the capacity of mixers, the output per hour shall be as follows:

7 cubic foot mixer .....	3 cu. yds.
10 cubic foot mixer .....	7 cu. yds.
1/2 cubic yard mixer .....	10 cu. yds.
1 cubic yard mixer .....	20 cu. yds.

The maximum continuous pouring for the various sized mixers, unless otherwise permitted by the Project Engineer, shall be as follows:

7 cubic foot capacity .....	35 cu. yds.
10 cubic foot capacity .....	70 cu. yds.
1/2 cubic yard capacity .....	100 cu. yds.

Under special conditions, and with satisfactory proof, the rating of mixers, as stated above, may be increased.

Blades: Pick-up and throw-over blades in the drum of the mixer which are worn down  $\frac{3}{4}$  inch, or more, in depth shall be replaced by new blades.

Unsatisfactory Mixers: When, in the opinion of the Project Engineer, a concrete mixer is not adequate or suitable for the work, it shall be removed from the job and a suitable mixer provided.

#### **MATERIALS:**

Portland Cement shall conform to the requirements specified in M-24.

Water shall conform to the requirements specified in M-121.

Fine aggregate shall conform to the requirements specified in M-14, Type "A".

Coarse Aggregate shall conform to the requirements specified in M-13.

Expansion joint filler shall conform to the requirements specified in M-33.

Sheet packing shall conform to the requirements specified in M-101.

#### **CONSTRUCTION METHODS:**

##### **Classification:**

Concrete shall be classified as Class "A," Class "D" or Class "S." Each class of concrete shall be used in

that part of the structure in which it is called for on the plans, or where directed. The following requirements shall govern unless otherwise shown on the plans.

Class "A" concrete shall be used for all parts of superstructures and for all parts of substructures (except where Class "D" or Class "S" concrete is stipulated) and for piling, retaining walls, concrete box culverts, pipe headwalls, counterweights and adjusting blocks, etc.

Class "D" concrete shall be used for pier footings and for unreinforced concrete, as required by the plans.

Class "S" concrete shall be used for all concrete deposited under water.

**PROPORTIONING:**

(a) Cement and Aggregates: The proportions by volume, of cement to aggregates, measured separately, for the different classes of concrete shall be approximately:

Class "A" Concrete .....	1:5
Class "D" Concrete .....	1:6
Class "S" Concrete .....	1:4

The contractor shall vary, without charge, the ratio of fine to coarse aggregate, as directed by the Project Engineer, but in no case shall it be varied so as to materially affect the unit volume of cement per unit volume of concrete as determined by the original proportions designed to obtain a cement factor of not less than the following:

	Bags of Cement of 94 lbs. each to one cu. yd. of concrete
Class "A" Concrete .....	6.0
Class "D" Concrete .....	5.0
Class "S" Concrete .....	7.0

Use of Cement: The contractor's attention is directed to the fact that the specified cement contents indicated in the above table are minimum cement contents permitted but are not assured by the Department since the cement content obtaining for any type of mix

is dependent upon the gradation of aggregates within the limits of the specifications for that type gradation. The cement content is based upon the most ideal combination and gradation of both fine and coarse aggregate.

(b) Water: The maximum amount of water per sack of cement permitted, including the free water in the aggregate, for the different classes of concrete shall not exceed the quantity shown in the following table. Free water shall be deemed to include all water entering the mix with the aggregate, except the water absorbed by the particles of aggregate.

Class "A" Concrete .....	5.5 Gallons
Class "D" Concrete .....	6.0 Gallons
Class "S" Concrete .....	6.0 Gallons

**Gradation of Coarse Aggregates:**

Coarse aggregate for the various classes of concrete shall be of the grade shown in the following table, and described in detail under "Materials:"

Class "A" Concrete .....	Grade A
Class "D" Concrete .....	Grade D
Class "S" Concrete .....	Grade A

Different classes of coarse aggregate, or aggregates from different sources, even if tested and approved, shall not be mixed during use nor used alternately in any one class of construction except when permitted by the Project Engineer in writing.

**Handling, Measuring and Batching:**

The aggregate shall be measured by weight, except for structures of less than 25 cubic yards, in which case the contractor may substitute approved volumetric measuring devices.

Concrete of the class indicated shall be made up of accepted material batches in the proportions set by the Project Engineer for the specific materials. Corrections necessitated by variations from day to day in the mois-

ture content of the raw materials or for other similar reasons shall be made as directed by the Project Engineer.

The coarse and fine aggregate shall be handled and measured separately.

Cement shall be measured by the bag as packed by the manufacturer or, when bulk cement is used, cement shall be measured by weight and the weighing equipment shall be approved by the Project Engineer prior to use. Cement scales shall be of either the beam or springless dial type and shall be the product of a reputable scale manufacturer. Scales shall be accurate within a tolerance of four pounds per 1000 net load in the hopper. The value of the minimum graduation of any scale shall not be greater than two pounds. The scales shall have a device to indicate the last fifty pounds of load. When bulk cement is hauled in batch trucks the cement shall not be in direct contact with the aggregates for a period exceeding one hour before the mixing water is added to the batch. After bulk cement is weighed, it shall be protected from loss in handling or in transit.

Water shall be measured either by volume or by weight. The allowable error in accuracy of water measuring equipment on the mixer shall be not more than one per cent. The equipment should preferably include an auxiliary tank from which the measuring tank shall be filled, and in any case shall be so arranged that the accuracy of measuring will not be affected by variations in pressure in the water supply line.

The allowable error in accuracy of weighing equipment for aggregates shall not be more than  $\frac{1}{2}$  of 1 per cent for all loads.

All weighing equipment shall be arranged so as to permit making compensation for changes in the weight of moisture contained in the aggregates and to permit the convenient removal of excess material, when weighing hoppers are provided.

Weighing equipment shall be so arranged that the operator has convenient access to all control levers

and cables. The weighing beam and auxiliary weighing device shall be in full view of the operator when manipulating the gates which deliver material to the weighing hopper.

The scales shall be of either the beam or springless dial type. A suitable device consisting of a graduated beam or dial, shall be used to register at least the last 100 pounds of either of the aggregates required for the batch. The value of the minimum graduation shall not be greater than 2 pounds. If the aggregate is measured by volume, the contractor shall use satisfactory hoppers or boxes which, when filled and struck off, will give the exact volume of aggregate specified. In no case will wheelbarrow measurement be permitted.

#### Mixing:

(a) Machine Mixing: The concrete shall be mixed only in such quantities as are required for immediate use. No retempering of concrete will be allowed. Aggregates or bags of cement containing lumps or crusts of hardened material shall not be used.

Concrete shall be mixed for a period of not less than one minute after all materials, including water, are in the mixer drum.

During such period, the drum shall be operated at drum speeds specified by the mixer manufacturer and shown on his nameplate on the machine. The entire contents of the mixer shall be removed from the drum before materials for the succeeding batch are placed therein and the mixer preferably shall be equipped with mechanical means for preventing the addition of aggregates after mixing has commenced.

(b) Hand Mixing: Hand mixing will not be permitted, except in case of emergency and with the written permission of the Project Engineer. When permitted, it shall be done only on watertight platforms. The sand shall be spread evenly over the platform and the cement spread upon it. The sand and cement shall then be mixed thoroughly while dry by means of shovels until the mixture is of a uniform color, after which it shall be formed into a "crater" and water added in an



amount necessary to produce mortar of the proper consistency. The material upon the outer portion of the "crater" ring shall then be shoveled to the center and the entire mass turned and sliced until a uniform consistency is procured. The coarse aggregate shall then be wetted thoroughly and added to the mortar and the entire mass turned and re-turned at least six times and until all of the stone particles are covered thoroughly with mortar and the mixture is of a uniform color and appearance. Hand mixed batches shall not exceed 1/2 cubic yard in volume. Hand mixing will not be permitted for concrete to be placed under water.

(c) The use of a central mixing plant will not be permitted unless specifically approved by the Chief Engineer in writing. When such approval is given, the concrete shall be mixed to such consistency that the hauling will cause no segregation of the constituent materials. The methods of storing and hauling materials and equipment used shall be subject to the approval of the Chief Engineer. Vehicles shall be equipped with suitable devices for slowly agitating the concrete during transit and for delivering of the concrete in an unsegregated condition of uniform consistency. Any vehicular load showing non-uniform consistency upon arrival will be subject to rejection.

**Consistency:**

The composition of the combined mixture shall be such as to produce concrete of maximum density consistent with workability, containing no free water, with the specified cement content, and not more than the volume of water specified in the table above.

The quantity of water used shall not be changed without the consent of the Project Engineer.

The consistency of the various classes of concrete shall be such as to have slumps within the following ranges using A. S. T. M. Method, Designation C 143-39.

- Class "A" Concrete.....2-4 inches slump
- Class "D" Concrete .....1-3 inches slump
- Class "S" Concrete .....4-8 inches slump

The above ranges represent the extreme limits of allowable slump. In all cases the amount of water used shall be the minimum necessary to secure the required workability of the concrete within the ranges of slump specified.

**Concrete Strength Requirements:**

When required by the Project Engineer, samples of concrete for compression tests as prescribed in the A. S. T. M. Designation C 31-33, shall show a minimum compressive strength in pounds per square inch as follows:

	7 days	28 days
Class "A" Concrete .....	2000	3000
Class "D" Concrete .....	1900	2500
Class "S" Concrete.....	2000	3000

**Falsework:**

Falsework for supporting concrete work shall be built on foundations of sufficient strength to carry the loads without appreciable settlement. Falsework which cannot be founded upon solid footings shall be supported by ample falsework piling. Falsework shall be designed to carry full loads coming upon it. All spans shall be given sufficient temporary camber to allow for shrinkage and settlement. Bridges shall have a permanent camber only when shown on the plans. If appreciable settlement occurs in the falsework, the work shall be stopped and any masonry affected shall be removed and the falsework rebuilt. In general, double wedges or other suitable means shall be provided for constructing and maintaining falsework and forms to correct lines.

If requested by the Project Engineer, detail drawings of the falsework shall be submitted to him for approval, but such approval shall not operate to relieve the contractor of any of his responsibility under the contract for the successful completion of the improvement.

## Forms:

Forms shall be so designed and constructed that they may be removed without injuring the concrete.

Forms for exposed surface shall be made of sized and dressed tongue and groove or shiplap lumber or metal in which all bolt and rivet holes are countersunk so that in either case a plane smooth surface of the desired contour is obtained. Rough lumber may be used for backing or for surfaces which will not be exposed in the finished structure. All lumber shall be free from knot holes, loose knots, cracks, splits, warps, or other defects affecting the strength or appearance of the finished structure. Form lumber shall be free from bulge or warp, and shall be cleaned thoroughly if used a second time.

In designing forms and centering, the concrete shall be treated as a liquid weighing 150 pounds per cubic foot for vertical loads, and not less than 85 pounds per cubic foot for horizontal pressure. The unsupported length of wooden columns and compression members shall not exceed 30 times the diameter of the least side.

The forms shall be substantial and unyielding and shall be so designed that the finished concrete will conform to the proper dimensions and contours. The design of the forms shall take into account the effect of vibration of concrete as it is placed.

The forms shall be so designed that portions where finishing is required may be removed without disturbing portions of forms which are to be removed later and as far as practicable, so that form marks will conform to the general lines of the structure. Column form marks shall be vertical and symmetrically placed.

When possible forms shall be daylighted at intervals not greater than 10 feet vertically, the opening being sufficient to permit of free access to the forms for the purpose of inspecting, working, and spading the concrete.

The forms shall be built to line and braced in a substantial and unyielding manner. Wires for tying forms shall not extend through faces of concrete that will be

exposed in the finished work. In general, forms shall be tied together with bolts that can be removed. The forms shall be mortar tight and if necessary to close cracks due to shrinkage, shall be soaked thoroughly with water. Forms for reentrant angles shall be chamfered and for edges shall be filleted. The interior surfaces of forms shall be adequately oiled, greased or soaped to insure non-adhesion of mortar. Forms shall be inspected by the Project Engineer immediately prior to placing concrete. Dimensions shall be checked carefully and any bulging or warping shall be remedied and all dirt, sawdust, shavings, or other debris within the forms shall be removed. Special attention shall be paid to ties and bracing, and where forms appear to be insufficiently braced or unsatisfactorily built, either before or during construction, the Project Engineer shall order the work stopped until the defects have been corrected to his satisfaction. Forms shall be so constructed that the finished concrete shall be of the form and dimension shown on the plans, and true to line and grade. Clean-out ports shall be provided at the top surfaces of concrete where a stoppage of placing occurs.

#### **Placing Concrete:**

Concrete shall be placed in the forms immediately after mixing and in no case shall concrete be used which does not reach final position in the forms within 1 hour after water is first added to the mix. The method of placing shall be such as to avoid segregation of the aggregates or displacement of reinforcement.

Use of long chutes or troughs for conveying concrete from mixing plant to forms will not be permitted. Troughs, pipes or short chutes used as aids in placing concrete shall be arranged and used in such a manner that the ingredients of the concrete are not separated. Where steep slopes are required, troughs and chutes shall be equipped with baffle boards or be in short lengths that reverse the direction of movement. When pipes are used they shall be kept full of concrete and have their lower ends kept buried in fresh concrete as

required when a tremie is used. All chutes, troughs and pipes shall be kept clean and free from coatings of hardened concrete by flushing thoroughly with water after each run. Water used for flushing shall be discharged clear of the concrete in place. Troughs and chutes shall be either metal or metal lined and shall extend as nearly as possible to the point of deposit. When the discharge must be intermittent, a hopper or other device for regulating the discharge shall be provided. At least two hours must elapse after depositing concrete in columns or walls before depositing in beams, girders, slabs or pier caps supported thereon.

Dropping the concrete a distance of more than 5 feet or depositing a large quantity at any point and running or working it along the forms will not be permitted.

Placing of concrete shall be so regulated that the pressures caused by the wet concrete shall not exceed those used in the design of the forms.

Special care shall be taken to fill each part of the forms by depositing concrete as near final position as possible, to work the coarser aggregates back from the face and to force the concrete under and around the reinforcement bars without displacing them. After the concrete has taken its initial set, care shall be exercised to avoid jarring the forms or placing any strain on the ends of projecting reinforcement.

The placing of concrete shall be done in such manner that the steel reinforcement is not coated with cement before its final embedment. In depositing concrete around steel shapes and closely spaced reinforcing bars the concrete shall be deposited on one side of the steel and worked until it flushes under the steel to the opposite side before any concrete is placed on the opposite side or over the steel.

Unless otherwise directed by the Project Engineer, the concrete after having been placed in the forms shall be thoroughly compacted by means of mechanical, high-frequency internal vibrators of a type approved by the Project Engineer, with a minimum frequency of 5,000

cycles per minute and shall be capable of visibly affecting a properly designed mixture with a 1" slump for a distance of at least 18" from the vibrator. Sufficient vibrators shall be used to consolidate the incoming concrete within 15 minutes after placing. The vibrator shall be placed directly in the forms and preferably shall not be operated while it is in contact either with the inside or the outside of the forms or to the reinforcing steel in any manner. The compaction shall be produced by inserting the machine in the concrete directly for a period of approximately twenty to thirty seconds. This insertion shall occur approximately every two and one-half feet, or where necessary to produce concrete of maximum density. Continuous attention shall be given to the working of concrete next to forms and around reinforcing steel, and embedded fixtures or inserts. The contractor shall furnish and use as a minimum, one vibrator for every 25 cubic yards of concrete placed per hour and shall keep spare units in reserve.

Concrete shall be placed in each section of the work in a continuous operation working day and night, if necessary, to avoid stoppage planes. It shall be deposited in horizontal layers, placing thin layers at first that can be thoroughly worked into intimate contact with the concrete beneath. After a depth of 6 inches has been built up in this manner, the thickness of the layers may be increased to a maximum of 12 inches. The depth of layers used shall be such that the succeeding layer is placed before the previous layer has attained initial set. Each layer shall be compacted in a manner that will break up and obliterate any tendency to form a plane of separation between the layers. If it is necessary, by reason of an emergency to stop placing concrete before any section is completed, bulkheads shall be placed as the Project Engineer may direct. Any place where the placing of concrete is discontinued for a sufficient time to allow the concrete to take initial set shall be deemed a construction joint and treated as hereinafter described under "Forming Joints."

Horizontal layers so located as to produce a con-

struction joint at a location wherein a "Featheredge" might be produced in the succeeding layer, shall be formed by inset work so that the succeeding layer will end in a body of concrete having a thickness of not less than 6 inches.

In no case shall the work on any section or layer be stopped or discontinued temporarily within 18 inches below the top of any face, unless the details of the work provided for a coping having a thickness of less than 18 inches, in which case at the option of the Project Engineer, the construction joint may be made at the under side of the coping.

After the concrete in finished surfaces has begun to set, it shall not be disturbed in less than 48 hours.

The method and manner of placing concrete shall be so regulated as to place all construction joints across regions in low shearing stress and in such locations as will be hidden from view to the greatest possible extent. The method and sequence of placing concrete for the various types of concrete bridge construction shall be as specified in "Concrete Bridges" for the particular type of construction involved.

#### **Depositing Concrete Under Water:**

Concrete shall not be exposed to the action of water before setting, or deposited in water, except with the approval of the Project Engineer and under his immediate supervision. When concrete is so deposited, the method and manner of placing shall be as hereinafter designated.

All concrete deposited under water shall be mixed in the proportions designated for Class "S" concrete.

Concrete deposited under water shall be placed carefully in compacted mass in its final position by means of a tremie, and shall not be disturbed after being deposited. Special care must be exercised to maintain still water at the point of deposit. No concrete shall be placed in running water and all form work designed to retain concrete under water shall be water tight. The

method of depositing concrete shall be so regulated as to produce approximately horizontal surfaces. Each seal shall be placed in one continuous operation.

The tremie used shall consist of a tube having a diameter of not less than 10 inches, constructed in sections having flange couplings fitted with gaskets. The means of supporting the tremie shall be such as to permit free movement of the tremie over the entire work and to permit its being lowered rapidly when necessary to choke off or retard the flow. The discharge end shall be entirely sealed at all times and the tremie tube kept full to the bottom of the hopper. When a batch is dumped into the hopper the tremie shall be slightly raised, but not out of the concrete at the bottom, until the batch discharges to the bottom of the hopper. The flow is then stopped by lowering the tremie. The flow shall be continuous and in no case shall be interrupted until the work is completed.

#### **Weather Limitations:**

Concreting operations of mixing and placing shall not be continued when a descending atmospheric temperature in the shade and away from artificial heat falls below 40° F., nor resumed until an ascending atmospheric temperature in the shade and away from artificial heat reaches 35° F.

#### **Forming Joints:**

(a) Construction Joints: When the work of placing concrete is delayed until the concrete has taken initial set, the point of stopping shall be deemed a construction joint. The location of construction joints shall be planned in advance and shall be subject to approval by the Project Engineer. The placing of concrete shall be carried continuously from joint to joint. These joints shall be perpendicular to the principle lines of stress and in general be located at points of minimum shear.

At all horizontal construction joints and at other locations, when directed, a gage strip not less than 2



inches thick shall be placed inside the forms along all exposed faces to give the joint a straight line and to eliminate wedge shaped particles of concrete that might chip off. In placing concrete up to construction joints, the forms shall be "over filled" at least one inch and all excess material removed, including all laitance.

In joining fresh concrete to concrete that has already set, the forms shall be drawn tight against the face of the set concrete and all gage strips and key forms removed. The surface of the set concrete to be contacted shall then be cut over with suitable tools to remove all residual laitance, and loose and foreign material. This surface shall then be washed and scrubbed with wire brooms, drenched with water until saturated and kept saturated until the new concrete is placed. Immediately prior to placing new concrete, the old surface shall be coated thoroughly with a very thin coating of neat cement mortar.

(b) Keys: In order to bond successive courses, suitable keys shall be formed at the top of the upper layer of each day's work and at other levels where work is interrupted. These keys shall be formed by the insertion and subsequent removal of beveled wood strips which shall be saturated thoroughly with water prior to insertion. Rough stone or steel dowels may, at the discretion of the Project Engineer, be used in lieu of keys. All construction joints shall be keyed or doweled as shown on the plans or directed by the Project Engineer.

(c) Sliding Joints: Sliding joints shall be true planes parallel to the direction of movement. Where sliding joints are to be provided at the ends of slabs, girders or beams, or between walls, etc., the surface of the supporting concrete shall be given a smooth finish and covered with two layers of three-ply roofing felt to separate the concrete.

(d) Expansion Joints: Expansion joints shall be used where shown on the plans. The thickness of the expansion joint shall be as required on the plans. Pre-

moulded bituminous joint filler, when required, shall be cut to the same shape as the area to be covered but  $\frac{1}{4}$  inch smaller along all surfaces that will be exposed in the finished work. It shall be fixed firmly against the surface of the concrete already in place in such manner that it will not be displaced when the concrete is deposited against it. Where necessary to use more than one piece to cover any surface, the abutting pieces shall be placed in close contact and the joint between the separate pieces shall be covered with a layer of two-ply roofing felt, one side of which shall be covered with hot asphalt to insure proper retention. The  $\frac{1}{4}$  inch space along the edges at exposed faces shall be filled with wooden strips of the same thickness as the joint material. These wooden strips shall be saturated with oil and have sufficient "draft" to make them readily removable after the concrete is placed. Immediately after the forms are removed the expansion joints shall be inspected carefully. Any concrete or mortar that has sealed across the joint shall be cut neatly and removed.

(e) Special Joints: Special water-tight and flashed expansion joints shall be constructed as shown on the plans.

#### **Curing Concrete:**

Careful attention shall be given by the contractor to the proper curing of finished concrete surfaces. Such surfaces shall be protected, within twenty-four hours of placing by a covering of canvas, straw, burlap, sand or other satisfactory material which shall be kept wet by flushing or sprinkling for a period of not less than seven days after placing of the concrete. Other precautions to insure the proper development of strength shall be taken as the Project Engineer may direct.

Unless otherwise permitted by the Project Engineer, concrete bridge floors shall be closed to traffic for a period of at least fourteen days after placing and for such additional time as may be considered advisable.

### Removal of Forms:

In order to facilitate finishing, forms on ornamental work, parapets and exposed vertical surfaces shall be removed in not less than 12 or not more than 48 hours, depending on weather conditions. Forms under beams and girders shall remain in place at least 14 days in warm weather and in cold weather at the discretion of the Project Engineer. Forms under floor slabs shall remain in place at least 7 days in warm weather. Forms shall always be removed from columns before removing shoring from beneath beams and girders in order to determine the condition of concrete in the columns. When the use of High-Early-Strength Cement is authorized for structures, all supporting forms shall remain in place until the modulus of rupture of the concrete as shown by test beams has reached 600 pounds per square inch and in no case before the elapse of 72 hours after the completion of concrete depending on such false work or forms for support. The beams shall be tested by laboratory methods using a simple beam with 3rd point loading (A. S. T. M. Designation C-78).

Forms shall not be removed at any time without the consent of the Project Engineer. Such consent shall not relieve the contractor of responsibility for the safety of the work. Blocks and bracing shall be removed with the forms and in no case shall any portion of the wood forms be left in the concrete. As soon as the forms are removed, all projecting wire or other metal devices used for holding the forms in place and which pass through the body of the concrete shall be removed or cut back at least  $\frac{1}{4}$  inch beneath the surface of the concrete and the holes or depressions thus made, and all other holes, depressions and small voids which show upon the removal of the forms, shall be filled with cement mortar mixed in the same proportions as that which was used in the body of the work. Lips of mortar and all irregularities caused by form joints shall be removed. The presence of excessive honeycomb areas may be considered sufficient cause for the rejection of the structure, and upon written notice from the Project Engineer, the

contractor shall remove and rebuild the structure in part or in whole as specified, at his own expense. In patching holes or porous spots, all coarse or broken material shall be chipped away until a dense uniform surface of concrete exposing solid coarse aggregate is obtained. Feathered edges shall be cut away to form a face perpendicular to the surface being patched. All surfaces of the cavity shall be saturated thoroughly with water, after which a thin layer of neat cement mortar shall be applied. The cavity shall then be filled with a thick, dry mortar composed of one part of Portland cement to two parts of sand, which shall be tamped into place thoroughly. The surface of this mortar shall be floated with a wooden float before initial set takes place and shall present a neat and workmanlike appearance. The patch shall be kept wet for a period of 5 days.

For patching large or deep areas, coarse aggregate shall be added to the patching material and special precautions shall be taken to insure a dense, well bonded and properly cured patch, all as required by the Project Engineer.

#### **Removal of Falsework:**

Falsework shall not be removed at any time without the consent of the Project Engineer. Such consent shall not relieve the contractor of responsibility for the safety of the work. Falsework shall remain in place after concreting is completed at least 14 days in warm weather and in cold weather at the discretion of the Project Engineer.

#### **Finishing Concrete:**

General: All concrete surfaces except handrails and posts not requiring "Concrete Floor Finish" or "Curb and Sidewalk Finish" shall be given an "Ordinary Finish." Handrails and posts shall be given a "Rubbed Finish."

(a) Rubbed Finish: After the pointing has set sufficiently to permit, surfaces to be rubbed shall be thor-

oroughly wetted and rubbed with a carborundum or other abrasive of equal quality to bring the surface to a smooth texture and remove all form marks. The paste formed by the rubbing as above described may be finished by carefully stripping with a clean brush, or it may be spread uniformly over the surface and allowed to take a reset, after which it shall be finished by floating with a canvas, carpet-faced or cork float or rubbed down with dry burlap.

(b) Ordinary Finish: An "Ordinary Finish" is a surface left by the removal of the forms with all holes left by form ties filled and all defects repaired. The surface shall be true and even, free from stone pockets, depressions or projections beyond the surface. Concrete bridge seats, caps, and tops of walls shall be struck off with a straight edge and floated to true grade. The use of mortar topping for concrete surfaces shall in no case be permitted.

(c) Concrete Floor Finish: The roadway surface shall conform to the grade and cross section shown on the plans. After the deck is placed, it shall be struck off with a longitudinal screed which shall be constructed of steel shapes and adjustable for sag. It shall be of sufficient length to strike off a full span or panel length in one operation. The screed shall pass over all floor surfaces a minimum of three times. The surface shall then be hand finished to produce an even riding surface by means of floats and belts. Before the concrete has taken its final set, the surface shall be tested for irregularities or waves by means of a ten-foot straight edge parallel to the center line of the roadway. Should any point of the concrete surfaces be  $\frac{1}{8}$  inch or more below or above the straight line, such defect shall be immediately remedied. The belt used in finishing floor slabs shall conform to the standard tools, termed the "Slat Belt," as used under Item 535.

(d) Curb and Sidewalk Finish: Exposed faces of curbs and sidewalks shall be finished to true surfaces having the lines and grades shown on the plans. Con-

crete shall be worked until the coarse aggregate is forced down into the body of the concrete. The surface shall then be struck off to obtain a true surface and given a brush finish. The junction of the sidewalk with masonry parapets shall be finished with a fillet of  $\frac{3}{4}$  inch radius. Walk surfaces shall be laid out in squares with a grooving tool, as shown on the plans or as directed by the Project Engineer.

(e) Special Finishes: The following finishes shall be used only when specifically called for on the plans:

**Ground or Terrazo Finish:** Using a number sixteen carborundum stone or an abrasive of equal quality, the surface shall be ground dry or in water until it is smooth and individual pebbles and aggregate particles are cut and polished. The surface shall then be completely cleansed with water, and the final rubbing done by means of a number thirty stone. The finished surface shall present the texture of polished marble and shall show the various aggregate particles in polished outline.

**Tooled Finish:** Finish of this character for panels and other like work may be secured by the use of a bush-hammer, pick, crandall or other approved tool. Air tools, preferably, shall be employed. No tooling shall be done until the concrete has set for at least 14 days and as much longer as may be necessary to prevent the aggregate particles from being picked out of the surface. The finished surface shall show a grouping of broken aggregate particles in a matrix of mortar, each aggregate particle being in slight relief.

**Sand Blast Finish:** This type of finish shall be similar to that above described for tooled finish, but finer grained in texture. The sand blasting shall be done by means of approved equipment and in such manner as to produce an even, fine-grained surface in which the mortar has been cut away leaving the aggregate particles exposed.

#### **Drainage and Weep Holes:**

Drainage and weep holes shall be constructed in the

manner and where indicated on the plans, or directed by the Project Engineer. Drains and weep holes in the faces of the abutments shall be connected with the roadway drains wherever indicated on the plans. Ports or vents for equalizing hydrostatic pressure shall be placed below low water. Weep holes shall be placed at the elevations shown, or as directed by the Project Engineer.

Forms for weep holes through concrete may be clay pipe, concrete pipe, metal or wooden boxes. If wooden forms are used they shall be removed after the concrete is placed. Drain pipes embedded in concrete shall be standard light weight cast iron water pipe or wrought iron pipe. The pipe shall be held rigidly against displacement during the laying of the concrete.

#### **METHOD OF MEASUREMENT:**

The yardage to be paid for shall be the number of cubic yards of concrete of the several classes, complete in place and accepted. In computing the concrete yardage for payment, the dimensions used shall be those shown on the plans or ordered in writing by the Project Engineer. No measurement or other allowance will be made for forms, falsework, cofferdams, pumping, bracing or expansion joint material.

No deductions in quantities of concrete shall be made for the enclosed reinforcing bars in counterweights and adjusting blocks, but the volume of structural steel so enclosed shall be deducted from the volume of concrete. Measurement will be based on the actual dimensions of the finished counterweights, including adjusting blocks.

No deductions will be made for the volume of reinforcing steel, small pipes and conduits, steel angles forming armored joints in roadway slabs, weep holes or cast iron drains.

Deductions will be made for the volume of steel beams embedded in concrete, for all expansion joints, and for all pile heads embedded in concrete. In computing the volume to be deducted for concrete pile heads

embedded in concrete, nominal butt dimensions, that is, 12 inches x 12 inches, 14 inches x 14 inches, etc., shall be used. In computing the volume to be deducted for timber piles embedded in concrete, a butt diameter of 12 inches shall always be used, regardless of size and length of pile.

**BASIS OF PAYMENT:**

The number of cubic yards of completed and accepted concrete, of the several classes, measured as provided above, shall be paid for at the contract price per cubic yard for Class "A," Class "D," or Class "S" concrete as the case may be, complete in place, which price and payment shall constitute full compensation for the concrete, for all materials, including expansion joint filler, sheet packing, weep holes and cast iron drains indicated on the plans and for installation of all joints, weep holes, and cast iron drains and for all timber bumpers, forms, falsework, placing and finishing, and for all labor, tools, equipment and incidentals necessary to complete the item, but shall not constitute payment for reinforcing steel, nor for metal expansion joints. Payment will not be made for structural excavation except as specified under item for "Structural Excavation."

No extra payment shall be made for steel punchings used in counterweights and adjusting blocks, cost of same to be included in price bid on concrete.

Metal expansion joints shall be paid for as pounds of structural steel complete in place and accepted.

Reinforcing steel shall be paid for under the pay item of that name.

**Payment will be made under:**

Item 426, Class "A" Concrete, per cubic yard.

Item 427, Class "D" Concrete, per cubic yard.

Item 428, Class "S" Concrete, per cubic yard.

or,

Item 710, Class "A" Concrete, per cubic yard.

Item 711, Class "D" Concrete, per cubic yard.

Item 712, Class "S" Concrete, per cubic yard.



# REINFORCING STEEL

## DESCRIPTION:

This item shall consist of furnishing and placing reinforcing steel of the quality, type, size, and quantity designated in accordance with these specifications and as shown on the plans.

The grades and types of reinforcing steel shall, unless otherwise shown on the plans, be as follows:

(a) Structures: Reinforcing steel for structures, including counterweights, shall be deformed bars, of new billet steel. The form of the bars shall be such as to maintain a net section equivalent to a plain square or round bar of equal nominal size.

The use of cold twisted bars will not be permitted.

The use of rail steel bars will not be permitted.

(b) Concrete Paving: Reinforcing steel for concrete paving shall be plain or deformed bars, either of billet or rail steel, or fabric reinforcement, as indicated on the plans.

## MATERIALS:

Billet steel shall conform to the requirements specified in M-110.

Rail steel shall conform to the requirements specified in M-111.

Cold-drawn steel wire shall conform to the requirements specified in M-107.

## CONSTRUCTION METHODS:

### General Requirements:

(a) Protection of Material: Steel reinforcement shall be protected at all times from injury. When placed in the work, it shall be free from dirt, detrimental scale, paint, oil or other foreign substance. However, when steel has on its surface, rust, loose mill scale and dust, which is easily removable, it may be cleaned by a satisfactory method if approved by the Project Engineer.

(b) Approval of Reinforcement Placing: Placing and fastening of reinforcement in each section of the work shall be approved by the Project Engineer before any concrete is deposited in that section.

(c) Bending: When bending is required, it shall be accurately done without the use of heat, and bars having cracks or splits at the bends shall be rejected.

#### **Structures:**

(a) Placing and Fastening: All reinforcement shall be accurately placed in the exact position shown on the plans and shall be so securely held in position by wiring and blocking from the forms and by wiring together at intersections so that it will not be displaced during the depositing and compacting of the concrete. Blocks for holding reinforcement from contact with forms and for separating layers of bars shall be precast mortar blocks of approved shape and dimensions.

The use of pebbles, pieces of broken stone or brick, metal pipes and wooden blocks shall not be permitted.

(b) Splices: All reinforcement bars shall be furnished in the full length shown on the plans. No splicing of bars, except where shown on the plans, will be permitted without the written approval of the Project Engineer. In no case will splicing of main girder bars be permitted.

Splices which are permitted shall not be located at points of maximum stress; they shall, where possible, be staggered; and they shall have a length of not less than 50 times the nominal diameter of the bars. The bars shall be rigidly clamped or wired at all splices in a manner approved by the Project Engineer.

(c) Welding: No welds will be permitted.

#### **Concrete Pavement:**

Reinforcing bars and fabric reinforcement shall be placed in accordance with the directions specified under "Portland Cement Concrete Pavement."

## METHOD OF MEASUREMENT:

(a) Reinforcement in Structures: Reinforcing steel placed and accepted in structures, including counterweights, shall be measured by the pound, theoretical weight, complete in place. In computing the quantity of reinforcing steel the plan quantities shall be used exclusively regardless of splices.

For the purpose of computing the weight of reinforcing bars in structures, the following table of unit weights shall be used:

### TABULATION OF WEIGHTS OF REINFORCING BARS

$\frac{3}{8}$ -Inch Round .....	0.376 lbs. per foot.
$\frac{1}{2}$ -Inch Round .....	0.668 lbs. per foot
$\frac{1}{2}$ -Inch Square .....	0.850 lbs. per foot
$\frac{5}{8}$ -Inch Round .....	1.043 lbs. per foot
$\frac{3}{4}$ -Inch Round .....	1.502 lbs. per foot
$\frac{7}{8}$ -Inch Round .....	2.044 lbs. per foot
1-Inch Round .....	2.670 lbs. per foot
1-Inch Square .....	3.400 lbs. per foot
$1\frac{1}{8}$ -Inch Square .....	4.303 lbs. per foot
$1\frac{1}{4}$ -Inch Square .....	5.313 lbs. per foot

No measurement of reinforcing steel in concrete piling will be made.

No measurement of reinforcing steel furnished for testing purposes will be made.

(b) Reinforcement in Concrete Pavement: Reinforcing steel placed and accepted in concrete pavement will be measured by the pound, complete in place. In computing the weight of reinforcing steel or fabric reinforcement in pavement, the product of the area of the pavement slab reinforced multiplied by the weight per unit of area shown on the plans will be used.

No measurement of reinforcing steel furnished for testing purposes will be made.

**BASIS OF PAYMENT:**

The number of pounds of completed and accepted reinforcing steel, measured as provided above, shall be paid for at the contract unit price per pound for "Deformed Reinforcing Steel," "Plain Reinforcing Steel," "Bar Reinforcement" or "Fabric Reinforcement," as the case may be, which price and payment shall constitute full compensation for furnishing, bending, delivering and placing all the reinforcing steel and for all labor, equipment, tools and incidentals necessary to complete the item.

**Payment will be made under:**

- Item 429, Deformed Reinforcing Steel, per pound.
- Item 430, Plain Reinforcing Steel, per pound.
- Item 457, Bar Reinforcement, per pound.
- Item 458, Fabric Reinforcement, per pound. or,
- Item 713, Deformed Reinforcing Steel, per pound.
- Item 714, Plain Reinforcing Steel, per pound.
- Item 715, Bar Reinforcement, per pound.
- Item 716, Fabric Reinforcement, per pound. or,
- Item 506, Bar Reinforcement, per pound.
- Item 507, Fabric Reinforcement, per pound.

**ASPHALT PLANK  
ITEM 431**

**DESCRIPTION:**

This item shall consist of the furnishing and installation of a wearing surface of asphalt plank for structure decks, all in accordance with these specifications and to the lines, grade and thickness shown on the plans.

## **MATERIALS:**

Asphalt plank shall conform to the requirements specified in M-7.

Copper paper shall be not less than 95 per cent pure copper. It shall be of a thickness not less than No. 40 on the American Wire or Browne and Sharpe Gage, which is equal to 0.0031 inch. It shall be strong enough to satisfactorily stand handling, laying and walking over without excessive breaking.

Cut-back asphalt shall conform to the requirements specified in M-1, Type RC-2.

## **CONSTRUCTION METHODS:**

The wood subfloor shall be laid in such a manner that the maximum difference in elevation between adjacent planks shall not exceed  $\frac{1}{8}$  inch. It shall be cleaned of all excess materials, tools, equipment and other materials not essential to the laying of the wearing surface, and shall be swept broom clean before proceeding with the application of separator or asphalt planks.

No separator will be required when asphalt planks are to be laid over salts-treated wood subdecking. The method of application in this case shall be the same as that described below after the separator has been laid over creosoted subdecking.

When a copper separator is required, a tack coat of RC-2 cut-back asphalt shall be applied to the subdeck at the rate of 0.15 to 0.20 gallons per square yard before the separator is placed. The separator shall be applied while the tack coat is still tacky.

If the wood subdeck is creosoted, a separator, of copper shall be applied over the surface before laying the asphalt planks. Edges of the separator shall be lapped two inches and tacked to the subdeck with three penny shingle nails, on approximately twelve inch centers along laps. All breaks or holes appearing in the separator shall be patched before proceeding with the application of the cut-back asphalt.

The surface of the separator shall then be swept clean and given a uniform coating of cut-back asphalt. Asphalt shall be applied with an air gun or sprinkling pot and shall be applied with a thickness of not less than one thirty-second ( $1/32$ ) inch and not more than one sixteenth ( $1/16$ ) inch. (One gallon to 40 to 50 square foot of surface). All vertical surfaces which come in contact with the asphalt planks shall be coated along the points of contact with the cut-back asphalt.

Asphalt plank, which shall be, preferably, of eight (8) inch width by a minimum of four feet in length, shall be laid not less than 15 minutes nor more than two hours after application of the asphalt. Each plank shall be nailed in the following manner: One nail (8-penny for  $1/2$ -inch thickness; 16-penny for 1 inch thickness, 30-penny for  $1\frac{1}{2}$ -inch thickness) shall be driven one and one-half ( $1\frac{1}{2}$ ) inches from each corner, and additional nails shall be driven at twelve (12) inch centers along each long side,  $1\frac{1}{2}$  inches from the edge. The rows shall be staggered on opposite sides. If planks wider than eight inches are used, additional nails shall be driven in the ends. Nail heads shall be countersunk not less than  $1/8$  inch nor more than  $1/4$  inch below wearing surface. Suitable methods employing either wedges or jacks shall be used to insure a close end and side fit between adjacent planks and against header boards. Planks shall be laid in a herringbone pattern with broken joints, and rolled or weighted to secure solid bearing in the cut-back asphalt.

Small spaces, cracks, and nail holes shall be filled with hot asphalt cement and all surplus material wiped clean.

#### **METHOD OF MEASUREMENT:**

Asphalt plank shall be measured by the square foot, complete in place, measured separately for each specified thickness. The width to be measured shall be the width from outside to outside of asphalt plank completed in accordance with the width shown on the plans. The length to be measured shall be the center line

length measured along the surface of the completed asphalt plank.

**BASIS OF PAYMENT:**

The number of square feet of asphalt plank, measured as specified shall be paid for at the contract unit price per square foot for "Asphalt Plank," which price and payment shall constitute full compensation for furnishing all materials, including cut-back asphalt and metal paper; for all tools, labor, equipment and incidentals and the performance of all work necessary to complete the item and for all royalties or payments whatsoever for patents covering processes or equipment used in connection therewith.

**Payment will be made under:**

Item 431a, Asphalt Plank, ( $\frac{1}{2}$ " thick), per square foot.

Item 431b, Asphalt Plank (1" thick), per square foot.

Item 431c, Asphalt Plank, ( $1\frac{1}{2}$ " thick), per square foot. or,

Item 750a, Asphalt Plank ( $\frac{1}{2}$ " thick), per square foot.

Item 750b, Asphalt Plank (1" thick), per square foot.

Item 750c, Asphalt Plank, ( $1\frac{1}{2}$ " thick), per square foot.

## CONCRETE CURB AND GUTTER

Plain Concrete Curb .....	Item 436
Plain Concrete Gutter .....	Item 437
Combination Curb and Gutter .....	Item 438
Combination Lip Curb and Gutter ..	Item 439
Integral Concrete Curb .....	Item 440
Integral Concrete Lip Curb .....	Item 441
White Reflecting Plain Curb .....	Item 442
White Reflecting Combination Curb and Gutter .....	Item 443
White Reflecting Integral Curb .....	Item 444

### DESCRIPTION:

This item shall consist of the construction of any of the types of curbs and gutters listed above in conformity with lines, grades, dimensions and typical sections indicated on the plans in accordance with these specifications. White reflecting curbs shall be constructed with white mortar or white concrete, as shown on the plans.

### PROPORTIONING AND MIXING:

Integral Types: All concrete for these items shall be the same as provided for the roadway slab of which it shall form an integral part and proportioned and mixed as set out in Item 535.

Plain and Combination Types: All concrete for these items shall be Class "A," proportioned and mixed as set out under "Concrete."

White Reflecting Types. White Concrete: White concrete shall be Class "A" concrete as set forth in "Concrete," of the standard specifications, except that white Portland cement and aggregates as hereinafter set forth shall be used.

White Mortar: White Mortar shall be composed of one part of white Portland cement to one and three-quarters ( $1\frac{3}{4}$ ) parts of fine aggregate by volume. The cement and fine aggregate shall be thoroughly mixed



and sufficient water added to produce the required consistency and workability.

**MATERIALS (GRAY CONCRETE OR MORTAR):**

Portland cement shall conform to the requirements specified in M-24.

Fine aggregate shall conform to the requirements specified in M-14, Type "A."

Coarse aggregate shall conform to the requirements specified in M-13, Type "A."

**MATERIALS (WHITE CONCRETE OR MORTAR):**

White Portland cement shall conform to the requirements specified in M-24, Type "White."

Fine aggregate shall conform to the requirements specified in M-14, Type "M."

Coarse aggregate shall conform to the requirements specified in M-13, Type "Q."

**MATERIALS (OTHER):**

Water shall conform to the requirements specified in M-121.

Expansion joint filler shall conform to the requirements specified in M-33.

Poured joint filler shall conform to the requirements specified in M-6.

**CONSTRUCTION METHODS:**

**Subgrade:**

The subgrade shall be shaped to the required depth below the finished surface in accordance with the dimensions shown on the plans and shall be compacted to a firm, even surface. When possible, the subgrade shall be shaped and compacted at the same time and in the same manner as the subgrade for the pavement slab. All soft and yielding spots or any unstable material encountered shall be removed and replaced with suitable material. When foundation underdrain is to be placed under curbing and gutter, the excavations and

backfilling for same shall be completed and compacted before subgrade for curbing and gutter is prepared.

**Forms:**

The forms for the curbing or gutter shall be of wood or metal, straight, free from warp and of sufficient strength when staked, to resist the pressure of the concrete without springing. At least three stakes shall be provided for each ten feet. Wood forms shall be minimum two-inch S1S plank. Metal forms shall be of approved section. Forms shall be of a depth equal to the depth of the curbing or gutter, so designed as to permit of secure fastening together at the tops. The outside form shall be straight from top to bottom. The inside form shall have a batter from the top of the curbing to the finished surface line of the pavement as shown on the plans, and shall be straight from this line to the bottom. All forms shall be cleaned thoroughly and greased or soaped before concrete is placed against them. Forms which have become worn, bent or broken shall not be used until satisfactorily repaired and straightened. Repaired forms shall not be used until inspected and approved by the Project Engineer.

**Joints:**

**Integral Types:** Joints shall be formed in the curbing to correspond with "Dummy Joints" and other transverse joints in the pavement slab. All expansion joints shall extend entirely through the curb section and shall be finished and filled with premoulded filler.

**All Types Except Integral:** One-fourth-inch joints shall be provided at intervals of six feet, unless otherwise indicated on the plans, except where shorter sections are necessary for closures. The separation shall be effected by using steel plates one-fourth-inch in thickness, cut to true section and set vertically in the forms until the concrete has set sufficiently to permit withdrawal of the plates.

**Depositing Concrete:**

**Integral Types:** After the concrete pavement slab has been struck off, the curb form shall be clamped or

otherwise securely fastened in place upon the slab form and the additional concrete for the curb shall then be deposited and thoroughly tamped. The additional concrete shall be placed within thirty minutes after the pavement slab has been finished and care shall be taken to secure monolithic construction. All concrete shall be spaded or vibrated sufficiently to eliminate all voids and shall be tamped to bring the mortar to the surface, after which it shall be finished smooth and even with a wooden float. All edges shall be rounded with an approved finishing tool to the radius shown on the plans.

Plain and Combination Types: The concrete shall be placed on the prepared subgrade, struck off, and compacted to the required thickness. All concrete shall be spaded or vibrated sufficiently to eliminate all voids and shall be tamped to bring the mortar to the surface after which it shall be finished smooth and even with a wooden float. All edges shall be rounded with an approved finishing tool to the radius shown on the plans.

Preparation for and Placing of White Mortar: The grey concrete shall be placed carefully so that none of it touches the forms above the required bottom elevation of the white mortar facing material. The grey concrete shall be spaded or vibrated, and struck off or screeded to the required bottom elevation of the white mortar facing. Any film or particles adhering to the forms shall be entirely removed before placing of the white mortar. The white mortar shall be placed before the grey concrete has attained its initial set in order to secure monolithic construction between the grey concrete and the white mortar. Care shall be taken that no evidence of the grey concrete is apparent on the surface of the curb.

Preparation for and Placing of White Concrete: The preparation for and placing of white concrete shall be the same as provided for white mortar specified hereinbefore. After the grey concrete has been placed, an approved face form, properly cleaned and prepared with parting oil, shall be located firmly in proper position. The white concrete shall be placed and carefully but firmly spaded so that it will be dense throughout.

### **Finishing:**

The forms shall be removed within twenty-four hours after the concrete has been placed and honey-combed places and other minor defects shall be filled with mortar composed of Portland cement and sand, mixed in the same proportion as provided for the concrete. Plastering will not be permitted on the faces of the curbing or gutter and all rejected curb or gutter shall be removed and replaced without additional compensation. The top and face of the curb or gutter shall be finished while the concrete is still green, by wetting a wood block and rubbing the surface until it is smooth. Plenty of water shall be used, either by dipping the block in water or by throwing water on the curb or gutter with a brush.

**Scoring and Finishing White Mortar:** After the white mortar is placed, it shall be smoothly struck off or screeded to the proper elevation. The white mortar curb surface shall then be scored uniformly in accordance with the details shown on the plans, using tools and guides as indicated on the plans or approved by the Project Engineer, care being taken to see that the scoring is smooth. As soon as the mortar begins to harden, the scoring operation shall be repeated so that the reflecting surfaces are sharp and smooth, and will require no further finishing. The curb surface shall be rounded at the upper and lower edges to the required radii by suitable edging tools as indicated on the plans or approved by the Project Engineer. Care shall be taken in edging the curb so that the mortar will not be displaced over the finished scoring. Any discoloration that may take place in the white mortar surface, either during or after the construction of the curb, shall be cleaned by rubbing with carborundum or by any other method satisfactory to the Project Engineer, so as to be white at the time of acceptance.

**Finishing of Faces and Fins on White Concrete:** All faces and fins and all recessed surfaces of the reflecting panels shall have smooth surfaces which require no further finishing when the forms are removed. All outside edges of the reflecting surfaces shall be sharp. The curb

shall be rounded at the upper edges to the required radii by suitable edging tools, and the top surfaces shall be finished smooth with a steel float and lightly brushed to remove all tool marks. After the face form is removed, any juncture marks between the face form and edging tools shall be removed by rubbing with carbonundum stone, and any defects in contour and finish shall be repaired at the direction of the Project Engineer. A grout or wash coat of neat white cement will not be permitted.

**Curing:**

After finishing, the curb or gutter shall be cured in the same manner as provided for Portland Cement Concrete Pavement.

Immediately after the finishing operations have been completed on the white curb surfaces, the white curb shall be protected and cured by a covering of canvas supported on frames to prevent contact with the curb. After the curb has hardened sufficiently to prevent marring a substantial waterproof paper approved by the Project Engineer and which will not stain the white surface may be used to replace the canvas and frames. The canvas and paper shall be kept securely in place by weights and adjoining ends shall be lapped at least eighteen inches. The curing shall continue for a period of not less than forty-eight hours, dating from the time the curb is finished.

**METHOD OF MEASUREMENT:**

Curb and combination curb and gutter shall be measured by the linear foot along the line for computing lengths indicated on the plans.

Gutter shall be measured by the square yard.

**BASIS OF PAYMENT:**

Curb and gutter placed and accepted, measured as provided above, shall be paid for at the contract price per unit of "Curb," "Gutter," and "Curb and Gutter," complete in place, which price and payment shall constitute full compensation for all necessary excavation,

preparation of subgrade and backfilling and for the furnishing of all materials and joints, forms, equipments, tools, labor and incidentals and the performance of all work necessary to complete the item.

**Payment will be made under:**

Item 436, Plain Concrete Curb, per linear foot.

Item 437, Plain Concrete Gutter, per square yard.

Item 438, Combination Curb and Gutter, per linear foot.

Item 439, Combination Lip Curb and Gutter, per linear foot.

Item 440, Integral Concrete Curb, per linear foot.

Item 441, Integral Concrete Lip Curb, per linear foot.

Item 442, White Reflecting Plain Curb, per linear foot.

Item 443, White Reflecting Combination Curb and Gutter, per linear foot.

Item 444, White Reflecting Integral Curb, per linear foot.

## RESETTING CURB AND COMBINATION CURB AND GUTTER

Resetting Curb ..... Item 445

Resetting Combination Curb and  
Gutter ..... Item 446

**DESCRIPTION:**

This item shall consist of resetting curb or combination curb and gutter in accordance with the plans and these specifications or as directed by the Project Engineer.

## **CONSTRUCTION METHODS:**

### **General:**

When required by the plans or special provisions of the contract, existing curb or combination curb and gutter shall be removed from its original position, cleaned and reset in the new location in a satisfactory manner upon the prepared subgrade. The curb or combination curb and gutter shall be set accurately to the line and grade given by the Project Engineer. Where unsatisfactory material is encountered in the preparation of the subgrade, it shall be removed and replaced with suitable material which shall be compacted by tamping in layers of not more than six inches in depth when in a loose condition. The entire subgrade shall be thoroughly compacted by rolling or tamping. If the subgrade material is too dry to compact to the satisfaction of the Project Engineer, it shall be wetted with water as directed by the Project Engineer. After the curb or combination curb and gutter has been reset, the space behind the curb shall be backfilled to the required elevation with suitable material which shall be tamped firm and neatly graded.

Where a uniform bearing on the subgrade cannot be obtained due to the unevenness of the bottom of the curb, gutter, or combination curb and gutter to be reset, the contractor shall be required to smooth up the bottom with a cement mortar or to place a cement mortar foundation that will provide a uniform bearing and permit the accurate setting to line and grade.

### **METHOD OF MEASUREMENT:**

Curb or combination curb and gutter reset will be measured by the linear foot. Reset curb or combination curb and gutter will be measured along the face of the curb and along the wearing surface of the road or along the surface of the gutter as the case may be. The length for measurement shall be the actual length reset.

**BASIS OF PAYMENT:**

All curb or combination curb and gutter reset, completed and accepted measured as provided above, shall be paid for at the contract unit price per linear foot for "Resetting Curb" or "Resetting Combination Curb and Gutter," which price and payment shall constitute full compensation for removing, cleaning and resetting the curb or combination curb and gutter as the case may be, the preparation of the subgrade, all hauling and other work in connection therewith; the furnishing of all equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

**Payment will be made under:**

Item 445, Resetting Curb, per linear foot.

Item 446, Resetting Combination Curb and Gutter, per linear foot.

**CATCH BASINS, MANHOLES,  
INLETS AND PIPE JUNCTIONS**

Catch Basins .....	Item 447
Manholes .....	Item 448
Inlets .....	Item 449
Pipe Junctions .....	Item 450

**DESCRIPTION:**

This item shall consist of the construction of catch basins, manholes, inlets, pipe junctions or similar structures with the required metal frames and gratings or covers, constructed in accordance with the detail plans and these specifications.

**PROPORTIONING AND MIXING:**

(a) Concrete: All concrete for this item shall be Class "A," proportioned and mixed as set out under "Concrete."



(b) Mortar: All mortar for this item shall be composed of one part cement and two parts of sand by volume. The cement and sand shall be thoroughly mixed and sufficient water added to produce a consistency of stiff paste.

#### **MATERIALS:**

##### **Cement, Sand, Coarse Aggregate and Water:**

These materials shall meet the requirements specified for Class "A" Concrete.

Reinforcing steel shall consist of deformed bars and shall conform to the requirements specified in M-110 or M-111.

Brick shall conform to the requirements specified in M-18.

Gray iron castings shall conform to the requirements specified in M-21.

#### **CONSTRUCTION METHODS:**

##### **General:**

Where concrete is specified, the structure shall be constructed with concrete placed in accordance with specifications for "Concrete." Reinforcing steel where required shall be placed in accordance with the plans and securely fastened with wire so as not to be displaced during the placing of the concrete.

Where brick is specified the structure shall be constructed of brick laid in courses in full and close joints of mortar. Adjoining courses shall break joints one-half brick as nearly as practicable. The courses shall be level in all places except where otherwise necessary. At least one course in every seven shall be composed of headers. All brick shall be thoroughly wetted immediately before being laid, and broken or chipped bricks will not be allowed in the face of the structure. No spalls or bats shall be used except for shaping around irregular openings or when unavoidable to finish out a course. All joints shall be completely filled with mortar and shall be finished properly as the work progresses.

Inlet and outlet pipes shall be of the same size and kind and meet the same requirements as the pipe with which they are to connect. They shall extend through the walls for a distance beyond the outside surface sufficient for the intended connections and the structure shall be so constructed around them as to prevent leakage along their outer surface.

All castings, metal frames, covers and gratings shall be of the size, type and kind shown on the plans and shall be coated with approved bituminous varnish.

Frames, casting and cast iron bearing plates shall be set in full mortar beds. Castings shall be set accurately to the finished elevation, so that subsequent adjustment will be unnecessary.

Any accumulation of silt, debris or foreign matter of any kind shall be removed from the inside of the structures before final acceptance.

After inspection of the completed structure by the Project Engineer and when directed, the excavated areas which are not occupied by the completed structure shall be refilled to the required elevation with suitable material which shall be placed in layers of not more than six inches in depth when in a loose condition and each layer thoroughly compacted by hand or mechanical tamping. If the backfill material is too dry to compact to the satisfaction of the Project Engineer, it shall be wetted with water, as directed by the Project Engineer.

#### **METHOD OF MEASUREMENT:**

Catch basins, manholes, inlets, pipe junctions and similar structures shall be measured by the structure complete in place.

#### **BASIS OF PAYMENT:**

The number of structures, completed and accepted, measured as provided above, shall be paid for at the contract unit price for the item applying thereto, which price and payment shall constitute full compensation for constructing the structure in accordance with

the plans, or as directed by the Project Engineer; all excavation and backfilling; for furnishing all castings, metal frames, covers and gratings and all other fittings, and materials, equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

Inlet and outlet pipes shall be measured with the adjoining pipe and paid for at the corresponding unit price per linear foot.

**Payment will be made under:**

- Item 447, Catch Basins, per each.
- Item 448, Manholes, per each.
- Item 449, Inlets, per each.
- Item 450, Pipe Junctions, per each.

**ADJUSTING CATCH BASINS,  
INLETS, MANHOLES AND  
PIPE JUNCTIONS**

Adjusting Catch Basins .....	Item 453
Adjusting Inlets .....	Item 454
Adjusting Pipe Junctions .....	Item 455
Adjusting Manholes .....	Item 456

**DESCRIPTION:**

This item shall consist of removing castings from existing catch basins, inlets, manholes, and pipe junctions, adjusting the height of the structure from which the casting was removed and resetting the casting at the required grade in accordance with the plans and these specifications.

**CONSTRUCTION METHODS:**

**General:**

All castings, metal frames, covers and gratings shall

be carefully removed, thoroughly cleaned, and all parts thereof placed in good repair and coated with an acceptable bituminous varnish. All cracks and breaks shall be welded and the surfaces of the welds dressed to correspond with the original surface.

All adjustments in catch basins, inlets, manholes and pipe junctions shall be made in a workmanlike manner and materials used shall conform with materials in the existing structure.

If the structure to be adjusted is of reinforced concrete, sufficient removal of the old concrete shall be made to permit bonding of the old and new reinforcing steel. Extensions to concrete structures shall be made with Class "A" concrete, proportioned, mixed and placed in accordance with specifications for "Class A Concrete."

Brick structures shall be extended or adjusted with brick laid in courses in full and close joints of mortar composed of one part Portland cement and two parts sand, by volume, and thoroughly mixed to a uniform consistency of stiff paste. Adjoining courses shall break joints one-half brick as nearly as practicable. The courses shall be leveled in all places except where otherwise may be necessary for the proper adjustment of the structure. At least one course in every seven shall be composed of headers. All brick shall be thoroughly wetted immediately before being laid. No spalls or bats shall be used except for shaping around irregular opening or when unavoidable to finish out a course. All joints shall be completely filled with mortar.

Frames for castings and cast iron bearing plates shall be set in full mortar beds composed of one part Portland cement and two parts sand by volume. Castings shall be set accurately to the finished elevations, so that no subsequent adjustment will be necessary.

After inspection of the completed structure by the Project Engineer and when directed, the excavated areas which are not occupied by the completed structure shall be refilled to the required elevation with suitable material which shall be placed in layers of not more

than six inches in depth when in a loose condition and each layer thoroughly compacted by hand, or mechanical tamping. If the backfill material is too dry to compact to the satisfaction of the Project Engineer, it shall be wetted with water as directed by the Project Engineer.

**METHOD OF MEASUREMENT:**

Catch basins, inlets, manholes and pipe junctions adjusted shall be measured by the structure and each structure adjusted shall be counted.

**BASIS OF PAYMENT:**

The number of structures adjusted, completed and accepted, measured as provided above, shall be paid for at the contract unit price each for the item applying thereto, which price and payment shall constitute full compensation for adjusting the structure in accordance with the plans or as directed by the Project Engineer; for all excavating and backfilling; and for furnishing all materials, equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

**Payment will be made under:**

- Item 453, Adjusting Catch Basins, per each.
- Item 454, Adjusting Inlets, per each.
- Item 455, Adjusting Pipe Junctions, per each.
- Item 456, Adjusting Manholes, per each.

## BEARING PILES

Precast Concrete Piles	Item 459 or Item 720
Untreated Timber Piles	Item 460 or Item 721
Creosoted Timber Piles	Item 461 or Item 722
Steel Bearing Piles	Item 462 or Item 723
Cast in Place Concrete Piles	
	Item 463 or Item 724
Jettings Piles	Item 464 or Item 725
Unloaded Concrete Test Piles	
	Item 465 or Item 726
Unloaded Timber Test Piles	
	Item 466 or Item 727
Unloaded Steel Bearing Test Piles	
	Item 467 or Item 728
Unloaded Cast in Place Concrete Test Piles	
	Item 468 or Item 729
Loading Test Piles	Item 469 or Item 730
Pilot Holes	Item 470 or Item 731

### DESCRIPTION:

These items shall consist of furnishing and driving precast concrete, untreated or creosoted timber, steel bearing and cast in place concrete piles of the kind and dimensions designated, complying with these specifications, and driven to the required penetration and in accordance with the lines and spacing shown on the plans.

### EQUIPMENT:

(a) Drivers for Concrete Piles: Concrete piles shall be driven with single acting steam hammers unless the Construction and Maintenance Engineer's permission in writing is obtained for use of other types. Steam hammers used for this purpose shall develop not less than the following energy:

For 12-inch pile .....	7000 ft. lbs. per blow ✓
For 14-inch and 16-inch piles .....	15,000 ft. lbs. per blow ✓

For 18-inch piles .....24,000 ft. lbs. per blow

For 20-inch piles .....30,000 ft. lbs. per blow

(b) Drivers for Timber Piles: Timber piles shall be driven with either steam or gravity hammer. Single acting and double acting steam hammers shall develop an energy per blow at each full stroke of the piston of not less than 6000 ft. pounds, or more than 8500 ft. pounds. Gravity hammers shall weigh not less than 2000 pounds and the fall shall be so regulated as to avoid injury to the pile, and in no case shall it exceed 15 feet.

(c) Drivers for Steel Bearing Piles: Steel bearing piles under 2000 lbs. in weight may be driven with a gravity hammer weighing not less than 2000 lbs. The fall of the hammer shall be so regulated as to avoid injury to the pile and shall in no case exceed 15 feet.

Steel bearing piles of any weight may be driven with a single acting or double acting steam hammer developing an energy per blow at each full stroke of the piston of not less than 7000 ft. pounds and not more than 15000 ft. pounds.

(d) Drivers for Cast in Place Concrete Piles: Unless otherwise provided, shells for cast in place piles shall be driven with a steam hammer developing an energy per blow at each full stroke of the piston of not less than 7000 ft.-pounds and not more than 15,000 ft.-pounds, or with a gravity hammer weighing not less than 2000 lbs. with a maximum drop of 8 feet. Cast in place piles shall be driven without the use of mandrels.

(e) Leads: Pile driver leads shall be constructed in such a manner as to afford freedom of movement of the hammer, and they shall be held in position by guys or stiff braces to insure support to the pile during driving. Except when piles are driven through water, the leads preferably shall be of sufficient length to avoid the use of a follower.

(f) Jets: When water jets are used, the number of jets and nozzle volume and pressure shall be sufficient to erode the material adjacent to the piling freely. The

plant shall have sufficient capacity to produce 350 gallons of water per minute under a pressure of at least 150 pounds per square inch. A pressure gage shall be provided on the discharge pipe.

#### **MATERIALS:**

Precast concrete piles shall be constructed of Class "A" concrete. The concrete used shall comply with the requirements for "Concrete."

Reinforcing steel used in concrete piles shall conform to the requirements for "Reinforcing Steel," and the dimensions shall be as shown on the plans.

Timber piles shall conform to the requirement specified in M-88 or M-89.

Steel bearing piles shall conform to the requirements specified in M-108.

Steel casings for cast in place concrete piles shall conform to the requirements specified in M-78.

#### **CONSTRUCTION METHODS:**

##### **General:**

(a) Order Lists for Piling: The Project Engineer will furnish the contractor with an itemized list showing the number and length of all piles which will be required and the contractor shall furnish piles in accordance with such itemized list.

(b) Piling Inspections: The contractor shall furnish the Department, through the Project Engineer, a copy of each of his orders for creosoted and untreated piling in order that the Department may supply their inspectors with copies of the orders. Inspections will not be made of materials for which copies of orders have not been received by the Department and supplied by them to inspectors.

##### **Casting Concrete Piles:**

(a) Beginning of Work: The contractor shall not begin the manufacture of permanent precast concrete piling nor order, or have delivered on the job steel reinforcement for same until he has been furnished the lengths and number required by the Project Engineer.



(b) Pouring: Concrete shall be placed and vibrated in accordance with the general method of placing concrete as specified under "Concrete." The piles shall be cast separately or, if alternate piles are cast in a tier, the intermediate piles shall not be poured until four days after pouring the adjacent piles. Piles cast in tiers shall be separated by tar paper carefully placed continuously between each pile. The completed piles shall be free from stone pockets, porous spots, or other defects, and be straight and true to form specified. The forms shall be true to line, built of dressed lumber and a 1½-inch chamfer strip shall be used in all corners; they shall be water-tight and shall not be removed within 24 hours after the concrete is placed.

All exposed surfaces of the pile shall be given an ordinary finish.

(c) Curing: Concrete piling shall be cured as required for Portland cement concrete which curing shall begin as soon as possible after completion of placement of the concrete. The surface of the concrete shall be kept continually wet during the curing period, which shall be continued for a period of not less than 14 days after placement.

(d) Marking: Each pile shall be stamped or marked with the date of its manufacture and with a number. Lifting points indicated on plans shall be plainly marked.

(e) Handling: As soon as the piles have set sufficiently to permit (not less than 15 days), they may be removed from the form bed and piled in a curing pile and separated from each other by wood spacing blocks.

Piles shall be handled carefully, avoiding dropping or severe jarring while in horizontal position.

The concrete piles shall be lifted by means of a suitable equalizing sling or bridle attached to the pile at the lifting points designated on the plans.

(f) Age Before Driving: No pile shall be driven until it has set for at least twenty-eight days and in cold weather this period may be increased, as determined by the Project Engineer.

(g) High-Early-Strength Cement: When the use of high-early-strength cement is permitted by the Construction and Maintenance Engineer, the curing period shall be 72 hours, during which time the concrete shall be kept continually wet; the piles shall remain in the form beds and shall not be handled until the elapse of a period of 7 days; the piles shall not be driven until after the elapse of a period of 10 days provided the compressive strength, as shown by the test cylinders, has reached 3000 pounds per square inch.

**Pouring of Cast in Place Concrete Piles:**

Cast in place concrete piles shall be steel encased. The steel casing or shell shall be driven to the required penetration, and filled with concrete. The contractor shall provide a suitable light for the inspection of each shell after it has been driven to penetration required. The shell shall be cleaned of all debris/or water and approved by the Project Engineer before placing any concrete therein. Driving of additional piles within a radius of 10 feet of a completed pile will not be permitted until the concrete has set for at least 36 hours. Concrete shall be Class "D" as specified under "Concrete." The concrete shall be handled by a method approved by the Project Engineer, in such a manner as to prevent segregation of aggregate in the mix. All piles shall be filled with concrete to the cut-off level. Reinforcing steel of the size and spacing shown on the plans shall be securely fastened together so as to form a rigid cage. The steel may be wired or welded together. Spacers shall be used so as to provide the clearance specified in the plans from cage to shell when the steel is lowered into position.

**DRIVING:**

**(a) General:**

1. Preparation for Driving: All excavation of foundation or filling of embankment in which piles are to be driven shall be completed before driving is commenced. After driving is completed, all loose and displaced materials shall be removed from around the piles leaving a

clean, solid surface to receive the concrete in excavations.

2. Protection of Heads: Concrete Piles: The heads of all concrete piles shall be protected during driving by using driving caps of an approved design having a wooden or other suitable cushion next to the pile head and fitting into a casting which in turn supports a timber shock block.

Timber Piles: The heads of timber piles shall be protected during driving by a driving cap of an approved design to prevent any brooming, splitting or other injury to the pile. When the area of the head of pile is greater than that of the face of the hammer, a cap shall be provided to distribute the blow of the hammer throughout the cross section of the pile head, and thus avoid as far as possible, the tendency to split or shatter the pile.

Steel Bearing Piles: The heads of steel bearing piles shall be protected during driving by a cast steel driving head provided with a wooden block to receive the impact from the hammer. The head shall fit closely over the top of the pile and shall extend down at least 4 inches on the pile head, in order to permit toggling of pile when necessary.

Cast in Place Concrete Piles: Shells shall be protected during driving by a pile cap equipped with a wooden block to receive the impact from the hammer. Pile caps shall be of a design recommended by the manufacturer of the pile shells for the driving of this type of pile.

3. Jetting: Adequate water jet equipment shall be provided and used where necessary or when directed by the Project Engineer. Where jetting is used, the hammer shall be used in conjunction therewith and the final two feet of penetration shall be obtained without the aid of the jet.

4. Followers: The driving of piling with followers shall be avoided if practicable and shall be done only under written permission of the Project Engineer. When followers are used, one pile from every group of 10 shall be a long pile driven without a follower, and shall

be used as a test pile to determine the average bearing power of the group.

5. Defective Piles: The procedure incident to the driving of piles shall not subject them to excessive and undue abuse causing injury to the pile. Any pile so injured in driving or handling shall be replaced by a new pile, or otherwise corrected to the satisfaction of the Project Engineer. Any piles so out of line or plumb as to impair its usefulness or the appearance of the structure shall be removed and re-driven, or cut off at ground level and an additional pile driven to replace it.

Any pile pushed up by the driving of adjacent piles or by any other cause shall be re-driven to the required penetration.

A concrete pile shall be considered defective if it has a visible crack, or cracks, extending around the four sides of the pile, or any similar defect, which, in the opinion of the Project Engineer, affects the strength or life of the pile.

6. Interrupted Driving: When driving is interrupted before final penetration is reached, the record for penetration shall not be taken until after at least 12 inches penetration has been obtained upon resumption of driving.

7. Extent of Driving: Driving shall be continued until plan cut-off is reached or until a rate of penetration satisfactory to the Project Engineer is obtained. If proper resistance to driving is not obtained at cut-off, the driving shall be continued and the additional length of pile required shall be supplied by splicing.

8. Determination of Bearing Values: The safe bearing values shall be determined by that one of the following formulas appropriate to the case:

$$\text{For gravity hammers .....} P = \frac{2 WH}{S+1}$$

$$\text{For single-acting steam hammers.....} P = \frac{2 WH}{S+0.1}$$

$$\text{For double-acting steam hammers.....} P = \frac{2 E}{S+0.1}$$

In the above formulas P= safe load per pile in pounds; W= weight of falling hammer in pounds; H= height of fall in feet; S= the average penetration per blow in inches for the last 5 blows of a gravity hammer or at the last 20 blows of a steam hammer; E shall be determined by counting the blows per minute and taking from the manufacturer's catalog the value in foot-pounds per blow, for the particular hammer being used, operating at the given rate.

The above formulas are applicable only when:

- I The hammer has a free fall.
- II The head of the pile is free from broomed or crushed wood fiber or other serious impairment.
- III The penetration is at a reasonably quick and uniform rate.
- IV There is no sensible bounce after the blow. Twice the height of the bounce shall be deducted from "H" before inserting the value in the formula.
- V The weight of pile is not more than the weight of the hammer used, if the hammer used is of the gravity type.

The bearing powers of the timber piles as determined by the foregoing formulas shall be considered effective only when they are less than the crushing strength of the piles.

In all cases when tested by formula, piles shall be driven until their safe bearing power is not less than the pile loadings shown on the plans.

In case the safe bearing power of any pile is found by test, or by formula if not tested, to be less than the load that it was intended to carry, additional piles shall be driven until the load per pile is reduced to the safe bearing power found, or plans showing the necessary modification of the design of the footings and the number and location of the piles required will be furnished by the Project Engineer and the work constructed accordingly.

The carrying capacity of jetted piles shall be deter-

mined by actual test or by the same method and formula as in the case of unjetted piles, provided that no jet be used during the test blows.

**(b) Concrete Piles:**

1. Storage and Handling: For precast piles, the method of storing and handling shall be such as to eliminate the danger of fracture by impact or undue bending stresses, in curing or transporting the piles from the molds and into the leads. In general, concrete piles shall be lifted by means of a suitable bridle or sling attached to the pile at points designated on the plans. In no case shall the method of handling be such as to induce stresses in the concrete of more than 650 pounds compression per square inch, or in the reinforcing steel in excess of 12,000 pounds per square inch, allowing one-hundred per cent of the calculated load for impact and shock effects.

In handling piles for use in sea water or alkali soils, special care shall be exercised to avoid injury to the surface of the pile.

2. Extensions: Extensions shall be avoided but when necessary they shall be made as follows:

After driving is completed, the concrete at the end of the pile shall be cut away leaving the reinforcing steel exposed for a length of 50 diameters. The final cut of the concrete shall be perpendicular to the axis of the pile. Reinforcement similar to that used in the pile shall be securely fastened to the projecting steel and the necessary form work shall be placed, care being taken to prevent leakage along the pile. The concrete shall be of the same quality as that used originally in the pile. Just prior to placing concrete, the top of the pile shall be cleaned of all loose particles, thoroughly wetted and covered with a thin coating of neat cement, retempered mortar or other suitable bonding material. The forms shall remain in place not less than 7 days and shall then be carefully removed and the entire exposed surface of the pile finished as above specified.

**(c) Timber Piles:**

1. Seasoning After Treatment: Creosoted piles shall

not be driven until they have been seasoned a minimum of 30 days after treatment.

2. Storage and Handling: The method of storage and handling shall be such as to avoid injury to the piling. Special care shall be taken to avoid breaking the surface of treated piles; cant-dogs, hooks or pike-poles shall not be used. Cuts or breaks in the surface of treated piling shall be given 3 brush coats of hot creosote oil of approved quality and hot creosote oil shall be poured into all bolt holes.

3. Collars: Collars or bands to protect piles against splitting and brooming shall be provided where necessary by the contractor at his own expense.

4. Pointing: Piles shall be pointed where soil conditions require it. When necessary, the piles shall be shod with metal shoes of a design satisfactory to the Project Engineer, the points of the piles being carefully shaped to secure an even and uniform bearing on the shoes.

5. Splicing Piles: Full length piles shall always be used where practicable but if splices cannot be avoided, the method of splicing shall be that given below. Piles shall not be spliced except by the written permission of the Project Engineer, and when this work is done under his direction, it will be paid for as hereinafter specified.

Whenever the Project Engineer considers it necessary to splice piling which are delivered on the work, the splice shall be made in accordance with the Department's standard splice plan. This splice consists of four 3-inch x 8-inch timbers 8 feet long, bolted to each section of pile with seven  $\frac{3}{4}$ -inch x 16-inch bolts with ogee washers, after each section of pile has been squared up to a minimum distance of 4 feet back from splice. For each splice made at the direction and under the supervision of the Project Engineer, an extra allowance of 10 feet of piling will be allowed, this allowance to cover the cost of all material, labor and delay of work incident to making splice and to be in addition to the total length of piling left in place which will be paid for as hereinafter specified.

6. Elevation of Cut-Off: The tops of all piling shall be sawed off at right angles to their axis at the elevation indicated on the plans or as directed by the Project Engineer. Piles which support timber caps shall be sawed to a horizontal plane and shall exactly fit the superimposed structure. Broken, split or misplaced piles shall be withdrawn and properly replaced. Piles driven below the cut-off grade fixed by the Project Engineer shall be withdrawn and replaced by new and, if necessary, longer piles, at the expense of the contractor. Timber piling supporting concrete footings shall be embedded at least 12 inches in the footing.

7. Treatment of Heads: After having been cut to receive the caps, and prior to placing the caps, pile heads shall be treated to prevent decay.

The heads of creosoted piles shall be treated as follows, unless a concrete cap is to be placed on the piles:

The sawn surface shall be thoroughly brush coated with three applications of hot creosote oil, after which shall be placed two layers of heavy canvas, size 20" x 20" saturated with hot asphalt, followed by a 24" x 24" number 28 gage galvanized metal cover. The cover shall be bent down over the pile at an angle of approximately 45 degrees.

**(d) Steel Bearing Piles:**

1. Splices: Steel bearing piles shall be furnished and driven in full lengths unless splices are indicated on the plans or authorized by the Project Engineer in order to secure lengths longer than those shown on the plans. When splices are authorized they shall be made in accordance with details shown on the plans.

2. Cut-Offs: Cut-offs of steel bearing piles shall be made at right angles to the axis of the pile. The cuts shall be made in clean, straight lines and any irregularity due to cutting or burning shall be leveled off with deposits of weld metal prior to placing bearing caps.

3. Painting: In addition to the shop coat of paint, steel bearing piles shall be given one field coat of red lead paint over the full length of piling prior to driving.



After driving, painted surfaces which have been damaged due to driving or welding of bracing members, shall be spot painted with red lead. After driving, the entire surface of pile above low water or the ground line shall be given one coat of aluminum paint.

**(e) Cast in Place Concrete Piles:**

1. Order Lengths: Unless otherwise specified, the contractor shall order shells for cast in place piles, prefabricated in lengths specified.

2. Splicing Piles: Field splices of shell sections shall not be permitted without permission of the Project Engineer. If field splices are used, they shall be made by electric arc metallic welding in accordance with the latest methods for "Welding Highway and Railroad Bridges" of the "American Welding Society."

3. Cut-Offs: When pile shells are fully driven, inspected and approved, they shall be neatly cut off at right angles to the axis of the pile, at the elevation specified.

4. Painting: In addition to the shop coat of paint the shells shall be given one field coat of red lead paint over the full length of the shell prior to the driving. After driving, painted surfaces which have been damaged shall be spot painted with red lead. After driving, if the shell is to remain exposed it shall be given one coat of aluminum paint above low water or ground elevation.

5. Collars: All sections of cast in place pile shells which are to be driven against shall be equipped with a metal collar welded to the section by the manufacturer.

**Test Piles:**

(a) Unloaded: When called for in the contract, the contractor shall drive test piles of the dimensions and at the locations designated by the plans. They shall be of the same material as the permanent piles. Unless otherwise specified on the plans they shall be of the same cross section as the permanent piles.

In general, the contractor will be required to drive one test pile for each foundation, and in trestle work at about 300 foot intervals.

When test piles are driven to determine the length of foundation piles required, it will be necessary to excavate a hole from the natural ground to elevation of bottom of footing, as shown on plans, and keep this hole open during the driving and loading of the test piles so that the driving and loading conditions will be representative of actual conditions of load on the permanent piles.

Test piles shall be driven in accordance with the specifications for the particular type of piling shown on the plans. They shall be driven until the capacity, as determined by the formulas above, is equal to the load shown on the plans, or until the required penetration is obtained, unless otherwise directed by the Project Engineer.

In case it is necessary, as determined by the Project Engineer to jet any piles, it shall be done in accordance with the above specifications for this class of work under "Construction Methods."

(b) Loading: After the test pile has been driven in accordance with these specifications, if loading is specified in the contract, the piles shall be loaded with any kind of material suitable to the Project Engineer, following as closely as possible the following loading periods:

Piles up to 18 inches and timber piles shall be loaded 24 hours after driving is completed.

Concrete piles 18 inches to 20 inches shall be loaded 48 hours after driving is completed.

Cast in place pile shells shall be loaded after driving and before filling with concrete.

The loading platform or box shall be so constructed that readings of the settlement may be taken directly on the pile. The loading platform or box shall be so built as to carry safely any amount of the approved material equal in weight to twice the loading shown on the plans. Broomed or split portions of the pile shall be cut off, leaving a sound surface to support the platform.

The loading material shall be applied gradually, and without causing vibration, and shall be so placed that at all times the load will be concentric with the pile. The loading shall be done as directed by the Project Engineer.

The capacity of any pile so tested shall be considered equal to  $\frac{1}{2}$  the load carried by the pile without exceeding a total permanent settlement of  $\frac{1}{4}$ -inch in 48 hours, unless otherwise specified by the Project Engineer.

(c) Utilizing Test Piles: After the completion of the loading tests, the load shall be removed as directed and the piles utilized in the structure if found satisfactory for use or disposed of in such other manner as ordered by the Project Engineer. Test piles not loaded shall be utilized similarly.

**Pilot Holes:**

When called for in the proposal, pilot holes shall be bored or dug to permit pile penetration into hard soil formations. The holes shall have, in general, a diameter of approximately  $\frac{2}{3}$  of the face width of the pile but shall, however, be of a size which will provide the desired results of proper pile penetration and carrying capacity. The number of pilot holes and depth of each hole shall be determined by the Project Engineer. A minimum penetration of 15 feet will be required for all piles.

**METHOD OF MEASUREMENT:**

(a) Piling: Piling driven in the location designated on the plans will be measured by the linear foot of pile, complete in place, below cut-off elevation.

(b) Cut-Offs: Cut-Offs made as directed by the Project Engineer, will be measured by the linear foot, but measurement will be made only when the amount of cut-off exceeds one linear foot on any particular pile. No measurement of cut-offs will be made where they have been caused by unnecessary crushing, brooming, splitting or other injuries resulting from careless driving.

(c) Extensions: Measurement of extensions on any type of pile will be by the linear foot, complete in place, for that portion of the pile added to the original length of pile driven. No measurement will be made for extensions made necessary by damage to the pile during driving.

**(d) Splices:**

1. Concrete Piles: Splices for precast concrete piles will not be measured as a splice.

2. Timber Piles: Measurement of splices on timber piles shall be by the linear foot, the number of linear feet will be determined by allowing 10 linear feet of piling for each splice made. The total number of linear feet of piling driven shall be determined by adding 10 feet to the net length of pile for each splice in place in the finished structure. No measurement will be made for splices except those made at the direction and under the supervision of the Project Engineer.

3. Steel Bearing Piles and Cast in Place Concrete Piles: Measurement of splices on steel bearing piles and cast in place concrete piles will be made by the linear foot, the number of linear feet will be determined by allowing 5 linear feet of piling for each splice made. The total number of linear feet of piling driven shall be determined by adding 5 feet to the net length of pile for each splice in place in the finished structure. No measurement will be made for splices except those made at the direction and under supervision of the Project Engineer.

(e) Jetting: The number of jetted piles to be paid for shall be the number of individual piles of any type jetted into place at the direction of the Project Engineer.

(f) Unloaded Test Pile: The number of test piles to be paid for shall be the number of individual piles of any type furnished and driven as directed by the Project Engineer. Test piles utilized as permanent piles shall be measured as test piles only. Cut-offs of test piles shall not be included in any pay footage.

(g) Loading Test Piles: The number of load tests to be paid for shall be the number of load tests made, completed and accepted.

(h) Pilot Holes: The number of pilot holes to be paid for shall be the number of holes completed and accepted by the Project Engineer.

#### **BASIS OF PAYMENT:**

(a) Piling: The number of linear feet of completed and accepted piling, measured as specified, shall be paid for at the contract unit price per linear foot for "Precast Concrete Piles," "Steel Bearing Piles," "Untreated Timber Piles," "Creosoted Timber Piles," or "Cast in Place Concrete Piles," which price and payment shall constitute full compensation for all materials, equipment, tools, labor and incidentals necessary to complete the item. This price shall include all materials, labor and incidentals required for bolting, wrapping or fastening timber fender piles, and shall include the cost of driving batter piles specified on the plans.

(b) Cut-Offs: Payment for cut-offs, measured as specified, shall be made at the rate of one-half the contract unit price per linear foot for the particular type of pile which has been cut off.

(c) Extensions: Payment for extensions shall be made at the contract unit price per linear foot for the size of pile being extended, measured as provided above, which price and payment shall constitute full payment for all materials, equipment and labor required to complete the item in accordance with these specifications.

(d) Splices: Payment for splices, measured as specified, shall be made at the contract unit price per linear foot for the particular type of piles spliced, which price and payment shall constitute full compensation for all materials, equipment and labor required to make the splice.

(e) Jetting: Payment for jetting piles, measured as specified, shall be made at the contract unit price each per pile jetted, which price and payment shall consti-

tute full compensation for all materials, equipment and labor required to jet the pile.

(f) Unloaded Test Piles: This work shall be paid for at the contract unit price each for "Unloaded Test Piles," complete in place. This price shall include the test pile and all materials, equipment, tools, jetting, labor, and work incidental thereto. No payment will be made for test piles driven that are not in accordance with these specifications or as directed by the Project Engineer and accepted by him.

(g) Loading Test Piles: This work shall be paid for at the contract unit price each for "Loading Test Piles." This price shall include all materials, equipment, tools, labor and work incidental to constructing the platform or box, procuring and placing the loading material, removing the platform or box and material, and disposing of same as directed by the Project Engineer. No payment will be made for test loadings that are not made in accordance with these specifications or as directed by the Project Engineer and accepted by him.

(h) Pilot Holes: Payment for pilot holes shall be made at the contract unit price per hole completed and accepted, which price and payment shall constitute full compensation for all materials, equipment and labor required to complete the item.

**Payment will be made under:**

Item 459a, 12-Inch Precast Concrete Piles, per linear foot.

Item 459b, 14-Inch Precast Concrete Piles, per linear foot.

Item 459c, 16-Inch Precast Concrete Piles, per linear foot.

Item 459d, 18-Inch Precast Concrete Piles, per linear foot.

Item 459e, 20-Inch Precast Concrete Piles, per linear foot.

Item 459f, 24-Inch Precast Concrete Piles, per linear foot.

Item 460a, Untreated Timber Piles (less than 60 ft. length), per linear foot.

Item 460b, Untreated Timber Piles (60 ft. length and over), per linear foot.

Item 461a, Creosoted Timber Piles (less than 60 ft. length), per linear foot.

Item 461b, Creosoted Timber Piles (60 ft. length and over) per linear foot.

Item 462a, 8" x 8" 33# Steel Bearing Piles, per linear foot.

Item 462b, 8" x 8" 36# Steel Bearing Piles, per linear foot.

Item 462c, 10" x 10," 42# Steel Bearing Piles, per linear foot.

Item 462d, 10" x 10" 49# Steel Bearing Piles, per linear foot.

Item 462e, 10" x 10" 57# Steel Bearing Piles, per linear foot.

Item 462f, 12" x 12" 53# Steel Bearing Piles, per linear foot.

Item 462g, 12" x 12" 65# Steel Bearing Piles, per linear foot.

Item 462h, 12" x 12" 74# Steel Bearing Piles, per linear foot.

Item 462j, 14" x 14" 73# Steel Bearing Piles, per linear foot.

Item 462k, 14" x 14" 89# Steel Bearing Piles, per linear foot.

Item 462L, 14" x 14½" 102# Steel Bearing Piles, per linear foot.

Item 462m, 14" x 14½" 117# Steel Bearing Piles, per linear foot.

Item 463a, 12" Cast in Place Concrete Piles, per linear foot.

Item 463b, 14" Cast in Place Concrete Piles, per linear foot.

Item 463c, 16" Cast in Place Concrete Piles, per linear foot.

Item 463d, 18" Cast in Place Concrete Piles, per linear foot.

Item 464, Jetting Piles, per each.

Item 465, Unloaded Concrete Test Piles, per each.

Item 466, Unloaded Timber Test Piles, per each.

Item 467, Unloaded Steel Bearing Test Piles, per each.

Item 468, Unloaded Cast in Place Concrete Test Piles, per each.

Item 469, Loading Test Piles, per each.

Item 470, Pilot Holes, per each.

or,

Item 720a, 12-Inch Precast Concrete Piles, per linear foot.

Item 720b, 14-Inch Precast Concrete Piles, per linear foot.

Item 720c, 16-Inch Precast Concrete Piles, per linear foot.

Item 720d, 18-Inch Precast Concrete Piles, per linear foot.

Item 720e, 20-Inch Precast Concrete Piles, per linear foot.

Item 720f, 24-Inch Precast Concrete Piles, per linear foot.

Item 721a, Untreated Timber Piles (less than 60 ft. length), per linear foot.

Item 721b, Untreated Timber Piles (60 ft. length and over), per linear foot.

Item 722a, Creosoted Timber Piles (less than 60 ft. length), per linear foot.

Item 722b, Creosoted Timber Piles (60 ft. length and over), per linear foot.



Item 723a, 8" x 8" 33# Steel Bearing Piles, per linear foot.

Item 723b, 8" x 8" 36# Steel Bearing Piles, per linear foot.

Item 723c, 10" x 10" 42# Steel Bearing Piles, per linear foot.

Item 723d, 10" x 10" 49# Steel Bearing Piles, per linear foot.

Item 723e, 10" x 10" 57# Steel Bearing Piles, per linear foot.

Item 723f, 12" x 12" 53# Steel Bearing Piles, per linear foot.

Item 723g, 12" x 12" 65# Steel Bearing Piles, per linear foot.

Item 723h, 12" x 12" 74# Steel Bearing Piles, per linear foot.

Item 723j, 14" x 14" 73# Steel Bearing Piles, per linear foot.

Item 723k, 14" x 14" 89# Steel Bearing Piles, per linear foot.

Item 723L, 14" x 14½" 102# Steel Bearing Piles, per linear foot.

Item 723m, 14" x 14½" 117# Steel Bearing Piles, per linear foot.

Item 724a, 12" Cast in Place Concrete Piles, per linear foot.

Item 724b, 14" Cast in Place Concrete Piles, per linear foot.

Item 724c, 16" Cast in Place Concrete Piles, per linear foot.

Item 724d, 18" Cast in Place Concrete Piles, per linear foot.

Item 725, Jetting Piles, per each.

Item 726, Unloaded Concrete Test Piles, per each.

Item 727, Unloaded Timber Test Piles, per each.

Item 728, Unloaded Steel Bearing Test Piles, per each.

Item 729, Unloaded Cast in Place Concrete Test Piles, per each.

Item 730, Loading Test Piles, per each.

Item 731, Pilot Holes, per each.

## UNTREATED AND TREATED TIMBER

### DESCRIPTION:

This item shall consist of furnishing lumber of the sizes and grade specified, and of furnishing timber of the stress grade, sizes and dimensions for the different uses specified, treated or untreated, as called for in the contract, and of preparing, framing, assembling, and erecting the same, including painting where specified, and including also all hardware required by the plans and specifications, all in accordance with these specifications and in conformity with the structure design and details as shown on the plans or directed by the Project Engineer.

The contractor shall furnish lumber of the species called for on the plans; he shall furnish timber of the species called for and of the stress grade quality stipulated herein for the several usages.

### MATERIALS:

Treated structural timber shall conform to the requirements specified in M-117.

Untreated structural timber shall conform to the requirements specified in M-118.

### CONSTRUCTION METHODS:

#### Storage:

Lumber and timber on the site of the work shall be stored in piles. Untreated material shall be open-

stacked at least 12 inches above the ground surface and piled to shed water and prevent warping. When required by the Project Engineer, it shall be protected from the weather by suitable covering. Creosoted timber and piling shall be close-stacked, piled to prevent warping, and the tops of the stacks shall be covered with a 2-inch layer of earth. The ground underneath and in the vicinity of all material piles shall be cleared of weeds and rubbish.

**Workmanship:**

All framing shall be true and exact. Unless otherwise specified, nails and spikes shall be driven with just sufficient force to set the heads flush with the surface of the wood. Deep hammer marks in wood surfaces shall be considered evidence of poor workmanship and sufficient cause for removal of the workman causing them. The workmanship on all metal parts shall conform to the requirements specified under "Steel Bridges."

**Handling:**

The timbers shall be handled carefully without sudden dropping, breaking of outer fibres, bruising or penetrating the surface with tools. It shall be handled with rope slings. Can't-dogs, peaveys, hooks or pike-poles shall not be used.

**Framing and Boring:**

All cutting, framing and boring of treated timbers shall be done before treatment insofar as is practicable. When treated timbers are to be placed in waters infested by marine borers, cutting and boring below high water elevation shall be avoided.

**Cuts and Abrasions:**

All cuts in creosoted timbers, and all abrasions after having been carefully trimmed, shall be coated with two applications of a mixture of 60 per cent creosote oil and 40 per cent roofing pitch, or brush coated with at least two applications of hot creosote oil and covered with hot roofing pitch.

### **Treating Bolt Holes:**

Before driving bolts, all holes bored after creosoting shall be impregnated with hot creosote oil by means of an approved bolt hole treater. Any unfilled holes, after being treated with creosote oil shall be plugged with creosoted plugs.

### **Untreated Timber:**

In structures of untreated timber, the following surfaces shall be coated thoroughly with two coats of hot creosote oil before assembling: Ends, tops, and all contact surfaces of posts, sills, caps, floor beams and stringers, and all ends, joints and contact surfaces of bracing. Timber bumpers, the back faces of bulkheads and all other timber which is to be in contact with earth shall be similarly treated. Where heart cypress is used, this treatment will not be required.

### **METHOD OF MEASUREMENT:**

The quantity to be paid for shall be the number of thousand feet board measure of lumber and timber, complete in place and accepted. Measurement of lumber and timber will be computed from the net dimensions shown on the plans, unless changes in such dimensions have been authorized in writing by the Project Engineer. The dimensions shown on the plans shall be interpreted as standard sizes. The standard size dimensions shall be used in the computations even though the actual size be scant in the amount provided above. The measurement of timber shall include only such timber as is a part of the completed and accepted work, and shall not include timber used for erection purposes, such as falsework, bracing, sheeting, etc.

No measurement shall be made for hardware required to construct the work in accordance with the plans.

The quantity of timber to be measured shall be the plan quantities for the particular structure.

## **BASIS OF PAYMENT:**

The quantities, measured as provided above, shall be paid for at the contract unit price per thousand feet board measure for the "Untreated Timber," or "Creosoted Timber," as the case may be, which prices and payment shall be full compensation for the furnishing and delivering of all timber, lumber and hardware including any preservative treatment required and galvanizing of hardware when specified for preparing framing, assembling, erecting and painting, and for all labor, equipment, tools and incidentals necessary to complete the item.

### **Payment will be made under:**

Item 471, Untreated Timber, per thousand feet board measure.

Item 472, Treated Timber, per thousand feet board measure. or,

Item 733, Untreated Timber, per thousand feet board measure.

Item 734, Treated Timber, per thousand feet board measure.

## **SHEET PILING**

Untreated Timber Sheet Piling,  
Item 473, or Item 735

Creosoted Timber Sheet Piling,  
Item 474, or Item 736

Concrete Sheet Piles Item 475, or Item 737

Steel Sheet Piles Item 476, or Item 738

### **DESCRIPTION:**

This specification covers only sheet piling shown on the plans, or ordered by the Project Engineer to be left

in place so that it becomes a part of the finished structure.

#### **MATERIALS:**

Timber sheet piles shall conform to the requirements specified in M-117 or M-118.

Concrete sheet piles shall conform to the requirements specified for item 459.

Steel sheet piles shall conform to the requirements specified in M-108 and shall be of standard shape as shown on the plans.

#### **CONSTRUCTION METHODS:**

Timber, concrete and steel piling shall be constructed in strict accordance with the detailed design.

##### **Driving:**

Sheet piling shall be driven with a maul, sledge, gravity or steam hammer, as approved by the Project Engineer.

##### **Jetting:**

In case it is necessary, in order to obtain the penetration required, the piling shall be jetted.

##### **Cut-Off:**

The tops of the piles shall be cut off, or driven down to a straight line at the elevation indicated.

##### **Cuts and Abrasions in Treated Timber:**

All cuts in treated timbers, and all abrasions, after having been carefully trimmed, shall be coated with two applications of a mixture of 60 per cent creosote oil and 40 per cent roofing pitch, or brush coated with at least two applications of hot creosote oil and covered with hot roofing pitch.

#### **METHOD OF MEASUREMENT:**

(a) Timber Sheet Piles: Timber sheet piles shall be

measured by the 1000 feet, board measure, of timber sheet piling, complete in place and accepted.

(b) Concrete Sheet Piles: Concrete sheet piles shall be measured by the cubic yard of concrete sheet piling, complete in place and accepted. No measurement will be allowed for reinforcing steel.

(c) Steel Sheet Piles: Steel sheet piles shall be measured by the pound of steel sheet piling, complete in place and accepted.

#### **BASIS OF PAYMENT:**

The number of 1000 feet board measure of timber sheet piles, cubic yards of concrete sheet piles or pounds of steel sheet piles, measured as provided above shall be paid for at the contract unit price for "Untreated Timber Sheet Piles," "Creosoted Timber Sheet Piles," "Concrete Sheet Piles" or "Steel Sheet Piles," as the case may be, complete in place, which price and payment shall constitute full compensation for all materials, including hardware and reinforcing steel, equipment, jetting if required, tools and labor necessary to complete the item.

#### **Payment will be made under:**

Item 473, Untreated Timber Sheet Piles, per 1000 feet board measure.

Item 474, Creosoted Timber Sheet Piles, per 1000 feet board measure.

Item 475, Concrete Sheet Piles, per cubic yard.

Item 476, Steel Sheet Piles, per pound.

or,

Item 735, Untreated Timber Sheet Piles, per thousand feet board measure.

Item 736, Creosoted Timber Sheet Piles, per thousand feet board measure.

Item 737, Concrete Sheet Piles, per cubic yard.

Item 738, Steel Sheet Piles, per pound.

# WATERPROOFING

## ITEM 477

### **DESCRIPTION:**

This item shall consist of waterproofing of concrete surfaces by the membrane method in accordance with the following specifications. Surfaces to be waterproofed shall be those indicated on the plans or as directed by the Project Engineer.

### **MATERIALS:**

Waterproofing asphalt shall conform to the requirements specified in M-8.

Pitch shall conform to the requirements specified in M-87.

Fabric shall conform to the requirements specified in M-41.

### **CONSTRUCTION METHODS:**

#### **General:**

All surfaces must be reasonably smooth, without projection or holes which might cause puncturing of the membrane. They shall be reasonably dry and shall be swept clean of dust and all loose material before the application of the waterproofing. Waterproofing shall not be done in freezing weather without written authorization from the Project Engineer.

The surface to be waterproofed shall be given one coat of a suitable primer of the same manufacture as the other waterproofing materials. The waterproofing shall then be started at the low point and the sheets so laid that the drainage will be over and not against or along the laps. Before the placing of each sheet of fabric the surface to be covered by the sheet shall be swabbed with waterproofing, the fabric immediately placed and swabbed with waterproofing until the sheet lies flat against the surface free from ridges and entrapped air. The fabric shall be "shingled" so that at



all points there will be two thicknesses and all edge laps shall be at least 4 inches and all end laps at least 12 inches. Under no circumstances shall one ply of fabric touch another at any point or touch the surface of the concrete as there must be at least three complete and unbroken moppings of waterproofing. All corners and angles shall be waterproofed without cutting or splitting the fabric. Flashing shall be carefully done around all openings and obstructions in a manner meeting the approval of the Project Engineer. At curbs, sprandrel walls, etc., the flashing shall be done with separate sheets lapping the main membrane not less than 12 inches. All expansion joints and cracks in the concrete surfaces shall be covered with specially designed flashing, as shown on the plans.

**METHOD OF MEASUREMENT:**

The yardage to be paid for shall be the number of square yards of waterproofing measured in place in the completed and accepted work.

**BASIS OF PAYMENT:**

The number of square yards of completed and accepted waterproofing, measured as provided above, shall be paid for at the contract unit price per square yard for "Waterproofing," which price and payment shall be full compensation for furnishing all materials, labor, equipment, tools, and incidentals necessary to complete the item.

**Payment will be made under:**

Item 477, Waterproofing, per square yard.

or,

Item 740, Waterproofing, per square yard.

# DAMPPROOFING

## ITEM 478

### DESCRIPTION:

This item shall consist of dampproofing concrete surfaces in accordance with these specifications at the location shown on the plans or directed by the Project Engineer.

### MATERIALS:

Tar shall conform to the requirements specified in M-114.

Tar seal coat shall conform to the requirements specified in M-115.

### CONSTRUCTION METHODS:

#### General:

After the concrete is cured in conformity with the requirements hereinbefore given in the specifications for "Concrete" the surfaces to be dampproofed shall be allowed to dry at least 10 days. They shall then be coated thoroughly with four coats of water gas tar, applied cold with a brush or spray gun, and each coat shall be absorbed before the succeeding one is applied. After absorption of the final coat, a seal coat of refined tar shall be applied at a temperature of about 80° F, and thoroughly brushed into all surfaces. The seal coat shall harden before any water or earth is allowed to come against it. No coat shall be applied when the concrete or the preceding coat is damp or at any time when in the opinion of the Project Engineer the weather is unsuitable.

### METHOD OF MEASUREMENT:

The yardage to be paid for shall be the actual number of square yards of surface dampproofed, measured in place in the completed structure and accepted.

**BASIS OF PAYMENT:**

The yardage, determined as provided above, shall be paid for at the contract unit price per square yard for "Dampproofing," which price and payment shall be full compensation for the furnishing all materials, and for all labor, equipment, tools and incidentals necessary to complete the item.

Payment will be made under:

Item 478, Dampproofing, per square yard.  
or,

Item 741, Dampproofing, per square yard.

**SOIL LOADING TEST  
ITEM 479**

**DESCRIPTION:**

This item shall consist of the loading of foundation soil at the roadway or bridge site for the purpose of determining its safe bearing value.

**PROPORTIONING AND MIXING:**

All concrete shall be Class "A," proportioned and mixed as set out under "Concrete."

**MATERIALS:**

**Testing Block:**

Materials used in constructing the testing block shall conform to the requirements of the specifications for "Concrete."

**CONSTRUCTION METHODS:**

**General:**

A block of concrete, measuring 3 feet by 3 feet by 1 foot 6 inches, shall be cast on a carefully prepared sur-

face at the elevation of the proposed footing and within the area of the proposed permanent footing.

The method of supporting the test load shall be determined by the contractor and drawings covering same submitted to the Project Engineer for his approval before starting the test. The loading platform or box shall be so constructed as to carry safely, in the opinion of the Project Engineer, an amount of approved material equal in weight to twice the unit loading shown on the plans for each square foot of area of the concrete block.

The loading material shall be applied gradually, without causing vibration, and shall be so placed that the load will at all times be concentric with the testing block.

The bearing value of any soil so tested shall be considered equal to  $\frac{1}{2}$  the load carried by the block without exceeding a total permanent displacement of  $\frac{1}{4}$ -inch in forty-eight hours, excluding initial settlement. The application of load to the test area until the area fails or until twice the design load has been sustained without failure shall constitute one loading.

The test hole shall be kept thoroughly dry from the time it is opened until the loading test has been completed.

#### **METHOD OF MEASUREMENT:**

Soil loading tests will be measured by the test and the number of tests completed shall be counted. No measurement of structural excavation will be made under this item.

#### **BASIS OF PAYMENT:**

The number of load tests completed and accepted, measured as provided above, shall be paid for at the contract price each for "Soil Loading Tests," which price and payment shall constitute full compensation for furnishing all materials, tools, labor, equipment and incidentals and the performance of all work necessary to complete the item.

Payment will be made under:

Item 479, Soil Loading Tests, per test.

or,

Item 749, Soil Loading Tests, per test.

## PIPE HANDRAILING

Black Steel Pipe Handrailing,  
Item 480 or Item 746.

Galvanized Steel Pipe Handrailing,  
Item 481 or Item 747

Wrought Iron Pipe Handrailing,  
Item 482 or Item 748

### DESCRIPTION:

This item shall consist of furnishing, erecting and painting pipe handrailing of the size and style indicated on the plans and in accordance with these specifications.

### MATERIALS:

Black steel pipe shall conform to the requirements specified in M-75.

Galvanized steel pipe shall conform to the requirements specified in M-75.

Wrought iron pipe shall conform to the requirements specified in M-86.

Pipe fittings shall conform to the requirements specified in M-80.

### CONSTRUCTION METHODS:

#### Erection:

Shop drawings for rails shall be submitted and approved before fabrication of rail is started.

Railing shall be constructed of the type specified in accordance with details shown on the plans, and in conformity with the requirements herein. It shall be con-

structed to the alignment, grade, and camber as designated on plans.

Railing posts shall be erected vertically and the tops constructed on a level line or parallel to the grade as may be indicated on plans. Unless otherwise provided, railing shall not be placed until after the falsework for the span has been released and deck constructed. During the construction of railing, care shall be exercised to insure proper function of expansion joints. When expansion sleeves are called for, they shall be reamed to permit of free play in the direction of expansion.

If rails are to form a part of the superstructure, they shall be attached by the method shown on the drawings. Holes in flanged bases or other parts shall match holes in the structural metal and the contractor shall make all necessary arrangements to insure the proper agreement of the holes.

Posts having their lower ends embedded in concrete shall be set in holes previously prepared for the purpose and grouted with Portland cement mortar.

**Painting:**

Unless otherwise provided, all metal for railing not specified to be finished by galvanizing shall be given one shop coat and two field coats of paint as specified for steel structures, under "Painting."

**METHOD OF MEASUREMENT:**

Pipe handrailing shall be measured by the linear foot. The length for measurement shall be the actual length of pipe handrailing measured along the top rail from end to end.

**BASIS OF PAYMENT:**

Pipe handrailing, placed and accepted, measured as provided above, shall be paid for at the contract unit price per linear foot for "Pipe Handrailing," complete in place, which price and payment shall constitute full compensation for furnishing all materials, erecting and painting the handrailing; all fittings, fillers, bolts, nuts

and other parts necessary to attach the handrailing to the structure upon which it is to be erected; the furnishing of all equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

**Payment will be made under:**

Item 480, Black Steel Pipe Handrailing, per linear foot.

Item 481, Galvanized Steel Pipe Handrailing, per linear foot.

Item 482, Wrought Iron Pipe Handrailing, per linear foot.

or,

Item 746, Black Steel Pipe Handrailing, per linear foot.

Item 747, Galvanized Steel Pipe Handrailing, per linear foot.

Item 748, Wrought Iron Pipe Handrailing, per linear foot.

## STRUCTURAL STEEL

### **DESCRIPTION:**

This item shall consist of furnishing, fabricating, preparing, assembling, erecting and painting (both shop and field) of all structural steel, wrought iron, steel castings, bronze castings or plates, anchor plates and anchor bolts, steel plates, and shapes for expansion joints and pier protection, pipes and drains in steel superstructures and in floors thereof (except for those features for which other payment is provided), all in accordance with these specifications and with applicable requirements prescribed for "Steel Bridges," "Concrete Bridges," "Concrete" and "Painting" and in conformity with the dimensions, shapes and designs shown on the plans.

## **MATERIALS:**

Structural steel shall conform to the requirements specified in M-108.

Rivet steel shall conform to the requirements specified in M-108.

Structural silicon steel shall conform to the requirements specified in M-109.

Steel forgings shall conform to the requirements specified in M-39.

Wrought iron shall conform to the requirements specified in M-120.

Steel castings shall conform to the requirements specified in M-23.

Gray-iron castings shall conform to the requirements specified in M-21.

Malleable castings shall conform to the requirements specified in M-22.

Bronze castings shall conform to the requirements specified in M-20.

Rolled bronze plates shall conform to the requirements specified in M-123.

Paint shall conform to the requirements specified under "Materials."

Galvanizing shall conform to the requirements specified in M-75.

## **CONSTRUCTION METHODS:**

### **Fabrication:**

(a) The contractor shall furnish the Project Engineer shop detail plans of all steel work, including expansion devices and curb angles for reinforced concrete spans, for approval, and no fabrication shall be started prior to final approval of these plans. These details shall conform to the general drawings, stress sheet and specifications, and no deviation from the approved shop plans will be allowed without the written consent of the



Project Engineer. The contractor shall be responsible for the correctness of the drawings and for shop fits and field connections even though the drawings have been approved by the Project Engineer.

Shop drawings shall be 22 inches by 36 inches in size. Three sets of blue print copies shall be submitted to the Project Engineer for checking, one of which will be returned with either approval or required revisions noted thereon. When changes on submitted drawings are requested by the Project Engineer and the contractor makes additional changes, other than those expressly requested, he shall direct attention to them on the next copy of blue prints submitted by underscoring with colored crayon or other suitable means. For final approval, the contractor shall submit nine blueprint copies in the case of federal aid projects, or six blue print copies in the case of state projects. Upon completion of fabrication, the original tracings shall be delivered to the Project Engineer. No additional payment will be made for these plans, the cost thereof shall be considered as included in the price bid for steel.

(b) Quality of Workmanship: Workmanship and finish shall be equal to the best general practice in modern bridge shops.

(c) Storage of Material: Structural material, either plain or fabricated, shall be stored at the shop upon platforms, skids, or other supports. It shall be kept free from dirt, grease and other foreign matter, and shall be protected as far as practicable from corrosion. It shall be kept properly drained.

(d) Straightening Material: Rolled material, before being laid off or worked, shall be straight. If straightening is necessary, it shall be done by methods that will not injure the metal. Sharp kinks and bends may be cause for rejection of the material.

(e) Finish: Portions of the work exposed to view shall be finished neatly. Shearing and chipping shall be done carefully and accurately.

(f) Rivet Holes :

1. Punched Work: If general reaming is not re-

quired, all main material, forming parts of a member composed of not more than 5 thicknesses of metal may be punched with a punch  $1/16$ -inch larger than the nominal size of the rivets, whenever the thickness of the metal is not greater than  $3/4$ -inch. When there are more than 5 thicknesses, or when any of the main material is thicker than  $3/4$ -inch, all of the holes shall be punched with a punch  $3/16$ -inch smaller, and after assembling reamed  $1/16$  larger than the nominal size of the rivets, except that when the metal is thicker than the nominal diameter of the rivet, the holes shall be drilled.

2. Punched Holes: Holes punched full size shall be  $1/16$ -inch larger than the nominal diameter of the rivet. The diameter of the die shall not exceed the diameter of the punch by more than  $3/32$ -inch. Holes shall be clean cut and without torn or ragged edges. If any holes must be enlarged to admit rivets they shall be reamed.

3. Accuracy of Punched and Subdrilled Holes: All holes punched full size, subpunched, or subdrilled shall be so accurately punched that after assembling (before any reaming is done) a cylindrical pin  $1/8$ -inch smaller in diameter than the nominal size of the punched hole may be entered perpendicular to the face of the member, without drifting, in at least 75 per cent of the contiguous holes in the same plane. If the requirement is not fulfilled, the badly punched pieces will be rejected. If any hole will not pass a pin  $3/16$ -inch smaller diameter than the nominal size of the punched hole, this will be cause for rejection.

4. General Reaming: General reaming will be required if provided for in the contract. If general reaming is required, holes shall be subpunched and reamed in material forming a part of the section of main members if the thickness of the material is not greater than the nominal diameter of the rivet. Holes may be punched full size in material used for lateral, longitudinal and sway bracing, lacing bars, stay plates and diaphragms, not forming a part of the section of main members if the thickness of the material is not greater than the nominal diameter of the rivet. Holes shall be

drilled in material the thickness of which is greater than the nominal diameter of the rivet.

5. Sub-Punched Holes: Sub-punched and reamed holes for rivets having diameters greater than  $\frac{3}{4}$ -inch shall be punched  $\frac{3}{16}$ -inch smaller than the nominal diameter of the rivet. For rivets having diameters  $\frac{3}{4}$ -inch, the holes shall be punched  $\frac{11}{16}$ -inch in diameter. For rivets having diameter of  $\frac{5}{8}$ -inch or less, the holes shall be punched full size and spear-reamed. The punch and die shall have the same relative sizes as specified for full size punched holes. After assembling, sub-punched holes shall be reamed to a diameter  $\frac{1}{16}$ -inch larger than the nominal diameter of the rivet. Reaming shall be done after the pieces forming a built member are assembled and firmly bolted together. Reamed parts shall not be interchanged.

Reaming of rivet holes shall be done with twist drills or with short taper reamers. Reamers, preferably, shall not be directed by hand. If oil or grease is used as a lubricant when reaming, it shall be applied so as not to soil surfaces which are to be painted. Burrs resulting from reaming shall be removed.

6. Drilled Holes: Drilled holes shall be  $\frac{1}{16}$ -inch larger than the nominal diameter of the rivet. If members are drilled while assembled, the parts shall be securely held together while the drilling is being done. Burrs on the outside surfaces shall be removed.

7. Accuracy of Reamed or Drilled Holes: Reamed or drilled holes shall be cylindrical and perpendicular to the member. After reaming or drilling, 85 of any group of 100 contiguous holes, or in like proportion for any smaller group of holes, shall not show an offset greater than  $\frac{1}{32}$ -inch between adjacent thicknesses of metal.

(g) Shop Assembly: Surfaces of metal in contact shall be cleaned before assembling.

The parts of a member shall be assembled, well pinned and firmly drawn together with bolts before reaming or riveting is commenced. Assembled pieces shall be taken apart, if necessary, for the removal of burrs and shavings produced by the reaming operation.

The member shall be free from twists, bends and other deformation.

Preparatory to the shop riveting of full sized punched material, rivet holes, if necessary, shall be spear reamed for admission of rivets. The reamed holes shall not be more than 3/32-inch larger than the nominal diameter of the rivets.

End connection angles, stiffener angles, and similar parts shall be adjusted carefully to correct position and bolted, clamped, or otherwise held firmly in place until riveted.

Parts not completely riveted in the shop shall be secured by bolts insofar as practicable to prevent damage in shipment and handling.

The drifting done during assembling shall be only such as to bring the parts into position, and not sufficient to enlarge the holes or distort the metal. If any holes must be enlarged to admit the rivets, they shall be reamed.

If general reaming is required, riveted trusses and skew portals shall be assembled in the shop, the parts adjusted to line and fit, and holes for field connections drilled or reamed while so assembled. Holes for other field connections, except those for lateral, longitudinal and sway bracing shall be drilled or reamed in the shop with the connecting parts assembled, or else drilled or reamed to a metal template without assembling.

The field connections in punched work, except those for lateral, longitudinal and sway bracing, shall be reamed to a metal template or else with the parts assembled.

(h) Match-Marking: Connecting parts assembled in the shop for the purpose of reaming holes in field connections shall be match-marked and diagram showing such marks shall be furnished to the Project Engineer.

(i) Rivets: Rivets before driving shall be of the diameter specified. They shall be free from furnace scale. Rivet heads shall be of approved shape, concentric with the shank, true to size, full, neatly formed and free from fins.

Bolted connections shall not be used unless specifically authorized. If bolted connections are permitted, the bolts shall be unfinished bolts, or turned bolts, as specified. Bolts shall have hexagonal heads and nuts and shall be of such length that they will extend entirely through the nut but not more than  $\frac{1}{4}$ -inch beyond. Bolts in tension shall have two nuts. Unfinished bolts in shear shall have not more than one thread within the grip. The diameter of the unfinished bolt shall not be more than  $\frac{1}{16}$ -inch smaller than the diameter of the hole. The threads of turned bolts shall be entirely outside the grip. The bolts shall be given a finished cut. Approved nut locks or flat washers  $\frac{1}{4}$ -inch thick shall be furnished, as required. The holes for turned bolts shall be reamed and their diameter shall be not more than  $\frac{1}{32}$ -inch greater than the diameter of the finished bolt.

(j) Riveting: Rivets shall be heated uniformly to a light cherry-red color and shall be driven while hot. Rivets, when heated and ready for driving, shall be free from slag, scale and other adhering matter. When driven, they shall completely fill the holes. The heads shall be of approved shape, full size, neatly formed, concentric with the shank, free from fins, and in full contact with the surface of the member. Loose, burned or otherwise defective rivets shall be replaced. In removing rivets, care shall be taken not to injure the adjacent metal and, if necessary, they shall be drilled out. Caulking or recupping will not be permitted.

Countersinking shall be neatly done, and countersunk rivets shall completely fill the holes.

Shop rivets shall be driven by direct-acting riveters, when practicable. The riveting machine shall retain the pressure for a short time after the upsetting is complete.

(k) Edge Planing: Sheared edges of plates more than  $\frac{5}{8}$ -inch in thickness and carrying calculated stress shall be planed to a depth of  $\frac{1}{4}$ -inch. Reentrant cuts shall be filleted before cutting.

(k-1) Flame Cutting: Steel or wrought iron may be flame cut, provided a smooth surface is secured by the

use of a mechanical guide. Flame cutting by hand shall be done only where approved by the Project Engineer and the surface shall be made smooth by planing, chipping or grinding. The cutting flame shall be so adjusted and manipulated as to avoid cutting beyond the prescribed lines. Reentrant cuts shall be filleted.

(1) Facing of Bearing Surfaces: The top and bottom surfaces of steel slabs and base plates and cap plates of columns and pedestals shall be planed, or else the plates or slabs hot straightened and annealed. Parts of members in contact with them shall be faced.

Sole plates of beams and girders shall have full contact with the flanges. Sole plates and masonry plates shall be planed or hot straightened. Cast pedestals shall be planed on surfaces to be in contact with steel and shall have the surface to be in contact with masonry rough finished.

Surfaces of bronze bearing plates intended for sliding contact shall be finished.

In planing the surfaces of expansion bearings, the cut of the tool shall be in the direction of expansion.

(m) Abutting Joints: Abutting joints in compression members and girder flanges, and in tension members where so specified on the drawings, shall be faced and brought to an even bearing. Where joints are not faced, the opening shall not exceed  $\frac{1}{4}$ -inch.

(n) End Connection Angles: Floorbeams, stringers, and girders having end connection angles shall be built to exact length back to back of connection angles. If end connections are faced, the finished thickness of the angles shall be not less than shown on the detail drawings.

(o) Lacing Bars: The ends of lacing bars shall be rounded neatly unless another form is required.

(p) Finished Members: Finished members shall be true to line and free from twists, bends and open joints.

(q) Web Plates: In girders having no cover plates and not to be encased in concrete, the top edge of the web plate shall not extend above the backs of the flange angles and shall not be more than  $\frac{1}{8}$ -inch below at any point. Any portion of the plate projecting beyond the

angles shall be chipped flush with the backs of the angles. Web plates of girders having cover plates may be  $\frac{1}{2}$ -inch less in width than the distance back to back of the flange angles.

At web splices, the clearance between the ends of the web plates shall not exceed  $\frac{3}{8}$ -inch. The clearance at the top and bottom ends of web splice plates shall not exceed  $\frac{1}{4}$ -inch.

(r) Fit of Stiffeners: End stiffener angles of girders and stiffener angles intended as supports for concentrated loads shall be milled or ground to secure an even bearing against the flange angles. Intermediate stiffener angles shall fit sufficiently tight to exclude water after being painted. Fillers under stiffeners shall fit within  $\frac{1}{4}$ -inch at each end.

(s) Pins and Rollers: Pins and rollers shall be turned accurately to the dimensions shown on the drawings and shall be straight, smooth, and free from flaws. The final surface shall be produced by a finishing cut. Pins more than 7 inches in diameter shall be forged and annealed. In pins larger than 9 inches in diameter, a hole not less than 2 inches in diameter shall be bored full length along the axis, before annealing.

(t) Boring Pin Holes: Pin holes shall be bored true to the specified diameter, smooth and straight, at right angles with the axis of the member and parallel with each other unless otherwise required. The final surface shall be produced by a finishing cut. The distance outside to outside of the holes in tension members and inside to inside of holes in compression members shall not vary from that specified more than  $\frac{1}{32}$ -inch. Boring of holes in built up members shall be done after the riveting is completed. The diameter of the pin hole shall not exceed that of the pin by more than  $\frac{1}{50}$ -inch for pins 5 inches or less in diameter, or  $\frac{1}{32}$ -inch for larger pins.

(u) Screw Threads: Screw threads shall make close fits in the nuts and shall be U. S. Standard, except that for pin ends of diameters greater than  $1\frac{1}{2}$  inches, they shall be made with 6 threads to the inch. Two pilot nuts and two driving nuts for each size of pin shall be furnished, unless otherwise specified.

(v) **Welding of Steel:** Welding of steel shall not be done except where shown on the plans for minor details or to remedy minor defects and then only with the approval of the Project Engineer. Defects may be corrected as and to the extent hereinbefore permitted. Structural welding, when contemplated in the fabrication, shall conform to the latest specifications for Welded Highway and Railway Bridges of the American Welding Society.

**Mill and Shop Inspection:**

The contractor shall give the Project Engineer ample notice of the beginning of the work at the mill or in the shop, so that inspection may be provided. The term "Mill" means any rolling mill or foundry where material for the work is to be manufactured. No material shall be manufactured or work done in the shop before the Project Engineer has been so notified. The contractor shall furnish facilities for the inspection of material and workmanship in the mill and shop, and the inspectors shall be allowed free access to the necessary parts of the works.

The inspector shall have the authority to reject any material or work which does not meet the requirements of these specifications.

The contractor shall furnish the Project Engineer with duplicate copies of mill orders and triplicate copies of shipping statements as the Project Engineer may direct. The completed weights of the individual members shall be shown on the statements. The contractor shall furnish test specimens, as specified herein, without extra charge; also the labor, testing machines and tools necessary to make the specimen tests.

The acceptance of any material or finished members by the inspector shall not be a bar to their subsequent rejection, if found defective.

**Painting:**

Shop paints and their application shall comply with the requirements under "Painting."



## **Erection of Structural Steel:**

All structural steel shall be erected in accordance with the specifications given for this class of work, under "Steel Bridges."

### **METHOD OF MEASUREMENT:**

#### **General:**

All structural steel shall be measured by the weight of metal in pounds remaining in the completed and accepted structures, and the weight shall be computed on the basis of theoretical net weight from the approved shop detail drawings. No allowance will be made for excess field rivets, and no deductions will be made for rivet holes, bolt holes, beam copings or cut flanges. Deduction will be made for pin holes, pintle and erection bolt holes in bearing plates and castings. All plates shall be estimated from the size billed and deductions made for cut corners. The weight of heads only of all rivets shall be included in the computed weight.

Such miscellaneous parts as ladders, stairways, platforms, structural supports and brackets for machinery and power equipment, including pit pumps; steel framework for counterweights; floor plates; keeper plates and their tap bolts; sheet metal covers for gears, drum switches and other parts where required; shim plates; bearing plates for approach spans of whatever material is required; curb angles; bolts connecting structural members to other structural members, or to concrete; anchor bolts, including those for roadway gates; and bronze and cast iron for expansion plates will be classified and measured as Structural Steel.

No measurement of structural steel of any class will be allowed for temporary work of any kind or for additional weight in members provided for erection purposes.

No allowance will be made in the pay quantity for any items not remaining in the finished structure.

No allowance will be made for shop paint.

No allowance will be made for over-run on plates or rolled sections.

The weight of standard fillet welds shall be as given in the following table:

Specified Size Inches	Weight lbs. per Lin. Ft.
$\frac{1}{8}$ "	.07
$\frac{2}{16}$ "	.14
$\frac{1}{4}$ "	.20
$\frac{5}{16}$ "	.25
$\frac{3}{8}$ "	.35
$\frac{1}{2}$ "	.55

The weight of bolt heads and nuts shall be as given in the following table:

WEIGHT OF BOLT HEADS AND NUTS IN POUNDS PER 100

Weight of 100 each		Diameter of Bolt, Inches										
		$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$
Regular	Square Heads.....	.7	1.4	2.2	3.2	5.1	10	18	29	42	60	84
	Hexagon Heads.....	.6	1.2	1.9	2.8	4.5	9	15	25	36	52	73
	Square Nuts.....	.81	1.7	2.3	4.1	5.6	10	14	23	35	49	67
	Hexagon Nuts.....	.64	1.4	1.9	3.7	4.2	9	12	18	28	42	54
Heavy	Square Heads.....					9.5	17	28	42	61	84	112
	Hexagon Heads.....					8.2	14	24	36	53	73	94
	Square Nuts.....					7.9	14	23	35	50	66	92
	Hexagon Nuts.....					6.6	11	19	28	41	56	73

### HEAVY BOLTS

Weights of bolts over 1<sup>1</sup>/<sub>4</sub> inches in diameter may be calculated from the following data. Standard practice is "American Standard Regular" head with "American Standard Regular" or "Heavy" nut, as specified.

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Weight of 100 each		Diameter of Bolt, Inches										
		1 <sup>1</sup> / <sub>2</sub>	1 <sup>3</sup> / <sub>4</sub>	2	2 <sup>1</sup> / <sub>4</sub>	2 <sup>1</sup> / <sub>2</sub>	2 <sup>3</sup> / <sub>4</sub>	3	3 <sup>1</sup> / <sub>4</sub>	3 <sup>1</sup> / <sub>2</sub>	3 <sup>3</sup> / <sub>4</sub>	4
Regular	Square Heads . . . . .	143	226	343	484	660	881	1148	1452	1830	2241	2710
	Hexagon Heads . . . . .	124	196	297	419	577	764	994	1257	1585	1941	2350
	Square Nuts . . . . .	116	184	276	391	539	666	874	.....	.....	.....	.....
	Hexagon Nuts . . . . .	102	162	231	337	472	606	825	.....	.....	.....	.....
Heavy	Square Heads . . . . .	190	295	432	608	825	1087	1401	1775	2115	2715	3312
	Hexagon Heads . . . . .	162	254	377	538	727	890	1234	1526	1906	2344	2845
	Square Nuts . . . . .	154	242	355	496	674	831	1082	1767	2043	2303	2969
	Hexagon Nuts . . . . .	123	208	303	422	573	742	1008	1196	1485	1789	2184
Pounds per linear in. of Shank . . . . .		.5007	.6815	.8900	1.127	1.391	1.683	2.003	2.348	2.723	3.126	3.556

**Fabricated Carbon Steel:** Fabricated Carbon Steel shall include all steel classified as such on the contract drawings, and unless otherwise noted on the plans, such minor items as rivet heads, anchor materials, including bolts, pins, rollers, metal railings, heads and nuts or permanent bolts connecting steel to steel, steel plates and shapes for expansion joints, ladders, wrought iron sheets, checkered floor plates, bronze castings and plates, steel castings, and iron castings (except cast iron drains in floors), and all other items described under "Method of Measurement," "General," necessary to complete this portion of the structure.

For the purpose of computing the pay quantity of the various metals which are classified as "Fabricated Carbon Steel" the following weights listed shall govern:

Material	Weight Lbs. per cu. ft.
Carbon Steel, anchor bolts, wrought iron, steel castings, and forgings, malleable casting ....	490
Cast iron—Class 30 or Class 40 .....	450
Bronze castings or plates .....	550

The weights of rivet heads shall be as given in the following table:

Weight of High Button (Acorn) Heads after Driving							
Diameter of Rivet, Inches	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4
Weight per 100 Heads, Lb.	4	7	12	18	26	36	48

Bridge hardware connectors for joining timber members, nails, spikes, and bolts (except as provided above) shall not be included in the poundage, or paid for.

**Fabricated Silicon Steel:** Fabricated Silicon Steel shall include all steel classified as such on the contract drawings. No incidentals will be measured as Fabricated Silicon Steel. The weight of fabricated silicon steel shall be computed at 490 pounds per cubic foot for pay quantity.

**Plain Carbon Steel:** Plain Carbon Steel shall include all steel classified as such on the contract drawings. The

weight of plain carbon steel shall be computed at 490 pounds per cubic foot for pay quantity.

**BASIS OF PAYMENT:**

The number of pounds of completed and accepted steel and other metal of the various categories, measured as provided above, shall be paid for at the contract unit price per pound for "Fabricated Carbon Steel," "Fabricated Silicon Steel," or "Plain Carbon Steel," as the case may be, which price and payment shall constitute full compensation for furnishing, fabricating, delivering, erecting, and painting all steel and other metal and for all labor, equipment, tools and incidentals necessary to complete the item.

Asphaltic Concrete filling for recesses in structural steel members, if required, shall be merged into the unit price for "Fabricated Carbon and Silicon Steel."

Payment will be made under:

Item 483, Fabricated Carbon Steel, per pound.

Item 484, Fabricated Silicon Steel, per pound.

Item 485, Plain Carbon Steel, per pound.

or,

Item 717, Fabricated Carbon Steel, per pound.

Item 718, Fabricated Silicon Steel, per pound.

Item 719, Plain Carbon Steel, per pound.

**CONCRETE STRUCTURE  
HANDRAILS  
ITEM 487 or ITEM 732**

**DESCRIPTION:**

This item shall consist of the construction of concrete handrails for structures. The handrails shall be of the design and built to lines and grades shown on the plans, all in accordance with these specifications.

**MATERIALS:**

Concrete handrails shall be constructed with Class "A" concrete as specified under "Concrete."

Cotton Fabric shall conform to the requirements specified in M-19.

#### CONSTRUCTION METHODS:

**Cast in Place Handrails:** The portion of the railing or parapet which is to be cast in place shall be constructed in accordance with the requirements for "Concrete." Special care shall be exercised to secure smooth and tight fitting forms which can be rigidly held to line and grade and removed without injury to the concrete. All mouldings, panel work, and bevel strips shall be constructed according to the detail plans with neatly mitred joints and all corners in the finished work shall be true, sharp and clean-cut and shall be free from cracks, spalls or other defects.

**Precast Handrails:** Precast railing members shall be cast in mortar tight forms. The precast members shall be removed from the moulds as soon as the concrete has set sufficiently to permit and shall then be kept covered with saturated cotton fabric or tarpaulin for at least three days. After this, the curing shall be completed by immersion in water or by spraying not less than twice a day, for a period of not less than seven days.

The method of storage and handling shall be such as to preserve true and even edges and corners, and any precast members which become chipped, marred or cracked before or during the process of placing shall be rejected and removed from the work.

In the construction of cast-in-place railing caps and copings built in connection with precast balusters, the balusters shall be protected from staining and disfigurement during the process of placing and finishing the concrete.

**Finishing:** All handrails shall be given a "Rubbed Finish," as specified under "Concrete."

The construction sequence of casting in place and/or aligning precast members shall be as required for and specified under "Steel Bridges" and "Concrete Bridges."

#### **METHOD OF MEASUREMENT:**

Concrete handrails shall be measured by the linear foot and the quantity to be measured shall be the actual linear feet of single line handrail placed and accepted measured along the inside face of the top of the handrail as shown on the plans.

#### **BASIS OF PAYMENT:**

The number of linear feet of concrete handrail measured as specified shall be paid for at the contract unit price for concrete handrails complete in place which price and payment shall constitute full compensation for all materials, (including reinforcing steel), tools, equipment, labor and incidentals and the performance of all work necessary to complete the item.

#### **Payment shall be made under:**

- Item 487, Concrete Handrail, per linear foot.
- or,
- Item 732, Concrete Handrails, per linear foot.

## **TIMBER BRIDGES**

#### **DESCRIPTION:**

This item shall consist of timber structures built as indicated on the plans, in conformity with the lines, profile grades, dimensions and design shown, in accordance with these specifications and in full compliance with the specifications for "Untreated and Treated Timber", "Bearing Piles" and other specifications and contract items, which are to contribute to and constitute the intended complete structure.

#### **MATERIALS:**

##### **Timber and Lumber:**

All timber and lumber to be used in timber bridges and fenders shall be Southern Yellow Pine surfaced four sides (S4S) unless otherwise indicated on the

plans. It shall meet all of the requirements for materials under "Untreated and Treated Timber".

#### **Hardware:**

Machine bolts, drift bolts and dowels may be either wrought iron or medium steel. Washers shall be cast ogee gray iron, unless washers cut from medium steel or wrought iron plate are called for on the plans. A standard circular washer shall be used under the heads of all lag screws.

Machine bolts shall have square heads and nuts unless otherwise called for. Nails shall be cut or round of standard form. Spikes shall be cut, wire, or boat spikes.

Hardware shall be black unless otherwise specified.

#### **Structural Shapes, etc.:**

All structural shapes, rods and plates shall be of structural steel or wrought iron, as specified or called for on the plans, meeting the respective requirements prescribed under "Structural Steel". All castings shall conform to the requirements therefor prescribed under "Materials".

### **CONSTRUCTION METHODS:**

#### **General:**

In addition to the requirements under construction methods of "Untreated and Treated Timber", the following specific requirements shall be adhered to in the construction of timber structures.

#### **Workmanship:**

All framing shall be true and exact. Unless otherwise specified, nails and spikes shall be driven with just sufficient force to set the heads flush with the surface of the wood. Deep hammer marks in wood surfaces shall be considered evidence of poor workmanship and sufficient cause for removal of the workman causing them. The workmanship on all metal parts shall conform to the requirements specified under "Steel Bridges".



### **Framing:**

All lumber and timber shall be accurately cut and framed to a close fit in such manner that the joints will have even bearing over the entire contact surfaces. Mortises shall be true to size for their full depth and tenons shall fit snugly. No shimming will be permitted in making joints, nor will open joints be accepted.

### **Pile Bents:**

The piles shall be driven as accurately as possible in the correct location and vertical or to the batter indicated on the plans. In case a pile is driven out of line, it shall be straightened without injury before it is cut off or braced. Piles damaged in driving or straightening, or piles driven below grade, shall be removed and replaced at the contractor's expense. No shimming on tops of piles will be permitted.

The piles for any one bent shall be carefully selected as to size, to avoid undue bending or distortion of the sway bracing. However, care shall be exercised in the distribution of piles of varying sizes to secure uniform strength and rigidity in the bents of any given structure.

Cut-offs shall be accurately made to insure perfect bearing between the cap and piles of a bent.

Pile heads shall be treated in accordance with the specifications under "Bearing Piles".

### **Framed Bents:**

Mudsills shall be firmly and evenly bedded to solid bearing and tamped in place.

Concrete pedestals for the support of framed bents shall be carefully finished so that the sills or posts will take even bearing on them. Dowels of not less than  $\frac{3}{4}$  inch diameter and projecting at least 6 inches above the tops of the pedestals, shall be set in them when they are cast, for anchoring the sills or posts.

Sills shall have true and even bearing on mud sills, piles or pedestals. They shall be drift bolted to mud sills

or piles with bolts of not less than  $\frac{3}{4}$  inch diameter and extending into the mud sills or piles at least 6 inches. When possible all earth shall be removed from contact with sills so that there will be free air circulation around them.

Posts shall be fastened to pedestals with dowels of not less than  $\frac{3}{4}$  inch diameter, extending at least 6 inches into the posts.

#### **Caps for all Bents:**

Timber caps shall be placed to secure an even and uniform bearing over the tops of the supporting posts or piles and to secure an even alignment of their ends. All caps shall be secured by drift bolts of not less than  $\frac{3}{4}$  inch diameter, extending at least 9 inches into the posts or piles. The drift bolts shall be approximately in the center of the post or pile.

#### **Bracing:**

The ends of bracing shall be bolted through the pile, post or cap with a bolt of not less than  $\frac{3}{4}$  inch diameter. Intermediate intersections shall be bolted, as indicated on the plans.

#### **Stringers:**

Stringers shall be sized at bearings and shall be placed in position so that knots near the edges will be in the top portions of the stringers. Outside stringers may have butt joints but interior stringers shall be lapped to take bearing over the full width of floor beam or cap at each end. The lapped ends of untreated stringers shall be separated at least  $\frac{1}{2}$  inch for the circulation of air and shall be securely fastened by drift bolting where specified. When stringers are two panels in length the joints shall be staggered. Cross bridging between stringers shall be neatly and accurately framed and securely toe-nailed with at least two nails at each end.

#### **Floors:**

Flooring on the roadway and sidewalk shall be of the type and dimensions shown on the plans.

**Wheel Guards:**

Wheel guards shall be constructed as shown on the plans. When the wheel guard is not blocked up from the floor, drain holes shall be provided at such intervals as to drain the floor adequately.

**Railings:**

Railings shall be built as shown on the plans. All rails shall be squarely butt-jointed at the posts and the rails shall break joints.

Rails and posts shall be untreated and shall be painted three coats of white lead paint as stipulated in "Painting".

**Holes for Bolts, Dowels, Rods and Lag Screws:**

Holes for round drift bolts and dowels shall be bored with a bit  $1/16$  inch less in diameter than the bolt or dowel to be used. The diameter of holes for square drift bolts or dowels shall be equal to the least dimension of the bolt or dowel.

Holes for machine bolts shall be bored with a bit of the same diameter as the bolt.

Holes for rods shall be bored with a bit  $1/16$  inch greater in diameter than the rod.

Holes for lag screws shall be bored with a bit not larger than the body of the screw at the base of the thread.

**Countersinking:**

Countersinking shall be done wherever smooth faces are required. Recesses formed for countersinking shall be painted with hot creosote oil and, after the bolt or screw is in place, shall be filled with hot pitch.

**Bolts and Washers:**

A washer of the size and type specified shall be used under all bolt heads and nuts which would otherwise come in contact with wood. A standard circular washer shall be used under the heads of all lag screws.

Unless otherwise specified,  $3/4$  inch and  $5/8$  inch bolts shall have cast ogee washers and  $1/2$  inch bolts shall

have cut wrought iron washers under both head and nut.

All bolts shall be effectively checked after the nuts have been finally tightened.

#### **METHOD OF MEASUREMENT:**

The quantities of timber and of the various other contract pay items which constitute the completed and accepted structure shall be measured for payment according to the specifications for the individual contract items. Only accepted work shall be included and the dimensions used shall be those shown on the plans or ordered in writing.

Hardware is not a pay item and no measurement of this item will be made.

Structural steel will be considered a pay item, only when so indicated on the plans and when the contract includes a unit price for this item.

#### **BASIS OF PAYMENT:**

The quantities measured as provided above, shall be paid for at the contract unit prices for the several pay items, which prices and payments shall constitute full compensation for furnishing, delivering, preparing, assembling, erecting and painting all lumber, timber and other materials, and for all labor, equipment, tools and incidentals necessary to complete the work. Such payments shall constitute full payment for the completed structure, ready for use, and no allowance will be made for cofferdam construction, falsework, or other erection expenses.

## **STEEL BRIDGES**

#### **DESCRIPTION:**

This item shall consist of steel bridges, including but not limited to superstructures to be placed on concrete, steel, or timber substructures, tower bents, etc., all of which shall be built and completed as indicated on the

plans in conformity with the lines, profile grade, dimensions and design shown on the plans. All work shall be in accordance with these specifications and in full compliance with the specifications for "Structural Excavation," "Structural Steel," and other specifications or contract items which are to contribute to and constitute the complete structure in each case.

#### **MATERIALS:**

##### **General:**

The materials to be furnished and used shall be those prescribed for the several specifications and contract items which are to constitute the structure, including primarily, but not limited to "Structural Steel."

Materials shall conform to the requirements specified under "Materials" for each specific material required.

#### **CONSTRUCTION METHODS:**

##### **General:**

The construction methods used shall be those prescribed for the several items which are to constitute the structure and in particular shall conform to the requirements for fabrication and erection, as hereinafter prescribed under "Structural Steel." No compensation for fabrication or erection of steel superstructures or structural steel shall be allowed except as provided under "Structural Steel" hereinafter.

Concrete: All concrete work specified on steel bridges shall comply with the requirements for the like class of work as specified under "Concrete Bridges."

##### **Handling and Storing Materials:**

Structural material, either plain or fabricated, shall be stored at the bridge site above the ground upon platforms, skids, or other supports. It shall be kept free from dirt, grease and other foreign matter, and shall be protected as far as practicable from corrosion. It shall be kept properly drained.

Girders and beams shall be placed upright and

shored. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent injury from deflection.

#### **Falsework:**

The falsework shall be designed properly, constructed substantially and maintained for the loads which will come upon it. The contractor, if required, shall prepare and submit to the Project Engineer for approval, plans for falsework or for changes in an existing structure necessary for maintaining traffic. Approval of the contractor's plans shall not be considered as relieving the contractor of any responsibility.

#### **Erection of Steel:**

Before starting the work of erection, the contractor shall inform the Project Engineer fully as to the method of erection he proposes to follow, and the amount and character of equipment he proposes to use, which shall be subject to the approval of the Project Engineer. The approval of the Project Engineer shall not be considered as relieving the contractor of the responsibility for the safety of his method or equipment or from carrying out the work in full accordance with the plans and specifications. No work shall be done until such approval by the Project Engineer has been obtained.

The parts shall be accurately assembled as shown on the plans and any match-marks shall be followed. The materials shall be carefully handled so that no parts will be bent, broken, or otherwise damaged. Hammering which will injure or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled. Unless erected by the cantilever method, truss spans shall be erected on blocking so placed as to give the trusses proper camber. The blocking shall be left in place until the tension chord splices are riveted fully and all other truss connections pinned and bolted. Rivets in splices of butt joints of compression members and rivets in railing shall not be

driven until the span has been swung. Splices and field connections shall have one-half of the holes filled with bolts and cylindrical erection pins (half bolts and half pins) before riveting. Splices and connections carrying traffic during erection shall have three-fourths of the holes so filled. The steel structures shall be entirely riveted and swung before any concrete in the deck is poured.

Fitting-up bolts shall be the same nominal diameter as the rivets, and the cylindrical erection pins shall be 1/32 inch larger.

Pneumatic hammers shall be used for field riveting, except when the use of hand tools is permitted by the Project Engineer. Rivets larger than 7/8 inch in diameter shall not be driven by hand. Cupfaced dollies, fitting the head closely to insure good bearing, shall be used. Connections shall be fitted up accurately and securely before the rivets are driven. Drifting shall be only such as to draw the parts into position and not sufficient to enlarge the holes or distort the metal. Unfair holes shall be reamed or drilled. Rivets shall be heated uniformly to a light cherry-red color and shall be driven while hot. They shall not be overheated or burned. Rivet heads shall be full and symmetrical, concentric with the shank and shall have full bearing all around. They shall not be smaller than the heads of the shop rivets. Rivets shall be tight and shall grip the connected parts securely together. Caulking or re-cupping will not be permitted. In removing rivets, the surrounding metal shall not be injured; if necessary, they shall be drilled out.

In bolted connections, the bolts shall be drawn up tight and the threads burred at the face of the nut with a pointed tool.

Pilot and driving nuts shall be used in driving pins. Nuts shall be screwed up tight and the threads burred at the face of the nut with a pointed tool.

Other details of field assembling, placing, erecting, adjusting, straightening bent material, bolting, field riveting and other connections and adjustment of mis-

fits shall be performed by the contractor in all respects as specified under "Structural Steel."

**Bearing and Anchorage:**

Masonry bearing plates shall not be placed upon bridge seat bearing areas which are improperly finished, deformed or irregular. Bearing plates shall be set level in exact position and shall have a full and even bearing upon the masonry. The bridge seat bearing area shall be swabbed thoroughly with red lead paint and then covered with three layers of 12 to 14 ounce duck, each layer being swabbed thoroughly on the top surface with red lead paint. The superstructure shoes or pedestals shall be placed in position while the paint is plastic.

The contractor shall drill the holes and set the anchor bolts, except where the bolts are built into the masonry. The bolts shall be set accurately and fixed with Portland cement grout completely filling the holes. The location of the anchor bolts in relation to the slotted holes in the expansion shoe shall correspond with the temperature at the time of erection. The nuts on anchor bolts at the expansion ends of spans shall be adjusted to permit the free movement of the span.

**Floors:**

(a) Concrete Floors: Concrete floors shall comply with the requirements for this work under "Concrete Bridges."

(b) Plank and Laminated Floors. Plank and laminated timber floors shall comply with the specifications under "Untreated and Treated Timber."

**Setting Bench Mark Plates:**

A bench mark plate furnished and delivered by the Project Engineer shall be set by the contractor without extra compensation on each bridge. It shall be located on the downstream side and at the end of the bridge on the right descending bank. If the bridge carries a concrete floor the bench mark plate shall be set at the end of the curb. No permanent plates or markers other



than those furnished or specified by the Project Engineer will be permitted on any structure.

**Railings:**

Steel or pipe railings shall be aligned and permanently fastened and concrete railings, (except precast members) shall be cast after the structure is self-supporting and after the deck has been constructed.

**Painting:**

Field painting after erection of structural steel shall comply with the requirements specified under "Painting."

**Cleaning Up:**

Upon completion and before final acceptance of the structure, the contractor shall remove all falsework, excavated or useless materials, rubbish and temporary buildings, replace or renew any fences damaged and restore in an acceptable manner all property, both public and private, which may have been damaged during the prosecution of the work, and shall leave the bridge site and adjacent highway in a neat and presentable condition satisfactory to the Project Engineer. All excavated material or falsework placed in the stream channel during construction shall be removed by the contractor before final acceptance.

**METHOD OF MEASUREMENT:**

The quantities of structural steel and the various other pay items, which constitute the completed and accepted structure shall be measured for payment, according to the specifications for the individual contract items. Only accepted work shall be included and the dimensions shall be those on the plans or ordered in writing.

**BASIS OF PAYMENT:**

The quantities of structural steel and other pay items, measured as provided above, shall be paid for at the contract unit price for the "Structural Steel" and

the several other pay items, which prices and payments shall constitute full compensation for furnishing, preparing, fabricating, transporting, placing and erecting all structural steel and all other materials for the complete structure; for all shop work, painting and field work; for all labor, equipment, tools and incidentals necessary to complete the work. Such payment shall constitute full payment for the completed structure ready for use, and no allowance shall be made for cofferdam construction, falsework, or other erection expenses.

## CONCRETE BRIDGES

### DESCRIPTION:

This item shall consist of concrete bridges, including also, concrete slabs on steel bridges and concrete substructures for steel, timber and combination bridges, all of which shall be built and completed as indicated on the plans in conformity with the lines, profile grades, dimensions and design shown, in accordance with these specifications and in full compliance with the specifications for "Structural Excavation," "Concrete," "Bearing Piles," and other specifications or contract items which are to contribute to and constitute the complete structure in each case.

### Equipment:

All equipment necessary for the proper mixing, placing and finishing of the concrete shall be on the project, in first class working condition, and shall have been inspected and approved by the Project Engineer before concreting operations will be permitted to begin. All equipment shall meet the specific requirements set forth under "Concrete," "Reinforcing Steel," and "Bearing Piles."

### General:

The materials to be furnished and used shall be those prescribed for the several specifications and con-

tract items which are to constitute the structure, including primarily, but not limited to, "Concrete," and "Reinforcing Steel."

Materials shall conform to the requirements specified under "Materials," for each specific material required.

#### **CONSTRUCTION METHODS:**

##### **Concrete:**

The proportioning, mixing, placing, curing and finishing of concrete for bridges shall be performed in accordance with the specifications for "Concrete."

##### **Foundations:**

All foundations shall be prepared as specified under "Structural Excavation," and concrete shall not be placed until the foundation area upon which it is to rest has been inspected and approved by the Project Engineer. All foundations shall be poured in the "dry" except as provided for "Depositing Concrete Under Water" or unless otherwise permitted in writing by the Project Engineer. Cofferdams and concrete seals shall be furnished and prepared as prescribed under "Structural Excavation."

##### **Pile Heads:**

The tops of timber piles shall project not less than twelve inches into the concrete after all damaged wood has been removed.

##### **Drainage of Substructures:**

The filling material back of abutments and wing walls shall be drained thoroughly and effectively by means of a system of tiling, French drains or other adequate construction. Drains shall be so located that the stream water cannot wash away fill material through the openings. The drainage water shall be discharged through abutment, wing or pier walls in such manner and at such locations as to eliminate as far as possible any objectionable discoloration of exposed masonry surfaces. Drainage outlets shall be fitted with suitable

screens where directed and the intakes shall be protected against clogging by means of screens, gratings or French drains.

**Placing Anchor Bolts:**

All necessary anchor bolts in piers, abutments or pedestals shall be set carefully in Portland cement grout in accordance with the requirements specified under "Steel Bridges."

The holes may be drilled in accordance with the provisions of the above mentioned articles or, if in concrete masonry, may be formed by the insertion in the fresh concrete of oiled wooden plugs or metal pipe sleeves or other approved devices which are subsequently withdrawn after the concrete has partially set. When the holes are formed by the latter method, they shall be not less than 4 inches in diameter to allow for horizontal adjustment of the bolts. All such holes shall be adequately protected against the formation of ice in same while they remain open.

In lieu of the above methods of placing, anchor bolts in concrete masonry may be set to exact location in the concrete when it is placed. In this case, great care shall be exercised to insure the proper setting of the bolts and inaccuracies which will be detrimental to the structure shall be corrected by suitable means.

**Setting Bed Plates:**

Bed plates preferably shall be set on layers of canvas and red lead as specified under "Steel Bridges."

**Placing Superstructures:**

No superstructure load shall be placed upon finished piers or abutments until the Project Engineer directs. In general, a minimum time of 14 days shall be allowed for the hardening of concrete before any superstructure load is placed thereon.

The method and sequence of placing concrete for the various types of concrete bridge construction shall be as specified below for the particular types of construction involved.

### **Reinforced Concrete Slab and Girder Bridges:**

Concrete preferably shall be deposited by beginning at the center of the span and working from the center toward the ends. Concrete in girders shall be deposited uniformly for the full length of the girder and brought up evenly in horizontal layers.

Concrete in girder haunches less than 3 feet in height shall be placed at the same time as that in the girder stems and the column or abutment tops shall be so shaped as to form seats for the haunches. Whenever any haunch or fillet has a vertical height of 3 feet or more, the abutment or columns, the haunch and the girder shall be placed in three successive stages; first, up to the lower side of the haunch; second, to the lower side of the girder; and third, to completion.

Concrete in slab spans shall be placed in one continuous operation for each span.

The floors and girders of through girder superstructures shall be placed in one continuous operation unless otherwise specified, in which case special shear anchorage shall be provided to insure monolithic action between girder and floor.

Concrete in T-beam or deck girder spans may be placed in one continuous operation or may be placed in two separate operations, each of which shall be continuous; first, to the top of the girder stems, and second, to completion. In the latter case, the bond between stem and slab shall be positive and mechanical, and shall be secured by means of suitable shear keys in the top of the girder stem. The size and location of these keys shall be as directed by the Project Engineer. In general, suitable keys may be formed by the use of timber blocks approximately 2 by 4 inches in cross section and having a length 4 inches less than the width of the girder stem. These key blocks shall be spaced along the girder stems as required, but the spacing shall be not greater than 1 foot center to center. The blocks shall be beveled and oiled in such a manner as to insure their ready removal, and they shall be removed as soon as the concrete has set sufficiently to retain its shape.

When concrete in reinforced concrete slabs or girder spans is placed in one continuous operation for each span, the contractor shall provide and use concrete mixing and placing equipment of adequate capacity to place the concrete in any span within a maximum time of 4 hours when regular or low heat type cement is used. If High-Early-Strength Cement is used, the placing time for each span shall be 3½ hours. The minimum capacity of the concrete mixing equipment shall be determined as set forth in these specifications and shall provide for the greatest volume of concrete to be placed in any span included in the contract.

Falsework and forms for all slab and girder spans shall be so constructed as to produce in the finished structure the camber indicated on the plans.

#### **Concrete Floors for Steel Bridges:**

The concrete floor shall be poured symmetrically about the center line of the span. Care shall be taken to prevent the displacement of reinforcing steel during the placing of concrete.

If, for any reason, it becomes necessary to introduce a construction joint, this joint shall be formed by means of a vertical bulkhead so constructed as to produce a keyed or dovetailed joint. In concrete floors not supported by long longitudinal joists, any necessary construction joints shall be located at the center of the slab span.

The pouring of concrete floors on the various types of steel bridges shall proceed as follows:

(a) Steel Truss Spans: Beginning at the center and working simultaneously toward each end, or beginning at the ends and working simultaneously toward the center.

(b) Swing Spans: Beginning at the ends and working simultaneously toward the center.

(c) I-beam Spans: Beginning at center and working simultaneously toward the ends, except on very short spans, where with the Project Engineer's written permission, the contractor may use other methods.

(d) Where continuity over intermediate supports would occasion negative reactions at end supports of steel truss or I-beam spans, a length of deck at each end, sufficient to overcome tendency to lift from bearings, shall be poured first, or adequate temporary loads may be provided.

**Roadway Crown, Concrete and Steel Bridges:**

The crown of roadway shall be shown on the plans. Gutters shall be effectively drained by means of cast iron drain pipes of the dimensions and at the locations shown on the plans. The under surface of cantilever brackets and overhanging slabs shall be provided with a "V" groove one-half inch in depth, at a point not more than six inches from the outside face, for the purpose of arresting the flow of moisture and thus preventing staining.

**Roadway Finish, Concrete and Steel Bridges:**

The finishing of roadway shall be performed as prescribed under "Concrete."

**Waterproofing and Dampproofing:**

When called for by the plans, concrete shall be waterproofed or damproofed as designated, and it shall be performed in accordance with the requirements under "Waterproofing," or "Dampproofing."

**Concrete Viaducts:**

Where concrete viaduct construction consists of a series of reinforced concrete slab or girder spans supported on bents or towers composed of concrete columns suitably braced by means of longitudinal and transverse struts, and sway braces, the superstructure shall be constructed in accordance with the requirements governing the construction of concrete slab and girder structures. The following provisions relate to the construction of the column substructures.

Column forms shall be composed of material not less than 1¼ inches in thickness after being dressed and

shall be effectively braced. Forms shall be daylighted at intervals not greater than 10 feet vertically, the openings being sufficient to permit of free access to the forms for the purpose of inspecting, working and spading the concrete.

Concrete in columns shall be placed in one continuous operation, unless otherwise directed. The concrete shall be allowed to set at least 12 hours before the caps are placed.

Unless otherwise permitted by the Project Engineer, no concrete shall be placed in the superstructure until the column forms have been stripped sufficiently to determine the character of the concrete in the columns. The load of the superstructure shall not be allowed to come upon the bents until they have been in place at least 14 days, unless otherwise permitted by the Project Engineer.

#### **Concrete Railings and Parapets:**

In no case shall concrete railings be placed until the centering for the falsework for the span has been released, rendering the span self supporting. Concrete railings shall be constructed as specified under Item 487.

#### **Expansion Joints:**

Expansion joints shall comply with the specifications for "Expansion Joints" under "Concrete."

#### **METHOD OF MEASUREMENT:**

The quantities of concrete and of the various other pay items which constitute the completed and accepted structure shall be measured for payment according to the specifications for the several individual contract items. Only accepted work shall be included and the dimensions used shall be those shown on the plans or ordered in writing.

#### **BASIS OF PAYMENT:**

The quantities, measured as provided above, shall



be paid for at the contract unit prices for the several pay items, complete in place, which prices and payments shall constitute full compensation for furnishing, hauling, and placing all materials, and for all labor, equipment, tools and incidentals necessary to complete the work. Such payment shall constitute full payment for the completed structure, ready for use, and no additional allowances shall be made for cofferdam construction, falsework, form lumber, or other erection expenses.

## PAINING

### DESCRIPTION:

The painting of all items specified shall include the preparation of surfaces, the application, protection and drying of the paint coatings, and the supplying of all tools, tackle, scaffolding, labor and materials necessary for the entire work.

The terms used in these specifications shall be the standard definitions adopted by the A. S. T. M. The gallon used is the United States gallon containing 231 cubic inches.

The paint schedule for the various types of structures shall be as follows:

(a) Steel Structures: Steel bridges, including hand-rail, steel towers, etc., shall be painted with three coats of paint, as follows:

1. Shop coat—red lead paint.
2. First field coat—red lead paint.
3. Second field coat—aluminum paint.

Alternate coats for the second and third coats specified above may be used only when the written approval of the Project Engineer has been obtained.

(b) Timber Structures: All handrails and posts of timber bridges, and other timber structures when speci-

fied on the contract drawings, shall be painted with three coats of paint as follows:

1. First coat—white lead paint.
2. Second coat—white lead paint.
3. Third coat—white lead paint.

(c) Guard Rails: Rails, and where specified, posts, shall be painted with two coats of paint as follows:

1. First coat—white lead paint.
2. Second coat—white lead paint.

(d) Blast Plates: Blast plates and hangers shall be painted on all surfaces with three coats of paint as follows:

1. Shop coat—red lead and oil.
2. First field coat—graphite.
3. Second field coat—bituminous paint.

#### **MATERIALS:**

Bituminous paint (blast plate) shall conform to the requirements specified in M-52.

Red lead paint shall conform to the requirements specified in M-55.

White lead paint shall conform to the requirements specified in M-58.

Aluminum paint shall conform to the requirements specified in M-50 or M-51.

Graphite paint shall conform to the requirements specified in M-54.

#### **CONSTRUCTION METHODS:**

##### **General Requirements:**

(a) Packing: Paint shall be delivered in containers not larger than 5-gallon capacity.

(b) Identification: Each container shall bear a label with the following information thereon: Name and address of the manufacturer, trade name or trade mark, kind of paint, and number of gallons.

(c) Analysis: A one quart sample shall be taken at random from any or all deliveries and acceptance or rejection of shipments will be based on the analysis of these samples. The contractor should, therefore, secure necessary paint in ample time so that no delay to work will be caused by the time necessarily used in testing for which twenty-one days should be allowed from the time the sample is collected by the inspector.

(d) Mixing of Paint: All paint shall be mixed thoroughly before applying and during application shall be stirred frequently so that the pigments are kept in suspension and the proper consistency maintained.

(e) Weather Conditions: Paint shall not be applied when the atmospheric temperature is below 40° F., or when the air is misty, or when, in the opinion of the Project Engineer, the conditions are otherwise unsatisfactory for the work. It shall not be applied upon damp or frosted surfaces. Material painted under cover in damp or cold weather shall remain under cover until dry or until weather conditions permit its exposure in the open. Painting shall not be done when the surface is hot enough to cause the paint to blister and produce a porous paint film. If it is necessary in cool weather to thin the paint on account of congealing, this shall be done only by heating.

(f) Protection of Public and Work: The contractor shall protect pedestrian, vehicular and other traffic upon or underneath the bridge and also portions of the bridge superstructure and substructure against damage or disfigurement by spatters, splashes and smirches of paint or paint materials.

(g) Cleaning Metal: Surfaces of metal to be painted shall be cleaned thoroughly, removing rust, loose mill scale, dirt, oil or grease and other foreign substances. The removal of rust, scale and dirt shall be done by the use of metal brushes, scrapers, chisels, hammers or other effective means. Oil and grease shall be removed by the use of gasoline or benzine. Bristle brushes shall be used for removing loose dirt.

(h) Application: Painting shall be done in a neat and workmanlike manner. Brushes preferably shall be

round or oval in shape, but if flat brushes are used they shall not exceed 4 inches in width. The paint when applied shall be so manipulated under the brush as to produce a coating of uniform color and even thickness in close contact with the surface or with previously applied paint and shall be worked into all corners and crevices. On surfaces which are inaccessible to paint brushes, the paint shall be applied with sheepskin daubers specially constructed for the purpose. All surfaces coated with impure or unauthorized paint shall be thoroughly cleaned and repainted to the satisfaction of the Project Engineer at the contractor's expense.

#### **Shop Painting:**

(a) Surfaces to be painted: When fabrication is complete and the work has been accepted, surfaces not painted before assembling, except surfaces to be in contact after erection, shall be thoroughly cleaned and painted one coat. Surfaces to be in contact with concrete shall be left unpainted.

(b) Erection Marks: Erection marks shall be painted on painted surfaces.

(c) Loading: Material shall not be loaded for shipment until the paint is dry.

(d) Contact and Inaccessible Surfaces: Surfaces to be riveted in contact either in the shop or field shall not be painted. Surfaces not in contact but which will be inaccessible after assembly or erection shall be painted two coats.

(e) Machine Finished Surfaces: With the exception of abutting chord and column splices and column and truss shoe bases, machine-finished surfaces shall be coated as soon as practicable after being accepted, and before removal from the shop, with a hot mixture of white lead and tallow. Surfaces of iron and steel castings, machine-finished for the sole purpose of removing scales, fins, blisters or other surface deformations, shall be given the shop coat of paint.

The composition used for coating machine-finished surfaces shall be mixed in the following proportions: 4

pounds tallow, 2 pounds white lead and 1 quart linseed oil.

**Field Painting:**

All steel work on bridges shall be painted according to these specifications unless otherwise specified.

The first field coat of paint applied to the steel work shall be tinted to a shade readily distinguishable from preceding and succeeding shop and field coats of paint.

The final coat of field paint shall not be applied to the steel work below the highway floor level until the concrete roadway slab has been completed and the metal work carefully cleaned of all concrete materials.

As soon as the field cleaning has been done to the satisfaction of the inspector, the heads of field rivets and bolts, and any surfaces from which the shop coat of paint has been worn off or has become otherwise defective shall be covered with one coat of the same paint as was used in the shop. When the paint applied for touching up rivet heads and abraded surfaces has become dry the first field coat may be applied. In no case shall a coat be applied until the previous coat has dried throughout the full thickness of the paint film.

Small cracks and cavities which have not been sealed in a watertight manner by the first field coat shall be filled with the red lead paste before the second field coat is applied.

All pins and pin holes shall be carefully cleaned of the shop coat of tallow and white lead, and of rust and dirt, and given before erection, a substantial coat of graphite and tallow in proportions satisfactory to the Project Engineer.

In the application of aluminum paint by brushing, the finish strokes shall generally be in the same direction.

Where timber decks are provided, the top flanges of all stringers and floor beams shall be protected by a covering composed of a heavy layer of bituminous material (tar, asphalt or pitch) applied hot and one thickness of two-ply tar paper wide enough to project three inches beyond the edges of the members. These edges shall be bent down at an angle of 45 degrees.

### Painting of Timber and Other Surfaces:

Parts of timber structures, other than rails and rail posts, which are to be painted shall be designated on the plans or in the special provisions.

Metal parts, except hardware, shall be given one coat of shop paint and, after erection, two coats of field paint.

### METHOD OF MEASUREMENT:

No measurement will be made for painting, unless specifically provided for in the contract.

### BASIS OF PAYMENT:

No direct payment will be made for painting of any of the structures or surfaces described above unless pay items for painting are included in the contract. The contract prices for the various structures and surfaces to be painted shall include the cost of furnishing all materials, labor, etc., to properly complete, in accordance with these specifications, all painting required.

## TREATMENT OF TIMBER WITH WATER-BORNE SALTS

### DESCRIPTION:

These items shall consist of the treatment of timber with water-borne salts as specified.

All lumber or timber to be treated shall retain the following amounts of preservative:

### Minimum Absorption of Preservative

USES	Pounds of Preservative per Cubic Foot of Wood		
	Wolman Salts	Zinc Meta-Arsenite	Zinc Chloride Chromated
Unpainted Timber for General Bridge Construction and other uses, except Marine.....	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{3}{4}$
Painted Timber.....	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{2}$

## **MATERIALS:**

Wolman salts shall conform to the requirements specified in M-119.

Zinc meta-arsenite shall conform to the requirements specified in M-122.

Chromated zinc chloride shall conform to the requirements specified in M-29.

## **CONSTRUCTION METHODS:**

### **Penetration of Treatments:**

Test for penetration shall be made by taking borings and all holes so bored shall be plugged by the contractor with tight fitting plugs. Any penetration exceeding two inches in depth shall be considered as full sapwood penetration. In the case of sawn timbers, the location of the test borings shall be selected at the point of maximum sapwood thickness. In gaging the depth penetrated by preservatives the method used shall be such as will enable the Project Engineer to determine, to his satisfaction, the actual depth penetrated. The Project Engineer reserves the right to reject any material which when tested shows insufficient penetration of preservatives.

### **Wolman Salts Treatment:**

Treatment with Wolman salts shall be by the full cell process; and the ranges of temperature, pressure, and time duration shall be controlled so as to result in maximum penetration by the quantity of preservative solution injected.

In general, the material to be treated shall have been seasoned by air drying, or kiln drying, or a combination of both until the moisture content in the treatable areas of the wood has been reduced to not more than 20 per cent of the oven-dry weight of the wood. When it is necessary to treat lumber or timber having a greater moisture content than 20 per cent, such material shall be artificially seasoned in the retort by alternate steam bath and vacuum of such intensity and duration and such number of cycles as will prepare

the material for a minimum absorption of solution to provide the stipulated net dry salt retention. In no case shall the steam pressure be such as to exceed a maximum temperature in the retort of 240°F; and for Douglas fir and other more sensitive woods, the maximum pressure shall be not more than 20 pounds per square inch and the steaming period shall not exceed six (6) hours, which pressure and temperature maxima shall not be reached in less than two (2) hours. The retort shall be relieved of condensate and wood extracts continuously during both the steaming and the vacuum periods. After the final vacuum, the treating solution shall not be admitted to the retort until all such condensate and wood extracts have been evacuated thoroughly.

The concentration of Wolman Salts in the solution shall be so adjusted that the injected quantity of solution, after the carrier water has dried out, shall leave not less than 90 per cent nor more than 100 per cent of the stipulated dry salt retention, in any one charge.

Concentration of the treating solution shall be taken as the percentage of weight of dry salt relative to the total weight of the solution, the weight of water being taken as 62.30 pounds per cubic foot at a temperature of 60° F. When the quantity of impregnated solution is determined by volume, the corresponding weight of the solution shall be corrected by the proper factor for any temperature other than 60° F., at which the reading for volume may have been taken. The weight of a solution shall be considered as the actual weight of the water plus 5/6 of the weight of the dissolved salts.

Before and after each charge, the density of the treating solution shall be observed by means of a calibrated hydrometer, and the concentration of the salts in the solution shall be calculated.

Refractory wood such as Douglas fir, green timber, partly seasoned timber or heartwood lumber, for which the heavier concentrations of treating solutions are required, shall not be placed for treatment in the same charge with non-refractory woods. For either class of



material the concentration of treating solution shall provide the net dry salt retention stipulated, with the largest amount of absorption practicable for the kind of material treated.

The properly conditioned material, closed off in a tightly sealed retort, shall be subjected to an initial vacuum of not less than 27 inches for not less than 15 minutes after the maximum has been reached. Then, with the vacuum apparatus remaining in operation so that the vacuum is fully maintained until the material to be impregnated has been wholly submerged, the treating solution shall be admitted to the retort, continuing until the retort is completely filled. Thereafter additional solution shall be forced into the retort by a pressure pump as rapidly as it is absorbed by the wood, and in such volume as gradually to build up the pressure of the solution within the retort to a maximum of 150 pounds per square inch for southern pine, and to a maximum of 175 pounds per square inch for Douglas fir and other similar refractory kinds of wood.

The pumping may be discontinued at intervals to observe the rate of absorption. The pressure shall be raised finally to the maximum and maintained until the amount of preservative solution required to comply with the stipulated net retention has been injected, or until less than five (5) percent of the total quantity required has been injected during the latter half of one hour throughout which the rate of absorption has steadily decreased while the pressure has been maintained at the maximum.

The temperature of the treating solution shall be not less than 120° F. nor more than 200° F. during the pressure period, except that when the wood is of resinous character and is to be painted, the temperature of the treating solution shall not be such as to result in interference with the painting, but it shall not be less than 100° F.

After the pressure period, the retort shall be emptied of preservative solution and the air pressure adjusted so that when the charge is removed it will be

free from drip or further loss of impregnated solution. All drip in the retort or solution extracted by final vacuum shall be returned to the work tank before the readings are taken to determine the amount of absorption of the preservative solution.

Readings of volume and temperature of the solution in the work tank shall be taken by means of suitable, accurate devices on the tank. Readings shall be taken before introduction of the solution into the charged retort, at the start of the pressure pumping, after the first return of solution from the retort, and after the final return. A record shall be made of the readings for use in calculation of the initial absorption, kick-back and total remaining solution that has been injected into the charge.

#### **Zinc Meta-Arsenite Treatment:**

Only properly conditioned material shall be treated. Treatment with zinc meta-arsenite shall conform to the following requirements: No charge shall retain less than 90 per cent of the quantity of preservative specified, but the average retention of preservative by the material treated under any contract or order shall be at least 100 per cent of the quantity specified. The amount of preservative retained shall be calculated on the basis of preservative at 60° F. The net amount of preservative retained in the wood shall be the difference between the salt in the measuring or weighing tank at the start and at the end of the treatment, after the solution from the cylinder, including all drip from the wood at the conclusion of the final vacuum period, has been returned to the measuring or weighing tank. This net retention shall be determined from the initial and final readings on the measuring or weighing tank using suitable, accurate devices thereon and from analysis of the solution in the tank at the start and at the end of the treatment.

The preservative solution shall have such a strength that the material to be treated shall have the required retention of preservative with the largest volumetric absorption practicable

### **Chromated Zinc Chloride Treatment:**

Treatment with chromated zinc chloride shall be by pressure process. The treating solution, which shall not have a strength exceeding five (5) per cent, and which shall be no stronger than necessary to obtain the required retention of preservative with the greatest volumetric absorption practicable, shall be thoroughly mixed before use. Air-seasoned timber may be steamed in the cylinder for not less than one (1) hour nor more than two (2) hours, at a pressure of not more than twenty (20) pounds per square inch. Green Douglas fir shall be steam-seasoned at a pressure of not more than twenty (20) pounds per square inch for a period not exceeding six (6) hours at not more than 260° F., which pressure and temperature maxima shall not be reached in less than two (2) hours. After steaming is completed, a vacuum of at least 22 inches shall be maintained for not less than 15 minutes or until the wood is as dry and free of air as practicable. If the vacuum is broken while the condensate is being drained from the cylinder, a second vacuum as high as the first shall be created. The preservative shall be introduced without breaking the vacuum until the cylinder is filled. The pressure shall then be raised to and maintained at a minimum of 100 pounds per square inch until the quantity of preservatives required to insure the final retention stipulated is injected into the timber, or until less than 5 per cent of the total quantity required has been injected during the latter half of 1 hour throughout which the rate of injection has decreased while the pressure has been held continuously at 125 or more pounds per square inch. The temperature of the preservative during the pressure period shall not be less than 140° F., nor more than 200° F., and shall average at least 150° F. After the pressure is completed, the cylinder shall be emptied speedily of preservative and a vacuum promptly created and maintained until the wood can be removed from the cylinder free of dripping preservative.

### **Full-Cell Process:**

The wood shall be subjected to a vacuum of suf-

ficient intensity and duration to insure that the wood is as dry and free of air as practicable, and to permit a retention of the specified amount of preservative per cubic foot of wood.

The preservative shall be introduced at atmospheric temperature or not less than 60°F. The cylinder shall be filled without breaking the vacuum. The pressure shall then be raised to and maintained at a minimum of 100 pounds per square inch or until the quantity of preservative required to insure the final retention stipulated is injected into the wood, or until the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not more than 110°F. After pressure is completed the cylinder shall be speedily emptied of preservative, and a vacuum of not less than 22 inches promptly created and maintained until the wood can be removed from the cylinder free of dripping preservative.

#### **BASIS OF PAYMENT:**

Payment for the preservative treatment of timber and piling will be made as provided for in the various contract items for treated materials.

## **CREOSOTE TREATMENT FOR TIMBER**

#### **DESCRIPTION:**

Preservative treatments for timber, lumber and piling shall consist of creosoting as specified on the plans or in the special provisions.

Timber and piling shall be treated to retain the following amount of creosote oil, as specified:

Timber, Southern Yellow Pine, Douglas Fir—12 or 16 lbs. per cu. ft.

Piling, Southern Yellow Pine, not located in coastal waters—16 lbs. per cu. ft.

Piling, Southern Yellow Pine, located in coastal waters, 20 lbs. per cu. ft.

## **EQUIPMENT:**

Treating plants shall be equipped with the thermometers and gages necessary to indicate and record accurately the conditions at all stages of treatment, and all equipment shall be maintained in a condition satisfactory to the purchaser. The apparatus and chemicals necessary for making the analysis and tests required by the purchaser shall also be provided by plant operators, and kept in condition for use at all times.

## **MATERIAL:**

Creosote shall conform to the requirements specified in M-27.

Creosote coal tar solution shall conform to the requirements specified in M-27.

Timber shall be treated with creosote.

Piling shall be treated with creosote coal tar solution.

## **CONSTRUCTION METHODS:**

### **Seasoning:**

(a) Air Seasoning: Materials to be treated, preferably, shall be air-seasoned until the moisture remaining in the wood will not prevent the injection and proper distribution of the specified amount of preservative. For air-seasoning the materials shall be stored as follows: Lumber shall be segregated according to size and each layer in the pile shall be separated by at least 1-inch strips with an air space of 1-inch or more between each two pieces of lumber in any layer; for large timbers, at least 2-inch strips shall be used to separate the layers. Alleys at least 3 feet wide shall be left between rows of stacks and the materials shall be at least 12 inches off the ground on concrete or treated timber sills. Piles shall be stored in like manner, placing as nearly as practical only one length in a stack, using at least 2-inch strips or saplings of equal size between each layer, and reversing all sticks in every other layer in order to keep the stack level. The space under and

between the rows of stacks shall be kept free at all times of wood, weeds or rubbish. The yard shall be so drained that no water can stand under the stacks or in their immediate vicinity.

(b) Steam Seasoning for Southern Yellow Pine: Southern Yellow Pine may be steam seasoned until the moisture remaining in the wood will not prevent the injection and proper distribution of the specified amount of preservative. The material shall be steamed in the cylinder at not more than 20 to 25 pounds pressure per square inch for not more than 12 hours for sawed timber and not more than 20 hours for piles, at a temperature not to exceed 274° F., the maximum pressure being reached in not less than 2 hours. The cylinder shall be provided with vents to allow the escape of air and insure proper circulation of the steam. After steaming is completed, a minimum vacuum of 22 inches shall be maintained for not less than 2½ hours, or until the wood is as dry and free from moisture as practicable. The cylinder shall be relieved continuously or frequently enough to prevent condensate from accumulating in sufficient quantity to reach the wood. Before the preservative is introduced the cylinder shall be drained of condensate.

(c) Oil Seasoning for Douglas Fir: Douglas Fir may be seasoned by boiling in oil under a vacuum until the moisture remaining in the wood will not prevent the injection and proper distribution of the specified amount of preservative.

The materials shall be boiled in creosote under a vacuum at temperatures which do not exceed 220°F. for piling, and 200°F. for sawed timber and lumber. A minimum vacuum of 20 inches shall be maintained during boiling. The seasoning period shall be maintained until condensation passing off from the timber is at the rate of approximately 1/10 of a pound per cubic foot of timber per hour for full-cell and open tank processes and ¼ of a pound per cubic foot of timber per hour for empty-cell process.

### **Preparation for Treatment:**

Each cylinder charge shall consist of pieces approximately equal in size and moisture and sapwood content, into which approximately equal quantities of preserving fluid can be injected. Pieces shall be so separated as to insure contact of steam and preservatives with all surfaces.

### **Creosote Treatments, Pressure:**

(a) Full Cell Process Southern Yellow Pine: Southern Yellow Pine shall be treated by the full-cell process, as follows:

The timber shall be subjected to a vacuum of sufficient intensity and duration to render the wood as dry and free from air as practicable, and to permit a retention of the specified number of pounds of preservative per cubic foot of wood.

The preservative shall be introduced between 165° F. and 200° F., and the cylinder filled without breaking the vacuum. The pressure shall then be raised to and maintained at a minimum of 100 pounds per square inch or until the specified quantity of preservative is injected into the wood, or until the Project Engineer's representative is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not less than 150° F., nor more than 200° F., and shall average at least 180° F. After the pressure is completed the cylinder shall be emptied speedily of preservative, and a vacuum of not less than 22 inches promptly created and maintained until the wood can be removed from the cylinder free of dripping preservative.

(b) Full Cell Process, Douglas Fir: Douglas Fir shall be treated by the full-cell process as follows.

It is not required that air-seasoned or kiln dried Douglas Fir be boiled under a vacuum, but it may be desirable to hold the materials in a creosote bath maintained at a temperature of 180° F., to 190° F., for a length of time which, combined with the pressure pe-

riod is, in the judgment of the operator, necessary to secure the specified absorption.

Following the heating period, in the case of air-seasoned material, and the period of seasoning under vacuum in the case of material artificially seasoned, the cylinder shall be filled with creosote and pressure applied as required to a maximum limit of 170 pounds per square inch and maintained, taking into consideration the quantity of creosote absorbed during the bath, until the specified absorption of creosote has been obtained.

Temperature of the creosote during the pressure period shall be as high as possible with a minimum limit of 160° F., and a maximum limit of 200° F.

After the pressure is completed the cylinder shall be emptied of creosote and a vacuum at least 20 inches promptly created and maintained for a sufficient period of time to free the material of dripping creosote.

(c) Penetration: The range of pressure, temperature, and time duration shall be controlled so as to result in a maximum penetration by the quantity of preservative injected. The vacuum requirements stipulated are in inches of mercury at sea level, and necessary corrections shall be made for altitude.

In southern yellow pine the preservative shall permeate all of the sapwood and as much of the heartwood as practicable.

In Douglas fir the minimum penetration for the specified amount of creosote oil shall be as follows:

Specified Amount of Creosote per Cubic Foot=16 pounds.

Piling .....	1.00 inch
Timber 12 inches by 12 inches and larger	1.00 inch

For timber less than 12 inches by 12 inches the required depth of penetration shall be determined by the formula:



$$P = P_s \frac{R}{R_s}$$

Where P = Required penetration.

$P_s$  = Specified penetration for 12-inch by 12-inch timbers.

R = Ratio of the volume of the piece in question to its superficial area.

$R_s$  = Ratio of the volume of a 12-inch by 12-inch timber to its superficial area.

The penetration of the preservative shall be based on black or dark oil, and in no case will light discoloration of the wood, due to treatment, be taken into consideration in measuring the depth of penetration.

Tests for penetration shall be made by taking borings with an increment borer, or a  $\frac{5}{8}$ -inch auger, all holes so bored to be plugged by the contractor with tight-fitting creosoted plugs.

As many penetration tests of timber and piling shall be made as is considered necessary by the inspector. In the case of piling, the holes shall be bored midway between the ends.

In the case of timber and lumber every fourth stick of the charge may be bored.

#### **Creosote Treatments, Non-Pressure:**

(a) Use: Non-pressure treatments shall not be used except when specifically shown on the plans or specified in the contract.

(b) Open-Tank Treatments:

1. General Requirements: Open tank treatment shall consist of a hot bath treatment or a hot and cold bath treatment as may be specified.

All timber to be treated shall be free from dirt, grease or other foreign matter which will in any way hinder the free penetration of the preservative. Framing shall be done before treatment. Round timber or timber with wane shall have the rough bark and inner bark removed as specified for timber piling in "Bearing Piles."

All tanks used in the open tank process shall be of sufficient size to allow free circulation of the liquid around the largest amount of timber being treated in any operation.

Sufficient liquid shall be maintained in the tanks to completely immerse the timber. When a number of pieces are being treated in each operation, each stick shall be separated from the others on all sides by square or round spacers not less than  $\frac{1}{4}$ -inch in least dimension. Suitable slings and handling devices shall be provided for the transfer of material necessary during the complete process without disturbing the stacked position of the pieces in the bundle.

For hot bath treatments at least one tank shall be supplied having suitable steam coils or other heating device to keep the liquid at a uniform temperature of not less than 240°F. throughout the tank during the complete process.

For hot and cold bath treatments at least one hot tank shall be supplied as for the hot bath treatment and one cold tank having the same capacity as the hot tank. The cold tank shall be equipped with suitable cold water coils or water jackets, so that the temperature of the liquid at the time of immersion of each batch of timber shall be no higher than the surrounding atmospheric temperature.

The time of immersion as specified below is for southern yellow pine. The specified time of immersion shall be increased  $66\frac{2}{3}$  per cent for southern cypress and Douglas fir.

2. Single or Hot Bath Treatment: The timber shall be completely immersed in preservative in the hot tank, which shall be maintained at a temperature of 190° F. for seasoned timber, and 230° F. for timber not seasoned. A tolerance of 10 degrees in either direction is permissible. For seasoned timber, the immersion shall be for a period of not less than 15 minutes for 2-inch timber with an increase of 5 minutes in the immersion period for each additional inch in thickness. For unseasoned timber, the immersion period shall be doubled.

3. Ordinary Hot and Cold Treatment: The timber shall be completely immersed in preservative in the hot tank, which shall be maintained at a temperature of 190° F., for seasoned timber and 230° F. for timber not seasoned. A tolerance of 10 degrees in either direction is permissible. For seasoned timber the immersion shall be for a period of not less than 15 minutes for 2-inch timber with an increase of 5 minutes in the immersion period for each additional inch in thickness. For unseasoned timber the immersion period shall be doubled. At the end of this period the timber shall be removed from the hot tank and immediately immersed in the cold tank. At the time of transfer, the preservative in the cold tank shall have a temperature as low as possible, but in no case higher than the surrounding air temperature. The timber shall be completely immersed in the cold tank for a period of one-half as long as for the hot bath.

Successive charges from the hot tank may be placed first in one cold tank and the next in a second cold tank in order to keep the cold tank temperature as low as possible at the time of immersion. Should the contractor supply a cold tank capable of handling all material and with a cooling system which will secure the specified temperature at the time of all cold treatments as specified, only one cold tank may be required. Single cold tank equipment shall be subject to the approval of the Project Engineer.

4. Heavy Hot and Cold Treatment: The requirements for this treatment are the same as those specified above for the ordinary hot and cold treatment except that the time of immersion in the cold bath shall be the same as the time of immersion in the hot bath.

(c) Brush Treatment:

All timber to be given brush treatment shall be free from atmospheric moisture, and in no case shall brush treatment be applied when the surface of the timber is wet. The surfaces to be treated shall be free from dirt, grease, or other foreign matter which will in any way hinder the maximum penetration of the preservative.

The preservative shall be heated in proper receptacles immediately adjacent to the point of application and shall be applied within the temperature range of 170° F. to 190° F. for seasoned wood and 220° F. to 240° F. for unseasoned wood.

A minimum of 2 coats shall be applied to all surfaces to be treated except cut ends, joints and mortises, which shall be given 3 coats. Each coat shall be allowed to penetrate before applying the next coat. All checks, bolt holes and cracks shall be run full of the preservative oil and an extra heavy treatment shall be given to knotty spots.

(d) Spray Treatment:

The condition of the timber prior to spray treatment shall conform to the requirements specified for brush treatment.

The temperature of the preservative shall be maintained at 240°F. The shortest length of hose practicable shall be used to prevent undue chilling between the spray tank and nozzle. Preservative shall be renewed frequently in the spray tank to prevent chilling. The spray shall be applied with a good pressure and only fine enough to prevent waste, until the preservative begins to run. Equipment employing air pressure which has a cooling effect on the hot preservative shall not be used.

Two liberal applications shall be made, allowing sufficient time for the absorption of the first application before the second is made.

**Creosote Treatments, Empty-Cell Process:**

Whenever it is desirable to warm dry lumber, it shall be heated in preservative gradually to not more than 190°F. and held at that temperature for not more than 6 hours.

(a) Empty-Cell Process With Initial Air:

Following the heating period, in the case of dry lumber, or the seasoning-by-boiling-under-vacuum period, in the case of green lumber, the cylinder shall be

emptied of preservative and the lumber shall be subjected to air pressure of sufficient intensity and duration to provide under a vacuum the ejection of surplus preservative and to insure a retention and proper distribution of the stipulated number of pounds of preservative per cubic foot of lumber.

The preservative shall then be reintroduced, the cylinder pressure being maintained constant until the cylinder is filled with preservative. The pressure shall then be raised and maintained within a maximum of 175 lbs. per sq. inch until there is obtained the largest practicable volumetric injection that can be reduced to the required retention by a quick high vacuum, or, failing this, until the Department's representative is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not less than 160°F. nor more than 200°F. and shall average at least 180°F.

After pressure is completed the cylinder shall be emptied speedily of preservative and a vacuum of at least 20 in. promptly created and maintained until the lumber can be removed from the cylinder free of dripping preservative; or, after pressure is completed and before removal of preservative from the cylinder, the preservative surrounding the lumber may be reheated to a maximum of 210°F., the steam to be turned off the heating coils within 30 minutes after the maximum temperature is reached. The total time consumed, until the steam is turned off the coils in this expansion bath, shall not exceed 2 hours. The preservative shall then be removed from the cylinder and the vacuum applied as specified above; or, after the pressure is completed and before removal of preservative from the cylinder, the preservative surrounding the lumber may be reheated to a maximum of 210°F., and a vacuum created during this heating period to further assist in expelling excess preservative from the lumber, the steam to be turned off the heating coils within 30 minutes after the maximum temperature is reached. The total time consumed, until the steam is turned off the coils in this

expansion bath, shall not exceed 2 hours. The preservative shall then be removed from the cylinder and the vacuum applied as specified above.

(b) Empty-Cell Process Without Initial Air:

Following the heating period, in the case of dry lumber, or the seasoning-by-boiling-under-vacuum period, in the case of green lumber, the cylinder shall be emptied of preservative and atmospheric pressure established. The preservative shall then be reintroduced to the lumber until the cylinder is filled. Pressure shall then be raised and maintained within a maximum of 175 lbs. per sq. in. until there is obtained the largest practicable volumetric injection that can be reduced to the required retention by a quick high vacuum or, failing this, until the Department's representative is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not less than 160°F. nor more than 200°F. and shall average at least 180°F.

After pressure is completed, the cylinder shall be emptied speedily of preservative and a vacuum of at least 20 in. promptly created and maintained for not less than 30 min. until the quantity of preservative injected is reduced to the required retention and the lumber can be removed from the cylinder free of dripping preservative; or, after pressure is completed and before removal of preservative from the cylinder, the preservative surrounding the lumber may be reheated to a maximum of 210°F., the steam to be turned off the heating coils within 30 minutes after the maximum temperature is reached. The total time consumed until the steam is turned off the coils in this expansion bath, shall not exceed 2 hours. The preservative shall then be removed from the cylinder and the vacuum applied as specified above; or, after the pressure is completed and before the removal of preservative from the cylinder, the preservative surrounding the lumber may be reheated to a maximum of 210°F., and a vacuum created during this heating period to further assist in expelling excess preservative from the lumber, the steam

to be turned off the heating coils within 30 minutes after the maximum temperature is reached. The total time consumed, until the steam is turned off the coils in this expansion bath, shall not exceed 2 hours. The preservative shall then be removed from the cylinder and the vacuum applied as specified above.

(c) Penetration:

The range of pressure, temperature, and time duration shall be controlled so as to result in a maximum penetration by the quantity of preservative injected. The vacuum requirements stipulated are in inches of mercury at sea level, and necessary correction shall be made for altitude.

The penetration of the preservative shall be based on black or dark oil, and in no case will light discoloration of the wood, due to treatment, be taken into consideration in measuring the depth of penetration. The right is reserved to reject any material which, when tested, shows insufficient penetration of preservative.

Test for penetration shall be made by taking borings with an increment borer, or a five-eighths ( $\frac{5}{8}$ " ) inch auger. All holes so bored shall be plugged with tight fitting creosoted plugs without expense to the Department. Every fourth stick of a charge may be bored.

(d) Retention of Preservative:

No charge shall contain less than 100 per cent of the quantity of preservative specified; but the average retention of the preservative by the material treated under any contract or order shall be at least 100 per cent of the quantity specified. The amount of preservative retained shall be calculated on the basis of preservative at 100°F., from readings of working-tank gauges or scales or from weights before and after treatment of loaded trams on suitable track scales, with a correction for difference in moisture content, and checked as may be desired by the Department's representative.

Note: The treating plants which are unfamiliar with the treatment of Douglas fir should keep well within

the maximum temperatures permitted in this specification as it has been found that Douglas fir from some localities and in various degrees of dryness may be damaged when held at these maximum temperatures too long or in combination with high pressures. In some cases the liability to damage increases with the dryness of the lumber.

**BASIS OF PAYMENT:**

Payment for the preservative treatment of timber and piling will be made as provided for in the various contract items for treated materials.

## STRUCTURAL EXCAVATION ITEM 709

**DESCRIPTION:**

This item shall include the excavation for abutments and piers for all types of bridges and the satisfactory disposal of the material excavated.

**CONSTRUCTION METHODS:**

**General:**

The contractor shall notify the Project Engineer a sufficient time in advance of the beginning of excavation for structures, so that the cross-sectional elevations and measurements may be taken of the undisturbed ground. Any materials removed or excavated before these measurements have been taken will not be paid for. The natural ground adjacent to the structure shall not be disturbed without permission of the Project Engineer.

Trenches or foundation pits for structures or structure footings shall be excavated to the lines and grades or elevations shown on the plans or as stated by the Project Engineer. They shall be of sufficient size to permit the placing of the full width and length of structure or structure footings shown.



Boulders, logs, or any other unforeseen obstacles encountered in excavation shall be removed. All rock or other hard foundation material shall be cleaned of all loose material and cut to a firm surface, either level, stepped, or serrated, as directed by the Project Engineer. All seams or crevices shall be cleaned out and grouted. All loose and disintegrated rock and thin strata shall be removed. When masonry is to rest on an excavated surface other than rock, special care shall be taken not to disturb the bottom of the excavation and the final removal of the foundation material to grade shall not be made until just before the masonry is to be placed. Where foundation piles are used, the excavation of each pit shall be completed before the piles are driven. After the driving is completed, all loose and displaced material shall be removed, leaving a smooth solid bed to receive the masonry.

No classification of structural excavation will be made, regardless of material encountered, unless specifically stated in the special provisions.

**Disposal of Material:**

All excavated material, so far as suitable, shall be utilized as backfill or embankment. The surplus material, whether or not temporarily allowed to be placed within the stream area, shall be disposed of finally in such manner as not to obstruct the stream or otherwise impair the efficiency or appearance of the structure. No excavated material shall be deposited at any time so as to endanger the partly finished structure, either by direct pressure or indirectly by over-loading banks contiguous to the operation, or other manner.

**Cofferdams:**

(a) Suitable and practically watertight cofferdams shall be used wherever waterbearing strata are encountered above the elevation of the bottom of the excavation. Upon request, the contractor shall submit drawings showing his proposed method of cofferdam construction and other pertinent features not shown in detail on the plans. Such drawings shall be approved

by the Project Engineer before construction is started, but such approval shall not operate to relieve the contractor of any of his responsibilities under the contract for the successful completion of the improvement.

(b) Cofferdams or cribs for foundation construction shall, in general, be carried well below the bottom of the footings and shall be well braced and as watertight as practicable. In general, the interior dimensions of cofferdams shall be such as to give sufficient clearance for the construction of forms and the inspection of their exteriors, and to permit pumping outside of the forms. Cofferdams or cribs which are tilted or moved laterally during the process of sinking shall be righted or enlarged so as to provide the necessary clearance and this shall be at the expense of the contractor.

(c) When conditions are encountered which, in the opinion of the Project Engineer, render it impracticable to unwater the foundation before placing masonry, the Project Engineer may require the construction of a concrete foundation seal of such dimensions as may be necessary, and of such thickness as to resist any possible uplift; concrete for such seal shall conform to all the special requirements for "Depositing Concrete Under Water," in item for "Concrete." The foundation shall then be pumped out and the balance of the masonry placed in the dry. When weighted cribs are employed and the weight utilized to overcome partially the hydrostatic pressure acting on the bottom of the foundation seal, special anchorage such as dowels or keys shall be provided to transfer the entire weight of the crib into the foundation seal. When a foundation seal is placed under water, the cofferdam shall be vented or ported at low-water level as directed.

(d) Cofferdams shall be constructed so as to protect green concrete against damage from sudden rising of the stream and to prevent damage to the foundation by erosion. No timber or bracing shall be left in cofferdams or cribs in such a way as to extend into the substructure masonry, without written permission from the Project Engineer.

(e) Any pumping from the interior of any foundation enclosure that may be permitted shall be done in such a manner as to preclude the possibility of any portion of the concrete materials being carried away. No pumping will be permitted during the placing of concrete, or for a period of at least twenty-four hours thereafter, unless it is done from a suitable pump separated from the concrete work by a watertight wall. Pumping to unwater a sealed cofferdam shall not commence until the seal has set sufficiently to withstand the hydrostatic pressure.

(f) Unless otherwise provided, cofferdams or cribs with all sheeting and bracing involved therein shall be removed by the contractor after the completion of the substructure. The removal shall be effected in such a manner as not to disturb or mar the finished masonry.

#### **Depth of Footing:**

The elevations of the bottoms of footings, as shown on the plans, shall be considered as approximate only and the Project Engineer may order, in writing, such changes in dimensions or elevations of footings as may be necessary to secure a satisfactory foundation.

#### **Approval:**

After each excavation is completed, the contractor shall notify the Project Engineer, and no masonry shall be placed until after the Project Engineer has approved the depth of the excavation and the character of the foundation material.

#### **Backfilling:**

After the structure has been completed, the areas around the foundations shall be filled with approved material, in horizontal layers not over six inches in depth, and compacted satisfactorily to the level of original surrounding surfaces.

No backfilling shall be placed against any abutment, wing wall or retaining wall until permission shall have been given by the Project Engineer. In the case of

concrete or other masonry, such permission will preferably not be given until the masonry has been in place fourteen days, or until tests made by the laboratory under the supervision of the Project Engineer have established that the concrete has attained sufficient strength to withstand any pressure created by the methods used and materials placed without damage or strain beyond a safe factor.

Adequate provision shall be made for thorough drainage and drains shall be placed at weep holes.

Fill placed around piers shall be deposited on both sides to approximately the same elevation at the same time. All filling adjacent to structures shall be deposited in horizontal layers and compacted as prescribed. Special care shall be taken to prevent any wedging action against the structure and all slopes bounding or within the areas to be backfilled shall be stepped or serrated to prevent such wedge action.

In backfilling abutments, retaining walls or other structures, the bed for the backfill shall be so prepared and serrated and the backfill shall be so built up in horizontal layers that at all times there shall be a horizontal berm of thoroughly compacted material beyond the structure for a distance at least equal to the height of the abutment or wall to be backfilled except insofar as undisturbed material obtrudes into this area. Each layer of this berm, if dry, shall be moistened and then compacted by tamping with mechanical rammers or by hand tamping with heavy iron tampers having a tamping face not exceeding twenty-five square inches in area.

By mechanical rammer is meant equipment designed to tamp the relatively thin layers herein prescribed. The use of drop pile hammers, loaded or unloaded clam shell or other similar unsuitable equipment for this purpose is prohibited within the berm area mentioned above as well as the dropping of any heavy weight for the purpose, more than ten feet. Jetting of fills, or other hydraulic methods involving or likely to involve liquid or semiliquid pressure within this berm area, is

prohibited within the area contiguous to the abutment or wall to be backfilled and for a distance therefrom equal to two and one-half times the height thereof above low water.

**METHOD OF MEASUREMENT:**

The cubic yards of structural excavation to be measured shall be the theoretical volume obtained by measuring the excavation to the bottom of the footings and of a size 12 inches outside of the neat footings and parallel thereto. The cross sectional area measured shall not include water or other liquid, but shall include mud, muck or semi-solid material which has not been disturbed by the contractor and which can not be drained away.

When it is necessary, in the opinion of the Project Engineer, to carry the foundations below the elevations shown on the plans, the excavation for the first three feet of additional depth will be included in the quantity for which payment will be made under the item "Structural Excavation." Excavation below this additional depth will be paid for as extra work.

Yardage of rehandling and excavation for pile bents not having a footing shall not be measured.

Backfill shall not be measured.

**BASIS OF PAYMENT:**

The number of cubic yards of excavation measured as specified shall be paid for at the contract unit price per cubic yard for "structural excavation," which price and payment shall constitute full compensation for all excavation, for furnishing, placing, moistening, and compacting backfill material, as required; for disposing of surplus material; for any clearing and grubbing work involved and not covered under an item for clearing or grubbing; for all bailing, draining and sheeting; for the construction of cribs or cofferdams, unless otherwise specified; and for furnishing all labor, equipment, tools and incidentals necessary to complete the excavation.

Payment will be made under:

Item 709, Structural Excavation, per cubic yard.

# CLEANING, SCRAPING AND PAINTING STRUCTURAL STEEL ITEM 739

## **DESCRIPTION:**

This item shall consist of the cleaning, scraping and painting of structural steel in existing bridges, or structures.

## **MATERIALS:**

### **Paint:**

Paint used on this work shall conform to the requirements of "Painting" of these specifications.

## **CONSTRUCTION METHODS:**

### **General:**

Surfaces of metal to be repainted shall be cleaned thoroughly removing rust, old paint, dirt, oil, grease and other foreign substances. Cleaning shall be done by means of metal brushes, scrapers, chisels, hammers or other effective means. Oil and grease shall be removed by the use of gasoline or benzine. Bristle brushes shall be used for removing loose dirt. Cleaning of metal shall be continued until, in the opinion of the Project Engineer, the condition is satisfactory for the application of paint.

The composition and application of the paint shall conform to the requirements of "Painting" of these specifications.

Structural steel surfaces to be repainted shall be given three coats of paint as follows:

1. First coat—red lead paint.
2. Second coat—red lead paint, tinted with 1 ounce of lamp black, paste form, to 1 gallon of finished paint.
3. Third coat—aluminum paint.

Alternate coats for the second and third coats spe-

cified above may be used only when the written approval of the Project Engineer has been obtained.

**METHOD OF MEASUREMENT:**

Cleaning, scraping and painting, where called for in the contract, will be measured on a lump basis, which shall include all work of this nature to be performed under the contract.

**BASIS OF PAYMENT:**

The item "Cleaning, Scraping and Painting Structural Steel," when included in the contract, shall be paid for on a lump sum basis, which price and payment shall constitute full compensation for all materials, labor, equipment and tools necessary to complete the item.

Payment will be made under:

Item 739, Cleaning, Scraping and Painting Structural Steel, per lump.

**MOVABLE BRIDGE MACHINERY  
ITEM 742  
POWER PLANT, ITEM 743  
OPERATING HOUSE, ITEM 744**

**DESCRIPTION:**

These items shall consist of the design, construction and installation of movable bridge machinery, power plant or operating house.

**MATERIALS:**

All materials shall conform to the requirements specified in "MOVABLE BRIDGES," specification.

**CONSTRUCTION METHODS:**

The design, construction and installation of movable bridge machinery, power plant and operating house

shall conform to the requirements specified in "MOVABLE BRIDGES," specification.

#### METHOD OF MEASUREMENT:

(a) Movable Bridge Machinery: Movable bridge machinery will be measured by the lump and the measurement shall include all gears, including gears for operating limit switches, shafts, couplings, bearings, castings, wedges, wedge bases, latches, speed reducers, lubricating system, center pivots, rack and track, bearing discs, balance wheels, trunnions, pins, trunnion bearings, sleeves, tower sheaves, counterweight ropes and fittings, bolts, screws, bolts and nuts connecting machinery parts to structural steel, steel castings which form an integral part of the machinery, hand-operated roadway traffic gates, oil burning navigation lights, mechanically operated position indicators, and all other parts and fittings necessary for the satisfactory operation of the bridge.

(b) Power Plant: Power plants will be measured by the lump and the measurement shall include all operating gear, lock and miscellaneous electrical motors; internal combustion engines with all incidental parts; electrical generator sets; mechanical or solenoid brakes as specified; service control desk, with all instruments and indicators; controller; resistances; limit switches; switch boards; transformers, circuit breakers; navigation signals and sirens; storage batteries; battery chargers, Selsyn indicators; electrically operated position indicators; service lighting; traffic signals, gates and flashing red lights; spot light; conduits and wiring; submarine cables, flexible cables; instructors; spare parts; pit pump, complete; and all other items and equipment required for the installation of a complete power plant.

(c) Operating House: The operating house will be measured by the lump and the measurement shall include all obviously necessary parts of the house, including table and chair. If the house is supported on piling, the piling will be measured as provided under "Bearing Piles."



### **BASIS OF PAYMENT:**

Machinery, power plant and operating house, measured as provided above shall be paid for at the contract prices per lump for "Movable Bridge Machinery," "Power Plant" and "Operating House," as the case may be, which prices and payments shall constitute full compensation for furnishing and placing all material; for equipment, tools, labor and incidentals and the performance of all work necessary to complete the item. The contractor will be required to furnish a complete set of suitable wrenches to fit all sizes of nuts used and a hand operated pressure grease gun of suitable capacity and all necessary fittings for the lubrication system, the cost of which shall be included in the lump sum price bid and the same shall become the property of the Department upon completion of the project.

Payment will be made under:

Item 742, Movable Bridge Machinery, per lump.

Item 743, Power Plant, per lump.

Item 744, Operating House, per lump.

## **STEEL GRID FLOORING ITEM 751 and 752**

### **DESCRIPTION:**

This item shall consist of the furnishing and installation of steel grid flooring, of the open type, or of the concrete filled type as shown on the plans.

### **MATERIALS:**

Except where otherwise provided, all members of steel grid flooring shall be of structural steel and rivets shall be of rivet steel. All structural steel, except where alloy steel is specified shall conform to the requirements specified in M-108, except that a copper content of approximately 0.2% will be permitted. Rivet steel shall conform to the requirements specified in M-108.

## **CONSTRUCTION METHODS:**

### **Fabrication:**

Before fabrication or construction is undertaken, the contractor shall submit three (3) sets of preliminary shop details to the Project Engineer for checking, one of which will be returned with either approved or required revisions noted thereon. All drawings shall measure 22" by 36" in size. When changes on submitted drawings are requested by the Department and the contractor makes additional changes, other than those expressly requested, he shall direct attention to them on the next copy of blueprints submitted by underscoring with colored crayon or other suitable means. For final approval, the contractor shall submit nine (9) blueprint copies in the case of Federal-aid projects or six (6) blueprint copies in the case of State projects. Upon completion of fabrication, the original tracings shall be delivered to the Department. No additional payment will be made for these plans, the cost thereof shall be considered as included in the price bid for steel grid floorings.

### **Quality of Workmanship:**

Workmanship and finish shall be equal to the best general practice.

### **Storage of Materials:**

Steel grid flooring shall be stored at the bridge site, above ground, upon platforms, skids, or other supports. It shall be kept free from dirt, grease, and other foreign matter, and shall be protected as far as possible from corrosion. It shall be properly drained.

### **Straightening Material:**

Steel grid flooring sections, before being installed, shall be straight, except for camber, if specified. If straightening is necessary, it shall be done by methods that will not injure the metal.

### **Arrangement of Sections:**

Where the main elements are normal to the center-

line of roadway, the units generally shall be of such length as to extend over the full width of the roadway for roadways up to 30', but in every case the units shall extend over at least three panels. Where joints are required, the ends of the main floor members shall be welded at the joints over their full cross-sectional area or otherwise connected to provide full continuity.

Where the main elements are parallel to centerline of roadway, the sections shall extend over not less than three panels, and the ends of abutting units shall be welded over their full cross-sectional area or otherwise connected to provide full continuity in accordance with the design.

#### **Provision for Camber:**

Unless otherwise provided on the plans, provision for camber shall be made as follows:

Steel units so rigid that they will not readily follow the camber required shall be cambered in the shop. To provide a bearing surface normal to the crown of the roadway the stringers shall be canted or provided with shop-welded beveled bearing bars. If beveled bars are used they shall be placed along the center line of the stringer flange, in which case the design span length shall be governed by the width of the bearing bar instead of by the width of the stringer flange.

Longitudinal stringers shall be mill cambered or provided with bearing strips so that the completed floor after dead-load deflection shall conform to the longitudinal camber shown on the plans.

#### **Field Assembly:**

Areas of considerable size shall be assembled before the floor is welded to its supports. The main elements shall be made continuous and sections shall be connected along their edges by welding of bars or by riveting them. The rivets may be cold driven.

#### **Connection to Supports:**

The floor shall be connected to its steel supports by welding. Before any welding is done, the floor shall

either be loaded to make a tight joint with full bearing, or it shall be clamped down. The location, length, and size of welds shall be subject to the approval of the Project Engineer, but in no case shall they be less than the manufacturer's standards.

The ends of all the main members of the slab shall be securely fastened together at the sides of the roadway for the full length of the span by means of steel plates or angles welded to the ends of the main members, as shown on the plans.

#### **Welding:**

All shop and field welding shall be done in accordance with specifications of the "American Welding Society for Welded Highway and Railway Bridges."

Surfaces to be welded shall be free from paint, grease, loose scale, rust, and other material that will prevent a proper weld. A thin coating of linseed oil without pigment, need not be removed. Any clinkers or slag caused by flame cutting or other causes shall be removed before welding.

#### **Galvanizing:**

Steel grid flooring shall be galvanized if specified on the plans.

#### **Repairing Damaged Galvanized Coatings:**

All galvanizing that has been chipped off or damaged in handling or in welding or riveting shall be repaired by field galvanizing by the application of a paste composed of approved zinc powder and flux with a minimum amount of water. The places to be coated shall be thoroughly cleaned, including removal of slag on welds, before the paste is applied. The surface to be coated shall first be heated with a torch to a sufficient temperature so that all metallics in the paste are melted when applied to the heated surface. Extreme care shall be taken to see that the galvanized surfaces are not damaged by the torch. The flux in the paste will cause a black surface to appear on surface

of coated parts, and this black surface shall be removed by wiping off with waste or by quick application of cold water.

#### **Concrete Filler:**

Floor types, with bottom flanges not in contact, shall be provided with bottom forms of metal or wood to retain the concrete filler without excessive leakage.

If metal forms are used they shall fit tightly on the bottom flanges of the floor members and be placed in short lengths so as to extend only about 1" onto the edge of each support, but in all cases the forms shall be such as will result in adequate bearing of slab on the support.

The concrete shall be mixed, placed, and cured in accordance with the specifications for "Concrete" under Item 426 of these specifications. All concrete shall be "Class A" unless otherwise specified. The concrete shall be thoroughly compacted by vibrating the steel grid floor. The vibrating device and the manner of operating it shall be subject to the approval of the Project Engineer.

#### **Painting:**

Open flooring furnished without galvanizing shall receive one shop coat and two field coats of paint. The shop coat may be applied either by brushing or by dipping. Field coats may be applied by brushing or spraying. Paint and painting shall meet the requirements of "Painting" of these specifications except as modified herein.

If paint is sprayed, it may be applied with either a single nozzle gun or a gang sprayer appropriately rigged up. Spraying of paint shall be done when the wind is comparatively calm and care shall be taken that movable parts of machinery are properly protected during the application of the paint. The flooring shall be sprayed before applying the final field coat to surface below which may receive paint during the spraying operations.

For the filled type of grid flooring, the underside of the bottom plate and the outer faces of headers, trim bars and end bars shall receive one coat of shop paint, and two coats of field paint.

#### **Use of Alternate Sections:**

If the contractor prefers to use a type of steel grid flooring other than that shown on the special plans for a particular bridge, he will be permitted to substitute another section selected from the various types shown on the standard plan titled "Steel Grid Flooring," included in the project plans. However, in each case, the plans will specify which of the alternate sections will be considered equal to the section shown on the special plan, and therefore acceptable to the Project Engineer. If the use of an alternate section requires supporting members in addition to those shown on the special plans, the maximum spacing of such members shall be as shown on the standard plan for the section being used. The size of such members shall be determined on the basis of the specified design load, as shown on the plans, and in accordance with the A. A. S. H. O. Standard Specifications for Highway Bridges of 1944, with amendments of December 18, 1944, for design methods. In the event an alternate section is used, all structural changes in the design of the floor system necessitated by the substitution shall be incorporated in the shop details covering the grid flooring so that it will be possible to check the entire floor system from the information shown in the shop details.

#### **METHOD OF MEASUREMENT:**

##### **Steel Grid Flooring:**

The steel grid flooring shall include all steel which enters into the fabrications, assembling, and erecting of the flooring and all welding and/or riveting required in the fabrication, assembling, and erecting of the flooring. Structural shapes such as curb plates and angles, risers, etc., if called for on the plans, will not be measured as steel grid flooring, but as fabricated carbon steel. If an alternate section is used, no support-

ing members in addition to those shown on the special plans will be measured, as they will be considered an integral part of the alternate flooring.

Measurement will be made by the square foot for the area of steel grid flooring remaining in the completed and accepted structure. Measurements will be made to the neat line of the grid flooring, excluding the headers, trim, or end bars surrounding the grid, after the flooring is in place. Openings for manholes, notches for leaf guide castings, etc., will not be deducted.

Concrete used for filling steel grid flooring will be measured by the cubic yard. Deduction in the quantity of concrete will be made for the volume of steel grid flooring enclosed by the concrete. In order to compute the net volume of concrete, the weight per sq. ft. of the open floor (weight taken from standard plan) shall be converted into volume per sq. ft. of flooring, at the rate of 490 lbs. per cubic foot.

#### **BASIS OF PAYMENT:**

##### **Open Steel Grid Flooring:**

The number of square feet of completed and accepted steel grid flooring, measured as provided above, shall be paid for at the contract price per sq. ft. for "Open Steel Grid Flooring" of the size shown on plans, or of the approved alternate. This price and payment shall constitute full compensation for furnishing, fabricating, erecting, and painting, and for all labor, tools, equipment and incidentals necessary to complete the item including all trim, header and end bars. It shall also include the cost of supporting members additional to those shown on the special plans, when such members are required in order to complete an alternate section.

Payment will be made under:

Item 751, Open Steel Grid Flooring, per sq. ft.

##### **Concrete Filled Steel Grid Flooring:**

The basis of payment for "Concrete Filled Steel

Grid Flooring" shall be identical with that for "Open Steel Grid Flooring" except that the contract price for this item shall not include the cost of furnishing or placing concrete filling.

Payment will be made under:

Item 752, Concrete Filled Steel Grid Flooring,  
per sq. ft.

Concrete filling shall be paid for under:

Item 740, Class "A" Concrete, per sq. yd.



## SURFACE AND BASE

Chemical, bituminous, cement, sand and other soil admixtures and treatment designed to increase the load bearing capacity of the sub-grade; all courses of untreated mineral aggregate and soil when used as either sub-base, base, or roadway surfaces. Mineral aggregate includes gravel, crushed stone, caliche, oyster shell, clam shell, reef shell, sand, clay, topsoil, etc. All courses of Portland cement concrete, block, brick, bituminous concrete and bituminous materials used in roadway surfacing, base or sub-base, including curb and gutter when integral with surface and base.

## RAILROAD GRADE CROSSING

Steel Plate Railroad Grade Crossing, Item 501  
Concrete Railroad Grade Crossing, Item 502  
Creosoted Plank Railroad Grade Crossing,  
Item 503

### DESCRIPTION:

This item shall consist of the construction of one of the types of railroad grade crossings listed above, complete in place, in accordance with the plans and specifications and as directed by the Project Engineer.

### MATERIALS:

Steel plate shall conform to the requirements specified in M-103.

Hardware shall conform to the requirements specified in M-46.

Creosoted Timber shall conform to the requirements specified in M-117.

Ballast shall conform to the requirements specified in M-45.

Concrete shall be class "A" and shall conform to the requirements specified in "Concrete."

Reinforcing steel shall consist of deformed bars and shall conform to the requirements specified in M-110 or M-111.

### CONSTRUCTION METHODS:

The contractor shall, except as otherwise provided herein, sublet all work to be performed in connection with "Railroad Grade Crossing" to the railroad company and shall permit the railroad company to perform such other work as is required by this contract to be performed within the limits of the railroad company's right of way as deemed advisable by said company for the protection of its interest. The contractor shall reim-

burse the railroad company for all work undertaken by the railroad company pursuant to this agreement. If agreeable to the railroad company, the contractor may perform any and all work to be done under this contract within the railroad company's right of way with his own forces, provided a satisfactory agreement has been reached with the railroad company. No work shall be commenced within the railroad company's right of way until the Department has been advised in writing by the railroad company that a satisfactory agreement has been reached and that the contractor has complied with all of the railroad company's requirements.

Concrete railroad grade crossing shall be constructed of Class "A" concrete in conformity with the requirements specified in "Concrete," of these specifications and as shown on the plans. The contractor will not be required to furnish rails but same shall be salvaged from the existing track or shall be furnished to the contractor by the owner of the track. The surface of the crossing shall be finished and cured as specified for concrete pavement except that hand methods of consolidating and finishing will be allowed.

**General:**

The contractor shall give the railroad company at least five days advance written notice of commencement of any work whatever by the contractor on the premises of the Railroad Company in order that the railroad company may have on hand any representatives that they may see fit to have present. This work shall be so conducted as not to interfere with the movement of trains or other operations of the railroad. All work performed by the contractor shall be done in strict compliance with railroad standards of construction.

Ballast shall be placed under and around ties in sufficient amounts to insure the stability of the rails.

**METHOD OF MEASUREMENT:**

Railroad grade crossing shall be measured by the square foot, and the area to be measured shall be the area bounded by the outer limits of the crossing.

**BASIS OF PAYMENT:**

The number of square feet of grade crossings completed and accepted, measured as provided above, shall be paid for at the contract unit price per square foot for "Railroad Grade Crossings," complete in place, which price and payment shall constitute full compensation for furnishing all materials (except rails, tie plates, or other rail hardware), equipment, tools, labor and incidentals, and the performance of all work necessary to complete the item.

**Payment will be made under:**

Item 501, Steel Plate Railroad Grade Crossing, per square foot.

Item 502, Concrete Railroad Grade Crossing, per square foot.

Item 503, Creosoted Plank Railroad Grade Crossing, per square foot.

## SALVAGED SURFACING MATERIAL ITEM 504

**DESCRIPTION:**

This item shall consist of the removal of the existing surfacing material from the highway; the hauling, placing and spreading of this material on the completed and approved subgrade or shoulders, or as directed, all in accordance with these specifications and at the locations shown on the plans.

**CONSTRUCTION METHODS:****General:**

The surfacing material that is to be removed shall be taken up to the full area and depth designated and the salvaged material stock-piled at convenient points adjacent to the roadway or hauled and placed directly on the prepared subgrade or shoulders. The salvaging operations shall be conducted so as to secure the maxi-

mum practical recovery of material and the Project Engineer shall be the sole judge as to the depth of material to be recovered.

The salvaged material shall be hauled from stock piles, or directly from where it is removed from the existing surface, and placed upon the prepared and approved subgrade or shoulders to the full width and depth as directed by the Project Engineer.

Salvaged surfacing material shall be compacted as specified under "Aggregate Type Base Course," for similar material.

**METHOD OF MEASUREMENT:**

Salvaged surfacing material shall be measured by the cubic yard and the quantity determined by measurement in vehicles at the point of delivery.

**BASIS OF PAYMENT:**

The number of cubic yards placed and accepted, measured as provided above, shall be paid for at the contract unit price per cubic yard for "Salvaged Surfacing Material," complete in place, which price and payment shall constitute full compensation of all loosening, excavating, loading, hauling and stockpiling; for unloading, spreading, shaping and compacting; and for the furnishing of all equipment, tools, labor and incidentals and for the performance of all work necessary to complete the item.

**Payment will be made under:**

Item 504, Salvaged Surfacing Material, per cubic yard.

## REMOVING OLD PAVEMENT ITEM 505

**DESCRIPTION:**

This item shall consist of removing old pavement and disposing of same in accordance with the plans and these specifications.

## **CONSTRUCTION METHODS:**

Where old pavement to be removed is of concrete, the concrete shall be broken into pieces of a size easily handled by one man and placed around the ends of drainage structures as indicated on the plans or otherwise disposed of as directed by the Project Engineer. Pavement other than of concrete shall be removed in a satisfactory manner and the materials salvaged or disposed of as directed by the Project Engineer. Materials having no salvage value may be disposed of in embankments, if permitted by the Project Engineer. Where a portion of the old pavement is to be left in place, the removed portion shall extend to an existing joint or shall be cut to true lines with a vertical face. Sufficient removal shall be made to provide for proper grades and connections with the new work.

## **METHOD OF MEASUREMENT:**

Removing old pavement shall be measured by the square yard.

## **BASIS OF PAYMENT:**

The number of square yards of old pavement removed, measured as specified, shall be paid for at the contract unit price for "Removing Old Pavement," which price and payment shall constitute full compensation for removing the pavement and placing same as rip rap, salvaging and disposing of all resulting materials, and all hauling and other work in connection therewith; the furnishing of all equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

### **Payment will be made under:**

Item 505, Removing Old Pavement, per square yard.

## RECONSTRUCTED BASE COURSE ITEM 508

### **DESCRIPTION:**

This item shall consist of the reshaping of an existing surface and the addition of the required amount of new material, all of which shall be compacted to form a foundation course for other base courses or for surface courses or pavement. Reconstructed base courses shall be constructed at the locations indicated on the plans, or as otherwise directed, and shall be constructed in accordance with these specifications, and in conformity with the lines, grades and typical cross section shown on the plans.

### **MATERIALS:**

New materials required in the reconstruction of the base course will be indicated in the plans or in the special provisions. They shall conform to the specifications for the respective materials set forth under these specifications.

### **CONSTRUCTION METHODS:**

The existing surface shall be scarified and broken up, in pieces that will pass a 1½" square screen, for the full width of the proposed base course, and to such uniform depth below the proposed finished surface as will eliminate all depressions and irregularities and permit of uniform shaping. Where the existing surface course is to be widened and where grade changes are indicated, the scarified material shall be windrowed or otherwise salvaged, as directed by the Project Engineer, and the necessary excavation or filling performed to permit the construction of a base course of the thickness and width indicated on the plans. Any satisfactory material excavated containing metal or binder shall be incorporated in the base course.

The existing material shall be shaped to conform to the required section and new material added. The new and old material shall be thoroughly mixed by plowing, harrowing, blading or other approved methods.

All other operations under this item shall be performed in accordance with the requirements set forth under "Construction Methods," for "Aggregate Type Base Courses."

**METHOD OF MEASUREMENT:**

Reconstructed base course will be measured by the square yard. The width of reconstructed base course to be paid for shall be the total width of base course indicated on the plans, or ordered by the Project Engineer, and the length shall be the actual center line length measured along the surface.

New materials will be measured as provided for "Aggregate Type Base Courses"; excavation will be measured as provided under item 305.

**BASIS OF PAYMENT:**

Reconstructed base course completed and accepted, measured as provided above, shall be paid for at the contract unit price per square yard for "Reconstructed Base Course," which price and payment shall constitute full compensation for scarifying, mixing, spreading, sprinkling with water, rolling, machining, dragging and all other work as provided herein; the furnishing of all tools, labor, equipment and incidentals and the performance of all work necessary to complete the item.

New materials will be paid for as provided for "Aggregate Type Base Course."

Excavation will be paid for as provided under Item 305.

**Payment will be made under:**

Item 508, Reconstructed Base Course, per square yard.



## AGGREGATE TYPE BASE COURSE

Crushed Stone Base Course	Item 509
Washed Gravel Base Course	Item 510
Washed Sand Gravel Base Course	Item 511
Sand Clay Gravel Base Course	Item 512
Iron Ore Base Course	Item 513
Clam Shell Base Course	Item 514
Reef Shell Base Course	Item 515
Cannery Shell Base Course	Item 516
Special Binder	Item 517
Rolling	Item 518
Sprinkling	Item 519

### DESCRIPTION:

This item shall consist of a foundation course for the traffic surfaces and for the shoulders of the road. The base shall be composed of the type of base material shown on the plans and shall be constructed on the prepared subgrade or reconstructed base course in accordance with these specifications and in conformity with the lines, grades, compacted thickness and typical cross sections shown on the plans.

### EQUIPMENT:

All equipment for the proper construction of the base course shall be on the project, in first class working condition, and shall have been approved by the Project Engineer before construction begins.

Rollers shall be of an approved type, such as three wheel power rollers, rubber tired rollers, or sheeps-foot rollers.

Provision shall be made by the contractor for furnishing water at the site of the work in sufficient quantities to moisten the base material sufficiently to obtain the desired compaction. Water wagons or other approved sprinkling devices shall be provided.

### MATERIALS:

Crushed Stone shall conform to the requirements specified in M-93.

Washed Gravel shall conform to the requirements specified in M-44.

Washed Sand Gravel shall conform to the requirements specified in M-45.

Sand Clay Gravel shall conform to the requirements specified in M-43, Type "A."

Cannery Shell shall conform to the requirements specified in M-94.

Iron Ore shall conform to the requirements specified in M-47.

Clam Shell shall conform to the requirements specified in M-95.

Reef Shell shall conform to the requirements specified in M-97.

Special Binder shall conform to the requirements specified in M-17.

#### **CONSTRUCTION METHODS:**

##### **Subgrade:**

The subgrade shall be prepared as provided under Item 305.

##### **Transporting and Spreading Base Material:**

Shell bases shall be spread and compacted in one course regardless of depth. For other types of bases where the total loose depth of material to be compacted is five inches or more, it shall be spread and compacted in two or more courses of equal depth, the maximum depth of each course being not more than five inches. The methods hereinafter specified for mixing, machining, and rolling shall apply to all courses.

The base material in the first course shall be dumped directly on the prepared subgrade and shall be uniformly distributed over the subgrade either by hand or with approved mechanical equipment. In the use of mechanical equipment for spreading material, dump piles shall be so spread as to insure uniform compaction of material. During the dumping, spreading and compacting operations the amount of moisture in the base material shall be controlled so as to obtain the maximum compaction of the material. The Project Engineer shall determine the proper moisture content of the base material. The contractor shall be responsible for the

uniform loading and distribution of the required amount of material throughout the length of each one hundred foot station.

**Mixing:**

When the base requires binder material as provided by the plans or when the base is composed of a combination of materials, mixing of the materials will be required. The proportions of the materials incorporated and used in the base shall be as shown on the plans or in these specifications and as directed by the Project Engineer. The several materials shall be thoroughly mixed by means of plowing, harrowing or other approved methods. This procedure shall continue until the entire surface is free from lumps or pockets of binder or other material and the Project Engineer is satisfied that the materials are uniformly distributed throughout the mass. As soon as the mixing of each course is completed to the satisfaction of the Project Engineer, the surface shall be shaped to conform with the typical section and compacted.

**Compacting:**

When each course of base material has been spread, mixed and shaped as above specified, the entire surface shall be watered and given a preliminary rolling. Any waves or irregularities that may develop under rolling shall be corrected by scarifying and adding or removing base material until the surface presents a smooth appearance. Between rollings, the surface shall be machined. Machining, watering and rolling shall continue until the material is thoroughly compacted. Rolling of all but the last course shall begin at one side and continue across the base course until the entire surface has been rolled. The rolling of the last course shall begin at one edge of the base course with the wheels overlapping the shoulders at least one-half the width of the roller and progress gradually to the center of the road overlapping each preceding track by one-half width. Rolling shall then begin at the opposite edge and proceed in like manner.

During the rolling and machining operations, the

surface of the base course shall be tested with a templet cut to the required cross section and with a ten-foot straight edge. All irregularities shall be corrected by scarifying to a depth of not less than four inches, removing or adding base material as may be required, after which the entire area shall be watered, rolled and brought to a satisfactory state of compaction. The finished surface shall not vary more than one-half inch from the approved cross section and grade when checked by the templet and straight edge. The templet and straight edge shall be furnished by the contractor.

**Opening to Traffic:**

The completed base course shall be opened to traffic for a period of not less than fifteen days before the wearing surface is laid, unless otherwise directed in writing by the Project Engineer. The base shall be kept free from holes, waves, and undulations and true to profile grade and cross section. The base shall not be allowed to become dusty with consequent loss of binder and loosening of the surface and shall be kept moist as directed by the Project Engineer. The contractor will be required to place saplings or other obstructions on the completed base course work so as to regulate traffic to avoid rutting of the base and also to facilitate setting up of the edges.

**Shoulders, Ditches and Slopes:**

The shoulders, ditches and slopes shall be constructed as set forth in Item 305.

**METHOD OF MEASUREMENT:**

Measurement of base course material will be made by the cubic yard or by the ton of two thousand pounds. The particular method of measurement to be used for any particular type of base course shall be as indicated on the plans or in the contract.

Measurement by Cubic Yard: In the event the unit of measurement as set out in the contract is the cubic yard, measurement of all aggregate and special binder will be made in the vehicle at the point of delivery on the road, as provided in C-150.

Measurement by Ton: In the event the unit of measurement as set out in the contract is the ton, measurement of all aggregate and special binder will be made by weighing on accurate and reliable platform scales, approved by the Project Engineer, which shall be furnished by the contractor at such points as may be designated. Such scales shall be constructed so that they are readily portable and can be transported without affecting the accuracy of the weighing device. They shall be "sealed" at the expense of the contractor as often as the Project Engineer may deem necessary to insure their accuracy. A weigher to be appointed and compensated by the State shall weigh all materials required to be weighed as herein provided.

Rolling shall be measured by the hour and pay quantities will be determined as follows:

The number of hours that the roller actually works, shall be divided by five (5), and the quotient thus obtained, multiplied by the actual outside rolling width of the roller in feet, shall be the number of hours for which payment will be made. In case of sheeps-foot roller, the width to be used shall be the sum of the width of the individual drums composing the roller. No time shall be allowed for moving the roller to and from the site of the work being rolled.

Sprinkling will be measured for payment by the one thousand (1000) gallons of water actually used and shall be measured as delivered in calibrated tank wagons or if water is obtained by pipe line, the contractor shall supply an accurate water meter for measuring the water.

#### **BASIS OF PAYMENT:**

The quantity of material placed and accepted, measured as provided above, shall be paid for at the contract price per unit for each of the various items which prices and payments shall constitute full compensation for the furnishing of all material except roadside binder; for all loading, hauling, unloading, spreading, mixing, shaping, rolling, watering, preparation of the subgrade, or clearing and reshaping the base course and shoulders; maintaining the finished surface until ac-

cepted and for the furnishing of all equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

**Payment will be made under:**

Item 509a, Crushed Stone Base Course, per cubic yard.

Item 509b, Crushed Stone Base Course, per ton.

Item 510a, Washed Gravel Base Course, per cubic yard.

Item 510b, Washed Gravel Base Course, per ton.

Item 511a, Washed Sand Gravel Base Course, per cubic yard.

Item 511b, Washed Sand Gravel Base Course, per ton.

Item 512a, Sand Clay Gravel Base Course, per cubic yard.

Item 512b, Sand Clay Gravel Base Course, per ton.

Item 513a, Iron Ore Base Course, per cubic yard.

Item 513b, Iron Ore Base Course, per ton.

Item 514a, Clam Shell Base Course, per cubic yard.

Item 514b, Clam Shell Base Course, per ton.

Item 515a, Reef Shell Base Course, per cubic yard.

Item 515b, Reef Shell Base Course, per ton.

Item 516a, Cannery Shell Base Course, per cubic yard.

Item 516b, Cannery Shell Base Course, per ton.

Item 517a, Special Binder, per cubic yard.

Item 517b, Special Binder, per ton.

Item 518, Rolling, per hour.

Item 519, Sprinkling, per M gallons.

## SUBGRADE TREATMENT ITEM 520

**DESCRIPTION:**

This item shall consist of treating or stabilizing the subgrade, by replacing unsuitable materials with selected materials or by admixing foreign materials into the subgrade material. Subgrade stabilization shall be performed to perfect a suitable foundation for base courses, surface courses or pavements.

## **MATERIALS:**

The particular method of stabilization and the quantity and type of materials to be used shall be as shown on the plans. Materials used may be as follows:

- Selected Soils.
- Aggregates.
- Calcium Chloride.
- Sodium Chloride.
- Portland Cement.
- Asphalt Emulsion.
- Cut-back Asphalt.
- Silicate of Soda.
- Resinous Materials.

## **CONSTRUCTION METHODS:**

### **Selected Soils:**

Soils used for stabilization shall be obtained from the excavation or from borrow pits as shown on the plans. Where the subgrade is to be stabilized by replacing unsuitable material with selected soils, all unsuitable material shall be excavated to the required width and depth, and disposed of as shown on the plans or directed by the Project Engineer. After the unsuitable material has been excavated, the selected soil shall be placed and compacted as specified under Item 305, of these specifications.

### **Aggregates:**

The use of aggregate for stabilization shall be by the admixture with or into the subgrade material. The type of aggregate to be used shall be the type shown on the plans. The subgrade material shall be loosened to the required width and depth before introducing the aggregate. The aggregate shall be applied and spread over the entire subgrade and compacted on or thoroughly mixed with the subgrade material and compacted. All aggregate shall meet the requirements, and shall be placed as specified for the particular aggregate, except where sand is specified as an admixture. Sand shall

be used when specified and the sand shall be approved by the Project Engineer prior to use.

**Other Methods:**

Other methods of stabilization shall be specified in special provisions to the contract.

**METHOD OF MEASUREMENT:**

Subgrade treatment will be measured by the square yard. The width of subgrade treatment to be measured shall be the total width indicated on the plans, or ordered by the Project Engineer, and the length shall be the actual center line length measured along the surface. New materials will be measured as provided under the method of measurement specified for the particular material. Excavation of unsuitable material shall be measured as provided under item for "Common Excavation."

**BASIS OF PAYMENT:**

Subgrade treatment completed and accepted, measured as provided, shall be paid for at the contract unit price per square yard for "Subgrade Treatment," which price and payment shall constitute full compensation for scarifying, mixing, spreading, sprinkling with water, rolling, machining and all other work as specified; the furnishing of all tools, labor, equipment and incidentals and the performance of all work necessary to complete the item.

New materials will be paid for under the item for the particular material.

Selected Soils shall be classified and paid for under item for "Common Excavation" or "Borrow Excavation" as specified in the contract.

The removal of unsuitable materials from the subgrade shall be classified and paid for under item for "Common Excavation."

**Payment will be made under:**

Item 520, Subgrade Treatment, per square yard.



## AGGREGATE TYPE SURFACE COURSE

Crushed Stone Surface Course	Item 523
Washed Gravel Surface Course	Item 524
Washed Sand Gravel Surface Course	Item 525
Sand Clay Gravel Surface Course	Item 526
Iron Ore Surface Course	Item 527
Clam Shell Surface Course	Item 528
Reef Shell Surface Course	Item 529
Shell Surface Course (Combination)	Item 530
Native Pit-run Shell Surface Course	Item 531

### DESCRIPTION:

This item shall consist of a surface course of the type shown on the plans constructed on the prepared subgrade or reconstructed base course in accordance with these specifications and in conformity with the lines, grades, compacted thickness and typical cross section shown on the plans.

This item shall be constructed by the feather-edge method.

### EQUIPMENT:

All equipment for the proper construction of the surface course shall be on the project, in first class working condition, and shall have been approved by the Project Engineer before construction begins.

### MATERIALS:

Crushed stone shall conform to the requirements specified in M-93.

Washed gravel shall conform to the requirements specified in M-44.

Washed Sand Gravel shall conform to the requirements specified in M-45.

Sand Clay Gravel shall conform to the requirements specified in M-43, Type B, C, or D.

Iron Ore shall conform to the requirements specified in M-47.

Clam Shell shall conform to the requirements specified in M-95.

Reef Shell shall conform to the requirements specified in M-97.

Shell shall conform to the requirements specified in M-98.

Native Pit-run shell shall conform to the requirements specified in M-96.

## **CONSTRUCTION METHODS:**

### **Subgrade:**

The subgrade shall be prepared accurately to line and grade and cross section as shown on the plans and directed by the Project Engineer and approved before any surfacing material is placed.

### **Feather Edge Method:**

The material shall be deposited in a windrow on the subgrade. The contractor shall be responsible for the uniform unloading and distribution of the required amount of material to obtain the section shown on the plans. The material shall be spread over the entire subgrade when and as so directed by the Project Engineer and in accordance with the typical section on the approved plans.

### **Binder:**

When shown on the plans, Special Binder shall be added to the surface course and thoroughly mixed as provided herein.

When the use of Special Binder is indicated on the plans, materials meeting the specifications for Special Binder shall be furnished by the contractor and incorporated in the surface course as herein provided.

### **Mixing:**

When the surface course consists of a combination of different materials, the contractor will be required to mix the materials by plowing, harrowing, blading or other approved methods.

**Shaping:**

The roadway shall be opened to traffic when directed by the Project Engineer and while being compacted under traffic, the material shall be shaped by the use of a blade grader or other suitable means. Ruts formed by traffic shall be filled by dragging the roadway at least once a day, and more frequently if necessary to prevent cutting through the surfacing material into the subgrade. Holes, waves, undulations and deficiencies in thickness which develop and which are not filled by blading shall be filled by adding more material. The material shall be shaped until it conforms to the cross section indicated on the plan and until it is free from ruts, waves and undulations. Shaping shall continue until the surface is accepted by the Project Engineer.

**METHOD OF MEASUREMENT:**

Measurement of surface course material will be made by the cubic yard or by the ton of two thousand pounds. The particular method of measurement to be used for any specific type of surface course shall be as indicated on the plans or in the contract.

Measurement by Cubic Yard: In the event the unit of measurement as set out in the contract is the cubic yard, measurement of all aggregate will be made in the vehicle at the point of delivery on the road as provided in C-150.

Measurement by Ton: In the event the unit of measurement as set out in the contract is the ton, measurement of all aggregate will be made by weighing on accurate and reliable platform scales, approved by the Project Engineer, which shall be furnished by the contractor at such points as may be designated. Such scales shall be constructed so that they are readily portable and can be transported without affecting the accuracy of the weighing device. They shall be "sealed" at the expense of the contractor as often as the Project Engineer may deem necessary to insure their accuracy. A weigher to be appointed and compensated by the State shall

weigh all material required to be weighed as herein provided.

Special Binder will be measured by the cubic yard or ton as provided under Item 517.

**BASIS OF PAYMENT:**

The quantity of material placed and accepted, measured as provided above, shall be paid for at the contract price per unit for each of the various materials incorporated in the surface course, which price and payment shall constitute full compensation for the furnishing of all material; for all loading, hauling, unloading, spreading, mixing, shaping, preparation of the subgrade, or clearing and reshaping the surface course and shoulders; maintaining the finished surface until accepted and for the furnishing of all equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

Special Binder will be paid for under Item 517a, per cubic yard or Item 517b, per ton.

**Payment will be made under:**

Item 523a, Crushed Stone Surface Course, per cubic yard.

Item 523b, Crushed Stone Surface Course, per ton.

Item 524a, Washed Gravel Surface Course, per cubic yard.

Item 524b, Washed Gravel Surface Course, per ton.

Item 525a, Washed Sand Gravel Surface Course, per cubic yard.

Item 525b, Washed Sand Gravel Surface Course, per ton.

Item 526a, Sand Clay Gravel Surface Course, per cubic yard.

Item 526b, Sand Clay Gravel Surface Course, per ton.

Item 527a, Iron Ore Surface Course, per cubic yard.

Item 527b, Iron Ore Surface Course, per ton.

Item 528a, Clam Shell Surface Course, per cubic yard.

Item 528b, Clam Shell Surface Course, per ton.

Item 529a, Reef Shell Surface Course, per cubic yard.

Item 529b, Reef Shell Surface Course, per ton.

Item 530a, Shell Surface Course (Combination), per cubic yard.

Item 530b, Shell Surface Course (Combination), per ton.

Item 531a, Native Pit-run Shell Surface Course, per cubic yard.

Item 531b, Native Pit-run Shell Surface Course, per ton.

## BITUMINOUS SURFACE TREATMENT COARSE AGGREGATE ITEM 532

### **DESCRIPTION:**

This item shall consist of a wearing surface of mineral aggregate and bituminous material, constructed on a prepared base, in accordance with these specifications and in conformity with the line, grades and typical cross sections shown on the plans.

### **COMPOSITION:**

This item shall be composed of one application each of mineral aggregate and bituminous material.

The particular type of bituminous material shall be as indicated on the plans or specified and shall be one of the following types:

1. Asphalt cement.
2. Cut back asphalt.
3. Emulsified asphalt.

The quantity of materials per square yard and the sequence of operations to be used in the applications shall be as shown in the following Tables I, II, and III for the particular type of bituminous material to be used.

The temperature of application for bituminous materials shall conform to the following limits:

Type and Grade	Temperature	
	Min.	Max.
AC-8 .....	275° F.	350° F.
AC-9 .....	275° F.	350° F.
RC-1 .....	105° F.	135° F.
RC-2 & RC-3 .....	125° F.	155° F.
EA-2 .....	100° F.	150° F.

**TABLE I**

**Asphalt Cement**

Asphalt (Gal. @ 60° F.).....	0.4
Coarse Aggregate (Cu. Yd.).....	0.02

**TABLE II**

**Cut Back Asphalt**

Asphalt (Gal. @ 60° F.).....	0.2
Coarse Aggregate (Cu. Yd.).....	0.02

**TABLE III**

**Emulsified Asphalt**

Asphalt (Gal. @ 60° F.) .....	0.2
Coarse Aggregate (Cu. Yd.) .....	0.02

The actual rate of distribution of bituminous material shall not vary from the rates shown in Tables I, II and III by more than 5 per cent. The quantity of bituminous material per square yard of treated surface shown in these tables indicates the volume of material to be used measured at a temperature of 60° F. All volumetric measurements of bituminous material shall be converted to this temperature in accordance with "Standard Abridged Volume Correction Table for Petroleum Oils," (this table will be found in the section on "Tables" in this volume).

**MATERIALS:**

Asphalt cement shall conform to the requirements specified in M-5, Type AC-8 or AC-9.

Cut back asphalt shall conform to the requirements specified in M-1, Type RC-1, RC-2, or RC-3.

Emulsified asphalt shall conform to the requirements specified in M-4, Type EA-2.

Bituminous primer shall conform to the requirements specified in M-3 Type P-1, or P-2; or M-4, Type EA-5.

Coarse aggregate shall conform to the requirements specified in M-13, Type R-1, S-1, or T-1, unless otherwise specified.

#### **EQUIPMENT:**

All equipment necessary for the proper construction of this work shall be in first class working condition and shall have been approved by the Project Engineer before construction begins and shall be maintained in a satisfactory working condition.

The equipment outfit used by the contractor shall be made up of the following units:

1. Broom dragging equipment, capable of covering  $\frac{1}{3}$  to  $\frac{1}{2}$  the width of the treatment.
2. Power distributor equipment, as hereinafter specified.
3. Pneumatic tired rollers.
4. Power revolving broom, or a power blower.
5. Accurately controlled aggregate spreading equipment.

The power distributor shall be equipped with pneumatic tires of such width and design so that the load produced on the road surface shall not exceed 650 pounds per inch width of tire. The distributor shall be equipped with suitable manifold and appliance so designed as to distribute evenly heated material within the temperature range specified with a positive controlled heat and temperature at all times, including thermometers to register the temperature of the material in the tank. The distributor shall be so designed as to maintain a constant and uniform pressure upon the bituminous material as it passes through the nozzles. Sufficient and proper screens shall be installed between the tank and the nozzles and the screen shall be cleaned

frequently to prevent clogging of the nozzles. The distributor shall be equipped with devices and charts to provide for accurate and rapid determination and control of the amount of bituminous materials being applied per square yard of surface under the operating conditions, and shall have a tachometer, reading speeds in feet per minute. The distributor shall be so designed as to apply bituminous material at a rate of from 0.05 gallons to 2.0 gallons per square yard at a pressure of from 25 to 75 pounds and in variable widths up to, and including, 22 feet.

### **CONSTRUCTION METHODS:**

#### **Preparation of Road Surface:**

The shoulders shall have been completed for full width of roadway prior to application of priming material. The surface to be covered shall be swept clean and free from dust, dirt, caked clay and loose foreign material by means of revolving brooms or other approved methods. Particular care shall be taken to clean thoroughly the outer edges of the strip to be treated. Sweeping shall continue until all dust or loose dirt is removed and the top surfaces of the larger size aggregate on the surface of the base are exposed.

#### **Weather Limitations:**

Bituminous materials shall not be applied on a wet base nor when the temperature of the air is less than 60° F. in the shade.

#### **Application of Primer:**

Before constructing the wearing surface, one of the following grades of bituminous primer shall be applied to the prepared base at the following rate and temperature:

P-1 . . . . 0.25 to 0.3 gallons per square yard, applied at a temperature between 125° F. and 150° F.

P-2 . . . . 0.25 to 0.3 gallons per square yard, applied at a temperature between 135°F. and 175° F.

EA-5 . . . . 0.25 to 0.3 gallons per square yard, applied at a temperature between 60° F. and 120° F.



The primer shall be applied to the prepared base and shall extend 6 inches beyond the width of surface treatment shown on the plans. The bituminous primers shall not be applied until the base has been compacted and bonded to the satisfaction of the Project Engineer, and then only when the surface has been properly swept, and is firm, compact and dry. The method of application shall be the same as provided under "Application of Bituminous Material."

#### **Patching and Repriming:**

The prime coats shall be maintained intact and, if required by the Project Engineer, the primed surface shall be thoroughly cleaned prior to the application of the wearing surface.

Where the prime coat has failed or depressions have occurred, the holes shall be swept clean and brush-coated with cut-back asphalt and refilled with a mixture of aggregate and cut-back asphalt and shall be thoroughly tamped so as to conform with the general crown and surface of the base. The aggregate used in the mixture shall be the same as used for cover material and shall be proportioned as directed by the Project Engineer. Not less than 5 per cent bituminous material by weight shall be used in the mixture. The materials used for patching shall be mixed in a manner satisfactory to the Project Engineer and shall be allowed to cure for two days before being placed on the road. If, in the opinion of the Project Engineer, the primer coat is generally unsatisfactory, the contractor shall be required to reprime the unsatisfactory surface.

#### **Application of Bituminous Materials:**

After the prime coat has been completed to the satisfaction of the Project Engineer, bituminous material and mineral aggregate shall be applied in the amounts and in the sequence herein specified.

All bituminous material shall be applied uniformly for the full width of the treatment at one application unless, due to the impracticability of detouring highway traffic, the contract specifies that the material be ap-

plied to one-half of the roadway at one time. If the contractor should be unable to keep the application of bituminous material consistently within the allowed variations as specified, he shall discontinue operations until he can provide an operator of greater experience or a better distributor, or both, or shall provide such precautions as may be necessary to keep the applications within the allowable variations.

If one or more nozzles should become blocked during the application of the bituminous materials, the distributor shall be stopped immediately and the nozzle, or nozzles, cleaned out. When the contract specifies that application be made over one-half width of the roadway at one time, all of the nozzles, except the one towards the outside of the roadway, shall have the same size opening; and care shall be taken to see that there is a slight longitudinal overlapping of the two applications along the center line of the road, so as to assure complete coverage. The distributor shall be operated along a marked edge in order to keep the surface treatment in a straight line.

In order to secure uniform distribution at the junction of two applications, the distributor shall be promptly stopped when the uniform flow decreases, indicating the tank is about empty. The distributor shall be equipped with a trough under the sprays, properly arranged to be swung out of the way after the sprayers are operating in a uniform manner at the desired pressure, or building paper shall be spread on the treated surface for a sufficient length back so that the sprayers are operating properly when the uncovered surface is reached. The building paper shall then be removed and burned.

Any excess of bituminous material at the junction between distributor loads shall be removed and corrected in a satisfactory manner, and any parts of the surface to be treated which are not covered with bituminous material directly from the distributor, shall be covered by means of a hand hose equipped with nozzles or by a hand pouring pot.

The application of the prime coat to the base shall

not exceed the application of bituminous material by more than four miles.

**Spreading Cover Material:**

The aggregate shall be spread by the use of power spreaders or trucks equipped to distribute the aggregate, provided such trucks or spreaders do not drive on the uncovered asphalt. Where one-half the width of road is treated at one time, the aggregate shall be spread to within 8 inches of the edge of the application along the center of the road until the bituminous material shall have been applied to the remaining portion of the road.

The spreading of aggregate shall at all times follow immediately the application of bituminous material. Immediately after spreading, as many men as are necessary, equipped with hand brooms, shall broom off all high spots. The surface shall then be dragged with a broom drag.

**Rolling Cover Material:**

Immediately after spreading and brooming the cover material, the entire surface shall be rolled with a pneumatic tired roller making a minimum of 3 trips and a maximum of 5 trips over the entire surface. Rolling shall proceed within  $\frac{1}{2}$  hour after the cover material has been spread. During rolling, the previously spread cover material shall be uniformly broomed and placed where necessary and in such quantity as to completely cover the bituminous surface. Rolling, brooming and spotting of additional cover material shall be continued until a uniformly closed surface has been obtained.

The pneumatic tired roller used shall be constructed with two axles. The wheels on the front and back axle shall be staggered and so spaced as to cover the entire width between the outside wheels with one passage of the roller. The roller shall be of the trailer type so constructed as to provide for the addition of weights. The roller shall weigh, under operating conditions, not less than 5 tons for a rolling width of 60 inches. The roller

shall be drawn by a pneumatic tired vehicle having sufficient power for the satisfactory operation of the roller.

**Finishing:**

The finished surface shall be uniform and smooth and such portions of the surface as are defective shall be taken up, removed and replaced with suitable material properly laid, and this work shall be done at the contractor's expense.

**Protection:**

Traffic should not be allowed to use the road until the cover material has been placed and thoroughly rolled.

After the prime coat has been applied, and unless it is impractical to detour highway traffic, the contractor shall keep all traffic off of the road until, in the opinion of the Project Engineer, the bituminous material has penetrated and dried out so as to not pick up under traffic.

In cases where traffic is permitted by the Project Engineer, the contractor shall spread the minimum necessary amount of approved cover material over the bituminous primer to avoid its "picking up."

During the period that brooming and rolling may have been necessary, the contractor shall re-spread the aggregate that may be swept to the sides by traffic. This re-spreading shall be done with shovels, hand brooms, or revolving broom, if and when directed by the Project Engineer, so as to prevent "bleeding" and to avoid the possibility of the bituminous coat "picking up" under traffic. If the repeated re-spreading of the aggregate is inadequate for this purpose and the Project Engineer so directs, the contractor shall spread additional aggregate as may be necessary to prevent "bleeding" and "picking up."

All other roadway construction items shall be completed before starting work on this item.

#### **METHOD OF MEASUREMENT:**

Bituminous surface treatment shall be measured by the number of cubic yards of aggregate and the number of gallons of bituminous material comprising the completed item. The quantity to be measured shall be the number of cubic yards of aggregate and the number of gallons of bituminous material placed and accepted

#### **BASIS OF PAYMENT:**

The number of cubic yards of aggregate and the number of gallons of bituminous material measured as specified shall be paid for at the contract unit price for the several items complete in place, which price and payment shall constitute full compensation for furnishing all tools, labor, equipment and incidentals and the performance of all work necessary to complete the item and for all royalties and payments whatsoever for patents covering processes or equipment used in constructing the item.

#### **Payment will be made under:**

- Item 532a, Bituminous Primer, per gallon.
- Item 532b, Asphalt Cement, per gallon.
- Item 532c, Cut Back Asphalt, per gallon.
- Item 532d, Emulsified Asphalt, per gallon.
- Item 532e, Coarse Aggregate (Crushed), per cu. yd.
- Item 532f, Coarse Aggregate (Uncrushed), per cu. yd.

### **BITUMINOUS SURFACE TREATMENT, FINE AGGREGATE ITEM 533**

#### **DESCRIPTION:**

This item shall consist of a wearing surface of mineral aggregate and bituminous material, constructed on a prepared base, in accordance with these specifications and in conformity with the lines, grades and typical

cross sections shown on the plans, or constructed on a previously constructed wearing surface.

**COMPOSITION:**

This item shall be composed of one application each of mineral aggregate and bituminous material.

The mineral aggregate shall be composed of crushed slag, crushed stone, or crushed gravel.

The particular type of bituminous material shall be as indicated on the plans or specified and shall be one of the following types:

1. Asphalt cement.
2. Cut back asphalt.
3. Emulsified asphalt.

The quantity of materials per square yard and the sequence of operations to be used in the applications shall be as shown in the following Tables I, II, and III for the particular type of bituminous material to be used.

The temperature of application for bituminous materials shall conform to the following limits:

Type and Grade	Temperature	
	Min.	Max.
AC-8 .....	275° F.	350° F.
AC-9 .....	275° F.	350° F.
RC-1 .....	105° F.	135° F.
RC-2 & RC-3 .....	125° F.	155° F.
EA-2 .....	100° F.	150° F.

**TABLE I**  
**Asphalt Cement**

Asphalt (Gal. @ 60°F.).....	0.4
Fine Aggregate (Cu. Yd.).....	.0118

**TABLE II**  
**Cut Back Asphalt**

Asphalt (Gal. @ 60°F.).....	0.3
Fine Aggregate (Cu. Yd.).....	.0118

**Table III**  
**Emulsified Asphalt**

Asphalt (Gal. @ 60°).....	0.3
Fine Aggregate (Cu. Yd.).....	.0118

The actual rate of distribution of bituminous material shall not vary from the rates shown in Tables I, II and III by more than 5 per cent. The quantity of bituminous material per square yard of treated surface shown in these tables indicates the volume of material to be used measured at a temperature of 60° F. All volumetric measurements of bituminous material shall be converted to this temperature in accordance with "Standard Abridged Volume Correction Table for Petroleum Oils," (this table will be found in the section on "Tables" in this volume).

**MATERIALS:**

Asphalt cement shall conform to the requirements specified in M-5, Type AC-8 or AC-9.

Cut back asphalt shall conform to the requirements specified in M-1, Type RC-1, RC-2, or RC-3.

Emulsified asphalt shall conform to the requirements specified in M-4, Type EA-2.

Bituminous primer shall conform to the requirements specified in M-3, Type P-1, or P-2; or M-4, Type EA-5.

Fine aggregate shall conform to the requirements specified in M-13, Type R-2, S-2, or T-2.

**EQUIPMENT:**

All equipment necessary for the proper construction of this work shall be in first class working condition and shall have been approved by the Project Engineer before construction begins and shall be maintained in a satisfactory working condition.

The equipment outfit used by the contractor shall be made up of the following units:

1. Broom dragging equipment, capable of covering  $\frac{1}{3}$  to  $\frac{1}{2}$  the width of the treatment.

2. Power distributor equipment, as hereinafter specified.

3. Power rollers, weighing not less than 5, or more than 7 tons.

4. Power revolving broom, or a power blower.

5. Accurately controlled aggregate spreading equipment.

The power distributor shall be equipped with pneumatic tires of such width and design so that the load produced on the road surface shall not exceed 650 pounds per inch width of tire. The distributor shall be equipped with suitable manifold and appliances so designed as to distribute evenly heated material within the temperature range specified with a positive controlled heat and temperature at all times, including thermometers to register the temperature of the material in the tank. The distributor shall be so designed as to maintain a constant and uniform pressure upon the bituminous material as it passes through the nozzles. Sufficient and proper screens shall be installed between the tank and the nozzles and the screen shall be cleaned frequently to prevent clogging of the nozzles. The distributor shall be equipped with devices and charts to provide for accurate and rapid determination and control of the amount of bituminous materials being applied per square yard of surface under the operating conditions, and shall have a tachometer, reading speeds in feet per minute. The distributor shall be so designed as to apply bituminous material at a rate of from 0.05 gallons to 2.0 gallons per square yard at a pressure of from 25 to 75 pounds and in variable widths up to, and including, 22 feet.

#### **CONSTRUCTION METHODS:**

##### **Preparation of Road Surface:**

Where this course is to be placed on a prepared base the shoulders of the road shall have been completed for full width of roadway prior to application of priming material. The surface to be covered shall be swept clean and free from dust, dirt, caked clay and loose foreign



material by means of revolving brooms or other approved methods. Particular care shall be taken to clean thoroughly the outer edges of the strip to be treated. Sweeping shall continue until all dust or loose dirt is removed and the top surfaces of the larger size aggregate on the surface of the base are exposed.

Where this course is to be placed on a previously constructed wearing surface the surface to be covered shall be swept clean of all dust, dirt and loose material before the application of the bituminous material.

**Weather Limitations:**

Bituminous materials shall not be applied on a wet surface nor when the temperature of the air is less than 60° F. in the shade.

**Application of Primer:**

Before constructing the wearing surface, and when a prime coat is specified, one of the following grades of bituminous primer shall be applied to the prepared base at the following rate and temperature:

P-1 . . . . 0.25 to 0.3 gallons per square yard, applied at a temperature between 125° F. and 150° F.

P-2 . . . . 0.25 to 0.3 gallons per square yard, applied at a temperature between 135° F. and 175° F.

EA-5 . . . . 0.25 to 0.3 gallons per square yard, applied at a temperature between 60° F. and 120° F.

The primer shall be applied to the prepared base and shall extend 6 inches beyond the width of surface treatment shown on the plans. The bituminous primers shall not be applied until the base has been compacted and bonded to the satisfaction of the Project Engineer, and then only when the surface has been properly swept, and is firm, compact and dry. The method of application shall be the same as provided under "Application of Bituminous Material."

**Patching and Repriming:**

The prime coat shall be maintained intact and, if required by the Project Engineer, the primed surface shall be thoroughly cleaned prior to the application of the wearing surface.

Where the prime coat has failed or depressions have occurred, the holes shall be swept clean and brush-coated with cut-back asphalt and refilled with a mixture of aggregate and cut-back asphalt and shall be thoroughly tamped so as to conform with the general crown and surface of the base. The aggregate used in the mixture shall be the same as used for cover material and shall be proportioned as directed by the Project Engineer. Not less than 5 per cent bituminous material by weight shall be used in the mixture. The materials used for patching shall be mixed in a manner satisfactory to the Project Engineer and shall be allowed to cure for two days before being placed on the road. If, in the opinion of the Project Engineer, the primer coat is generally unsatisfactory, the contractor shall be required to reprime the unsatisfactory surface.

#### **Application of Bituminous Materials:**

After the prime coat, if specified, has been completed to the satisfaction of the Project Engineer, bituminous material and mineral aggregate shall be applied in the amounts and in the sequence herein specified

All bituminous material shall be applied uniformly for the full width of the treatment at one application unless, due to the impracticability of detouring highway traffic, the contract specifies that the material be applied to one-half of the roadway at one time. If the contractor should be unable to keep the application of bituminous material consistently within the allowed variations as specified, he shall discontinue operations until he can provide an operator of greater experience or a better distributor, or both, or shall provide such precautions as may be necessary to keep the applications within the allowable variations.

If one or more nozzles should become blocked during the application of the bituminous materials, the distributor shall be stopped immediately and the nozzle, or nozzles, cleaned out. When the contract specifies that application be made over one-half width of the roadway at one time, all of the nozzles, except the one towards the outside of the roadway, shall have the

same size opening; and care shall be taken to see that there is a slight longitudinal overlapping of the two applications along the center line of the road, so as to assure complete coverage. The distributor shall be operated along a marked edge in order to keep the surface treatment in a straight line.

In order to secure uniform distribution at the junction of two applications, the distributor shall be promptly stopped when the uniform flow decreases, indicating the tank is about empty. The distributor shall be equipped with a trough under the sprays, properly arranged to be swung out of the way after the sprayers are operating in a uniform manner at the desired pressure, or building paper shall be spread on the treated surface for a sufficient length back so that the sprayers are operating properly when the uncovered surface is reached. The building paper shall then be removed and burned.

Any excess bituminous material at the junction between distributor loads shall be removed and corrected in a satisfactory manner, and any parts of the surface to be treated which are not covered with bituminous material directly from the distributor, shall be covered by means of a hand hose equipped with nozzles or by a hand pouring pot.

The application of the prime coat to the base shall not exceed the application of bituminous material by more than four miles.

One application of bituminous surface treatment shall not exceed the next application by more than 1500 feet.

#### **Spreading Cover Material:**

The aggregate shall be spread by the use of power spreaders or trucks equipped to distribute the aggregate, provided such trucks or spreaders do not drive on the uncovered asphalt. Where one-half the width of road is treated at one time, the aggregate shall be spread to within 8 inches of the edge of the application along the center of the road until the bituminous mate-

rial shall have been applied to the remaining portion of the road.

The spreading of aggregate shall at all times follow immediately the application of bituminous material. Immediately after spreading, as many men as are necessary, equipped with hand brooms, shall broom off all high spots. The surface shall then be dragged with a broom drag.

**Rolling Cover Material:**

Immediately after spreading and brooming the cover material, the entire surface shall be rolled with a power roller. Rolling shall proceed in a longitudinal direction, beginning at the outer edges of the treatment and progressing toward the center, each trip overlapping the prior trip about one-half the width of the roller. The first rolling shall be completed within one-half hour after the cover material has been spread. During rolling, the previously spread cover material shall be uniformly broomed and placed where necessary in such quantity as to completely cover the bituminous surface. Rolling, brooming and spotting of additional cover material shall be continued until a uniformly closed surface has been obtained.

**Finishing:**

The finished surface shall be uniform and smooth and such portions of the surface as are defective shall be taken up, removed and replaced with suitable material properly laid, and this work shall be done at the contractor's expense.

**Protection:**

Traffic should not be allowed to use the road until the cover material has been placed and thoroughly rolled.

After the prime coat has been applied, and unless it is impractical to detour highway traffic, the contractor shall keep all traffic off of the road until, in the opinion of the Project Engineer, the bituminous material has

penetrated and dried out so as to not pick up under traffic.

In cases where traffic is permitted by the Project Engineer, the contractor shall spread the minimum necessary amount of approved cover material over the bituminous primer to avoid its "picking up."

During the period that brooming and rolling may have been necessary, the contractor shall re-spread the aggregate that may be swept to the sides by traffic. This re-spreading shall be done with shovels, hand brooms, or revolving broom, if and when directed by the Project Engineer, so as to prevent "bleeding" and to avoid the possibility of the bituminous coat "picking up" under traffic. If the repeated re-spreading of the aggregate is inadequate for this purpose and the Project Engineer so directs, the contractor shall spread additional aggregate as may be necessary to prevent "bleeding" and "picking up."

All other roadway construction items shall be completed before starting work on this item.

#### **METHOD OF MEASUREMENT:**

Bituminous surface treatment shall be measured by the number of cubic yards of aggregate and the number of gallons of bituminous material comprising the completed item. The quantity to be measured shall be the number of cubic yards of aggregate and the number of gallons of bituminous material placed and accepted.

#### **BASIS OF PAYMENT:**

The number of cubic yards of aggregate and the number of gallons of bituminous material measured as specified shall be paid for at the contract unit price for the several items complete in place, which price and payment shall constitute full compensation for furnishing all tools, labor, equipment and incidentals and the performance of all work necessary to complete the item and for all royalties and payments whatsoever for patents covering processes or equipment used in constructing the item.

**Payment will be made under:**

Item 533a, Bituminous Primer, per gallon.

Item 533b, Asphalt Cement, per gallon.

Item 533c, Cut Back Asphalt, per gallon.

Item 533d, Emulsified Asphalt, per gallon.

Item 533e, Fine Aggregate, per cubic yard.

**BITUMINOUS SURFACE  
TREATMENT, SEAL COAT  
AGGREGATE  
ITEM 534**

**DESCRIPTION:**

This item shall consist of a wearing surface of mineral aggregate and bituminous material, constructed on a previously constructed wearing surface, in accordance with these specifications and in conformity with the lines, grades and typical cross sections shown on the plans.

**COMPOSITION:**

This item shall be composed of one application each of mineral aggregate and bituminous material.

The mineral aggregate shall be composed of crushed slag, crushed stone, or crushed gravel.

The particular type of bituminous material shall be as indicated on the plans or specified and shall be one of the following types:

1. Asphalt cement.
2. Cut back asphalt.
3. Emulsified asphalt.

The quantity of materials per square yard and the sequence of operations to be used in the applications shall be as shown in the following Tables I, II and III

for the particular type of bituminous material to be used.

The temperature of application for bituminous materials shall conform to the following limits:

Type and Grade	Temperatures	
	Min.	Max.
AC-8 .....	275° F.	350° F.
AC-9 .....	275° F.	350° F.
RC-1 .....	105° F.	135° F.
RC-2 & RC-3 .....	125° F.	155° F.
EA-2 .....	100° F.	150° F.

**TABLE I**

**Asphalt Cement**

Asphalt (Gal. @ 60° F.) .....	0.2
Seal Coat Aggregate (Cu. Yd.) .....	.0075

**TABLE II**

**Cut Back Asphalt**

Asphalt (Gal. @ 60° F.) .....	0.6
Seal Coat Aggregate (Cu. Yd.) .....	.0075

**TABLE III**

**Emulsified Asphalt**

Asphalt (Gal. @ 60° F.) .....	0.6
Seal Coat Aggregate (Cu. Yd.) .....	.0075

The actual rate of distribution of bituminous material shall not vary from the rates shown in Tables I, II and III by more than 5 per cent. The quantity of bituminous material per square yard of treated surface shown in these tables indicates the volume of material to be used measured at a temperature of 60° F. All volumetric measurements of bituminous material shall

be converted to this temperature in accordance with "Standard Abridged Volume Correction Table for Petroleum Oils," (this table will be found in the section on "Tables" in this volume).

#### **MATERIALS:**

Asphalt cement shall conform to the requirements specified in M-5, Type AC-8 or AC-9.

Cut back asphalt shall conform to the requirements specified in M-1, Type RC-1, RC-2, or RC-3.

Emulsified asphalt shall conform to the requirements specified in M-4, Type EA-2.

Bituminous primer shall conform to the requirements specified in M-3, Type P-1, or P-2; or M-4, Type EA-5.

Seal coat aggregate shall conform to the requirements specified in M-13, Type R-3, S-3, or T-3.

#### **EQUIPMENT:**

All equipment necessary for the proper construction of this work shall be in first class working condition and shall have been approved by the Project Engineer before construction begins and shall be maintained in a satisfactory working condition.

The equipment outfit used by the contractor shall be made up of the following units:

1. Broom dragging equipment, capable of covering  $\frac{1}{3}$  to  $\frac{1}{2}$  the width of the treatment.
2. Power distributor equipment, as hereinafter specified.
3. Power rollers, weighing not less than 5, nor more than 7 tons.
4. Power revolving broom, or a power blower.
5. Accurately controlled aggregate spreading equipment.

The power distributor shall be equipped with pneumatic tires of such width and design so that the load produced on the road surface shall not exceed 650



pounds per inch width of tire. The distributor shall be equipped with suitable manifold and appliance so designed as to distribute evenly heated material within the temperature range specified with a positive controlled heat and temperature at all times, including thermometers to register the temperature of the material in the tank. The distributor shall be so designed as to maintain a constant and uniform pressure upon the bituminous material as it passes through the nozzles. Sufficient and proper screens shall be installed between the tank and the nozzles and the screen shall be cleaned frequently to prevent clogging of the nozzles. The distributor shall be equipped with devices and charts to provide for accurate and rapid determination and control of the amount of bituminous materials being applied per square yard of surface under the operating conditions and shall have a tachometer, reading speeds in feet per minute. The distributor shall be so designed as to apply bituminous material at a rate of from 0.05 gallons to 2.0 gallons per square yard at a pressure of from 25 to 75 pounds and in variable widths up to, and including, 22 feet.

#### **CONSTRUCTION METHODS:**

##### **Preparation of Road Surface:**

Where this course is to be placed on a previously constructed wearing surface the surface to be covered shall be swept clean of all dust, dirt and loose material before the application of the bituminous material.

##### **Weather Limitations:**

Bituminous materials shall not be applied on a wet surface nor when the temperature of the air is less than 60° F. in the shade.

##### **Application of Bituminous Materials:**

Bituminous material and mineral aggregate shall be applied in the amounts and in the sequence herein specified.

All bituminous material shall be applied uniformly

for the full width of the treatment at one application unless, due to the impracticability of detouring highway traffic, the contract specifies that the material be applied to one-half of the roadway at one time. If the contractor should be unable to keep the application of bituminous material consistently within the allowed variations as specified, he shall discontinue operations until he can provide an operator of greater experience or a better distributor, or both, or shall provide such precautions as may be necessary to keep the applications within the allowable variations.

If one or more nozzles should become blocked during the application of the bituminous materials, the distributor shall be stopped immediately and the nozzle, or nozzles, cleaned out. When the contract specifies that application be made over one-half width of the roadway at one time, all of the nozzles, except the one towards the outside of the roadway, shall have the same size opening; and care shall be taken to see that there is a slight longitudinal overlapping of the two applications along the center line of the road, so as to assure complete coverage. The distributor shall be operated along a marked edge in order to keep the surface treatment in a straight line.

In order to secure uniform distribution at the junction of two applications, the distributor shall be promptly stopped when the uniform flow decreases, indicating the tank is about empty. The distributor shall be equipped with a trough under the sprays, properly arranged to be swung out of the way after the sprayers are operating in a uniform manner at the desired pressure, or building paper shall be spread on the treated surface for a sufficient length back so that the sprayers are operating properly when the uncovered surface is reached. The building paper shall then be removed and burned.

Any excess of bituminous material at the junction between distributor loads shall be removed and corrected in a satisfactory manner, and any parts of the surface to be treated which are not covered with bituminous material directly from the distributor, shall

be covered by means of a hand hose equipped with nozzles or by a hand pouring pot.

One application of bituminous surface treatment shall not exceed the next shot by more than 1500 feet.

#### **Spreading Cover Material:**

The aggregate shall be spread by the use of power spreaders or trucks equipped to distribute the aggregate, provided such trucks or spreaders do not drive on the uncovered asphalt. Where one-half the width of road is treated at one time, the aggregate shall be spread to within 8 inches of the edge of the application along the center of the road until the bituminous material shall have been applied to the remaining portion of the road.

The spreading of aggregate shall at all times follow immediately the application of bituminous material. Immediately after spreading, as many men as are necessary, equipped with hand brooms, shall broom off all high spots. The surface shall then be dragged with a broom drag.

#### **Rolling Cover Material:**

Immediately after spreading and brooming the cover material, the entire surface shall be rolled with a power roller. Rolling shall proceed in a longitudinal direction, beginning at the outer edges of the treatment and progressing toward the center, each trip overlapping the prior trip about one-half the width of the roller. The first rolling shall be completed within one-half hour after the cover material has been spread. During rolling, the previously spread cover material shall be uniformly broomed and placed where necessary in such quantity as to completely cover the bituminous surface. Rolling, brooming and spotting of additional cover material shall be continued until a uniformly closed surface has been obtained.

#### **Finishing:**

The finished surface shall be uniform and smooth and such portions of the surface as are defective shall be taken up, removed and replaced with suitable ma-

terial properly laid, and this work shall be done at the contractor's expense.

**Protection:**

Traffic should not be allowed to use the road until the cover material has been placed and thoroughly rolled.

During the period that brooming and rolling may have been necessary, the contractor shall re-spread the aggregate that may be swept to the sides by traffic. This re-spreading shall be done with shovels, hand brooms, or revolving broom, if and when directed by the Project Engineer, so as to prevent "bleeding" and to avoid the possibility of the bituminous coat "picking up" under traffic. If the repeated re-spreading of the aggregate is inadequate for this purpose and the Project Engineer so directs, the contractor shall spread additional aggregate as may be necessary to prevent "bleeding" and "picking up."

All other roadway construction items shall be completed before starting work on this item.

**METHOD OF MEASUREMENT:**

Bituminous surface treatment shall be measured by the number of cubic yards of aggregate and the number of gallons of bituminous material comprising the completed item. The quantity to be measured shall be the number of cubic yards of aggregate and the number of gallons of bituminous material placed and accepted.

**BASIS OF PAYMENT:**

The number of cubic yards of aggregate and the number of gallons of bituminous material measured as specified shall be paid for at the contract unit price for the several items complete in place, which price and payment shall constitute full compensation for furnishing all tools, labor, equipment and incidentals and the performance of all work necessary to complete the item and for all royalties and payments whatsoever for patents covering processes or equipment used in constructing the item.

Payment will be made under:

Item 534a, Bituminous Primer, per gallon.

Item 534b, Asphalt Cement, per gallon.

Item 534c, Cut Back Asphalt, per gallon.

Item 534d, Emulsified Asphalt, per gallon.

Item 534e, Seal Coat Aggregate, per cubic yard.

## PORTLAND CEMENT CONCRETE PAVEMENT ITEM 535

### DESCRIPTION:

This item shall consist of a pavement of Portland cement concrete with or without reinforcement as shown on the plans, constructed on the prepared sub-grade or completed and accepted base course in accordance with these specifications and in conformity with the line, grade, thickness and typical cross section shown on the plans.

### Proportions and Consistency of Concrete:

Type "B" Concrete Pavement shall be composed of one part of Portland cement and five parts of total fine and grade "B" gravel coarse aggregate by dry rodded volume, measured separately. The mix shall be approximately one part cement, two parts fine aggregate, and three parts of gravel coarse aggregate, by volume.

\*Type "C" Concrete Pavement shall be composed of one part of Portland cement and five and three-quarters parts of total fine and small size and large size grade "C" coarse aggregate by dry rodded volume, measured separately. The mix shall be approximately one part cement, two parts fine aggregate and three and three-quarters parts of coarse aggregate by volume.

Type "D" Concrete Pavement shall be composed of one part of Portland cement and five and one-half parts

of total fine and grade "D" gravel coarse aggregate by dry rodded volume, measured separately. The mix shall be approximately one part cement, two parts fine aggregate and three and one-half parts of gravel coarse aggregate, by volume.

\*Type "E" Concrete Pavement shall be composed of one part Portland cement and six and six-tenths parts of total, fine and small size and large size grade "E" coarse aggregate by dry rodded volume, measured separately. The mix shall be approximately one part cement, two parts fine aggregate, and four and six-tenths parts of coarse aggregate, by volume.

Type "F" Concrete Pavement shall be composed of one part Portland cement, and five and one-half parts of total fine and grade "F" crushed stone coarse aggregate by dry rodded volume, measured separately. The mix shall be approximately one part cement, two parts fine aggregate and three and one-half parts of coarse aggregate, by volume.

Should the contractor desire to use High-Early-Strength Portland cement in any part of the work, other than as specifically provided for by the plans or in the special provisions, and if considered desirable by the Construction and Maintenance Engineer, the contractor may be permitted to use High-Early-Strength Portland cement. The additional cost involved (if any) shall be assumed by the contractor. In the event the Chief Engineer orders the contractor to use High-Early-Strength Portland cement in any part of the work, other than as specifically provided for by the plans or in the special provisions, the contractor shall furnish and use such cement instead of Standard Portland cement, and the Department will reimburse the contractor for the difference between the delivered cost of the Standard Portland cement otherwise being furnished for the use on the project. The contractor

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\*NOTE: The contractor's attention is directed to the fact that in Type "C" and Type "E" pavements, the two coarse aggregates will reduce in volume approximately eight per cent on becoming mixed.

will be required to furnish freight bills and invoices to substantiate statements showing differences in cost.

After the job materials provided by the contractor have been accepted for use in the project, the Project Engineer will set the "job mix" in accordance with the above requirements as to total weight of aggregate, designating such relative amounts of fine to coarse aggregate, and such water cement ratio as will produce concrete of the consistency desired within the range of slump as hereinafter limited; during the progress of the work, the ratio of the amount of fine aggregate to the amount of coarse aggregate shall be altered as required by the Project Engineer but the weight of total dry aggregate per bag of cement shall not be altered unless tests made under the authority of the Project Engineer indicate that the specific gravity of either or both of the aggregates has changed. There will be no adjustment of cost of cement. Substitute mixes will not be accepted.

The unit weight of the aggregates in a dry and rodded condition shall be determined by the "Testing Laboratory" in accordance with A.S.T.M. Method C 29-27. The unit weight of aggregate, of a given specific gravity, is controlled by the voids and may affect the yield of concrete materially and the contractor's attention is directed to the type and grading requirements of the coarse aggregate hereinbefore specified for the several types of mixes.

The batch weights of aggregates, as given the contractor, will be corrected weights, adjusted by the Project Engineer to compensate for moisture content, and shall be used by the contractor as job condition weights. The amount of water will be adjusted by the Project Engineer to compensate for moisture content of the aggregates and for absorption of water by the aggregate during mixing. The contractor shall at once alter his batch whenever directed to conform to an adjusted or altered "job mix".

The minimum cement content in barrels per cubic yard of concrete for various types of mixes shall not be less than indicated in the following table:

The maximum water content, including free water in the aggregate in gallons per bag of cement shall not be greater than the following:

Type of Pavement	Maximum Gallons per Bag	Minimum Barrels per Cu. Yd.
"B" .....	5.50	1.45
"C" .....	5.75	1.30
"D" .....	5.75	1.35
"E" .....	6.00	1.25
"F" .....	5.50	1.50

The cement content indicated above is in each case the minimum permitted, but is not guaranteed by the Department. The cement content obtaining for any type mix is dependent upon the gradation of the aggregates and the cement content indicated above is based upon the most ideal combination and gradation of both fine and coarse aggregate for the respective type of pavement shown.

The consistency of the concrete shall be such that the slump of the concrete shall be not less than one and one-half inches nor more than three inches when subjected to the following test: A frustrum of a cone having a top diameter of four inches, a base diameter of eight inches and a height of twelve inches shall be placed on its base and filled with concrete in four inch increments, each increment being rodded twenty-five times with a smooth, round, bullet pointed, steel rod, twenty-four inches long and five-eighths of an inch in diameter. The frustrum of the cone shall then be immediately removed slowly and the vertical settlement or slump of the concrete measured. (See A. S. T. M. C 143-39 for more detailed information).

#### **ENGINEER'S FIELD LABORATORY:**

The contractor shall provide a field laboratory in which to house and use the testing equipment. This laboratory shall be not less than ten feet wide, twelve feet long and seven feet high, floored and provided with



a work bench with necessary drawers and shall have not less than one door and two windows. The laboratory shall be for the exclusive use of the Project Engineer and for testing purposes, but shall remain the property of the contractor and be removed by him upon completion of the project.

#### **EQUIPMENT:**

All equipment necessary for the proper preparation of the subgrade, mixing concrete, the laying and finishing of the pavement shall be on the project, in first class working condition, and shall have been inspected and approved by the Project Engineer before concreting operations will be permitted to begin. All equipment shall meet the specific requirements hereinafter set forth. The contractor shall maintain all equipment in first class working condition throughout the construction of the project.

#### **MATERIALS:**

Portland cement shall conform to the requirements specified in M-24.

Water shall conform to the requirements specified in M-121.

Fine aggregate shall conform to the requirements specified in M-14, Type A.

Coarse aggregate shall conform to the requirements specified in M-13, Type B, C, D, E or F.

Bar reinforcement shall conform to the requirements specified in M-110 or M-111.

Fabric reinforcement shall conform to the requirements specified in M-107.

Parting strip shall conform to the requirements specified in M-49.

Dowell bars shall conform to the requirements specified in M-110 or M-111.

Expansion joint filler shall conform to the requirements specified in M-33.

Poured filler shall conform to the requirements specified in M-6.

Cut-back asphalt shall conform to the requirements specified in M-1, Type RC-1.

Cotton fabric shall conform to the requirements specified in M-19.

Cotton mats shall conform to the requirements specified in M-26.

Waterproofed paper shall conform to the requirements specified in M-73.

Dowel assembly shall conform to the requirements specified in M-30.

## **CONSTRUCTION METHODS:**

### **Method of Measuring Materials:**

All cement and aggregate for concrete pavement shall be measured by weight. Cement shall be measured by the bag as packed by the manufacturer or in bulk as shipped by the manufacturer. When cement in bags is used, one bag of cement shall be assumed to be one cubic foot in volume and to weigh ninety-four pounds. When cement in bulk is used, one barrel of cement shall be assumed to weigh 376 pounds. The weights of coarse and fine aggregates to be used shall be calculated from the proportions specified by the Project Engineer. Water shall be measured by volume or by weight.

### **Weighing and Batching Equipment:**

The batching plant shall include batcher bins, either of the stationary or mobile types, with adequate separate compartments for fine aggregate and for each required "separated size" of coarse aggregate, each compartment designed to discharge efficiently and freely into the weighing hopper or hoppers. Means of control shall be provided in each case so that as the quantity desired in the weighing hopper is being approached, the material may be added slowly in minute quantities and shut off with precision. Means of removing the overload of any one of the several ma-

terials shall be provided. In the type where more than one aggregate is weighed into one hopper, each aggregate shall be held in a separate compartment and so arranged that an overload of any aggregate can be removed. Hoppers shall be constructed so as to eliminate accumulations of tare materials and to fully discharge without jarring the scales. Partitions between compartments, both in bins and in hoppers, shall be ample to prevent spilling under any working conditions. All batching plant structures shall be maintained properly leveled within the accuracy required by the design of the weighing mechanism.

The scales for weighing aggregates shall be either the horizontal beam or the springless dial types, designed of rugged construction as an integral unit of the batching plant, with a maximum allowable error of one-half per cent of net load and with significant graduation down to two pounds. Provision such as a "tell tale" dial, shall be made for indicating to the operator that the required load in the weighing hopper is being approached, which device shall indicate at least the last two hundred pounds of load. A device on weighing beams shall indicate critical position clearly. Poises shall be designed for locking in any position and to prevent unauthorized removal. The weigh beam and "tell tale" device shall be in full view of the operator while charging the hopper and he shall have convenient access to all controls and a clear view of all operations at the batching plant. If necessary, burlap or other suitable materials shall be arranged about the scales to afford protection against wind.

Clearance between scale parts, hoppers and bin structures shall be such as to avoid displacement of or friction between working parts due to accumulations, vibrations or other causes. Pivot mountings shall be designed so none of the parts will jar loose and so as to assure unchanging spacing of knife edges under all circumstances. Scales shall be so designed that all exposed fulcrums, clevises and similar working parts may readily be kept clean. Scales shall be constructed of noncorrosive materials, excluding material softer

than brass. Ten fifty pound weights shall be available for checking. Weigh beams shall have leveling lugs, and weighing parts of other types shall be provided with means for precision adjustment. Scales shall be "sealed" at the expense of the contractor when required by the Project Engineer. If necessary to provide stability, concrete foundations for batching and weighing equipment shall be provided. All structural members of the batching plant shall be of sufficient size to withstand the load to which they will be subjected and the Project Engineer may require the contractor to submit for approval, plans showing structural design and type of foundation to be used. The contractor shall maintain the equipment in good condition and adjustment and shall provide for accurate operation. If, for any reason, equipment previously approved becomes unsatisfactory, it shall be repaired or replaced before proceeding with the work.

Water measuring equipment shall be accurate to within one per cent, and shall be so arranged that the measurement will not be affected by variations of pressure in the water supply line, or tilting of the mixer, and will be uniformly accurate under all construction conditions encountered. Unless the water is to be weighed, the water measuring equipment shall include an auxillary tank from which the measuring tank shall be filled. The volume of the auxiliary tank shall be at least equal to that of the measuring tank.

#### **Handling Materials:**

All aggregate shall be stock-piled before being placed in the bins. In stock-piling aggregates, the location and preparation of the sites, the minimum size of pile, the method adopted to prevent "coning" or other segregation of the component sizes shall be subject to the approval of the Project Engineer. In any case, stock piles shall be at least six feet in height and built up in layers of not more than three feet in thickness. Each layer shall be completely in place before beginning the next, which shall not be allowed to "cone" down over the under layer. Aggregates from different sources

and of different gradings shall not be stock-piled together. Each "separated size" of coarse aggregate, if such are required by the contract, shall be stored separately. The contractor shall fill the bins exclusively from the stock pile. Storing of aggregates in stock piles or otherwise upon the subgrade or shoulders will not be permitted.

The aggregates shall be handled from the stock pile to the batching plant in such a manner as to secure a typical grading of the material. Aggregates that have become mixed with earth or foreign material or coated with dust shall not be used. All aggregates, where handled by hydraulic methods or where washing is involved, shall be stock-piled for draining at least twelve hours before being batched.

Aggregates shall be transported from the batching plant to the mixer in batch boxes, vehicle bodies or other containers of adequate capacity and construction to properly carry the volume required. Partitions separating batches shall be adequate and effective to prevent spilling from one compartment to another while in transit or being dumped.

Cement in original shipping packages may be transported on top of the aggregates, each batch containing the number of bags required by the "job mix". Bulk cement may be transported in direct contact with the aggregates provided the cement is not in direct contact with the aggregate for a period exceeding one hour before the mixing water is added to the batch.

Batches shall be delivered to the mixer separate and intact and each batch container shall be dumped cleanly into the mixer without loss of cement or mixing or spilling of material from one batch compartment into another.

#### **Mixing Conditions:**

Concrete shall be mixed only in the quantity required for immediate use. Concrete which does not meet the requirements for consistency at the time of placing shall be rejected. Retempering concrete by adding water or by other means will not be permitted.

The use of admixtures for the purpose of increasing the workability of the mix or for accelerating the set, will be permitted only when specifically approved by the Chief Engineer in writing.

Materials containing frost shall not be used. Fine aggregate containing lumps of hardened materials shall not be used.

Salt or other chemical admixtures shall not be added to the concrete to prevent freezing.

The use of a central mixing plant will not be permitted unless specifically approved by the Chief Engineer in writing. When such approval is given, the concrete shall be mixed to such consistency that hauling will cause no segregation of the constituent materials. The methods of storing and hauling materials and equipment used shall be subject to the approval of the Chief Engineer. Vehicles shall be equipped with suitable devices for slowly agitating the concrete during transit and for delivering of the concrete in an unsegregated condition of uniform consistency. Any vehicle load showing nonuniform consistency upon arrival will be subject to rejection.

When a central mixing plant is used, a subgrade planer shall be used, complying with requirements for the subgrader hereinafter provided under conditioning of subgrade.

#### **Mixers:**

Mixers, except those at central mixing plants, shall be of the boom and bucket type, full power controlled, and no mixer shall be used which requires less than five bags of cement per batch except that where it is impracticable to use machine methods of placing and finishing the concrete, a smaller mixer of the design approved by the Project Engineer and having a capacity of not less than two bags will be permitted.

Mixers shall operate at the drum speed shown on the manufacturer's name plate, which, unless otherwise approved, shall be not less than fourteen and not more than twenty revolutions per minute.

The mixer shall be equipped with an approved batch meter and timing device which will automatically lock the discharge lever and release it only at the end of the mixing period; the device shall be equipped with a bell adjusted to ring each time the lock is released. If the timing device becomes broken or out of order, the contractor shall be permitted to operate the mixer while same is being repaired, provided he furnishes an approved timepiece equipped with a minute hand and a second hand and each batch is mixed one minute while the timing device is out of order. If, in the opinion of the Project Engineer, the repair of the timing device is unreasonably delayed, the failure of the timing device shall be cause for the discontinuance of the use of the mixer until the device is repaired or a new timer substituted.

The water measuring equipment shall meet the requirements set forth under "Weighing and Batching Equipment".

Pickup and throw over blades in the drum of the mixer which are worn down three-quarters of an inch or more in depth shall be replaced by new blades.

Tandem or dual drum mixers will be permitted provided the mixer units are designed and built for synchronized operation and provided the material is mixed in the first drum for a period of not less than thirty seconds.

Central-plant mixed concrete may be used, provided that the materials are handled, measured and batched as specified in these specifications. Delivery of concrete is to be so regulated that placing is at a continuous rate. The intervals between delivery of batches shall not be so great as to allow the concrete in place to harden partially, and in no case shall such an interval exceed 30 minutes. The mix shall be transported from the central mixing plant to the site of the work in approved agitator trucks. Unless otherwise permitted by the Project Engineer, the agitator shall be a closed water-tight revolving drum. The drum shall be capable of transporting and discharging the mix without segregation. The agitating speed of the drum shall be not

less than two and not more than six revolutions per minute. The volume of mixed concrete permitted in the transporting vehicle shall not exceed the manufacturer's rating and shall not exceed eighty per cent of the gross volume of the drum.

The interval between introduction of water into the mixer drum and final discharge of the concrete from the drum shall not exceed one hour. During this interval the mixture shall be agitated continuously.

When central-plant mixed concrete is used, the Project Engineer shall have full control over the operations and materials incidental to the mix. After a stock pile of aggregates or a stock of cement has been inspected and approved by the Project Engineer, the contractor shall dedicate these materials exclusively to the use for which they were approved. The Project Engineer shall enjoy all rights and privileges of access and control exercised by him on batching plants and materials set up exclusively for the project.

#### **Mixing Concrete:**

Concrete shall be mixed in a batch mixer of approved type and capacity for a period of not less than one minute after all materials except water are in the drums. If tandem or dual drum mixers are used, the mixing time required shall be exclusive of the time of transfer or materials between mixing drum or compartments.

The batch shall be so charged into the drums that some water shall enter in advance of cement and aggregate and shall continue to flow at a uniform rate for a period not exceeding twenty seconds. The rate of flow shall be so regulated that the water will enter the drum for approximately five seconds before the materials and continue to flow for approximately ten seconds after the materials have been charged into the drum, and after the mixing time begins.

During the period of mixing, the drum shall operate at the speed for which it was designed. Any concrete mixed less than the minimum mixing time specified shall be rejected. If, in the opinion of the Project



Engineer, the concrete resulting from mixing the specified minimum time is not of a uniform texture, a sufficient number of additional revolutions of the drum at the same rate shall be given until a thorough mixing of each batch of concrete is secured.

No batch shall be run requiring fractional sacks of cement, when sacked cement is used, and the volume of mixed concrete per batch shall not exceed the manufacturer's rated capacity by more than ten per cent, except where the rated capacity of the mixer exceeds the volume of concrete involving three-tenths or more of a bag of cement, in which case the volume of concrete produced per batch may be that produced from a number of bags of cement which exceeds the nearest to rated capacity number by one bag. The entire contents shall be removed from the drum before the succeeding batch is introduced. The skip and the throat of the drum shall be kept free of accumulations.

**Forms:**

Side forms shall be made of steel except that, on curves having radii of one hundred to three hundred feet, inclusive, wooden forms of approved thickness may be used. Metal forms shall have a minimum length of ten feet. On curves having radii less than one hundred feet, flexible or curved forms of proper radius shall be used. The forms shall be of approved section, straight, free from warp or bends and of sufficient strength when staked to resist the pressure of the concrete and finishing machine or finishing tools without springing, settlement or lateral movement. The depth of forms shall equal the depth of the concrete and the base width shall be not less than eight inches for all forms eight inches or more in height. All side forms less than eight inches in height shall have a base width of not less than six inches. The steel forms shall be not less than nine gauge (U. S. Standard Gauge 1893) except that a minimum thickness of twelve gauge will be acceptable if the section of the form is trapezoidal and thoroughly welded.

Steel forms shall meet the following minimum

weights per linear foot of form exclusive of pedestals, piers, or other fastenings:

Depth of Form in Inches	Minimum Net Weight per linear foot
6	8.0 lbs.
7	8.5 lbs.
8	9.0 lbs.
9	9.5 lbs.

Forms varying more than one-eighth of an inch in ten feet from a true line on its upper edge or more than one-fourth of an inch from a true line on its inside face shall be rejected.

The method of connection between sections shall be such that the joint thus formed shall be free from movement in any direction and will allow no leakage.

Bent, twisted or broken forms shall be removed from the work until satisfactorily repaired and straightened. Repaired forms shall not be used until inspected and approved by the Project Engineer. Built up forms shall not be used.

The supply of forms shall be sufficient to permit their remaining in place not less than twelve hours after the concrete has been placed or longer if deemed necessary by the Project Engineer.

#### **Setting Side Forms:**

Forms shall be set so that they rest firmly throughout their entire length upon the thoroughly compacted subgrade. Any subgrade, which at the form line is found below established grade, shall be filled to grade in lifts of one-half inch or less for a distance of eighteen inches on each side of the base of the form and thoroughly rerolled or tamped. Imperfections and variations above grade shall be corrected by tamping or cutting as necessary. In exceptional cases, the Project Engineer may require suitable stakes driven to the grade of the bottom of the forms to afford additional firmness. The Project Engineer may require the contractor to operate the finishing machine and subgrader over the

forms prior to the starting of construction in order to determine whether the forms will remain true to line and grade during the construction of any portion of the pavement. Any weakness or defect which may develop in the forms under this operation will be cause for their immediate rejection. The length and number of pins required for each section of forms shall be such as may be required to maintain the form at the correct line and grade at all times, but in no case shall less than three pins for each ten foot section be used and a pin shall be placed at each side of every joint. Conformity of the alignment and grade elevation of forms with the alignment and grade elevation shown on the plans, or designated by the Project Engineer, shall be checked and necessary corrections made by the contractor immediately prior to placing the concrete. Where any form has been disturbed or any subgrade becomes unsuitable, the form shall be reset and re-checked. Forms shall be set for at least five hundred feet in advance of the point where concrete is being placed. Forms shall be cleaned and oiled each time they are used.

#### **Conditioning of Subgrade:**

The subgrade shall be properly prepared, shaped, rolled and maintained in accordance with Item 305. After the forms have been set and approved, the subgrade shall be tested in advance of the mixer as to crown and elevation by the use of an approved template. The subgrade template shall be so constructed that its lower or testing edge will come to the true position of the subgrade when the template is riding on the forms. Testing of the subgrade surface shall be done by moving the template back and forth on the forms without tilting or lifting. Any excess material indicated by this template shall be removed and deposited upon the adjacent shoulders, or disposed of as directed. Approved material shall be furnished and tamped or rolled in place to bring low areas to the correct elevation. The subgrade shall be kept in a condition so that it will drain readily.

There shall be provided for final shaping of the

subgrade, an approved subgrade planer which shall ride on the forms. When the mixer is in the lane of pavement being laid, the subgrade planer shall ride on the forms and shall be attached to the discharge end of the mixer. The subgrade planer shall have a cutting edge or edges made of steel plates accurately adjustable vertically and shall be of sufficient weight to properly plane off any high spots encountered and shall have such strength and rigidity as will prevent vertical deflection. Any material planed off the subgrade shall be removed before any concrete is placed. Low places in the subgrade, as indicated by this check, shall be filled with concrete integral with the pavement, and no additional compensation shall be allowed for the extra quantity of concrete involved. The finished subgrade shall be maintained in a smooth, compacted condition until the pavement is placed.

The subgrade shall be in a moist but not muddy condition at the time of placing the concrete. If required by the Project Engineer, it shall be saturated the previous night or not less than six hours previous to the placing of the concrete. If it subsequently becomes too dry, the subgrade shall be sprinkled, but the method of sprinkling shall be such as will not form mud or pools of water.

#### **Placing Concrete:**

Concrete shall be placed only on a subgrade prepared and maintained as hereinbefore prescribed and no concrete shall be placed until the subgrade has been approved by the Project Engineer. The concrete shall be deposited on the subgrade in such manner as to require as little rehandling as possible. It shall be thoroughly spaded against and along the face of the forms. Necessary hand spreading shall be done with shovels, not with rakes. Workmen shall not be allowed to walk in the green concrete with boots covered with earth. The concrete shall be distributed to such depth and sufficiently above grade that, when consolidated and finished, the required slab thickness will be ob-

tained and the surface will at all points be true to grade specified for the finished surface.

No concrete shall be placed around manholes or other structures until they have been brought to the required grade and alignment and all structures, or other fixtures such as valve boxes, poles, etc., shall be separated from the concrete by expansion joints constructed as hereinafter specified and of the material specified in the plans or in the special provisions.

The pavement may be constructed to its full width in a single construction operation unless the plans or special provisions require construction in longitudinal sections. Concrete in a longitudinal section shall not be placed until the adjacent slab has attained an age of ten days, or has attained a modulus of rupture of six hundred pounds as shown by test of standard specimens cured under the same climatic and moisture conditions as the slab. The junction line shall not deviate from a true line by more than one-half inch at any point and shall be tooled to the radius shown on the plans. Contact edges of slabs, except where tie rods are required, shall be painted with a heavy coat of asphalt conforming to the requirements prescribed for "poured filler" before the fresh concrete of the adjacent slab is placed against them, unless joint filler is required and used between the longitudinal slabs.

Where a center longitudinal joint is being constructed in pavement, the first batch of concrete shall be discharged and distributed along such center joint and the succeeding batches alternately on each side thereof. The concrete shall be well spaded on each side of the center joint and succeeding batches shall be lapped at least twelve inches over the previous batch. Placing shall be continuous between transverse joints without the use of intermediate bulkheads.

All ends of pavement slabs not supported by dowel bars imbedded in adjoining concrete slabs or directly supported by bearing on adjoining structures shall be thickened as required by the plans.

No more concrete shall be mixed and placed than

can be properly compacted and finished, as hereinafter specified, during daylight hours, without the written consent of the Project Engineer and then only when an adequate lighting system satisfactory to the Project Engineer is provided.

#### **Placing Reinforcing Steel:**

Where required by the plans, reinforcing steel of the type and size designated on the plans shall be placed in the slab. All reinforcing metal shall be cleaned and free from foreign materials that will prevent the proper bond with the concrete.

Fabric reinforcement shall be handled carefully and kept straight and free from bends and warps. It shall be placed parallel to the finished surface and at the depth shown on the plans. At all places where continuity of reinforcement is required, adjacent sheets of fabric shall be properly lapped. Unless otherwise shown on the plans where laps are made along the sides of the sheets, the transverse wires of the fabric shall be lapped not less than six inches and where laps are made at the ends of sheets, the longitudinal wires of the fabric shall be lapped not less than twelve inches. If the length of lap as set out herein is insufficient to permit the first wires parallel to the lapped joint of adjacent sheets to overlap, the length of the lap shall be increased so as to permit the overlapping of these wires.

Reinforcing bars shall be placed in the position shown on the plans and shall be securely fastened together at each intersection by means of approved spring clips, wire ties, or other approved devices, so that they will not be displaced during handling or during depositing and compacting of the concrete. Electric welding will be permitted provided the bars, after having been welded, meet the requirements of the specifications. When bars are spliced all adjacent ends shall be lapped at least forty diameters.

Strike-off boards or templates, designed to ride on the side forms and operated either mechanically or by hand, shall be used to level the concrete and secure the correct elevation for placing the reinforcing steel.

Prior to the installation of the reinforcement, concrete shall be deposited upon the subgrade in sufficient amount that, when leveled by a strike-off board, the surface will be at the elevation specified for the reinforcing steel. After the concrete has been struck off and leveled to the elevation specified, and before any initial set of the concrete has occurred, the reinforcing steel shall be placed thereon and covered with additional concrete in such quantity and so deposited and distributed that when finished, the pavement shall have the required thickness and crown. Sleds, chairs or other devices suspending the reinforcing steel, with the consequent depositing of the concrete through the steel, will not be permitted.

#### **Forming Joints:**

Expansion joints, unless otherwise provided, shall be formed with the specified joint filler and sealed with a bituminous filler meeting the requirements of the specified poured filler. Expansion joints of the poured type will be used when specifically provided for by the plans and special provisions. Expansion joints not less than one-half inch in width shall be formed about all existing structures and fixtures projecting through or into or against the pavement.

Longitudinal joints and transverse joints shall be constructed in all cases where and as indicated on the plans and construction joints shall be made as herein prescribed. Longitudinal joints shall be strip joints, except as otherwise noted on the plans. Transverse joints shall be expansion joints, dummy joints or construction joints. Unless other locations are shown on the plans, all longitudinal joints shall be along or parallel to the center line of the pavement and all transverse joints shall be at right angles to the center line and shall extend the full width of the pavement. All joints shall be perpendicular to the surface of the slab and when tested with a straightedge, the surface across any joint shall not vary from the straightedge by more than one-eighth inch. Concrete edges at all joints shall be tooled to the radius shown on the plans. All joints shall be

trimmed and topped out with prescribed material. Each kind of joint shall be of the type and of the dimensions required by the plans or special provisions and shall conform in each case to the appropriate requirements hereinafter set forth.

#### **Longitudinal Joints:**

Tie bars shall be placed across longitudinal joints, if and as shown on the plans, and shall be held in position at the spacing shown by approved chairs or other supports at both ends. Sleds shall not be used. Tie bars shall be deformed bars and of the diameter and length shown on the plans and in no case shall the bars be painted, greased or otherwise treated to prevent bonding with the concrete. Any other approved method of tying the adjacent slabs together, shown on the plans, may be used. Tie bars shall not be used across expansion joints.

Longitudinal strip joints shall be formed by first installing a parting strip of the required gauge, shape and dimensions to be left permanently in place. The strip shall be securely held in place, true to line and grade, by approved steel channel pins, at intervals not greater than three feet. Adjoining sections shall be securely fastened together by lapping and pinning, or by means of slip joints or other approved methods. The contractor shall furnish an approved gauge, riding on the side forms, for accurately checking the position of the parting strip before concrete is placed against it. The parting strip shall not extend across any transverse joint.

#### **Transverse Joints:**

Expansion joints shall be installed at intervals shown on the plans and in conformity therewith.

Transverse expansion joints shall be formed during the placing of the concrete and such methods of construction shall be employed that joints to the full depth and width of slab are secured. The finished joint shall be true to the line prescribed within an allowable variation of one-quarter inch in the width of one traffic lane.



The specified joint filler shall be cut to the required section and appropriately punched to admit the dowels. All holes for dowel bars shall be accurately spaced as specified on the plans and shall be of the same diameter as the bars to be placed therein. All joint filler shall be furnished in pieces of the required width and thickness and not less than one lane in length, except where the joint for which the filler is intended is less than one lane in length, the length of the piece shall be equal to the entire length of the joint. When in position, the filler shall be accurately perpendicular to the surface of the pavement. The bottom edge of the filler shall project to or slightly below the bottom of the slab and the top edge, unless otherwise prescribed, shall be held about three-fourths inch below the surface of the proposed pavement to provide space for the sealing of the joint with a bituminous filler. The top edge of the filler shall be protected, while the concrete is being placed, by a metal channel cap of at least ten gauge material, having flanges of sixteen gauge material not less than two inches in depth. The clear width between the flanges shall be three-sixteenths inch greater than the width of the filler. The channel cap and filler shall be securely held in place with the top thereof about one-fourth inch below the proposed surface of the pavement in order to allow the finishing operations to be executed continuously.

After the concrete on both sides of the joint has been placed and struck off, the channel cap shall be withdrawn. Unless otherwise directed, preference shall be given to the use of the joint filler as a guide in edging the joints. After the removal of the protecting cap, the filler shall be exposed for the full width of the slab. After the removal of side forms, the ends of the transverse expansion joints at the edges of the pavement shall be carefully opened for the entire depth of the slab.

Transverse dummy joints shall be formed by impressing a groove or cleft in the slab, of the dimension shown on the plans. The groove formed in the soft concrete by a suitable tool or device, shall extend across

the width of the slab in a straight line and shall extend vertically downward from the surface to the depth shown. The groove shall be filled with the specified bituminous materials in the manner specified under pouring joints.

Unless other prescribed joints occur at the same points, transverse construction joints shall be made at the end of each day's run or where interruption in the concreting operations of more than thirty minutes occurs and where the length of pavement laid from the last joint is more than ten feet. Sections less than ten feet in length between joints will not be permitted. A clean plank having a thickness of not less than three inches and cut to conform with the typical cross section of the slab may be used as a header board. The header board shall be accurately set and held in place in a plane perpendicular to the surface. The edge along the end of the pavement shall be finished with an edging tool of the radius shown on the plans. Upon the resumption of work, the header board shall be cleaned away and the fresh concrete deposited directly against the old. A groove shall be made in the fresh concrete and the groove filled with bituminous material which shall be in every respect the same as provided for dummy joints.

#### **Dowel Assembly:**

Dowels shall be prepared and placed across all transverse joints unless otherwise shown on the plans. The dowel bars shall be held in position, parallel to the surface and center line of the slab, by an approved device which shall be left in the slab.

Each dowel bar placed in an expansion joint shall be provided with an approved, close fitting, closed end sleeve, of the dimensions shown on the plans. The sleeve shall have a suitable flange or other device to hold the closed end of the sleeve from the end of the dowel bar during placing of concrete so that a space of not less than the thickness of the joint will be provided for subsequent movement of the dowel bar in the

sleeve. The type of sleeve used shall be approved by the Project Engineer.

The dowel bars shall be round smooth bars of the dimensions, and at the locations shown on the plans. The dowel bars shall not be burred on the ends.

The entire length of each dowel bar shall be dipped in and completely coated with hot asphalt meeting the requirements specified in M-5, type AC-9.

#### **Pouring Joints:**

A tack coat of cut-back asphalt, Grade RC-1, shall be applied to all joints before placing poured filler. The joint shall be cleaned thoroughly and the tack coat applied by painting the inside of the grooved joint as shown on the plans. All joints and cracks shall be filled and kept filled with "Poured Filler", immediately after the curing operation is completed or as directed by the Project Engineer. Prior to the sealing of the expansion joints, the top of the joint shall be thoroughly cleaned and the top edge of the joint filler trimmed with a special tool or device so that the top of the joint filler shall not be less than the required depth below the surface of the pavement. All joints shall be clean and dry before being poured. The poured filler shall be heated to such temperature that it will satisfactorily penetrate to the full depth and width of the joint. In pouring, the opening shall first be poured part full, allowed to settle and then completely filled. Any material spilled over the surface of the adjacent pavement, curbs or structures shall be immediately and completely removed by the contractor at his expense. After the pavement is opened to traffic, and prior to final acceptance, all filler in joints which extends above the surface of the pavement shall be trimmed flush with the pavement as often as directed by the Project Engineer and to his satisfaction.

#### **Consolidating and Finishing:**

The sequence of operations shall be, first, the strike-off and consolidation, second, longitudinal floating, and removal of laitance, followed by straightedging and

belting. The machine method of strike-off and consolidation shall be employed. Compacting and finishing by hand will be allowed only where machine finishing is impracticable. After a breakdown of the finishing machine, only material which is already in transit shall be finished by hand.

#### **Strike-off and Consolidation:**

The concrete, as soon as placed, shall be accurately struck-off and screeded, with approved machine equipment, to the crown and cross section shown on the plans and to an elevation slightly above grade so that, when properly consolidated and finished, the surface of the pavement shall be at the exact grade elevation indicated by the plans and free from porous places.

The machine equipment shall be of the screeding and troweling type, designed and operated both to strike off and to consolidate. The machine shall go over each area of pavement as directed and as many times and at such intervals as required to take advantage of the conditions of the concrete, to give the proper compaction and to leave a surface of uniform texture, true to grade and contour. At least two trips will be required. Prolonged operation over a given area, however, shall be avoided. The last trip for a given area shall be a continuous run of approximately forty feet. The top of the forms shall be kept free from accumulations by an effective device attached to the machine and the travel of the machine on the forms shall be maintained true without lift, wobbling or other variations tending to affect the precision of finish. The machine shall be of ample strength to withstand severe use and shall be fully and accurately adjustable to the correct crown or for derangement due to wear.

#### **Hand Methods for Strike-off and Consolidation:**

When the hand method is permitted, concrete as soon as placed, shall be struck off and screeded to the crown and cross section shown on the plans and to an elevation above grade so that, when consolidated and finished, the surface of the pavement shall be at

the exact grade elevation indicated by the plans. The entire surface shall then be tamped and the tamping operations continued until the required compaction and reduction of surface voids is secured. A strike or tamping template shall be provided on the work. It shall be durably constructed of three or four inch lumber, steel shod, or of steel of channel cross section two feet longer than the proposed width of pavement slab and sufficiently strong and rigid to retain its shape under all working conditions. In making the strike-off above mentioned, the template shall be moved forward with a combined longitudinal and transverse shearing motion, moving always in the direction in which the work is progressing and so manipulated that neither end is raised from the side forms during the striking off process. All templates shall be subject to the approval of the Project Engineer and shall be discarded when adjudged unfit for use.

#### **Consolidation With Vibrators, Reinforced Concrete Thickened Edge Pavement:**

When consolidation with vibrators is specified, the following shall apply:

The concrete shall be deposited upon the subgrade in two layers of approximately the same depth. After placing the first layer, the concrete shall be struck-off and tamped with approved tamping device. The steel mat or bars shall then be placed in position on the first layer of concrete.

After this operation, the second or upper layer of concrete shall be poured and struck off and compacted by means of a mechanical screed. During the second finishing or screeding, vibrators suspended from the screed shall be operated in the thickened edges. Vibrators to be of the bullet type and shall be placed at a point directly eighteen inches ahead of the screed and three-eighths the distance of the thickened edge, measured from the outer edge of the pavement. The vibrators shall be of such size and construction and placed so as to have an effective radius of vibration to

completely vibrate the concrete the entire width of the thickened edges.

Means shall be provided for vertical adjustment as well as stops for depth of operation below surface of the slab or for simultaneously lifting the vibratory members. The controls shall be located on the deck of the finishing machine, convenient to the operator's position.

The extreme edges of slab and all joints shall be thoroughly vibrated by means of a portable vibrator, hand operated.

The frequency of vibration of all vibrators mentioned shall be not less than 3600 cycles per minute.

The concrete shall be struck off and compacted by means of a screed resting upon it and moved upon it in such a manner as to leave the top of the concrete slab at the proper elevation and the concrete thoroughly compacted.

#### **Consolidation With Vibrators, Non-reinforced Concrete Pavement:**

When consolidation with vibrator is specified the following shall apply:

The concrete shall be deposited upon the subgrade in one continuous operation for the required depth of the pavement. The concrete shall be internally vibrated directly ahead of the front screed of the paving finisher with the vibratory unit or units in parallel relationship to the screed.

Consolidating of the concrete shall be accomplished by means of the vibrator operating as a part of the finishing screed or as an independent unit. If operated from the finishing screed the vibratory members shall be flexibly suspended from and pulled by hanger units to insulate the finishing machine from vibration. The vibrator is to consist of two or more pairs of electrically actuated tubular vibrators in parallel relationship with each other or units consisting of a series of individual vibrators or shoes, so spaced and operated that the

effective radius of vibration of each member shall be such that it completely overlaps the distance between tubes or individual vibrators when submerged in concrete and penetrates well under the front screed.

Means shall be provided for vertical adjustment as well as stops for depth of operation below surface and for crown of the slab. Further provision shall permit front and rear tubular vibratory members or individual vibrators to operate on the same or different planes as may be required. Means shall be provided for simultaneously lifting the vibratory members and the controls shall be located on the deck of the finishing machine, convenient to the operator's position.

The frequency of vibration shall be not less than 3600 cycles per minute.

The combined lengths of the pairs of tubes or series of vibrators shall be substantially the width of the pavement.

The concrete shall be struck off and compacted by means of a screed resting upon it and moved upon it in such a manner as to leave the top of the concrete slab at the proper elevation and the concrete thoroughly compacted.

**Finishing Tools:** After the concrete has been struck off, the contractor shall provide and use as hereinafter provided and directed by the Project Engineer the following named finishing tools: Longitudinal Float, Straightedge Float, Bow Belt, Long Handle Float, Hand Float, and Edging Tools. All tools for finishing the pavement shall comply with requirements of the Department's Standard Tool Sheets unless other equipment is specifically permitted by the Project Engineer. The use of tools other than these specifically provided for will not be permitted unless same is found to be effective for the purpose used. Any and all tools and equipment necessary for the finishing and checking of the pavement surface shall be furnished and used by the contractor as directed. Tools or equipment adjudged by the Project Engineer as unfit for use shall be immediately discarded by the contractor.

Longitudinal Floating: In this operation, a mechanical or hand operated longitudinal float shall be worked with a sawing motion while held in floating position parallel to the road center line and passed gradually from one side of the pavement to the other. Movements ahead along the center line of the road shall be in successive advances not more than one-half the length of the float. The float may be operated from foot bridges resting on the side forms and spanning but not touching the concrete.

Straightedging: While the concrete is still plastic, the slab surface shall be tested for trueness with a straightedge. The straightedge shall be held in successive positions parallel to the road center line in contact with the surface and the whole area gone over from one side of the slab to the other as necessary. Advance along the road shall be in successive stages of not more than one-half the length of the straightedge. Any depressions found shall be immediately filled with freshly mixed concrete, struck off, consolidated and refinished. Projections also shall be struck off and refinished. The straightedge testing and refloating shall continue until the entire surface is found to be free from observable departures from the straightedge and the slab has the required grade and contour.

Belting: When most of the water sheen has disappeared and just before the concrete becomes nonplastics, the surface shall be belted. The belt shall be operated with short strokes transverse to the road center line and with a rapid advance parallel to the road center line. Mechanically operated belts may be substituted for bow belt when approved in writing by the Project Engineer.

Finished Surface: The finished surface shall be free from porous spots, irregularities, depressions and small pockets or rough spots such as are or may be caused by accidental disturbance during the final belting, of particles of coarse aggregate embedded near the surface. The edges of the slab shall be carefully finished with an edger of the radius required by the plans at about the time the concrete becomes hard and non-



plastic and the pavement edge left smooth and true to line. Immediately after finishing is completed, channels through the shoulders or other means shall be provided to drain away surplus water.

#### **Correction of Defective Surface:**

After the concrete has hardened, and not later than ten o'clock of the morning following the placing of the concrete, the surface of the pavement shall be again tested with a ten-foot straightedge or device, which shall be operated as previously described, so as to reveal any and all irregularities. Any portion of the pavement, which shows a variation or departure from the testing edge of more than one-eighth inch and has not been satisfactorily corrected by rubbing or other approved methods, shall be removed and replaced by and at the expense of the contractor and any area or section so removed shall be not less than ten feet in length and for the full width of the section under construction.

#### **Cold Weather Concreting:**

Except by specific written authorization by the Project Engineer, concreting operations shall not be continued when a descending air temperature in the shade and away from artificial heat falls below 40°F. nor resumed until an ascending air temperature in the shade and away from artificial heat reaches 35°F.

When concrete is being placed during cold weather and the air temperature may be expected to drop below 35°F., a sufficient supply of straw, hay, grass or other suitable blanketing material shall be provided along the line of the work and at any time when the air temperature may be expected to reach the freezing point during the day or night, the material so provided shall be spread over the pavement to a sufficient depth to prevent freezing of the concrete before it has thoroughly hardened. The contractor shall be responsible for the quality and strength of the concrete laid during cold weather and any concrete injured by frost action shall be removed and replaced at his expense.

### **Curing of Concrete:**

After finishing operations have been completed, the newly laid concrete pavement shall be cured by one of the following methods: Cotton Fabric, Cotton Mat or Water-proofed Paper. High-Early-Strength Portland Cement shall be cured by the cotton fabric method.

The cotton fabric method shall be used for the initial curing period of 24 hours regardless of the type of final curing.

Curing methods requiring the use of water shall have prior rights to all water supplies, and water shall be applied by spraying to avoid damage to the fresh concrete.

Newly laid concrete shall be protected from the direct action of the sun, and in no case shall the finished concrete surface be unprotected for more than one-half hour.

### **Cotton Fabric Method:**

Immediately after finishing operations have been completed, the entire surface of the concrete shall be covered with water saturated fabric laid directly upon the finished surface. The fabric shall be kept water saturated continuously for 24 hours. Cotton fabric strips or blankets shall be lapped 6 inches over the adjoining strip or blanket, and all strips or blankets shall overlap the slab width one foot on each side. The fabric shall be removed after a period of 24 hours, the surface of the slab shall be thoroughly wetted and the final curing method shall be started immediately. Where High-Early-Strength Portland Cement is used, the cotton fabric shall remain in place and shall be kept water saturated for a period of 48 hours.

### **Cotton Mat Method:**

Immediately after cotton fabric is removed from the slab, the entire surface of the slab shall be covered with water saturated cotton mats for a period of 72 hours. The mats shall be so laid as to contact the

surface of the slab at all points. The mats shall be kept water saturated continuously throughout the 72 hour curing period.

**Water-proofed Paper Method:**

Immediately after the cotton fabric is removed from the slab, the entire surface of the slab shall be covered with a water-proofed paper for a period of 72 hours. The paper shall be so laid and weighted down as to have the paper mat in intimate contact with the surface of the slab at all points and separate mats shall be lapped 18 inches.

**Wet Earth Method For Curing Pavement Edges:**

Immediately after the forms are removed the pavement edges shall be banked with earth and the earth water saturated and kept water saturated for a period of 72 hours.

**Cold Weather Curing:**

When temperatures below 50°F. are apparent in the opinion of the Project Engineer, the final curing period shall be omitted and immediately after the cotton fabric is removed from the slabs, the entire surface of the slab shall be covered to a depth of 12 inches with clean, dry and loose straw, hay, grass or other suitable blanketing material, which shall be maintained in place 10 days.

**Protection of Concrete:**

The contractor shall erect and maintain suitable barricades and employ watchmen, if required by the Project Engineer, to exclude traffic from the newly constructed pavement for the period herein prescribed but these barriers shall be so arranged as not in any way to interfere with or impede public traffic on any lane intended to be kept open and necessary signs and lights shall be maintained by the contractor clearly indicating the open lanes. When it is necessary to provide for traffic across the pavement, the contractor shall at his expense construct suitable and substantial

crossings to bridge over the concrete which will be adequate for the traffic and satisfactory to the Project Engineer. When bridges or ramps are required by property holders, the contractor shall be required to construct same in the following manner: If it is necessary for trucks, tractors or similar heavy vehicles to cross the highway, a timber bridge shall be constructed without bearing on the pavement. If a crossing is required for automobiles, the contractor may bridge as specified above or construct an earth ramp, by first placing twelve inches of earth on the pavement and covering same full length with two inch planks placed parallel to the center line of the highway. However, no earth ramp shall be constructed until the pavement is at least twenty-four hours old, and then only in a manner as specified above.

Any part of the pavement damaged by traffic or other causes occurring prior to its final acceptance shall be repaired or replaced by, and at the expense of, the contractor in a manner satisfactory to the Project Engineer. The contractor shall protect the pavement against both public traffic and the traffic caused by his own employees and agents. All ditches and drains shall be in such condition as to provide effective drainage. When berms of earth are placed along the shoulders, proper provision shall be made for surface drainage.

#### **Handling and Facilitating Public Traffic:**

Normal, unimpeded use of the thoroughfare of which the proposed pavement is to be a portion or unit, is of value to the public and it is, therefore, mutually understood, under the contract of which these specifications form a part, that for the special sections of the thoroughfare stated in the special provisions and identified on the plans as requiring special traffic handling and for the stated distances, commodious adequately surfaced road lanes shall be made available by the contractor for unimpeded public traffic at all times and maintained in proper condition throughout the construction period. These lanes shall be of the clear widths

indicated on the plans or stated in the special provisions, and shall be kept entirely free from encroachment at any time by any equipment of the contractor or by any workmen or employees of the contractor or by reason of storage or transportation of any materials intended for the work.

For the information of bidders, the desired scheme and sequence of construction of the several lanes, slabs and sections of pavement will be given on the plans, or stated in the special provisions, including information prescribing the sequence of the shifting of public lanes as necessary during progress of construction. The scheme and sequence when prescribed shall be followed in all details by the contractor.

Where the edge of any stipulated public traffic lane is contiguous to an edge of the particular slab or lane being placed, a substantial temporary guard fence shall be erected as directed by the Project Engineer, or as detailed on the plan, along the prescribed dividing line and maintained there until the slab is cured and opened to traffic. The fence shall be such as will effectually prevent workmen from moving into or standing on the public traffic lane, or impeding traffic. Workmen and employees of the contractor shall not be allowed to be in the reserved public lanes or in any way impede traffic at any time. The plan of operations and equipment of the contractor shall be such as to obviate any necessity of encroachment on the public traffic lane or lanes. Where so shown, special lanes for the contractor's trucks and similar vehicles shall be provided, separate from and not interfering with the prescribed public traffic lanes. Where the clearance between public traffic lane and the contractor's operating equipment is restricted, special delivery equipment may be necessary, designed to deliver and depart within the width of the slab actually being placed without encroaching on any public lane. Such equipment shall be provided when and if required by the plans or special provisions.

Except where a special contract price for "traffic handling" is included in the contract, all cost and extra expense of such handling and protection, special equip-

ment and temporary road surfacing and maintaining shall be at the expense of the contractor. Before making his bid, the contractor shall examine the site of these special traffic accommodations and give detailed consideration to the probable cost and extra expense to which he will be put, including the use of special equipment. Attention is directed to C-126.

#### **Opening to Traffic:**

Traffic shall be excluded from newly constructed pavement, constructed with Standard Portland cement, for a period of seven days after the concrete is finished (from pavement constructed with High-Early-Strength Portland cement, for a period of forty-eight hours) or longer if, in the opinion of the Project Engineer, weather or other conditions make it advisable to extend the time, provided, however, that at the discretion of the Project Engineer cross bending test specimens, prepared at regular intervals from the mix as it comes from the mixer and cured under the same temperature, moisture and climatic conditions as the corresponding slabs of pavements, may be employed as a means of fixing the time of opening to traffic. These beams shall be tested by standard laboratory third point loading method and when these specimens under test indicate that the corresponding pavement has attained a modulus of rupture of not less than six-hundred pounds per square inch, the pavement shall be cleaned, the joints filled and trimmed and the pavement opened to traffic. In all cases the pavement shall be cleaned and the joints shall be filled and trimmed or topped out as herein required. The joint or line of separation between adjacent strips or slabs of concrete, when the pavement is constructed in lanes or strips, shall be cleaned and filled with bituminous material herein prescribed for the purpose.

#### **Tolerance in Pavement Thickness:**

It is the intent of these specifications that the pavement shall be constructed strictly in accordance with the thickness shown on the plans. Where any pavement

is found not so constructed, the following rules relative to replacement of the faulty pavement and adjustment of payment shall govern.

For pavement slab, the average thickness of which, determined as hereinafter provided, is equal, within one-eighth inch, to the thickness required by the typical cross section shown on the plans, the contract unit price shall be used in payment.

For pavement slab, the average thickness of which, determined as hereinafter provided, is less than the thickness shown on the plans by more than one-eighth inch, but less than one-half inch, an adjusted unit price shall be used in payment, which price shall bear the same ratio to the contract unit price as the square of the average thickness of the slab bears to the square of the thickness specified on the plans.

No additional payment over the unit contract price will be made for any slab, should the average thickness of the pavement, determined as hereinafter provided, exceed the thickness shown on the plans.

The thickness of the slab will be determined by average measurement of the thickness of cores taken from it. At such points as the Project Engineer may select and in each one-thousand linear feet of pavement, cores will be taken and measured. The average thickness of each full mile of slab, or any fraction of a mile, if the contract cannot be divided into an integral number of miles, will be determined from these measurements. An adjusted unit price shall be calculated for each mile or fraction and shall be used as the basis of payment for accepted yardage therein. In calculating the average thickness of the slab, measurements which are in excess of the thickness specified on the plans by more than one-eighth inch shall be considered as the specified thickness plus one-eighth inch, and measurements which are less than the specified thickness by one-half inch or more shall not be included in the average.

Payment shall be withheld for slab which is found deficient in thickness by one-half inch or more by excluding it from the accepted yardage. When the mea-

surement of any core indicates that the slab is deficient in thickness by one-half inch or more, determination shall be made of the actual thickness of transverse sections of the slab at twenty-five foot intervals set off along the center line of the road in each direction from the affected location until, in each direction, a transverse section of the slab is found which is not deficient in thickness by as much as one-half inch. The area of slab for which no payment will be made shall be the product of the full width of pavement multiplied by the sum of the distance in such direction from the affected location along the center line of the road to the transverse sections found not deficient in thickness by as much as one-half inch.

With respect to slab, payment for which is withheld because of deficiency in thickness, if in the opinion of the Project Engineer such deficiency is sufficient to seriously impair the traffic service expected from the pavement, the contractor will be required to remove such deficient areas and to replace them with slab of a satisfactory quality and thickness which, when accepted, will be duly included in the pay yardage. The contractor, however, shall receive no compensation for materials or labor involved in the removal of the defective slab. If, on the other hand, in the opinion of the Project Engineer, there is no probability of immediate failure, he may allow the contractor the choice of leaving the defective slab in place and receiving no compensation or payment for same, or of removing and replacing the pavement as provided above. All pavements more than one inch deficient in thickness shall be removed and replaced by the contractor at his own expense.

If the contractor believes that the cores and measurements taken are insufficient to indicate the actual thickness of pavement, he may request additional cores and measurements. Such measurements shall be made at intervals of not less than two hundred feet. The cost of additional cores and measurements shall be deducted from any sums due the contractor unless such measure-



ments indicate that the slab within the area in question is of specified thickness.

Deductions for deficient thickness may be entered on any estimate after the information becomes available. No pavement shall be accepted until it has been duly cored and found within the one-half inch tolerance in depth.

#### **Finishing Shoulders:**

The construction, shaping and dressing of the shoulders shall follow the completion of the pavement as closely as practicable. Shoulders shall be compacted with rubber tired rollers.

#### **METHOD OF MEASUREMENT:**

Portland cement concrete pavement shall be measured by the square yard, complete in place. The width for measurement shall be the width from outside to outside of completed pavement, as constructed in accordance with the plans or as directed by the Project Engineer. The length shall be the actual center line length measured along the riding surface.

If shown on the plans, mud pump connections shall be measured, complete in place, and each completed and accepted connection shall be counted.

#### **BASIS OF PAYMENT:**

The number of square yards of completed and accepted concrete pavement, measured as specified, shall be paid for at the contract unit price per square yard for "Portland Cement Concrete Pavement," complete in place, which price and payment shall constitute full compensation for preparing the subgrade, shaping the shoulders and the furnishing of all materials (except reinforcing steel), equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

Provided, that payment shall be withheld for slab which is found deficient in thickness by one-half inch or more from the thickness required by the typical

cross section shown on the plans by excluding it from the accepted yardage, and provided that for slab which is found to be deficient by less than one-half inch from the thickness required by the typical cross section shown on the plans but is included in the accepted yardage, only the reduced price shall be paid as hereinbefore stated.

Mud pump connections measured as provided above shall be paid for under Item 542.

**Payment will be made under:**

Item 535b, Portland Cement Concrete Pavement, Type "B," per sq. yd.

Item 535c, Portland Cement Concrete Pavement, Type "C," per sq. yd.

Item 535d, Portland Cement Concrete Pavement, Type "D," per sq. yd.

Item 535e, Portland Cement Concrete Pavement, Type "E," per sq. yd.

Item 535f, Portland Cement Concrete Pavement, Type "F," per sq. yd.

## APPROACH SLAB

**DESCRIPTION:**

This item shall consist of the construction of concrete approach slabs for structures, at the location and of the dimensions shown on the plans.

**MATERIALS:**

**Concrete:**

Concrete for approach slabs shall be of the same type and specifications as specified for concrete pavement. Materials entering into the concrete used shall conform to the requirements of the specifications for "Portland Cement Concrete Pavement".

**Reinforcing Steel:**

Reinforcing steel shall be deformed bars of new billet steel and shall conform to the requirements specified in M-110.

Poured filler shall conform to the requirements specified in M-6.

**CONSTRUCTION METHODS:****General:**

Approach slabs shall be poured along with the Portland cement concrete pavement and construction methods shall conform to the construction methods for "Portland Cement Concrete Pavement".

**Roadway Finish:**

The roadway finish shall be the same as that specified for "Portland Cement Concrete Pavement".

**Mud Pump Connections:**

Mud pump connections shall be fabricated in accordance with the dimensions shown on the plans. In the event a metal cap is not provided, the contractor shall fill each connection with firmly packed earth to within 2 inches from the top, then fill remainder of hole with poured filler.

**METHOD OF MEASUREMENT:**

Approach slabs shall be measured by the square yard and the quantity to be measured shall be the length and width shown on the plans. No measurement will be made of reinforcing steel. Mud pump connections will be measured per each and the measurement shall be made by counting the number of mud pump connections.

**BASIS OF PAYMENT:**

The number of square yards of approach slab and the number of mud pump connections measured as

specified shall be paid for at the contract unit price for "Concrete Approach Slab" or "Mud Pump Connections" which price and payment shall be full compensation for furnishing, hauling, and placing all materials and for all labor, equipment, tools and incidentals required to complete the items.

**Payment shall be made under:**

Item 542, Mud Pump Connections, each.

Item 543, Approach Slab, per square yard.

## BITUMINOUS PATCHING ITEM 544

**DESCRIPTION:**

This item shall consist of the furnishing and placing of cold mix bituminous material on a previously constructed surface. The material is to be used as patching material at various locations as directed by the Project Engineer.

**MATERIALS:**

Cold mixed bituminous material shall conform to the requirements specified in M-9 or M-10, and the particular type of material to be used shall be specified on the plans or in the special provisions.

Bituminous tack-coat shall conform to the requirements specified in M-1, or M-4, as indicated on the plans.

**CONSTRUCTION METHODS:**

All surfaces to be patched shall first be cleaned thoroughly with brushes and given a bituminous tack-coat at the rate of from 0.15 or 0.25 gallons per square yard. While the tack-coat is still tacky, the bituminous material shall be placed thereon in layers not to exceed one inch in thickness until the patch is built up to the re-

quired thickness. Each layer of bituminous material shall be thoroughly compacted either with mechanical rollers, hand rollers or rubber tired vehicles, except in places inaccessible to these methods a hand tamp may be used.

**METHOD OF MEASUREMENT:**

Bituminous patching shall be measured by the ton of 2,000 pounds and the quantity to be measured shall be the number of tons of bituminous material used in the patches. The bituminous material shall be weighed in the hauling vehicle on scales acceptable to the Project Engineer.

**BASIS OF PAYMENT:**

The number of tons of bituminous patching, measured as provided, shall be paid for at the contract unit price for "Bituminous Patching," which price and payment shall constitute full compensation for furnishing all materials (including tack-coat); tools, labor, equipment and incidentals and the performance of all work necessary to complete the item.

**Payment will be made under:**

Item 544, Bituminous Patching, per ton.

**ASPHALTIC CONCRETE,  
COLD MIX  
ITEM 555  
CLASS H**

**DESCRIPTION:**

This item shall consist of a surface course composed of cold laid asphaltic concrete constructed on the prepared base course in accordance with these specifications and in conformity with the lines, grades and typical cross sections shown on the plans.

**COMPOSITION:**

The asphaltic concrete shall be composed of a mixture of mineral aggregate, hydrated lime, asphalt cement and liquefier.

The mineral aggregate shall be composed of coarse and fine aggregate. The coarse aggregate shall be crushed stone or crushed slag and the fine aggregate shall be coarse sand.

The aggregate shall be combined in such proportions as to meet the following gradation requirements when tested by weight passing square opening standard laboratory sieves:

Sieve	Per Cent
1/2" .....	95—100
No. 4 .....	15— 40
No. 8 .....	10—25
No. 20 .....	5— 15

To the above mineral aggregate (considered as 100% ) shall be added the following proportions of materials:

Material	Per Cent
Asphalt cement .....	5—7
Liquefier .....	0.2—1.5
Hydrated Lime.....	0.5—1.00

**Formula for Job Mix:**

The general composition limits prescribed above are extreme ranges of tolerances that shall not be exceeded regardless of any formula that may be submitted or set up.

Before starting work the contractor shall submit to the Project Engineer a proposed job mix formula, in writing, to be supplied for the project. The formula so submitted shall stipulate a single definite percentage of aggregate passing each required sieve size, percentage of bitumen, percentage of liquefier and percentage of hydrated lime, all of which shall fall within the ranges

of composition prescribed above, and a single definite temperature at which the mixture is to leave the mixer. The Project Engineer shall set the job mix at his discretion, fixing definite percentages for each material and a definite temperature for the completed mix as it comes from the mixer.

After the job mix formula is established by the Project Engineer, all mixtures furnished for the project shall conform to the formula within the following ranges of tolerances:

Passing No. 4, 8 and 20 Sieves.....	± 4%
Liquefier .....	± 0.2%
Bitumen .....	± 0.4%
Temperature of Mixture.....	±20° F.

Each day the Project Engineer shall take as many samples as he considers necessary to check the uniformity of the mixture. The Project Engineer may establish a new job mix formula when conditions require.

A new job mix formula shall be submitted when sources of material are changed and the Project Engineer shall re-establish a job mix formula before the new materials can be used.

#### **MATERIALS:**

Asphalt cement shall conform to the requirements specified in M-5, Type AC-5.

Crushed stone shall conform to the requirements specified in M-13, Type R-2, except for gradation.

Crushed slag shall conform to the requirements specified in M-13, Type R-3, except for gradation.

Fine aggregate shall conform to the requirements specified in M-14, Type A, except for color and mortar test.

Hydrated lime shall conform to the requirements of A. S. T. M. Designation C-6.

Liquefier for use during warm weather shall be a petroleum naphtha which, when distilled in accordance with A. S. T. M. Designation D-86, shall have an initial

boiling point of not more than 220° F. and an end point of not more than 450°F. At least 45% and not more than 55% of the distillate shall be distilled off at 325° F.

Liquefier for use during cold weather shall be a petroleum naphtha which, when distilled in accordance with A. S. T. M. Designation D-86, shall have an initial boiling point of not more than 270° F. and an end point between 425° F. and 450° F. The distillate shall pass off continuously at regular intervals between 275° F. and the end point so as to give a nearly straight line on the distillation graph.

#### **Sources of Supply:**

Approval of source of supply of all materials shall be obtained from the Project Engineer prior to delivery of material. Samples shall be submitted as directed by the Project Engineer.

#### **Pavement Samples:**

The contractor shall furnish for test, when required by the Project Engineer, samples cut from the completed pavement. The areas of pavement so removed shall be replaced with new mixture and refinished. No additional compensation will be allowed for furnishing test samples and replacing the areas with new pavement.

### **CONSTRUCTION METHODS:**

#### **Weather Limitations:**

Asphaltic concrete mixture shall not be placed when the atmospheric temperature is below 50° F. or during a rain. This temperature limit may be lowered by the Project Engineer at his discretion.

#### **Plant and Machinery:**

The paving plant used in the preparation of the bituminous mixture shall conform to the following requirements:

- (a). Drier: The plant shall include a drier capable



of heating evenly the aggregate necessary to supply the mixing unit continuously at its operating capacity and of removing the moisture from the aggregate to the limit herein prescribed without burning or over-heating any portion.

(b). Screens: Plant screens, capable of screening all aggregates to the specified sizes and having normal capacities slightly in excess of the full capacity of the mixer, shall be provided.

(c). Bins: The plant shall include storage bins of sufficient capacity to supply the mixer when it is operating at full capacity. Bins shall be divided into at least three compartments arranged to insure separate and adequate storage of appropriate sizes of the aggregate. Each compartment shall be provided with an overflow pipe that shall be of such size and at such a location as to prevent any backing up of material into other bins.

(d). Weigh Box or Hopper: The plant shall have a weigh box capable of holding the maximum amount of material for one batch. The weigh box or hopper shall be supported on fulcrums and knife edges so constructed that they will not be easily thrown out of line or adjustment. All edges, ends and sides of the weighing hopper shall be free from contact with any supporting rods or columns or other equipment that will, in any way, affect proper functioning of the hopper. There shall be sufficient clearance between the hopper and supporting device to prevent the accumulation of foreign materials. The discharge gate of the weigh box shall be so hung that the aggregates will not be segregated when dumped into the mixer. If necessary to correct any such tendency, baffles shall be inserted or other means provided to discharge the materials in a blended condition. The discharge gate shall be tight enough to prevent leakage of fine aggregate into the mixer.

(e). Scales: Scales for the weigh box may be of either the beam or the springless dial type and shall be of a standard make and design, sensitive to  $\frac{1}{2}$  of 1% of the maximum load that may be required.

When scales are of the beam type, there shall be a separate beam for each size of aggregate. There shall be provided a tell-tale dial that will start to function when the load being applied is within 100 pounds of the load desired. Sufficient vertical movement shall be provided for the beams to permit the tell-tale dial to function properly. Each beam shall have a locking device designed and so located that the beam can easily be suspended or thrown into action. The weighing mechanism shall be balanced on knife edges and fulcrums and so constructed that it can not be easily thrown out of alignment and adjustment.

Dial scales shall be springless, of a standard make, and of such size that the numerals on the dial can be read at a distance of at least 25 feet. The dials shall be of the compounding type having full complement of index points. Points so placed as to give excessive parallax errors shall not be used. The scales shall be substantially constructed, and those that get out of adjustment easily shall be replaced with other makes when so ordered. All dials shall be so located as to be plainly visible to the operator at all times.

Scales for the weighing of asphalt cement shall conform to the specifications for the scales for aggregate except that each beam scale shall be equipped with a tare and a full capacity beam. The value of the minimum graduations shall not be greater than two pounds. Dial scales for weighing asphalt cement shall not have a capacity of more than twice the weight of the material to be weighed and shall read to the nearest pound. Beam scales shall be equipped with a tell-tale device which will start to function when the load being applied is within 10 pounds of the load desired.

The weighing equipment, in addition to complying with the requirements above, shall be constructed with adjustable devices that will permit any part thereof that gets out of alignment or adjustment, to be readjusted easily so that the weighing device will function properly.

Scales shall be satisfactory to the Project Engineer and shall be sealed as often as the Project Engineer

may deem it necessary to insure their accuracy. The contractor shall provide and have at hand the necessary number of standard test weights for frequent testing of all scales.

(f). Asphalt Weigh Bucket: The asphalt weigh bucket shall be steam-jacketed and shall have a capacity equal to 10% of the maximum capacity of the mixer. It shall be supported on fulcrums and knife edges in the same manner as is the weigh box.

(g). Kettles: Kettles for storage of asphalt cement shall have a combined capacity sufficient for one day's run and shall be capable of heating the asphalt cement with an effective and positive control of the heat at all times to a temperature between 250° F. and 350° F. An approved recording thermometer shall be furnished and installed so as to show the temperature of the asphalt cement at all times.

Flame from oil or other fuel shall not be permitted to come into direct contact with the heating kettles. The asphalt circulating system shall be of adequate size to insure the proper and continuous circulating of asphalt cement during the entire operating period. All asphalt lines and fittings shall be steam-jacketed.

(h). Thermometers: An armored thermometer reading from 100° F. to 400° F. shall be fixed in the asphalt feed line at a suitable location near the weigh bucket discharge valve.

The plant shall be further equipped with an approved dial scale mercury thermometer, an electrical pyrometer, or other approved thermometric instruments so placed that the discharge chute of the drier has to register or indicate automatically the temperature of the aggregate.

The instruments used for measuring the temperature of aggregates shall be approved by the Project Engineer.

(i). Liquefier Control Unit: There shall be an accurate calibrated device installed for the measurement of liquefier. The discharge pipes from such device shall be

installed to spray liquefier into the mixer in such a manner as to insure uniform distribution of the material.

(j). Mixers: The mixer shall be of the pugmill type having a capacity of 1,500 pounds minimum. It shall be of a design to permit visual inspection of the condition of the mix and shall be steam-jacketed and heated to prevent chilling of the mixture. The Project Engineer may require that the mixer be provided with an approved, accurate time lock that will lock the discharge gates of the weigh box after all aggregates have been placed in the mixer, and that will not release the gates until the specified time has elapsed.

#### **Grade Control Forms:**

(a) Forms shall be set at least 200 feet ahead of the point where mixture is being placed. Enough forms shall be provided to make it unnecessary to remove any until all adjacent rolling and back finishing has been completed. The alignment and grade of all forms set shall be approved immediately prior to the placing of any material against them. Forms shall be cleaned thoroughly each time they are used.

(b). Except under conditions given in 1 and 2 below, fixed side forms for grade control shall be provided and shall be of steel or wood set to grade. String or wire lines staked to grade will not be accepted as an equivalent for grade control forms.

1. When a suitable abutting curb or header is available and is approved by the Project Engineer as in conformity with the intended profile grade, it may be utilized as a grade-control form. Curbs or headers shall be armored with appropriate bearing plates if necessary to produce satisfactory results.

2. The requirements for grade control forms may be waived when the surface course is being placed on a base that is itself parallel to the proposed finished surface of the course being laid and has been finished to the same surface tolerance as is required for such course, provided that the finishing machine in use has

a longitudinal wheelbase of approximately 10 feet or more in length or the screed or strike-off action is controlled by an independent support of approximately 10 feet in length measured parallel to the direction of advance of the machine and provided such wheelbase or support is in contact with such base and, as the machine advances, provides continuous and positive mechanical control of the screed or strike-off assembly so as to strike off the mixture to the exact profile grade and elevation intended without the aid of manual adjustment during operation.

#### **Timber for Grade Control Forms:**

Lumber for these forms shall be of common (or better) structural, joist and plank, or beam and stringer, grade. Pieces shall be not less than 16 feet long. When a form is set in position, the horizontal dimensions shall be not less than 4 inches (nominal). The face next to the mixture and the bottom and top faces shall be surfaced. Timber forms shall rest on the ground and on 2-inch by 3-inch supporting stakes not less than 8 inches long and not more than 4 feet apart and shall be secured by side stakes not more than 4 feet apart driven vertically at intermediate points between the supporting stakes; the side stakes shall be not less than 1½ inches by 3 inches, and not less than 18 inches long. Timber forms shall be spliced with sections of plank. The joints of timber forms shall be so placed as to provide a gap of ¼-inch between the ends of timbers, and shall rest upon supporting stakes of the size specified above. Wood will not be permitted for grade control forms of 3 inches or less in depth.

The top edges of timber grade control forms shall be temporarily faced with steel strips during the passing of the finishing machine. A steel strip shall be not less than ⅝-inch by 2½ inches in cross section and not less than 8 feet long. The strips shall be firmly attached to the tops of the forms and a sufficient number of strips shall be provided to keep the forms faced well ahead of operations and to prevent delay of the work. The

steel strips may be removed after the equipment has passed.

**Retaining Forms:**

When the plan of construction and the equipment and type of grade control forms in use are such that any edge of any bituminous course may be left unsupported during the construction operations, retaining forms of any suitable material and design shall be used so far as considered necessary to prevent lateral displacement or squeezing out or side shoving under the roller.

**Preparation of Bituminous Material:**

The asphalt cement shall be heated in the melting kettles or tanks so that the entire mass is heated evenly. The material shall be brought to a temperature between 200° F. and 300° F.

**Preparation of Aggregates:**

All aggregate shall be dried until it has no surface moisture and not more than four-tenths per cent of contained moisture. Mixing temperatures of the aggregate shall at no time be less than 45° F. nor more than 110° F., except when slag aggregate is used, the Project Engineer may direct that the upper limit be raised to 125° F.

After drying, all aggregate shall be screened into 3 sizes and the fractions shall be held or stored separately in their respective bins or compartments for feeding into the weigh box.

**Preparation of Mixture:**

The separated fractions of dried mineral aggregate, prepared as prescribed above, shall be combined into uniform batches by weighing and conveying into the mixer the proportionate amount of each fraction required to meet the job-mix formula. After these fractions have been thoroughly mixed, liquifier shall be sprayed over the aggregate and mixing shall be continued until all the stone is coated. The quantity or

character of liquifier used shall be varied within the limits prescribed above and shall depend on weather, time, and the distance the material is to be transported. The liquifier shall be used in such manner as will insure the desired consistency of the mixture when it is delivered and deposited on the road.

The asphalt cement and hydrated lime shall then be successively introduced and the mixing continued until the mixture is thoroughly uniform and homogeneous. The dry mixing period shall be set by the Project Engineer after he has considered the nature of the aggregate used. The total mixing time shall be varied according to the nature of the aggregates and the capacity of the mixer but in no case shall the mixing time, after the introduction of the asphalt, be less than 2 minutes. The mixture shall be so prepared that it may be unloaded and applied at the prevailing air temperature without application of heat. The details of plant operation shall be arranged to meet the requirements above and at the same time produce the workability of mix and thickness of film coating found most advantageous. Each batch shall be kept separate throughout the mixing operations.

The mixture shall be uniform in composition, free from lumps or balls of material containing an excess quantity of asphalt and free from pockets containing less than the required amount of asphalt.

#### **Transportation:**

The prepared mixture shall be transported from plant to point of use in tight vehicles, previously cleaned of all foreign materials. The bodies of transportation units shall be in good condition, free from obstructions tending to clog materials. In rail transportation, car bottoms shall be sanded; loaded cars shall be covered with paper or suitable substitute. In truck transportation, bodies may be thinly coated inside with soapy water or with a mixture of water and not more than 10 per cent of lubricating oil; the use of kerosene, gasoline, or similar products is not permitted.

Truck bodies shall be covered with waterproofed canvas when so ordered.

Shipments found to contain a surplus amount of bituminous material in the bottom of the car or truck will be rejected upon arrival.

#### **Conditioning of Existing Base:**

Where tack coat is not to be applied prior to placing the bituminous concrete mixture, the existing base upon which the pavement is to be constructed shall be swept thoroughly and cleaned of all loose dirt and other objectionable materials immediately before spreading the mixture.

Contact surfaces of curbs, gutters, manholes, and other structures shall be painted with a thin, uniform coating of hot asphalt cement (or asphalt cement dissolved in naphtha) just before the bituminous concrete mixture is placed against them.

The condition of the base shall be approved by the Project Engineer prior to placing the pavement mixture.

#### **Spreading and Finishing:**

Upon arrival at the point of use, the mixture shall be spread and struck off to the profile grade, elevation and cross section shape intended. For this purpose self-powered spreading and finishing equipment provided with an activated screed or strike-off assembly, heated if necessary, shall be used, distributing the mixture either over the entire width or over such partial width lanes as may be practicable. Blade graders or drags shall not be used. The assembly shall be adjustable to give the cross section shape prescribed and shall be so designed and operated as to place the weight per square yard of surface course material required.

If during construction it is found that the spreading and finishing equipment in operation leaves in the new surface course tracks or indented areas that are not satisfactorily corrected by the scheduled operations, or if it produces other permanent blemishes, the use of



such equipment shall be discontinued and other satisfactory spreading and finishing equipment shall be provided by the contractor.

The term "screed" includes any cutting, crowding, or other practical action that is effective in producing, from the mixture specified without tearing, shoving, or gouging, a finished surface of the evenness and texture specified.

Unless the spreader is integral with the screeding machine, a mechanical rake or its equivalent shall be used in front of the finishing machine to loosen thoroughly the material and make possible uniform distribution.

On areas where irregularities or unavoidable obstacles make the use of the self-powered spreading and finishing equipment impracticable, in the judgment of the Project Engineer, the mixture shall be spread and screeded by hand. On such areas the mixture shall be dumped on steel dump boards and spread and screeded to leave the weight of material required.

The contractor shall provide suitable means for keeping all small tools clean and free from accumulations of bituminous material. He shall provide and have ready for use at all times enough tarpaulins or covers, as may be directed by the Project Engineer, for use in any emergency such as rain, chilling wind, or unavoidable delay, for the purpose of covering or protecting any material that may be dumped and not spread.

#### **Compaction:**

Promptly after each course has been screeded, it shall be rolled in accordance with the following requirements:

Before any rolling is started, the finished surface struck off by the machine shall be checked and any inequalities adjusted. All "drippings," fat sand accumulations from the screed, and all fat spots from any source, shall be removed and replaced with satisfactory material.

The work shall be rolled when the course spread has

set sufficiently or come to the proper condition to be rolled and when the rolling does not cause undue displacement or shoving.

Rollers to be used to compact the courses shall be either 10-ton 3-wheel rollers or tandem rollers. Rollers of the tandem type shall weigh not less than 8 tons each. The weights specified are the manufacturer's guaranteed weights. No additional weighting of the rollers will be permitted. The surfaces of the rear wheels of the 3-wheel rollers shall be concentric cylinders.

Rolling shall begin at the sides and progress gradually to the center, except that on superelevated curves rolling may progress from the lower to the upper edge parallel with the center line of the road and uniformly lapping each preceding track, as directed by the Project Engineer, until the entire surface has been rolled by the rear wheels. Alternate trips of the roller shall be terminated in stops at least three feet distant from any preceding stop. Other rolling procedure may be directed by the Project Engineer, as conditions may require.

Rolling shall progress continuously at the rate of not more than 150 square yards per hour per roller, and shall include transverse, longitudinal, diagonal and, when practical, crescent and full circle rolling, as may be necessary to obtain the maximum density possible with several mixture compositions.

In all places adjacent to curbs, headers, gutters, bridges, manholes, etc., and inaccessible to a roller the required compression shall be obtained with tampers. Depressions which may develop before the completion of the rolling shall be remedied by loosening the surface mixture laid and adding new material to bring the depressions to a true surface. Should any depressions remain after final compaction, enough surface mixtures shall be removed and new material added to form a true and even surface. All high spots, high joints, and honeycombs shall be adjusted as directed by the Project Engineer.

**Joints:**

Placing of a course shall be as nearly continuous as possible and the roller shall pass over an unprotected end of freshly laid mixture only when the laying of the course is to be discontinued or interrupted for an appreciable period. Joints shall be formed at such points. Ends of freshly laid mixtures shall be cut "square" with the pavement, slightly set up with the back of a rake, and rolled at slow roller speed so as to cause as little feathering as possible.

**Surface Test of the Pavement:**

Before final acceptance, the finished pavement shall be tested by a crown template and a 10-foot straight-edge applied at right angles and parallel, respectively, to the center line of the roadbed. The crown template shall conform to the typical cross section shown on the plans. The variation of the surface from the testing edge of the crown template between any two contacts with the surface shall at no point exceed  $\frac{1}{4}$ -inch. The variation of the surface from the testing edge of the straightedge between any two contacts with the surface shall at no point exceed  $\frac{1}{4}$ -inch. A standard template cut to the true cross section of the road, and a 10-foot straightedge, shall at all times be available on the work. The contractor shall designate some employee to use the straightedge and template in checking all rolled surfaces under the direction of the Project Engineer.

**Protection of Pavement:**

No vehicular traffic of any kind shall be permitted on the pavement until it shall have set sufficiently, in the opinion of the Project Engineer, and in no case shall traffic be permitted on the pavement in less than 24 hours after the pavement's completion.

**Application of Tack-Coat:**

Where specified on the plans or directed by the Project Engineer, a bituminous tack-coat shall be applied as specified for Item 556.

**METHOD OF MEASUREMENT:**

Asphaltic concrete, cold mix surface course, shall be measured by the ton of 2,000 pounds, based on weights obtained by weighing the material in the hauling vehicles on scales and in a manner acceptable to the Project Engineer, and the quantity to be measured shall be the number of tons laid and accepted. Bituminous tack-coat shall be measured by the gallon and the quantity to be measured shall be the number of gallons at 60° F., applied as specified.

**BASIS OF PAYMENT:**

The number of tons of asphaltic concrete, cold mix surface course, measured as specified, shall be paid for at the contract unit price for "Asphaltic Concrete, Cold Mix Surface Course"; the number of gallons of bituminous tack-coat measured as specified, shall be paid for at the contract unit price for "Bituminous Tack-Coat," which price and payments shall constitute full compensation for furnishing all material, tools, labor, equipment and incidentals and the performance of all work necessary to complete the items.

**Payment will be made under:**

Item 555a, "Asphaltic Concrete, Cold Mix Surface Course," per ton.

Item 555b, "Bituminous Tack-Coat," per gallon.

**ASPHALTIC CONCRETE, HOT MIX  
ITEM 556  
CLASS I**

**DESCRIPTION:**

This item shall consist of a pavement composed of asphaltic concrete constructed on the prepared base in

accordance with these specifications and in conformity with the lines, grades, thickness, and typical cross section shown on the plans.

The surface course shall have a thickness not less than the maximum dimension of the aggregate used.

The asphaltic concrete shall be composed of a mixture of coarse mineral aggregate, fine mineral aggregate, mineral filler, and bituminous material. Mineral filler shall be considered to include any mineral dust naturally present in the bituminous material.

**COMPOSITION:**

The several mineral constituents for the asphaltic concrete shall be so sized and graded and shall be combined in such proportions that the resulting composite blend will meet the grading requirements of Table 1, and the fraction retained between any two consecutive sieves will be not less than 4 percent of the total, and at least one-half of the fraction passing the 200 sieve shall be mineral filler. To such composite blended aggregate (considered as 100 percent) shall be added bitumen within the percentage limits set forth under table 1.

**Table 1—Requirements for Composition of Mixture**

Sieve	Percent Passing
1" .....	100
½" .....	55 - 95
No. 4 .....	28 - 50
No. 10 .....	22 - 44
No. 20 .....	17 - 37
No. 40 .....	12 - 31
No. 80 .....	8 - 18
No. 200 .....	4 - 8
<hr style="width: 10%; margin-left: auto; margin-right: 0;"/>	
Bitumen (sol. CS <sub>2</sub> ), percent.....	5.5 - 8

**Formula for Job Mix:**

The general composition limits prescribed in Table 1

are extreme ranges of tolerance that shall not be exceeded regardless of any formula that may be submitted or set up.

Before starting work, the contractor shall submit to the Project Engineer a proposed formula, in writing, for each mixture to be supplied for the project. The formulas so submitted shall stipulate for each mixture a single definite percentage of aggregate passing each required sieve size, a single definite percentage of bitumen to be added to the aggregate, and a single definite temperature at which the mixture is to be delivered on the road. The Project Engineer shall then set the job mix. In setting the job mix, the Project Engineer at his discretion may use the submitted formula, in whole or in part. In any event, the job mix formula for each mixture shall fix a single definite percentage of aggregate passing each required sieve size, a single definite percentage of bitumen to be added to the aggregate, and a single definite temperature at which the mixture is to be delivered on the road.

#### **Application of Job-Mix Formula and Allowable Tolerances:**

After the job-mix formula is established as prescribed above, all mixtures furnished for the project shall conform thereto within the following ranges of tolerances:

Passing No. 1/2" sieve.....	± 7%
Passing Nos. 4, 10, 20, 40, & 80 sieves..	± 7%
Passing No. 200 sieve .....	± 1%
Bitumen .....	± 0.25%
Temperature of mixture on delivery..	± 20° F.

Each day the Project Engineer shall take as many samples as he considers necessary for checking the uniformity of the mixture. When unsatisfactory results or changed conditions make it necessary, the Project Engineer may establish a new job mix.

Should a change in sources of materials be made, a new job-mix formula shall be submitted and ap-

proved before the mixture containing the new materials is delivered.

Job materials found to have voids or other characteristics requiring, for a balanced mix, a bitumen content greater or less than the bitumen content range tabulated above, shall be rejected.

#### **MATERIALS:**

Asphalt cement shall conform to the requirements specified in M-5, Type AC-5.

Crushed stone shall conform to the requirements specified in M-13, Type R-2, except for gradation.

Crushed slag shall conform to the requirements specified in M-13, Type R-3, except for gradation.

Fine aggregate shall conform to the requirements specified in M-14, Type A, except for color and mortar test.

Mineral filler shall conform to the requirements specified in M-14, Type L.

#### **Sources of Supply:**

Approval of sources of supply of aggregate and mineral filler shall be obtained from the Project Engineer prior to delivery of material. Samples of each material shall be submitted as directed.

The contractor shall furnish for test, when required by the Project Engineer, samples cut from the completed work. The area of pavement so removed shall be replaced with new mixture and refinished. No additional compensation will be allowed for furnishing test samples and replacing the areas with new pavement.

#### **CONSTRUCTION METHODS:**

##### **Weather Limitations:**

Asphaltic concrete mixtures shall be placed only when the atmospheric temperature is above 50° F. and when the weather is not foggy or rainy. The temperature requirements may be waived, but only when the Project Engineer so directs in writing.

### **Plant and Equipment:**

All plants used by the contractor for the preparation of asphaltic concrete mixture shall conform to all of the requirements under subsection (a) below except that scale requirements shall apply where weight proportioning is used, and in addition any batch mixing plants shall conform to the special requirements under subsection (b), and continuous mixing plants shall conform to the special requirements under subsection (c).

#### **(a) Requirements for All Plants:**

1. Uniformity: The plants shall be so designed, coordinated, and operated as to produce a mixture within the job-mix tolerances fixed by the contract.

2. Scales: Scales for any weigh box or hopper may be of either the beam or springless dial type and shall be of a standard make and design, sensitive to one-half of 1 percent of the maximum load that may be required.

When scales are of the beam type, there shall be a separate beam for each size of aggregate. There shall be provided a "telltale" dial that will start to function when the load being applied is within 100 pounds of that desired. Sufficient vertical movement shall be provided for the beams to permit the "telltale" dial to function properly. Each beam shall have a locking device designed and so located that the beam can easily be suspended or thrown into action. The weighing mechanism shall be balanced on knife edges and fulcrums and shall be so constructed that it cannot be easily thrown out of alignment and adjustment.

Dial scales shall be springless, of a standard make, and of such size that the numerals on the dial can be read at a distance of at least 25 feet. The dials shall be of the compounding type having full complements of index pointers. Pointers so placed as to give excessive parallax errors shall not be used. The scales shall be substantially constructed, and those that easily get out of adjustment shall be replaced with other makes when so ordered. All dials shall be so located as to be plainly visible to the operator at all times.



Scales for the weighing of bituminous material shall conform to the specifications for the scales for aggregate except that each beam scale shall be equipped with a tare beam and a full capacity beam. The value of the minimum graduation shall not be greater than 2 pounds. Dial scales for weighing the bituminous material shall not have a capacity of more than twice the weight of the material to be weighed and shall read to the nearest pound. Beam scales shall be equipped with a "telltale" device which will start to function when the load being applied is within 10 pounds of that desired.

Scales shall be satisfactory to the Project Engineer and shall be sealed as often as the Project Engineer may deem it necessary to insure their accuracy. The contractor shall provide and have at hand the necessary number of standard test weights for frequent testing of all scales.

3. Equipment for preparation of bituminous material: Tanks for storage of bituminous material shall be capable of heating the material, under effective and positive control at all times, to the temperature requirements set forth in the specifications. The heating system shall provide uniform heating of the entire contents of the tanks. Heating shall be accomplished by steam coils, electricity, or other means so that no flame shall come in contact with the heating tank. The circulating system for bituminous material shall be of adequate size to insure proper and continuous circulation during the entire operation period. All pipe lines and fittings shall be steam-jacketed or otherwise properly insulated to prevent heat loss. Storage tank capacity shall be sufficient for at least 1 day's run.

4. Feeder for drier: The plant shall be provided with an accurate mechanical means for uniformly feeding the mineral aggregate into the drier so that uniform production and uniform temperature will be obtained.

5. Drier. A rotary drier of any satisfactory design for drying and heating the mineral aggregates shall be provided. The drier shall be capable of drying and

heating the mineral aggregate to specification requirements.

6. Screens: Plant screens, capable of screening all aggregates to the specified sizes and having normal capacities slightly in excess of the full capacity of the mixer, shall be provided.

7. Bins: The plant shall include storage bins of sufficient capacity to supply the mixer when it is operating at full capacity. Bins shall be divided into at least three compartments arranged to insure separate and adequate storage of appropriate fractions of the aggregate. Each compartment shall be provided with an overflow pipe that shall be of such size and at such a location as to prevent any backing up of material into other bins.

8. Bituminous control units: Satisfactory means, either by weighing or metering, or the taking of volumetric measurements, shall be provided to obtain the proper amount of bituminous material in the mix within the tolerance specified for the job mix. Suitable means shall be provided, either by steam-jacketing or other insulation, for maintaining the specified temperature of bituminous material in the pipe lines, meters, weigh buckets, spray bars, and other containers or flow lines.

9. Thermometric Equipment: An armored thermometer reading from 200° F. to 400° F. shall be fixed in the bituminous feed line at a suitable location near the discharge valve at the mixer unit.

The plant shall be further equipped with an approved dial scale mercury thermometer, an electric pyrometer, or other approved thermometric instrument so placed at the discharge chute of the drier as to register or indicate automatically the temperature of the heated aggregates.

The Project Engineer reserves the right to pass upon the efficiency of thermometric instruments and, for better regulation of the temperature of aggregates, may direct replacement of any instrument by some approved temperature-recording apparatus and may fur-

ther require that daily temperature charts be filed with him.

10. Control of mixing time: The plant shall be equipped with positive means to govern the time of mixing and to maintain a constant mixing time unless changed by order of the Project Engineer. The time of mixing shall be considered as the interval between the time the bituminous material is spread on the aggregate and the time the same aggregate leaves the mixing unit.

(b). Special Requirements for Batching Plants:

1. Weigh box or hopper: The equipment shall include a means for accurately weighing each bin size of aggregate in a weigh box or hopper suspended on scales and of ample size to hold a full batch without hand raking or running over of the aggregate. The weigh box or hopper shall be supported on fulcrums and knife edges so constructed that they will not be easily thrown out of alinement or adjustment. All edges, ends, and sizes of weighing hoppers shall be free from contact with any supporting rods or columns or other equipment that will in any way effect proper functioning of the hopper. Also, there must be sufficient clearance between the hopper and supporting devices to prevent accumulation of foreign materials. The discharge gate of the weigh box shall be so hung that the aggregates will not be segregated when dumped into the mixer. The gate shall close tightly when the hopper is empty so that no material will be allowed to leak into a batch in the mixer during the process of weighing the next batch.

2. Mixer unit for batch method: The plant shall include a batch mixer of an approved twin pugmill type or a rotary drum type, steam-jacketed, and capable of producing a uniform mixture within the job mix tolerances fixed by the contract.

(c). Special Requirements for Continuous Mixing Plants:

1. Gradation control unit: The plant shall include

means for accurately proportioning aggregate from each bin either by weighing or by volumetric measurement.

When gradation control is by volume, the unit shall include a feeder mounted under the compartment bins. Each bin shall have an accurately controlled individual gate to form an orifice for volumetrically measuring the material drawn from each bin compartment. The orifice shall be rectangular, its dimension about 8 inches by 9 inches, with one dimension adjustable by positive mechanical means provided with a lock. Indicators shall be provided on each gate to show the size of gate opening in inches.

2. Weight calibration of aggregate feed: The plant shall include a means for calibration of gate openings with weight test samples. The materials fed out of the bins through individual orifices shall be by-passed to a suitable test box, each compartment material being confined in a separate box section. The plant shall be equipped to handle conveniently such test samples weighing up to 800 pounds each and to weigh them on accurate platform scales.

3. Synchronization of aggregate feed and bitumen feed: Satisfactory means shall be provided to afford positive interlocking control between the flow of aggregate from the bins and the flow of bitumen from the meter or other proportioning source. This control shall be accomplished by interlocking mechanical means or by any positive method under the Project Engineer's control.

4. Mixer unit for continuous method: The plant shall include a continuous mixer of an approved twin pugmill type, steam-jacketed, and capable of producing a uniform mixture within the job-mix tolerance fixed by the contract. The paddles shall be adjustable for angular position on the shafts and reversible to retard the flow of the mix. The mixer shall carry a manufacturer's plate giving the net volumetric contents of the mixer at the several heights inscribed on a permanent gage and also giving the rate of feed of aggregate per minute, at plant-operating speed.

Unless otherwise required, determination of mixing time shall be by weight method under the following formula:

$$\text{Mixing time in seconds} = \frac{\text{Pugmill dead capacity in pounds}}{\text{Pugmill output in pounds per second}}$$

The weights shall be determined for the job by tests made by the Project Engineer.

#### **Grade Control Forms:**

(a). Forms shall be set for at least 200 feet ahead of the point where mixture is being placed. Enough forms shall be provided to make it unnecessary to remove any until all adjacent rolling and back finishing has been completed. The alinement and grade of all forms set shall be approved immediately prior to the placing of any material against them. Forms shall be cleaned thoroughly each time they are used.

(b). Except under conditions given in subsections 1, and 2 below, fixed side forms for grade control shall be provided and shall be of steel or wood set to grade. String or wire lines staked to grade shall not be accepted as an equivalent for grade control forms.

1. When a suitable abutting curb or header is available and is approved by the Project Engineer as in conformity with the intended profile grade, it may be utilized as a grade control form. Curbs or headers shall be armored with appropriate metal bearing plates if necessary to produce satisfactory results.

2. The requirements for grade control forms may be waived when the surface course is being placed on a base that is itself parallel to the proposed finished surface of the course being laid and has been finished to the same surface tolerance as is required for such course, provided that the finishing machine in use has a longitudinal wheelbase of approximately 10 feet or more in length or the screed or strike-off action is controlled by an independent support of approximately 10 feet in length measured parallel to the direction of advance of the machine and provided such wheelbase or

support is in contact with such base and, as the machine advances, provides continuous and positive mechanical control of the screed or strike-off assembly so as to strike off the mixture to the exact profile grade and elevation intended without the aid of manual adjustment during operation.

#### **Timber for Grade Control Forms:**

Lumber for these forms shall be of common (or better) structural, joist and plank, or beam and stringer, grade. Pieces shall be not less than 16 feet long. When a form is set in position, the horizontal dimension shall be not less than 4 inches (nominal). The face next to the mixture and the bottom and top faces shall be surfaced. Timber forms shall rest on the ground and on 2-inch by 3-inch supporting stakes not less than 8 inches long and not more than 4 feet apart and shall be secured by side stakes not more than 4 feet apart driven vertically at intermediate points between the supporting stakes; the side stakes shall be not less than 1½ inches by 3 inches, and not less than 18 inches long. Timber forms shall be spliced with sections of plank. The joints of timber forms shall be so placed as to provide a gap of ¼-inch between the ends of timbers, and shall rest upon supporting stakes of the size specified above. Wood will not be permitted for grade control forms of 3 inches or less in depth.

The top edges of timber grade control forms shall be temporarily faced with steel strips during the passing of the finishing machine. A steel strip shall be not less than ⅝-inch by 2½ inches in cross section and not less than 8 feet long. The strips shall be firmly attached to the tops of the forms and a sufficient number of strips shall be provided to keep the forms faced well ahead of operations and to prevent delay of the work. The steel strips may be removed after the equipment has passed.

#### **Retaining Forms:**

When the plan of construction and equipment and type of grade control forms in use are such that any edge of any bituminous course may be left unsupported

during the construction operations, retaining forms of any suitable material and design shall be used so far as considered necessary to prevent lateral displacement or squeezing out or side shoving under the roller.

**Preparation of Bituminous Material:**

The bituminous material shall be melted in kettles or tanks designed to heat the entire contents uniformly. The material shall be brought to a temperature between 250° F. and 350° F.

When refined asphalt is to be combined with a flux, the mixture shall be thoroughly agitated until a homogeneous asphalt cement of the required penetration is produced. The penetration of the asphalt shall be tested at suitable intervals to insure that it is maintained at a uniform consistency throughout the period of use.

**Preparation of Mineral Aggregate:**

The aggregate for the mixture shall be dried and heated at the paving plant before being placed in the mixer. Flames used for drying and heating shall be properly adjusted to avoid injury to the aggregate. The aggregates shall be heated to a temperature between 225° F. and 350° F. as determined on the mixing platform. When more than two ingredients enter into the composition of the mineral aggregate, they shall be combined as directed by the Project Engineer.

The aggregates, immediately after heating, shall be screened into three or more fractions and conveyed into separate bins ready for batching and mixing with bituminous material.

**Preparation of Asphaltic Concrete Mixture:**

The dried mineral aggregate, prepared as prescribed above, shall be combined in the plant in the proportionate amount of each fraction of aggregate required to meet the job-mix formula. Where a batching plant is used, the Project Engineer shall determine the quantity of bituminous material for each batch. In any case, the bituminous material shall be measured or gaged and introduced into the mixer in the proportionate amount

determined by the Project Engineer for the particular material being used. Prior to adding bituminous material, the combined mineral aggregate shall be thoroughly mixed dry, after which the proper amount of bituminous material shall be distributed over the mineral aggregate and the whole thoroughly mixed for a period of at least 45 seconds, and longer if necessary to produce a homogeneous mixture in which all particles of the mineral aggregate are coated uniformly. In any event, the mixing time shall be regulated by the Project Engineer and suitable locking means shall be provided for such regulation. For the continuous mixing plant, the mixing time may be regulated by fixing a minimum depth in the mixer unit and/or by other mixing unit adjustment.

The aggregate and the bituminous material shall be introduced into the mixer at the individual temperatures directed by the Project Engineer within a tolerance of  $\pm 20^{\circ}$  F.

The ingredients shall be heated and combined in such manner as to produce a mixture which, when discharged, shall be at a temperature of not less than  $250^{\circ}$  F. nor more than  $350^{\circ}$  F.

#### **Transportation and Delivery of Mixtures:**

The mixture shall be transported from the mixing plant to the point of use in vehicles having tight bodies previously cleaned of all foreign materials. When directed by the Project Engineer, each load shall be covered with canvas or other suitable material of sufficient size and thickness to protect it from the weather. No loads shall be sent out so late in the day as to prevent completion of the spreading and compaction of the mixture during daylight, unless artificial light satisfactory to the Project Engineer is provided. The mixture shall be delivered at a temperature between  $225^{\circ}$  F. and  $350^{\circ}$  F. and within  $20^{\circ}$  F. of the temperature set in the job-mix formula.

#### **Conditioning of Existing Base:**

Where no tack coat is to be applied prior to placing



the asphaltic concrete mixture, the existing base upon which the pavement is to be constructed shall be swept thoroughly and cleaned of all loose dirt and other objectionable materials immediately before spreading the mixture.

Contact surfaces of curbs, gutters, manholes, and other structures shall be painted with a thin uniform coating of hot asphalt cement (or asphalt cement dissolved in naphtha) just before the bituminous concrete mixture is placed against them.

The condition of the base shall be approved by the Project Engineer prior to placing the pavement mixture.

#### **Spreading and Finishing:**

Upon arrival at the point of use, the mixture shall be spread and struck off to the profile grade, elevation and cross section shape intended. For this purpose self-powered spreading and finishing equipment provided with an activated screed or strike-off assembly, heated if required, shall be used, distributing the mixture either over the entire width or over such partial width lanes as may be practicable. Blade graders or drags shall not be used. The assembly shall be adjustable to give the cross section shape prescribed and shall be so designed and operated as to place the weight per square yard of surface course material required.

If during construction it is found that the spreading and finishing equipment in operation leaves in the new surface course tracks or indented areas that are not satisfactorily corrected by the scheduled operations, or if it produces other permanent blemishes, the use of such equipment shall be discontinued and other satisfactory spreading and finishing equipment shall be provided by the contractor.

The term "screed" includes any cutting, crowding, or other practical action that is effective in producing, from the mixture specified without tearing, shoving, or gouging, a finished surface of the evenness and texture specified.

Unless the spreader is integral with the screeding

machine, a mechanical rake or its equivalent shall be used in front of the finishing machine to loosen thoroughly the material and make possible uniform distribution.

On areas where irregularities or unavoidable obstacles make the use of the self-powered spreading and finishing equipment impracticable, in the judgment of the Project Engineer, the mixture shall be spread and screeded by hand. On such areas the mixture shall be dumped on steel dump boards and spread and screeded to leave the weight of material required.

The contractor shall provide suitable means for keeping all small tools clean and free from accumulations of bituminous material. He shall provide and have ready for use at all times enough tarpaulins or covers, as may be directed by the Project Engineer, for use in any emergency such as rain, chilling wind, or unavoidable delay, for the purpose of covering or protecting any material that may be dumped and not spread.

#### **Compaction:**

After the spreading and strike-off and while still hot, the course shall be compacted thoroughly and uniformly by rolling. Two types of rollers shall be used for obtaining compaction. One shall be an 8- to 10-ton tandem roller and the other shall be a 10- to 12-ton 3-wheel power roller. The latter, however, may be replaced by a 10-ton tandem roller upon written permission from the Project Engineer. A sufficient number of rollers shall be furnished on the work to provide one roller for each 25 tons of bituminous mixture laid per hour. All rollers shall be kept in good condition, and each shall weigh not less than 250 pounds to the inch width of tread.

Each roller shall be operated by a competent, experienced roller operator and, while the work is under way, shall be kept as nearly as practicable in continuous operation. Rolling shall begin at the sides and progress gradually to the center, except that on super-elevated curves rolling may progress from the lower to the upper edge parallel with the center line of the

road and uniformly lapping each preceding track, as directed by the Project Engineer, until the entire surface has been rolled by the rear wheels. The course shall be subjected to a diagonal rolling in two directions, the second diagonal rolling crossing the lines of the first. If the width of the course permits, it shall be rolled also at right angles to the center line. Rolling shall be continued until all roller marks are eliminated. The motion of the roller at all times shall be slow enough to avoid displacement of the hot mixture. Any displacement occurring as a result of the reversing of the direction of the roller, or from any other cause, shall be corrected at once by the use of rakes and of fresh mixture when required. To prevent adhesion of the mixture to the roller the wheels shall be kept properly moistened but excess water or oil will not be permitted. Care shall be exercised in rolling not to displace the line and grade of the side forms.

Along forms, curbs, headers, and walls and at other places not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers or with mechanical tampers giving equivalent compression. Each hand tamper shall weigh not less than 25 pounds and shall have a tamping face area of not more than 50 square inches. On depressed areas, a trench roller may be employed, or cleated compression strips may be used under the roller, to transmit compression to the depressed area.

No surface course material shall be placed against the edge of a course or layer that has been rolled and has cooled, unless such edge is vertical or has been cut back to a vertical face and in either case has received a brush coat of asphalt.

The surface of the mixture after compaction shall be smooth and true to the established crown and grade. Any mixture that becomes loose and broken, mixed with dirt, or in any way defective prior to the application of the finish coat shall be removed and replaced with fresh hot mixture, which shall be immediately compacted to conform with the surrounding area. Any area of one square foot or more showing an excess of bituminous material shall be removed and replaced.

**Joints:**

Placing of a course shall be as nearly continuous as possible and the roller shall pass over an unprotected end of freshly laid mixture only when the laying of the course is to be discontinued long enough to permit the mixture to become chilled. In all such cases, including the formation of joints as hereinafter specified, provision shall be made for proper bond with the new surface for the full specified depth of the course. Joints shall be formed by cutting back on the previous day's run so as to expose the full depth of the course. When the laying of the course is resumed, the exposed edge of the joint shall be painted with a thin coat of hot asphalt cement or asphalt cement thinned with naphtha. The fresh mixture shall be raked against the joint, thoroughly tamped with hot tampers, and rolled.

**Surface Test of the Course:**

Before final acceptance, the finished course shall be tested by a crown template and by 3-foot and 10-foot straightedges applied at right angles and parallel, respectively, to the center line of the roadbed. The crown template shall conform to the typical cross section shown on the plans. The variation of the surface from the testing edge of the crown template between any two contacts with the surface shall at no point exceed  $3/16$  inch. The variation of the surface from the testing edges of the straightedges between any two contacts with the surface shall at no point exceed  $3/16$  inch for the 10-foot straightedge or  $1/8$  inch for the 3-foot straightedge.

Tests for conformity with the specified crown and grade shall be made by the contractor immediately after initial compression, and variations shall be corrected by removing or adding materials as may be necessary. Rolling shall then be continued as specified. After application of the surface course, and after final rolling but before acceptance of the work, the smoothness of the course shall be checked again and all humps or depressions exceeding the specified tolerances shall be corrected by removing defective work and replacing it with new material as specified.

**Application of Tack-Coat:**

Where specified on the plans or directed by the Project Engineer, a bituminous tack-coat meeting the requirements specified for cut-back asphalt shall be applied at a maximum rate of .3 gallons per square yard with a pressure distributor. The distributor shall meet the requirements provided in Item 532.

The tack-coat shall be allowed to cure for a period specified by the Project Engineer before surface course is applied thereon.

**Protection of Pavement:**

Sections of the newly finished pavement shall be protected from traffic until they have become properly hardened by cooling. In no case shall traffic be permitted less than six hours after the pavement's completion.

**METHOD OF MEASUREMENT:**

The tonnage to be paid for shall be the number of tons of asphaltic concrete placed and accepted in the completed pavement. The tonnage shall be actual weight. Tack coat shall be measured by the gallon of tack coat applied, measured at 60° F.

**BASIS OF PAYMENT:**

The tonnage, determined as provided above, shall be paid for at the contract unit price per ton for "Asphaltic Concrete, Hot Mix Surface Course"; the number of gallons of bituminous tack-coat measured as specified, shall be paid for at the contract unit price for "Bituminous Tack-Coat," which price and payment shall constitute full compensation for furnishing all materials, tools, labor, equipment and incidentals and the performance of all work necessary to complete the items.

**Payment will be made under:**

Item 556a, "Asphaltic Concrete, Hot Mix Surface Course," per ton.

Item 556b, "Bituminous Tack-Coat," per gallon.

## TRAFFIC AND PEDESTRIAN SERVICE AND MISCELLANEOUS FACILITIES

Guard fence, guide post, route and direction markers, project markers, signs, safety and signal devices, railroad crossing signals, highway lighting, pedestrian underpasses and overheads, sidewalks, permanent traffic lane stripes, etc.

## GUARD RAIL

Guard Rail.....	Item 801
Rebuilt Guard Rail.....	Item 802
Precast Concrete Guard Rail Posts and Braces.....	Item 803

### DESCRIPTION:

This item shall consist of furnishing and installing a rigid type guard rail, at the points indicated on the plans or designated by the Project Engineer. The guard rail shall be constructed in accordance with the plans and these specifications.

### MATERIALS:

Guard rail plates shall conform to the requirements specified in M-102.

Fastenings shall conform to the requirements specified in M-46.

Posts and braces shall conform to the requirements specified in specifications for "Precast Concrete Posts and Braces".

### CONSTRUCTION METHODS:

#### Erection:

The posts shall be set plumb and firm, spaced and set in the ground as shown on the plans and to the lines and grades given. Posts shall be located as directed by the Project Engineer. The post holes shall be back-filled, care being taken to select suitable material for the backfill and same shall be thoroughly compacted by constant tamping during backfilling operations. Sufficient water shall be added in order to insure the desired compaction. Before final completion, the posts shall be accurately aligned and realigned as often as necessary until final acceptance. After posts are aligned.

and approved by the Project Engineer, the guard rail plates shall be erected to the posts with fastenings as shown on the plans.

**Painting, Field Coats:**

After erection, all metal parts of the guard rail shall be thoroughly cleaned. The spot coat shall be allowed to dry at least twelve hours before applying field coats. After the spot coat is thoroughly dry, all metal parts of the guard rail shall be painted with two coats of white lead. Before applying paint to galvanized surfaces, same shall be slightly etched with a diluted solution of vinegar composed of one quart of vinegar and two gallons of water.

**Rebuilt Guard Rail:**

Where indicated on the plans or directed by the Project Engineer, the contractor will be required to take down and rebuild the existing guard rail at the locations shown on the plans. The guard rail shall be rebuilt and repainted in the same manner as specified for new guard rail. The contractor shall take every possible precaution and care against damage in removing and rebuilding the guard rail.

**METHOD OF MEASUREMENT:**

Guard rail shall be measured by the linear foot and the length of guard rail to be measured shall be the overall length in linear feet, measured from center to center of end posts.

**BASIS OF PAYMENT:**

The number of linear feet of guard rail completed and accepted, measured as provided above, shall be paid for at the contract unit price per linear foot of "Guard Rail," complete in place, which price and payment shall constitute full compensation for furnishing all materials including posts and braces, (except new posts and braces installed in "Rebuilt Guard Rail," unless otherwise specified), equipment, tools, labor and



incidentals and the performance of all work necessary to complete the item.

Payment will be made under:

- Item 801, Guard Rail, per linear foot.
- Item 802, Rebuilt Guard Rail, per linear foot.
- Item 803, Precast Concrete Guard Rail Posts and Braces, per each.

## PLAIN PORTLAND CEMENT CON- CRETE WALK AND BUMPER STRIP

- Portland Cement Concrete Walk.....Item 804.
- Portland Cement Concrete Bumper Strip, Item 805.

### DESCRIPTION:

This item shall consist of the construction of concrete walks or bumper strips in one course on the prepared subgrade in conformity with the lines, grades, thickness and cross section shown on the plans.

### PROPORTIONING AND MIXING:

All concrete for this item shall be class "A," proportioned and mixed as set out under "Concrete."

### MATERIALS:

#### CEMENT, SAND, COARSE AGGREGATE, WATER AND PREMOULDED FILLER:

These materials shall meet the requirements specified under "Class "A" Concrete."

### CONSTRUCTION METHODS:

#### Subgrade:

The subgrade shall be constructed as provided under subgrade in Item 305 insofar as applicable hereto.

The sidewalk area shall be rolled at the same time that the subgrade for the surface course is rolled. All areas inaccessible to a power driven roller shall be thoroughly hand or mechanically tamped.

**Forms:**

The forms shall be either metal or wood and shall be straight, free from warp, of sufficient strength to resist springing during construction, and of a height equal to the full depth of the walks or bumper strips to be constructed. Wood forms shall have a minimum thickness of two inches. Metal forms shall be of a type approved by the Project Engineer. The forms shall be thoroughly cleaned, well oiled, securely staked, braced, and held to the required line and grade before any concrete is deposited.

**Depositing and Finishing Concrete:**

The concrete shall be deposited between the forms on the moistened subgrade and shall be struck off and compacted to the required thickness. It shall be tamped sufficiently to bring the mortar to the top surface. The surface shall be finished with a wood float or steel trowel, provided that the surface is finally brushed in order to leave a slightly rough finish. All joints and edges shall be rounded with an edging tool having a one-fourth inch radius.

**Joints:**

The walks and bumper strips shall be marked in sections approximately square, or of such dimensions as are indicated on the plans or directed by the Project Engineer. Three-fourths inch expansion joints shall be placed at intervals not to exceed thirty-two feet and at all junctions of new walks with drives, curbs, buildings, structures and old walks and same filled with premoulded filler three-fourths of an inch thick.

**Curing:**

The walks or bumper strips shall be cured in the same manner as provided for concrete pavement.

**Backfilling:**

After the concrete has set sufficiently, the forms shall be removed and the space adjacent to the walks or bumper strips shall be backfilled with suitable material, which shall be firmly compacted and neatly graded.

**METHOD OF MEASUREMENT:**

Concrete walks and bumper strips shall be measured by the square yard.

**BASIS OF PAYMENT:**

The number of square yards, completed and accepted, measured as provided above shall be paid for at the contract unit price per square yard for "Walks" or "Bumper Strips," complete in place, which price and payment shall constitute full compensation for preparing the subgrade; furnishing all materials and joints, for furnishing all forms, equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

Payment will be made under:

- Item 804a, Portland Cement Concrete Walk, 4" thick, per square yard.
- Item 804b, Portland Cement Concrete Walk, 5" thick, per square yard.
- Item 804c, Portland Cement Concrete Walk, 6" thick, per square yard.
- Item 804d, Portland Cement Concrete Walk, 7" thick, per square yard.
- Item 804e, Portland Cement Concrete Walk, 8" thick, per square yard.
- Item 805a, Portland Cement Concrete Bumper Strip, 4" thick, per square yard.
- Item 805b, Portland Cement Concrete Bumper Strip, 5" thick, per square yard.
- Item 805c, Portland Cement Concrete Bumper Strip, 6" thick, per square yard.

Item 805d, Portland Cement Concrete Bumper Strip, 7" thick, per square yard.

Item 805e, Portland Cement Concrete Bumper Strip, 8" thick, per square yard.

## PRECAST CONCRETE GUARD RAIL POSTS AND BRACES

### PRECAST CONCRETE POSTS AND BRACES

#### DESCRIPTION:

This work shall consist of furnishing precast concrete posts and braces; excavating and setting the posts at the locations indicated on the plans or as directed, and backfilling, and tamping. All concrete posts and braces shall be of the design and size indicated on the plans for the particular use for which they are intended.

#### PROPORTIONING AND MIXING:

All concrete for this item shall be class "A," proportioned and mixed as specified under "Concrete."

#### MATERIALS:

Reinforcing steel shall consist of deformed bars and shall conform to the requirements specified in M-110 or M-111.

#### CONSTRUCTION METHODS:

##### Casting:

The concrete posts and braces shall be cast in mortar tight forms. Special care shall be exercised to puddle and tamp the concrete around the reinforcing steel and to avoid the formation of stone pockets. Concrete shall be placed continuously in each post or brace.

**Finishing:**

Forms shall be removed as soon as the concrete has hardened sufficiently to permit. All holes and voids shall then be filled with sand-cement mortar of the same mix as used in the body of the posts and braces and the entire surface of the posts or braces brought to a smooth, neat appearance by rubbing off rough spots with a carborundum block.

**Curing:**

As soon as finished, the posts and braces shall be covered with three thicknesses of wet burlap and kept continuously moist for a period of seven days. No posts shall be set until at least two weeks old.

**Erection:**

The posts shall be set plumb and firm, spaced and set in the ground as shown on the plans and to the lines and grades given. Posts holes shall be backfilled with selected soil or other suitable material and thoroughly tamped during the backfilling. Water shall be added, as specified by the Project Engineer, to facilitate compaction of the backfill.

**BASIS OF PAYMENT:**

No direct payment will be made for precast concrete posts and braces, and the cost of same shall be incidental to the cost of the item for which they are used, except in the case of their use as guard rail posts and braces when Item 803 is specified along with Item 802.

## ROADSIDE DEVELOPMENT

Seeding, sodding, and planting shoulders, back slopes, and roadside for the purpose of landscape and for protection of earthwork, bridle paths, roadside parks, picnic grounds, and shelter houses; minor diversion ditches for protection of planting.

## SODDING

Sprigging .....	Item 901
Spot Sodding.....	Item 902
Solid Sodding .....	Item 903
Top Soil Planting.....	Item 904
Broadcast Sprigging.....	Item 905

### DESCRIPTION:

This item shall consist of furnishing, hauling, planting, watering, rolling and maintaining live Bermuda grass sod or some other sod approved by the Project Engineer and native to the locality of the work. This item is to be placed at locations shown on the plans and as directed by the Project Engineer. This item shall include the surface dressing of all areas to be sodded except when a pay item for surface dressing is included in the contract. The sod shall be free from noxious weeds and vegetation.

### CLASSIFICATION:

Sodding shall be classified as follows:

- Sprigging
- Spot Sodding
- Solid Sodding
- Top Soil Planting
- Broadcast Sprigging

Sprigging shall consist of sprigs of sod planted twelve inches center to center.

Spot sodding shall consist of strips of sod three inches wide and two and one-half inches thick planted to form continuous rows parallel to the shoulder line.

The rows of sod shall be planted twelve inches apart, center to center.

Solid sodding shall consist of slabs of sod twelve inches wide and two and one-half inches thick planted side to side and completely covering the area to be sodded.

Top soil planting shall consist of a combination of grass roots and top soil spread to a maximum depth of four inches over the area to be sodded. Depth of sod shall be as directed by the Project Engineer, and shall be considered as its completed depth.

Broadcast sprigging shall consist of furnishing, hauling, dumping and spreading top soil suitable for growing grass and further, furnishing, hauling dumping and spreading broadcast, of Bermuda grass roots and tops on the surface of the top soil areas, together with discing in, rolling, and watering to secure grass growth.

#### **EQUIPMENT:**

All equipment specified shall be on the project and in working condition before any sodding operations are started.

A soil pulverizer or cultipacker shall be furnished and it shall weigh not less than 500 pounds and not more than 1500 pounds and shall be single or double gang type.

Water wagons or tanks of sufficient capacity shall be furnished.

#### **CONSTRUCTION METHODS:**

After the roadway has been completed in accordance with the plans and specifications, it shall be sodded at locations shown on the plans or as directed by the Project Engineer. The areas to be sodded shall be surface dressed, and shall be broadcast fertilized when a pay item for this work is included in the contract. Sodding shall be done at such times as directed by the



Project Engineer and in such a manner that the grass shall take root. Sod shall be watered when directed by the Project Engineer. The contractor shall be required to replace any sod which is unsatisfactory. All sod shall be alive and growing at the time of final acceptance.

The contractor shall have adequate water tanks and other watering equipment and supply of water available when beginning sodding operations and shall keep same available throughout such operations and until final acceptance of the project. Sodding operations shall not begin until such equipment and supply acceptable to the Project Engineer is on hand and ready for use as directed by the Project Engineer.

#### **Sprigging, Spot Sodding and Solid Sodding:**

All sod shall be cut to a minimum depth of 2½" with acceptable sod cutters or with sharp, flat shovels or spades. After cutting in the field, and within 48 hours, the sod shall be placed flat, grass side up, on boards of convenient length, acceptable to the Project Engineer, and hauled to the project with the soil intact. Only one layer of sod shall be placed on each board and such boards shall be of sufficient thickness to prevent bending and of sufficient width that the slabs of sod shall not hang over the edges. The sod slabs shall be placed closely without leaving spaces between them. In no case shall sprigging, spot sodding or solid sodding be loaded in bulk on vehicles or dumped in bulk on the planting site.

Sod for sprigging or spot sodding may be cut in larger pieces at the source, loaded on boards as such, and cut to proper size and lengths on the boards at the planting site.

It being necessary to handle sod for sprigging and spot sodding principally by hand, picking it up from the boards to plant, the contractor is cautioned to use care to insure that no more soil is lost from the grass roots than is necessary. In spot sodding the lengths of strips

shall be of convenient length for handling, acceptable to the Project Engineer. Furrows to plant sprigging and spot sodding shall be made with tools sufficient for the purpose and acceptable to the Project Engineer. In sprigging and spot sodding the sod shall not be totally covered with soil and a sufficient amount of grass tops shall be left uncovered to insure quick growth.

In cutting sod for solid sodding the strips shall be cut uniformly 12" wide so that the slabs will be uniform in planting close together. The lengths of this sod shall be cut for convenient handling acceptable to the Project Engineer.

Upon delivery at the planting site, solid sodding shall be planted directly from the boards onto the surface soil by tilting the boards slightly on edge, jamming the edges of the sod on the board against the edges of the sod already on the soil and then slipping the boards out from underneath. If the slabs of sod do not contact close enough they shall be pulled together with rakes, hoes, shovels or other suitable tools. In no case shall the slabs of sod be removed from the boards and handled by hand, except to use as fillers of small cracks or spots where it would be impracticable to fill by direct board methods as described.

The placing of solid sodding on hard pans, slicked or hard packed areas, where it would slide or the roots of grass would be delayed in taking hold in the natural soil, will not be allowed. All areas to receive solid sodding shall be thoroughly scarified and pulverized to a depth of not less than 4", and shall be rolled with a cultipacker or soil pulverizer until the surface is smooth. In the case of sprigging and spot sodding the preparation of the holes or furrows to receive same with the necessary re-covering of soil is considered sufficient in scarifying or pulverizing the surface soil.

If fertilizer is specified for solid sodding it shall be applied broadcast as specified under Item 909. If specified for sprigging or spot sodding it shall be placed directly in the planting furrows or holes.

All planting of sprigging, spot sodding and solid

sodding shall be rolled as soon after planting as practicable using plain rollers, cultipackers or soil pulverizers. In case rolling is impracticable, the contractor shall use hand methods of tamping the sod in place, suitable to the Project Engineer.

**Top Soil Planting:**

Sod for top soil planting shall be dug to a maximum depth of 6". The contractor shall notify the Project Engineer of the locations where the sod is to be obtained and the Project Engineer shall approve the source before the sod is dug. The sod shall predominate in Bermuda grass roots, and shall be dug by machine or hand methods and loaded and unloaded in bulk.

In digging sod for top soil planting the contractor shall first thoroughly disk the area from which the sod is to be obtained. He may then plow up in rows, blade into windrows or otherwise pile up the sod for convenience in loading; however, he shall not disk, plow, windrow or otherwise stock pile the sod on any source area too large for early removal and use, and shall load, haul, and spread on the job all such stock piled sod within 48 hours after stock piling same.

There shall be no contamination of sod for top soil planting with tree and shrub roots, tops, branches or other debris and such foreign materials shall be dug up, cleared and removed from any source area before beginning the disking of the area and the removal of the mulch sod. The Project Engineer may direct the contractor to mow the area from which sod is to be obtained.

After the roadway has been completed according to plans and specifications, and before placing and spreading sod for top soil planting on any area, such area shall have the approval of the Project Engineer as to its physical condition and otherwise. The placing of such sod on hard pans, slicked or hard packed areas where it would slide or the roots of grass would be delayed in taking hold in the natural surface soil, will

not be allowed. All such areas shall have the surfaces made loose and friable by plowing, discing, scarifying, harrowing or otherwise by machine or hand methods to a depth of not less than 4" and acceptable to the Project Engineer. The contractor shall be required to put the surface soil area in a suitable pulverized condition as specified under the item of "Surface Dressing," Item 907.

The sod for top soil planting shall be placed and spread over all areas specified to a maximum depth of 4" or less, as directed by the Project Engineer. After the sod has been dumped on the site, the spreading of same shall be done in a manner that will not tear up and leave an excess of grass roots on the surface which would be exposed to the elements. Spreading may be done directly from the trucks if approved by the Project Engineer, but in no case shall spike tooth harrows, drags with spikes or other similar tools be permitted. Ample watering of all top soil planting will be required as necessary and as directed by the Project Engineer.

If fertilizer or other materials are specified under separate items to be broadcast then such materials shall be broadcast according to their respective item specifications or special provisions.

#### **Broadcast Sprigging:**

Top soil used in broadcast sprigging shall consist of good loamy top soil from fields, woods, creek banks or other sources where good top soil may be found and shall not be dug deeper than 6" unless in the opinion of the Project Engineer deeper digging will supply as good top soil as in the upper 6" strata. The contractor shall notify the Project Engineer of the location where top soil is to be obtained and the Project Engineer shall inspect the location to determine its suitability for use. Top soil shall not be dug from locations except those approved by the Project Engineer. The top soil shall be free of tree and shrub roots, stumps, rocks, weeds, trash and other debris, and the contractor may be required to move, clear and grub and otherwise clean up a source area of top soil, if in

the opinion of the Project Engineer it is desirable before digging the top soil. The top soil may be removed and loaded by hand or machine methods and may or may not contain Bermuda roots and tops.

Bermuda roots and tops shall be dug from an area where Bermuda grass is predominate and the Project Engineer shall inspect the location to determine the suitability of the roots and tops to be used. Bermuda roots and tops may be "bare-rooted" or with a small amount of soil attached to the roots. All grass roots and tops shall be kept moist in digging, transporting and spreading.

The top soil shall be spread on the area shown on the plan or as designated by the Project Engineer to a maximum depth of 4", and the depth of sod shall be considered as its completed depth. After the roadway has been completed according to plans and specifications, and before placing and spreading the top soil on any area, it shall have the approval of the Project Engineer as to its physical conditions and otherwise. The placing of top soil on hard pans, slicked or hard packed surfaces where it will slide or the roots of grass would be delayed in taking hold in the natural surface soil, or where any area is not loose to a depth of not less than 4", will not be allowed. All areas shall have their surfaces made loose and friable by plowing, discing, scarifying, harrowing or otherwise, by machine or hand methods to a depth of not less than 4" acceptable to the Project Engineer. If surface dressing is specified under Item 907, then it is the intention that placing top soil shall follow this item, but if the item surface dressing is not specified under a separate item, the contractor shall be required to put the surface soil area in a suitable pulverized condition acceptable to the Project Engineer as specified under Item 907, and shall include the cost of same in his bid price on broadcast sprigging.

After spreading the top soil over the area, all stiff clods, stones, roots, litter or any other foreign matter shall be raked up and removed from the area. If the top soil is of heavy texture, not breaking down in the

spreading operation, the contractor shall disc or otherwise pulverize the top soil to the satisfaction of the Project Engineer, but shall not use any type of roller at this stage of the construction. Spreading shall be completed in such manner by bulldozers, blades, discs and drags and in inaccessible places by hand implements according to specified grades so that Bermuda roots and tops may be broadcast over the areas to be sodded.

If fertilizer or other materials are specified under separate items to be broadcast, such materials shall be spread on the surface areas of the top soil during the finishing processes or the spreading operations in order to incorporate same into the top soil.

After spreading the top soil and placing same in a pulverized horticultural condition, Bermuda roots and tops shall then be spread over all areas and placed closely together on the surface to fully cover the ground so that no spaces will be left between individual clumps of roots and tops. All Bermuda roots and tops shall be kept wet from the time of digging to that of spreading on the top soil areas. All dried out roots or tops will be rejected. Spreading shall not be done over any area which is too large to be immediately disced.

Immediately after spreading, the Bermuda roots and tops shall be thoroughly disced into the top soil so they will be chopped and covered without disturbing the uniform distribution.

After discing the areas thus sodded shall be dragged if necessary, and then rolled with a cultipacker or soil pulverizer until the surface presents a level appearance. In places where rolling is impracticable, around culverts, along fences and the like, the contractor shall hand tamp the area. Toothed harrows, rakes, drags with spikes, and other implements which would tend to tear out the grass roots and tops from the top soil shall not be used to spread or level any areas after the broadcasting of the Bermuda roots and tops.

**METHOD OF MEASUREMENT:**

Sprigging, spot sodding and solid sodding shall be measured by the square yard, and the areas to be measured shall be the area of the sodded surface, placed and accepted.

Top soil planting and broadcast sprigging shall be measured by the cubic yard of volume, and shall be measured in the hauling vehicles at the point of delivery on the project.

**BASIS OF PAYMENT:**

Sod planted and accepted, measured as specified, shall be paid for at the contract unit price for units of sodding, which price and payment shall constitute full compensation for the furnishing of all materials, equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

Payment will be made under:

- Item 901, Sprigging, per square yard.
- Item 902, Spot Sodding, per square yard.
- Item 903, Solid Sodding, per square yard.
- Item 904, Top Soil Planting, per cubic yard.
- Item 905, Broadcast Sprigging, per cubic yard.

**MULCHING BROADCAST  
ITEM 906**

**DESCRIPTION:**

This item shall consist of furnishing, hauling, dumping and spreading broadcast a covering of mulch material over the ground surfaces of shoulders, front-slopes, ditches, backslopes and other parts of the right of way, at such locations indicated on the plans or as directed by the Project Engineer and in accordance with these specifications.

**CLASSIFICATION:**

Mulching by this method shall be classified as Mulching Broadcast and shall be for the purposes of covering seeded or sodded areas, covering areas to

retard erosion, and covering areas and discing in the mulch to supply organic matter.

**MATERIALS:**

The kinds of materials for mulching broadcast shall be specified. As mulches may be applied with or without discing into the surface soil, the method to be used will be specified.

The following is a list of materials or combinations thereof, which may be specified, or any other material that may be approved as a mulch by the Project Engineer.

- (a) Rice, oat or other approved straw.
- (b) Rice hull ashes.
- (c) Rotten sawdust, not less than ten years old and taken from underneath piles which show a decomposed condition. Fresh sawdust that is not decomposed shall not be used.
- (d) Hay, or native grass cuttings.
- (e) Hardwoods litter, leaf mold. Pine needles shall not be used.
- (f) Gin cleanings, oilmill cleanings, cotton burrs.
- (g) Local peat, marsh peat, bog hay.
- (h) Bagasse.
- (i) Hardwood brush and twigs.

Mulch materials shall be applied as specified, in the following depths:

Material Designation	Average loose depths in inches applied as a covering for seeded or sodded areas. (Not to be disced into the soil)	Average loose depths in inches applied to retard erosion or to supply organic matter (to be disced into the soil)	
	A	B	
(a) .....	1/2-1	2-3	For use under "B", shall be at least 2 years old.
(b) .....	1/2 Max.	1-2	
(c) .....	1/2 Max.	2-3	
(d) .....	1-2	3-4	For use under "B", shall be decomposed or partially so.
(e) .....	1/2-1	3-4	
(f) .....	None	2-3	Shall be at least 2 years old.
(g) .....	1/4-1/2	1-2	
(h) .....	1/2 Max.	2-3	
(i) .....	2-3	None	



## **CONSTRUCTION METHODS:**

After the surface areas have received suitable ground preparation, fertilization, seeding, sodding or other preparation as specified and after such areas have been approved by the Project Engineer, the areas shall be covered with mulch as shown in the table or as specified.

In using mulch for covering seeded or sodded areas, (not to be disced into the surface soil), it is the intent of these specifications that the mulch shall be loose enough to allow the penetration of sun light and air but thick enough to shade the ground partially. Thick mats of mulch tending to smother the vegetation shall not be applied.

Where slopes are steep and the mulch is likely to slide or be blown away before a ground cover of grass is established, the contractor shall furnish and apply an anchoring material without extra cost and shall place such material on top of the mulch at suitable intervals as directed by the Project Engineer. The anchoring material may consist of pieces of brush or any other material suitable to the Project Engineer. The contractor shall maintain all mulching including anchoring material in a satisfactory condition and if necessary, due to fire or other causes, replace without extra cost any damaged mulch or anchoring material until acceptance of the project.

In using mulch as a soil amendment the mulch shall be broadcast to cover all disced areas and then these areas shall be thoroughly disced to incorporate the mulch in the surface soil. The depth of discing shall be not less than 4".

If broadcast fertilizer is specified the fertilizer shall be broadcast just prior to spreading the mulch and both fertilizer and mulch incorporated in one operation. If seeding or sodding is specified these operations shall follow the discing in of the mulch.

**METHOD OF MEASUREMENT:**

Acceptable mulching broadcast shall be measured by the square yard and mulching broadcast shall be determined by the measurement of the areas mulched.

**BASIS OF PAYMENT:**

The number of square yards mulched, measured as specified, shall be paid for at the contract unit price per square yard for "Mulching Broadcast" which price and payment shall constitute full compensation for furnishing, transporting, spreading, anchoring, and discing in where specified; and for all labor, equipment, tools and incidentals necessary to complete the item.

Payment will be made under:

Item 906, Mulching Broadcast, per square yard.

**SURFACE DRESSING  
ITEM 907**

**DESCRIPTION:**

This item shall consist of the conditioning of the ground surface to put such surface in excellent horticultural condition for sodding, seeding or planting trees and other plants. In general, it shall follow the grading work and shall include all areas indicated on the plans and by the special provisions or areas designated by the Project Engineer in accordance with the plans and these specifications.

**CONSTRUCTION METHODS:**

**Surface Dressing Methods:**

Surface dressing shall be done by machine or hand methods or a combination of both as indicated on the plans or directed by the Project Engineer.

**Machine Method:**

All hard pan areas, where practicable and necessary, shall be plowed, disced, cross-disced, harrowed,

bladed or dragged as designated by the Project Engineer so that the surface soil will be left up to grade in a smooth and thoroughly pulverized condition to a minimum depth of four inches and acceptable to the Project Engineer. On any part of a previously graded area, where the surface is loose to a depth of approximately four inches, it will not be necessary to plow same when discing will accomplish the purpose, but where a hard pan occurs on the graded surface, such areas shall be plowed if and when directed by the Project Engineer. Where corners, borders, fences, sides of ditches, canals or any other obstructions occur, the contractor will be required to disc same by hand methods if discing by machine method is considered impracticable by the Project Engineer. The final blading, dragging and smoothing of the surface shall be done so as to leave the surface up to specified grade. All sticks, clumps of grass, roots, stones, and large clods which cannot be broken up easily and any other material or debris which are detrimental to a smooth or well prepared surface shall be removed from the project and satisfactorily disposed of as directed by the Project Engineer.

**Hand Method:**

All hard pan areas shall be spaded and thoroughly pulverized by the use of hand tools, such as hoes and rakes. Rakes shall be used to dress the surface to the required grade and the ground surface shall be left in a horticultural condition satisfactory to the Project Engineer. The areas dressed shall be cleared of all debris as specified in preceding paragraph.

**METHOD OF MEASUREMENT:**

Surface dressing shall be measured by the square yard or acre. The particular method of measurement to be used shall be as indicated on the plans or in the contract. The area of surface dressing shall be determined by measurement of the area actually dressed.

**BASIS OF PAYMENT:**

The number of units dressed and accepted, measured as provided above, shall be paid for at the contract price per unit for "Surface Dressing," which price and payment shall constitute full compensation for furnishing all equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

Payment will be made under:

Item 907a, Surface Dressing (Machine Method), per square yard.

Item 907b, Surface Dressing (Machine Method), per acre.

Item 907c, Surface Dressing (Hand Method), per square yard.

**FERTILIZING  
ITEM 909**

**DESCRIPTION:**

This item shall consist of furnishing and applying fertilizer at the location indicated on the plans in accordance with these specifications and as directed by the Project Engineer.

**MATERIALS:**

Fertilizer shall conform to the requirements specified in M-42.

**CONSTRUCTION METHODS:**

**Fertilizing Broadcast:**

Fertilizer shall be uniformly broadcast over the area to be fertilized either by hand or machine methods.

When fertilizer is applied following surface dressing, it shall be thoroughly incorporated in the soil by light discing or harrowing. Fertilizer may be ap-

plied just before final discing or harrowing during the process of surface dressing or, if surface dressing is being done by hand, it may be applied just before final raking and leveling.

If fertilizer is broadcast for the purpose of increasing existing grass growth, it shall be evenly scattered over the grass and thoroughly wet down with water as directed by the Project Engineer.

#### **Fertilizing Sodding:**

When fertilizing of sod is required, the fertilizer shall be applied between the tufts, or sprigs or broadcast over the slabs of sod in the amount shown on the plans and as directed by the Project Engineer. Where required, the area fertilized shall be thoroughly watered.

#### **Fertilizing Existing Trees:**

A circle of holes three to four feet apart shall be drilled in the soil under the outer edge of the branches called the "drip." Another circle of holes shall be made inside the first circle a distance of three to four feet inside of the first circle. The holes in the inner circle shall not be placed opposite the holes in the outer circle but shall be staggered or alternated. All holes shall be from twelve to eighteen inches deep and approximately two and one-half to three inches in diameter. The holes may be made by driving an iron bar, pipe or other suitable sharp instrument in the ground and twisting same or they may be made with a soil auger suitable for the purpose. Spades, shovels, or other large tools shall not be used for making the holes. After the holes are made, the required amount of fertilizer is to be placed in each hole and the remainder of the hole filled with suitable soil and the filling watered down.

#### **METHOD OF MEASUREMENT:**

Commercial fertilizer shall be measured by the pound and the number of pounds of fertilizer actually used shall be measured.

Domestic fertilizer shall be measured by the cubic yard in vehicles at the point of delivery on the project as specified under C-150.

**BASIS OF PAYMENT:**

The number of units of fertilizer placed and accepted, measured as provided above, shall be paid for at the contract unit price per unit for "Fertilizer," complete in place, which price and payment shall constitute full compensation for furnishing all material, equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

Payment will be made under:

Item 909a, Fertilizing Broadcast, (Commercial Fertilizer) per pound.

Item 909b, Fertilizing Broadcast, (Domestic Fertilizer) per cubic yard.

Item 909c, Fertilizing Sodding, (Commercial Fertilizer) per pound.

Item 909d, Fertilizing Sodding, (Domestic Fertilizer) per cubic yard.

Item 909e, Fertilizing Existing Trees, (Commercial Fertilizer) per pound.

Item 909f, Fertilizing Existing Trees, (Domestic Fertilizer) per cubic yard.

## PRUNING EXISTING TREES ITEM 910

**DESCRIPTION:**

This item shall consist of shaping existing trees and removing rotten limbs, branches or any other parts of the tree designated by the Project Engineer in accordance with the plans and these specifications.

**CONSTRUCTION METHODS:**

**Pruning:**

All pruning work shall be done by or under the supervision of a competent and expert pruner.

All rotten stubs which remain from previous pruning or damage; all dead branches and limbs; all broken or badly scarred branches and limbs; all crossing branches particularly where rubbing of the bark is evident and any other limbs and branches designated by the Project Engineer shall be removed. The natural shape of the tree shall not be changed by "Topping" or any other unnatural pruning methods.

Limbs of over one inch caliper shall be cut not less than one and one-half feet away from the trunk or base limb by making an undercut and then making a downward cut just over and forward of the undercut so that the limb will break and fall without injury to the trunk or base limb. The stub remaining shall then be cut off at its base. No stubs, regardless of size, shall be left.

The cut surface of branches of one inch caliper and over shall be painted with a mixture of one-fourth creosote and three-fourths tar by volume or other approved material. The application shall thoroughly cover all portions of the cut.

#### **METHOD OF MEASUREMENT:**

Pruning of existing trees shall be measured by the tree and all trees actually pruned shall be counted.

#### **BASIS OF PAYMENT:**

The number of trees pruned and accepted, measured as provided above, shall be paid for at the contract unit price per tree for "Pruning Existing Trees," which price and payment shall constitute full compensation for furnishing all materials, equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

**Payment will be made under:**

Item 910, Pruning Existing Trees, per tree.

# PLANTING TREES, SHRUBS, VINES AND OTHER PLANTS ITEM 912

## **DESCRIPTION:**

This item shall consist of furnishing and planting the various types and sizes of plants shown on the plans and in the Planting List and Summary Plant List of the special provisions in accordance with the plans and these specifications.

The plans and special provisions are prepared with a **KEY NUMBER SYSTEM** with a detailed planting list accompanying, showing the location of plants. These locations are approximate and may be adjusted or changed to suit actual field conditions at the discretion of the Project Engineer. The Planting List and Summary Plant List are included in the special provisions.

## **MATERIALS:**

Trees, shrubs, vines and other plants shall conform to the requirements specified in M-112.

## **CONSTRUCTION METHODS:**

### **Seasonal Operations:**

All planting operations shall be performed in the proper season. In general, the planting of balled and burlapped plants shall not begin before November first in any portion of the State and planting shall cease by April first in the southern half of the State and by April fifteenth in the northern half. The planting of bare rooted plants shall not begin before November fifteenth in any portion of the State and shall cease by March tenth in the southern half of the State and by March twentieth in the northern half.

However, due to varying weather conditions, the kind of plants and the origin of plants, the above dates may be varied when directed by the Project Engineer.



In the event that the planting season expires before the completion of the contract, the Department reserves the right to suspend the item until the next planting season. If the item is suspended, the Project Engineer shall accept the completed portion of the item and relieve the contractor from all responsibility in connection therewith.

### **Care and Handling of Plants Before and During Planting:**

The contractor shall in loading, unloading, or handling plants, exercise the utmost care to prevent injuries to trunks, limbs, branches and roots. Immediately following delivery and inspection at the site of the work, all plants shall be cared for in an approved horticultural manner satisfactory to the Project Engineer. Plants shall not be allowed to dry out.

If not immediately planted, balled plants shall be adequately protected by covering the balls of dirt with soil, hay or straw and shall be watered at frequent intervals. The solidity of the balled plants shall be carefully preserved. They shall not be handled by their tops in lifting, moving or setting, but shall be handled at all times by their balls of dirt.

All bare rooted plants shall be "heeled in" immediately in moist soil, watered and otherwise cared for in a satisfactory manner as soon as they are received and inspected, unless they are immediately planted. While bare rooted plants are being transported to and from "heeled in" beds, are being distributed, or are awaiting planting after distribution, they shall be protected from drying out by means of wet canvas, burlap, straw, hay, puddling, or as directed.

### **Pruning:**

Pruning shall be done as soon as possible after the arrival of the plants and shall conform to the best horticultural practice and shall be appropriate to the various types of plants and the special requirements of each. Care shall be taken to preserve the natural character of each plant. All pruning operations shall be car-

ried on under the supervision of the Project Engineer and satisfactory to him.

The trunks of large growing deciduous trees shall be cleared of small side branches to a height of approximately six to seven feet and all inside crossing branches shall be removed. Lateral branches shall not be cut too far back nor excessively thinned out. The tree top shall be well framed in order that it will assume its normal and natural appearance as soon as possible. Approximately one-third of the tops of deciduous trees and shrubs having heavy tops shall be removed as directed by the Project Engineer. "Leaders" shall not be removed or cut back on trees normally having "leaders." All broken branches shall be removed with a clean cut.

Plants requiring excessive cutting or pruning which would ruin their appearance shall be rejected.

All cut surfaces on hardy shade trees over one inch in diameter shall be painted with a mixture of one-fourth creosote and three-fourths tar or other approved materials.

Trees whose cambium is tender shall be treated with shellac instead of the above mixture.

Extra care shall be used in the pruning of broad-leaf evergreen trees, live oaks and magnolias. The branches of the live oak shall be thinned out to remove about one-half of the foliage. The magnolia shall be pruned by removing approximately three-fourths of its leaves rather than by cutting branches or twigs.

Balled evergreen shrubs shall not be pruned unless specifically designated by the Project Engineer.

All broken or badly bruised roots shall be removed with a clean sharp cut.

#### **Preparation of Planting Pits:**

Planting stakes shall be set by the Project Engineer at the designated locations of all plants, except where group plantings are to be made of the same plants, such as vines and small shrubs. Each stake shall

bear the key number of the plant for the particular location.

Planting pits shall be dug square or round with vertical sides and flat bottoms. The topsoil and subsoil shall be placed in separate piles and before backfilling shall be rendered loose and friable. The minimum sizes of planting pits shall be as follows:

Type of Plant	Minimum Size of Pit
Dwarf shrubs and vines	20 inch diameter and 14 inches deep.
Small trees less than 1 inch caliper & large shrubs whose mature height is less than 7 feet.	3 foot diameter and 2 feet deep.
All trees commonly known as shade trees from 1 inch to 3 inch caliper; and large flowering trees and shrubs whose mature height is more than 7 feet.	4 foot diameter and 30 inches deep.

For larger sizes of trees the pit sizes shall be increased.

Before planting any plant, the bottom of the pit shall be thoroughly chopped up and dirt rendered friable.

#### **Fertilizing:**

Fertilizer in the amounts and of the kind shown on the plans or in the special provisions shall be applied to each plant designated on the plans or in the special provisions to be fertilized. The fertilizer shall be applied at the time of planting. Approximately  $\frac{1}{3}$  of the amount of fertilizer shall be mixed with the topsoil and placed in the bottom of the planting pit; approximately one-third shall be mixed with the soil which is to be placed in the pit around the roots of the plant and the remaining one-third shall be used with the soil at the surface of the ground as the backfilling is being completed. In no event shall the contractor be allowed to

dump the fertilizer into the planting pit, it shall always be thoroughly incorporated with the soil before such soil is used for backfilling. The contractor shall be required to weigh the fertilizer required for each plant and place same in paper bags for distribution to the planting pits if deemed necessary by the Project Engineer.

#### **Planting and Backfilling:**

All plants shall be carefully plumbed and planted in the previously prepared planting pits as directed by the Project Engineer. Where indicated on the plans or directed by the Project Engineer, group plantings of shrubs shall be outlined and made into beds. The topsoil removed from planting pits shall be placed in the bottom of each hole. Backfilling shall then be completed by adding as much of the subsoil as is necessary to completely fill the hole.

Where "Topsoil" is furnished under Item 913, it shall be used together with the top soil removed from planting pits and the mixture placed in the bottom of the hole. Backfilling is then to be completed by using this mixture and as much of the subsoil as is necessary to fill the hole. If the amount of top soil is sufficient to fill the hole, then no subsoil is to be used.

When "Special Soil" is furnished under Item 914, it shall be used for the entire backfill and no other soil shall be used.

The backfill shall be built up to a height of three to four inches above the surface of the ground around each plant in order to leave a cup or depression to catch and hold water. On steep slopes, the soil on the lower side of the plant shall be left sufficiently high to act as a dam to hold water. All soil used for backfilling shall be rendered loose and friable. No sticks, clods, sods or other material which would tend to form air pockets shall be included in the backfill and all such material shall be removed from the project. Sods may be used near the bottom of the pits in limited amounts only, if broken into small pieces and only when approved by the Project Engineer.

When backfilling around balled plants, the dirt shall be pressed or firmed around the balls of dirt as backfilling progresses. After backfilling has progressed from one-half to two-thirds the depth of the ball, the burlap covering shall be cut away from the upper half of the ball and the remaining burlap spread or otherwise adjusted on the surface of the backfill in order to prevent the formation of air pockets.

When backfilling around bare rooted plants, the dirt shall be worked in around the roots and thoroughly pressed or firmed at intervals during the process of backfilling. Roots shall be well spread out and not cramped or crowded into the holes.

Where trees are planted in impervious clay soils, care shall be taken to provide proper under-drainage wherever considered necessary by the Project Engineer to avoid standing water in planting holes.

#### **Water:**

The contractor shall furnish water in sufficient quantities for proper irrigation of the plants. The plants shall be watered immediately after planting and at intervals as directed by the Project Engineer until final acceptance.

#### **Staking Trees:**

All trees shall be staked and tied as soon after planting as possible. The contractor shall provide two stakes 2" x 2" x 8' long for each tree, placed uniformly throughout the project in order to present a neat appearance. The stakes shall be driven vertically into the ground two feet deep and close enough to the trunk of the tree to insure stability. The stakes and trunk shall be securely tied with black wire or hay wire by wrapping one end of the wire around the top of one stake and then by wrapping the trunk and the top of the other stake followed by wrapping the trunk again but beginning on the opposite side and finally back to the first stake, the whole forming a figure eight on each side of the tree. Folded burlap shall be securely wrapped around the trunk of each tree at the point

of contact with wire before applying same in order to avoid injury to the tree.

**Staking Palms:**

The contractor shall provide three stakes 2" x 4" x 6' long for each palm. The stakes shall be driven vertically into the ground two feet deep and six feet away from the palm spaced so as to form a triangle. Each stake shall be securely guyed to an angle post. Three strands of barbed wire shall be stapled to the outside of the stakes forming a fence. The three strands of barbed wire shall be "stayed" halfway between stakes by making a vertical connection to each strand with barbed or black wire.

**Finishing Surfaces Around Plants After Backfilling:**

All excess dirt remaining after backfilling shall be spread evenly over the surface of the ground adjacent to the plants and shall be brought to a smooth even surface by raking or other hand methods. However, when directed by the Project Engineer, the contractor shall be required to remove any part or all excess dirt to other portions of the project or completely dispose of same beyond the limits of the highway right of way.

Around each planted tree, shrub, or vine a shallow basin, or rain cup, shall be formed in the ground, having a diameter equal to that of the planting hole. These basins or rain cups shall be maintained in shape during the life of the contract.

**Transplanting:**

All plants designated on the plans to be transplanted shall be properly dug, cared for, replanted, staked, pruned, mulched and watered as specified herein. Plants to be transplanted, balled and burlapped and those to be transplanted bare rooted shall be shown on the plans or in the special provisions.

**Maintenance and Acceptance:**

Upon completion of all items of the contract, the Project Engineer shall notify the contractor in writing

that the contract is provisionally accepted and the contractor is released from all contractual obligations except maintenance of planted areas and replacement plantings. The contractor shall be required to maintain all planted areas for sixty days after date of such provisional acceptance. Such maintenance shall include cultivation, watering, weeding, and any or all other horticultural work necessary to insure the life and growth of all plants.

At the expiration of this maintenance period, the Project Engineer shall make an inspection and prepare an estimate showing the amount of plant materials in an acceptable growing condition and other items complete, and the amount due the contractor for those items complete at their contract unit bid price. Plant materials which are not in an acceptable growing condition shall not be included in the estimate. If the Project Engineer decides that the plants which are not in an acceptable and growing condition are not detrimental to the appearance of the project as a whole, he may allow same to remain in place but no payment shall be made therefor and the above estimate shall be considered final.

If, on the date of this inspection, the Project Engineer finds that the dead, missing, damaged or injured plant material is detrimental to the appearance of the project as a whole, he shall so notify the contractor in writing, deferring final acceptance until replanting is performed.

The contractor shall then immediately upon receipt of such notification replace all plants itemized thereon, provided that the date for such replanting is not in conflict with paragraph on "Seasonal Operations." Bare rooted plants which are to be replaced shall be balled and burlapped, if so directed. Immediately upon the completion of this replanting work, the Project Engineer shall make a final inspection and if all replantings have been made in accordance with the specifications the Project Engineer shall prepare the final estimate.

If the season is further advanced than provided in paragraph on "Seasonal Operation," such replanting

shall be performed during the following planting season. During the following planting season, all planting not previously accepted as shown on above notifications, shall be replaced in accordance with these specifications. Upon completion of such replanting, the Project Engineer shall prepare the final estimate.

Contract days stated in the contract shall apply to the initial construction period only (exclusive of sixty day maintenance period) and shall not include added time for subsequent replanting.

**METHOD OF MEASUREMENT:**

The various trees, shrubs, vines and plants shall be measured by the plant and the number of plants actually planted, living and growing, shall be counted.

**BASIS OF PAYMENT:**

Fifteen percent of the total cost of all plants shall be withheld until the final acceptance of all planting, provided this amount is equal to or more than the total cost of the plants to be replaced. If this amount is less than the total cost of the plants to be replaced then the actual cost of the plants to be replaced shall be withheld in lieu of the fifteen percent.

The number of plants planted and accepted, measured as provided above, shall be paid for at the contract unit price per each for the various plants, complete in place, which price and payment shall constitute full compensation for preparation of planting pits, pruning, fertilizing, planting, replanting, transplanting, backfilling, staking and maintenance; for furnishing of all materials (except topsoil furnished under Item 913 and special soil furnished under Item 914), equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

Payment will be made under the various item numbers as specified in the Summary Plant List of the Special Provisions.

The pay item for this group shall be 912 with an



alphabetical suffix for each separate species or size of growth.

## TOPSOIL ITEM 913

### DESCRIPTION:

This item shall consist of furnishing topsoil for use in backfilling the particular plants designated on the plans or in the special provisions in accordance with these specifications or as directed by the Project Engineer.

### MATERIALS:

#### Topsoil:

The topsoil shall consist of approved mellow, loamy topsoil. Topsoil shall be approved by the Project Engineer before the contractor will be permitted to use same on the project.

### CONSTRUCTION METHODS:

#### Application:

The topsoil shall be used in backfilling plants as specified under Item 912. Unless otherwise specified the following amount of topsoil shall be provided for each plant.

Size of Planting Pit	Amt. of Topsoil
4 foot diameter, 30 inches deep.....	1 cubic yard
3 foot diameter, 2 feet deep.....	½ cubic yard
20 inch diameter, 14 inches deep.....	¼ cubic yard

### METHOD OF MEASUREMENT:

Topsoil shall be measured by the cubic yard in vehicles at the point of delivery on the project.

### BASIS OF PAYMENT:

The number of cubic yards of topsoil placed and

accepted, measured as provided above, shall be paid for at the contract unit price per cubic yard for "Topsoil," complete in place, which price and payment shall constitute full compensation for all hauling and for the furnishing of all materials, equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

Payment will be made under:

Item 913, Topsoil, per cubic yard.

## SPECIAL SOIL ITEM 914

### **DESCRIPTION:**

This item shall consist of furnishing special soil for use in backfilling the particular plants designated on the plans or in the special provisions in accordance with these specifications or as directed by the Project Engineer.

### **MATERIALS:**

#### **Special Soil:**

Special soil shall consist of acid muck obtained from swampy places or from the edges of fresh water streams or ponds; it may consist of good woods-mold obtained from beneath oak, hickory, sweet gum or other hardwood trees or it may be obtained from areas supporting a growth of acid soil plants, either or a combination of any or all of the above. This soil shall consist only of acid soil, rotten roots, partially decayed leaves, rotten wood or other decayed vegetable matter suitable for acid soil plants. All special soil shall be approved by the Project Engineer before the contractor will be permitted to use same on the project.

### **CONSTRUCTION METHODS:**

#### **Application:**

The special soil shall be used for backfilling plants as specified under Item 912. When special soil is used in the backfill it shall be used exclusively.

**METHOD OF MEASUREMENT:**

Special soil shall be measured by the cubic yard in vehicles at the point of delivery on the project.

**BASIS OF PAYMENT:**

The number of cubic yards of special soil placed and accepted, measured as provided above, shall be paid for at the contract price per cubic yard for "Special Soil," complete in place, which price and payment shall constitute full compensation for all hauling and the furnishing of all materials, equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

Payment will be made under:

Item 914, Special Soil, per cubic yard.

**MULCHING PLANTS**

**ITEM 915**

**DESCRIPTION:**

This item shall consist of furnishing and applying mulch to plants in accordance with the plans and these specifications or as directed by the Project Engineer.

**MATERIALS:**

Mulch shall conform to the requirements specified in Item 906.

**CONSTRUCTION METHODS:**

**Application:**

Mulch shall be spread evenly around each plant to a depth specified in item 906 over the surface of the ground to the edge of the planting pit or in the case of groups or beds of plants, it shall be spread over the entire bed. Mulch shall not be banked against the trunk of the plant but shall be placed so that a small space remains between the trunk and mulch. The plants shall

be mulched as soon after planting as practicable. After the mulch is placed, it shall be held in place by scattering a small quantity of soil over it.

**METHOD OF MEASUREMENT:**

Mulching of plants shall be measured by the plant and each plant mulched shall be counted.

**BASIS OF PAYMENT:**

The number of plants mulched and accepted, measured as provided above, shall be paid for at the contract unit price per plant for "Mulching Plants," which price and payment shall constitute full compensation for furnishing all materials, tools, equipment, labor and incidentals and the performance of all work necessary to complete the item.

Payment will be made under:

Item 915, Mulching Plants, per plant.

## SEEDING

### ITEM 916

**DESCRIPTION:**

This item shall consist of furnishing and sowing grass seed on the areas designated on the plans, or special provisions, in accordance with these specifications or as directed by the Project Engineer. This item shall include the surface dressing of all areas to be seeded, except when an item of surface dressing is included in the contract.

**MATERIALS:**

**Seed:**

The varieties of seed and the proportions to be used shall be as designated on the plans for both grass seed and seed of other than true grasses such as lespedezas, clovers, vetches, rye and others, and shall be furnished and delivered in separate bags. All seed mixtures when

specified shall be mixed after delivery of their separate seed ingredients.

All seed shall comply with applicable state and federal seed laws, and shall meet the requirements of these laws as to proper labeling and otherwise, and be reasonably free of noxious weed seed.

All true grass seed and other than true grass seed shall be fresh seed of the previous season's crop prior to the time of planting. Samples of seed shall be furnished by the contractor for testing if required by the Project Engineer.

## **CONSTRUCTION METHODS:**

### **Seeding:**

All seeding shall be performed in the proper seeding season for the variety of seed or mixture specified.

The contractor shall notify the Project Engineer at least 48 hours in advance of the start of seeding operations and shall not proceed with such work until permission to do so has been granted by the Project Engineer.

Topsoil, humus, fertilizer or other materials required by specific items in the contract shall be spread over the areas to be seeded and the areas shall then be surface dressed.

Seed, separately or in mixture, of the type and quantity specified shall be sown on the surface dressed area. Seed shall be sown by a rotary or other mechanical seeder, or hand methods may be used with the approval of the Project Engineer. Sowing shall be done in two directions at right angles to each other.

Leguminous seeds such as clover requiring inoculation, shall be inoculated before being sown.

After sowing the seed, the area shall be dragged, raked, harrowed, or rolled lightly with a cultipacker to cover the seed, unless in the opinion of the Project Engineer such covering is not necessary.

The contractor shall have adequate water tanks and other watering equipment and supply of water avail-

able at the beginning of seeding operations and shall keep same available throughout such operations and until the final acceptance of the project and shall water all seeded areas as directed by the Project Engineer. If, at the expiration of 21 days, areas do not show sufficient germination in the opinion of the Project Engineer, such areas shall be reseeded at the contractor's expense.

When seeding areas in order to augment or increase the present native grass, the area to be seeded shall not be surface dressed except that of discing, harrowing or raking lightly, after which the seed shall be sown broadcast over the area and the area dragged or rolled with a cultipacker and watered. If fertilizer is specified, it shall be broadcast prior to the discing, harrowing or raking. Watering shall be done as directed by the Project Engineer.

All seeded areas shall show sufficient germination and growth in the opinion of the Project Engineer before its acceptance.

**METHOD OF MEASUREMENT:**

Seeding shall be measured by the pound and the number of pounds of seed sowed shall be measured.

**BASIS OF PAYMENT:**

The number of pounds of seed sowed and accepted, measured as provided above, shall be paid for at the contract unit price per pound for "Seeding," which price and payment shall constitute full compensation for furnishing all materials (except fertilizer or topsoil) equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

Payment will be made under:

Item 916, Seeding, per pound.

**PLACING TOPSOIL  
ITEM 917**

**DESCRIPTION:**

This item shall consist of removing topsoil from

stockpiles and loading, hauling, depositing and spreading it on locations shown on the plans, in conformity with lines and grades specified.

#### **CONSTRUCTION METHODS:**

Topsoil shall be spread on specified areas when, in the opinion of the Project Engineer, a sufficient area has been completed to grade and in an acceptable condition to receive the topsoil.

Topsoil shall be spread on the areas shown on the plans or specified by the Project Engineer to an approximate depth of four inches or a depth sufficient to conform to the lines and grades specified.

All areas that require excavating to accommodate the topsoil shall be excavated to such depths that after normal settlement the thickness of topsoil required to conform such areas to finished grade shall be four inches. All areas to receive topsoil shall be scarified or otherwise roughened prior to the spreading of topsoil to a minimum depth of four inches.

All precautions shall be taken by the contractor to avoid damage or injury to plants or trees to be left in place. In excavating around any such growth care shall be exercised not to damage the roots of such growths.

In handling topsoil and spreading same all traveled roadway surfaces shall be kept reasonably clean to avoid hazards to traffic.

After spreading the topsoil, all clods, stones, roots, litter, or other foreign materials shall be removed from the areas. If the topsoil does not break down easily in the process of spreading, the topsoil shall be manipulated in such a manner by blades, discs, drags or hand implements, so that seeding, sodding or other planting operations can proceed without further soil preparation.

All topsoil areas shall be rolled with a roller weighing not less than 500 pounds and not more than 1500 pounds, such as a cultipacker or a soil pulverizer, except when separate items for seeding, sodding or other

planting operations are included in the contract, in which case rolling shall not be done under this item. If fertilizer is specified, such fertilizer shall be incorporated into topsoil during the finishing process of spreading where it can be disced into the topsoil.

The contractor shall use all precautions in properly spreading the topsoil uniformly over all areas and pulverizing same and leaving it in a suitable horticultural condition to furnish a base for future planting operations.

When topsoil contains grass roots which, in the opinion of the Project Engineer, will grow after the topsoil has been spread, the contractor shall not use any tools like a spike toothed harrow or other implements which would tend to pull out the grass roots during the spreading or finishing operation.

**METHOD OF MEASUREMENT:**

Placing topsoil shall be measured by the cubic yard in vehicles at the point of delivery on the project.

**BASIS OF PAYMENT:**

The number of cubic yards of topsoil placed and accepted, measured as specified, shall be paid for at the contract unit price per cubic yard for "Placing Topsoil," which price and payment shall constitute full compensation for loading, hauling, dumping, spreading, rolling and for the furnishing of all equipment, tools, labor and incidentals and the performance of all work necessary to complete the item.

Payment will be made under:

Item 917, Placing Topsoil, per cubic yard.

## STRIPPING AND STORING TOPSOIL

**DESCRIPTION:**

This item shall consist of removing topsoil within the right of way or other areas designated on the plans,



and transporting and storing it in stockpiles in convenient locations for future spreading over constructed areas.

**CONSTRUCTION METHODS:**

The areas from which stripping of topsoil is to be done shall be indicated on the plans or directed by the Project Engineer and the best available topsoil is to be stripped to a minimum depth of six inches and the specific depth shall be designated by the Project Engineer. The topsoil is to be stored in stockpiles at locations shown on the plans or directed by the Project Engineer.

All stripping of topsoil shall be completed on any designated area prior to the beginning of regular excavation or embankment work within that area. All topsoil shall be kept separate from other materials. The contractor shall remove material not acceptable as topsoil from stockpiles at his own expense.

**METHOD OF MEASUREMENT:**

Acceptable topsoil shall be classified as "Common Excavation" and shall be measured as specified for common excavation; overhaul shall be measured as specified for overhaul on excavation.

**BASIS OF PAYMENT:**

The number of cubic yards of acceptable topsoil measured and specified shall be paid for at the contract unit price for "Common Excavation," which price and payment shall constitute full compensation for removing, hauling 1,000 feet and storing in stockpiles all acceptable topsoil, and the furnishing of all equipment, labor, tools and incidentals necessary to complete the item. The number of station yards of overhaul in excess of 1,000 feet measured as specified shall be paid for at the contract unit price for "Overhaul on Excavation," which price and payment shall constitute full compensation for hauling topsoil in excess of 1,000 feet and the furnishing of all equipment, tools, labor and incidentals necessary to complete the item.

DIVISION III  
MATERIALS

## **RAPID CURING CUT-BACK ASPHALT: M-1**

### **Scope:**

These specifications cover liquid petroleum products, produced by fluxing an asphaltic base with a suitable light volatile solvent.

### **General Requirements:**

The cut-back asphalt shall be free from water and shall show no separation or curdling prior to use.

### **Properties and Test:**

Cut-back asphalt of the grade specified shall conform to the following requirements:

Rapid Curing Cut-Back Asphalt—M-1

GRADES

	RC-0		RC-1		RC-2		RC-3		RC-4		RC-5	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Flash Point, Open Tag, °F. ....					80		80		80		80	
Furol Viscosity												
@77°F, Sec. ....	75	150										
@122°F, Sec. ....			75	150								
@140°F, Sec. ....					100	200	250	500				
@180°F, Sec. ....									125	250	300	600
Distillation Test; Distillate Per- centage by Volume of total dis- tillate to 680°F												
to 374°F. ....	15		10									
to 437°F. ....	55		50		40		25		8			
to 500°F. ....	75		70		65		55		40		25	
to 600°F. ....	90		88		87		83		80		70	
Residue from distillation to 680°F, percentage volume by difference. ....	50		60		67		73		78		82	
Test on residue from distillation;												
Penetration. ....	80	120	80	120	80	120	80	120	80	120	80	120
Ductility @ 77°F. ....	100		100		100		100		100		100	
Soluble in Carbon tetrachloride, %	99.5		99.5		99.5		99.5		99.5		99.5	
Homogeneity Test. ....	Negative for all Grades											

**Tests:**

Testing of all cut-back asphalts shall be in accordance with the latest revisions of A.S.T.M. except for Flash Point (Open Tag) and Homogeneity. The test for Flash Point (Open Tag) shall be in accordance with method approved by Bureau of Explosives.

The test for Homogeneity shall be in accordance with A.A.S.H.O. Method T-102.

**ADDITIONAL REQUIREMENTS:**

A "wetting agent" shall be incorporated with the bituminous materials called for under this specification which gives the bituminous materials the property of readily coating the wet or dry stone, when mixed with such stone. The character of the wetting agent shall be such that it will not appreciably alter the normal mixing, setting and binding qualities of the bituminous materials, when the treated bituminous materials are used in field service as a coating of wet or dry stone, and the coating shall resist the stripping action of water.

The treated bituminous materials shall be capable of indefinite storage without detriment to the above properties.

**TESTS FOR WETTING AGENT:****Coating Test:**

The aggregate used to determine stone coating qualities of the bituminous material shall be dry Standard Massachusetts Rhyolite (Standard Massachusetts Rhyolite is a hydrophilic ledge rock which may be obtained from the "CENTRAL SCIENTIFIC COMPANY, CAMBRIDGE, MASSACHUSETTS"). The gradation of the stone used shall be 100% passing the  $\frac{1}{2}$ " and retained on the No. 4 screen.

The asphalt cut-back shall be heated to 140°F. The stone shall be at room temperature. Mixing time shall be three (3) minutes. In making up the mix, 500 grams of the aggregate, and sufficient asphalt cut-back to

give 5.5% asphalt content to the total mix, shall be used.

**Stripping Test:**

The mixture produced in the stone coating test shall be spread out in a loose layer, approximately  $\frac{3}{4}$  of an inch thick and allowed to cure for 5 hours at 100°F. A suitable size sample of the seasoned material shall then be placed in a glass jar, completely covered with distilled water and fitted with a tight cover. The jar and contents shall then be allowed to stand for a period of sixteen (16) hours at normal laboratory room temperature. The sample shall then be vigorously shaken for a period of fifteen minutes. The sample shall then be examined for stripping of the bituminous film from the aggregate.

**Test Requirements:**

The stone surface shall be coated to not less than 95% with a bituminous film in coating test outlined above.

When subjected to the Stripping Test given above, the stone surfaces shall not strip to less than 95%.

Any treated bituminous materials, acceptable at the time of delivery, and which fail to meet the above coating and stripping requirements over any six months storage period, shall be replaced with acceptable material by the contractor, at no additional cost to the Department.

**MEDIUM CURING CUT-BACK ASPHALT: M-2**

**Scope:**

These specifications cover liquid petroleum products, produced by fluxing an asphalt base with suitable distillates.

**General Requirements:**

The cut-back asphalt shall be free from water and shall show no separation or curdling prior to use.

**Properties and Tests:**

Cut-back asphalt of the grade specified shall conform to the following requirements:

## Grades

	MC-0		MC-1		MC-2		MC-3		MC-4		MC-5	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Flash Point Open Tag. °F.....	100		100		150		150		150		150	
Furol Viscosity												
@77°F, sec.....	75	150										
@122°F, sec.....			75	150								
@140°F, sec.....					100	200	250	500				
@180°F, sec.....									125	250	300	600
Distillation test, distillate, percentage by volume of total distillate to 680°F;												
to 437°F.....		25		20		10		5		0		0
to 500°F.....	40	70	25	65	15	55	5	40		30		20
to 600°F.....	75	93	70	90	60	87	55	85	40	80	20	75
Residue from distillation to 680°F, percentage volume by difference.....	50		60		67		73		78		82	
Tests on residue from distillation;												
Penetration.....	120	300	120	300	120	300	120	300	120	300	120	300
Ductility @77°F, for residue, 120- 200 pen, cm.....	100		100		100		100		100		100	
Ductility @60°F, for residue, 200- 300 pen cm.....	100		100		100		100		100		100	
Solubility in Carbon tetrachloride, %	99.5		99.5		99.5		99.5		99.5		99.5	
Homogeneity Test.....	Negative for all Grades											

**Tests:**

Testing of all cut-back asphalts shall be in accordance with the latest revisions of A.S.T.M. except for Flash Point (Open Tag) and Homogeneity. The test for Flash Point (Open Tag) shall be in accordance with method approved by Bureau of Explosives.

The test for Homogeneity shall be in accordance with A.A.S.H.O. Method T-102.

**ADDITIONAL REQUIREMENTS:**

A "wetting agent" shall be incorporated with the bituminous materials called for under this specification which gives the bituminous materials the property of readily coating the wet or dry stone, when mixed with such stone. The character of the wetting agent shall be such that it will not appreciably alter the normal mixing, setting and binding qualities of the bituminous materials, when the treated bituminous materials are used in field service as a coating of wet or dry stone, and the coating shall resist the stripping action of water.

The treated bituminous materials shall be capable of indefinite storage without detriment to the above properties.

**TEST FOR WETTING AGENT:****Coating Test:**

The aggregate used to determine stone coating qualities of the bituminous material shall be dry Standard Massachusetts Rhyolite (Standard Massachusetts Rhyolite is a hydrophilic ledge rock which may be obtained from the "CENTRAL SCIENTIFIC COMPANY, CAMBRIDGE, MASSACHUSETTS"). The gradation of the stone used shall be 100% passing the 1/2" and retained on the No. 4 screen.

The asphalt cut-back shall be heated to 140°F. The stone shall be at room temperature. Mixing time shall be three (3) minutes. In making up the mix, 500 grams



of the aggregate, and sufficient asphalt cut-back to give 5.5% asphalt content to the total mix, shall be used.

#### **Stripping Test:**

The mixture produced in the stone coating test shall be spread out in a loose layer, approximately  $\frac{3}{4}$  of an inch thick and allowed to cure for 5 hours at 100°F. A suitable size sample of the seasoned material shall then be placed in a glass jar, completely covered with distilled water and fitted with a tight cover. The jar and contents shall then be allowed to stand for a period of sixteen (16) hours at normal laboratory room temperature. The sample shall then be vigorously shaken for a period of fifteen minutes. The sample shall then be examined for stripping of the bituminous film from the aggregate.

#### **Test Requirements:**

The stone surface shall be coated to not less than 95% with a bituminous film in coating test outlined above.

When subjected to the Stripping Test given above, the stone surfaces shall not strip to less than 95%.

Any treated bituminous materials, acceptable at the time of delivery, and which fail to meet the above coating and stripping requirements over any six months storage period, shall be replaced with acceptable material by the contractor, at no additional cost to the Department.



with such stone. The character of the wetting agent shall be such that it will not appreciably alter the normal mixing, setting and binding qualities of the bituminous materials, when the treated bituminous materials are used in field service as a coating of wet or dry stone, and the coating shall resist the stripping action of water.

The treated bituminous materials shall be capable of indefinite storage without detriment to the above properties.

#### **TESTS FOR WETTING AGENT:**

##### **Coating Test:**

The aggregate used to determine stone coating qualities of the bituminous material shall be dry Standard Massachusetts Rhyolite (Standard Mass. Rhyolite is a hydrophilic ledge rock which may be obtained from the "CENTRAL SCIENTIFIC COMPANY, CAMBRIDGE, MASSACHUSETTS"). The gradation of the stone used shall be 100% passing the  $\frac{1}{2}$ " and retained on the No. 4 screen.

The asphalt cut-back shall be heated to 140°F. The stone shall be at room temperature. Mixing time shall be three (3) minutes. In making up the mix, 500 grams of the aggregate, and sufficient asphalt cut-back to give 5.5% asphalt content to the total mix, shall be used.

##### **Stripping Test:**

The mixture produced in the stone coating test shall be spread out in a loose layer, approximately  $\frac{3}{4}$  of an inch thick and allowed to cure for 5 hours at 100°F. A suitable size sample of the seasoned material shall then be placed in a glass jar, completely covered with distilled water and fitted with a tight cover. The jar and contents shall then be allowed to stand for a period of sixteen (16) hours at normal laboratory room temperature. The sample shall then be rigorously shaken for a period of fifteen minutes. The sam-

ple shall then be examined for striping of the bituminous film from the aggregate.

**Test Requirements:**

The stone surface shall be coated to not less than 95% with a bituminous film in coating test outlined above.

When subjected to the Stripping Test given above, the stone surfaces shall not strip to less than 95%.

Any treated bituminous materials, acceptable at the time of delivery, and which fail to meet the above coating and stripping requirements over any six months storage period, shall be replaced with acceptable material by the contractor, at no additional cost to the Department.

**EMULSIFIED ASPHALT—M-4**

Emulsified asphalt shall be homogeneous and show no separation of asphalt after thorough mixing, within thirty days after delivery, provided separation was not caused by freezing and shall conform to the following requirements:

GRADE

	EA-1		EA-2		EA-3		EA-4		EA-5	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Furol Viscosity @77°F.....	20	100			30	100	40	400	40	400
Furol Viscosity @122°F.....			100	500					40	400
Miscibility—2 hours.....						meet		meet		
Modified Miscibility %.....						4.5		4.5		
Residue by Distillation %.....	55	60	62	67	55	60	60	65	60	
Specific Gravity.....	1.00		1.00		1.00		1.00			
Settlement, 10 days.....		3		3		3		3		
Demulsibility, 50ml. 0.1N CaCl <sub>2</sub> %.....			65			2		2		
Demulsibility, 35ml. .02N CaCl <sub>2</sub> %.....	75									
Sieve test, ret. on 20 mesh.....		.05		.05		.05		.05		
Cement mixing, % broken.....						2		2		
Stone Coating Test.....						meet		meet		meet
Dehydration, 100°F, 96 hrs.....						0.6		0.6		
Adhesion (Standard Rhyolite) %.....	75		75		75		75		75	
Water Content %.....									3	8
Test on Residue from Distillation										
Penetration @77°F, 100g, 5 sec.....	100	200	100	200	35	85	100	200		
Soluble in CS <sub>2</sub> .....	97		97		97		97		97.5	
Loss @325°F, 5 hrs. %.....		1.0		1.0		1.0		1.0		
Ductility @77°F, cm.....	60		60		60		60			
Float test @122°F.....									80	
Asphalt content %.....										
Ash.....		2		2		2		2		3

**Sampling:**

At least one sample of not less than one gallon shall be taken from each lot or shipment of the emulsified asphalt after arrival at its destination. The samples shall be stored in clean, air-tight containers at a temperature not lower than 4°C (40°F) until tested.

**Method of Testing:**

The properties enumerated in these specifications shall be determined in accordance with the A.S.T.M. Designation D-244 except as follows:

Float test: ASTM D-139-27.

Loss @ 325°F: ASTM D-6-39 T.

**Dehydration Test:**

A 100 gram sample of the emulsion to be tested shall be placed in a tared, heat-resistant glass dish, 77mm. inside diameter, 40mm. in height, and having a flat bottom and straight sides. The dish and sample shall be placed in the center of a shallow pan about 5 inch inside diameter, and 50 grams of granular anhydrous CaCl<sub>2</sub> shall be spread in the pan so that it surrounds the dish containing the emulsion. The entire unit shall then be placed in an oven at a constant temperature of 100°F. At the end of exactly 96 hours, during which time the sample shall not be disturbed by stirring or excessive movement, the loss in weight of the emulsion shall be determined. The dehydration loss shall be expressed as the ratio of loss in this test in 96 hours to loss in the test for residue at 163°C.

**Adhesion Test:**

The adhesive qualities of the emulsified asphalt shall be tested by the following method:

Two hundred grams of dry Standard Massachusetts Rhyolite\*\*, graded to pass a No. 4 standard laboratory sieve and to be retained on a No. 10 standard laboratory sieve, shall be mixed with sixteen grams of the emulsion to be tested, until all particles of the aggregate are completely coated. Three, fifty gram

samples shall be selected from this mixture and spread on small metal discs. The prepared samples shall then be placed in an oven and dried for a period of twenty-four hours at a constant temperature of 200° F.

Each sample shall then be dropped into 400 cc. of boiling distilled water in a 600 cc. beaker and stirred for exactly three minutes at the rate of sixty times per minute, while boiling continues. The beaker shall then be removed from the fire, and after ebullition ceases, cold water shall be run into the beaker through a ¼ inch hose submerged about one inch below the surface. The addition of water shall be continued until the film of asphalt floating on the water in the beaker has flowed over the side. As soon as this is accomplished each sample shall be removed and laid on absorbent paper for air-drying. In removing the samples from the beaker, care shall be taken to prevent the recoating of the samples with asphalt which has deposited on the beaker. When dry, the mixture shall be immediately examined. Areas showing any asphaltic film, either a heavy black or a very thin translucent asphaltic film, shall be considered coated and an estimate shall be made of the per cent coated.

\*Pyrex glass is very satisfactory for this purpose.

\*\*Standard Massachusetts Rhyolite is a hydrophilic ledge rock which may be obtained from the "Central Scientific Company, Cambridge, Massachusetts", graded to the size specified.

#### **ASPHALT CEMENT:—M-5**

##### **Scope:**

These specifications cover asphalt cements which have been prepared from petroleum.

##### **General Requirements:**

Asphalt cement shall be homogeneous, free from water and shall not foam when heated to a temperature of 347°F. ✓

##### **Properties and Tests:**

Asphalt cement of the grade specified shall conform to the following requirements:





**Tests:**

Testing of all asphalt cements shall be in accordance with the latest revisions of A.S.T.M. except for Homogeneity.

The test for Homogeneity shall be in accordance with A.A.S.H.O. Method T-102.

**ADDITIONAL REQUIREMENTS:**

A "wetting agent" shall be incorporated with the bituminous materials called for under this specification which gives the bituminous materials the property of readily coating the wet or dry stone, when mixed with such stone. The character of the wetting agent shall be such that it will not appreciably alter the normal mixing, setting and binding qualities of the bituminous materials, when the treated bituminous materials are used in field service as a coating of wet or dry stone, and the coating shall resist the stripping action of water.

The treated bituminous materials shall be capable of indefinite storage without detriment to the above properties.

**TESTS FOR WETTING AGENT:****Coating Test:**

The aggregate used to determine stone coating qualities of the bituminous material shall be dry Standard Massachusetts Rhyolite (Standard Massachusetts Rhyolite is a hydrophilic ledge rock which may be obtained from the "CENTRAL SCIENTIFIC COMPANY, CAMBRIDGE, MASSACHUSETTS"). The gradation of the stone used shall be 100% passing the  $\frac{1}{2}$ " and retained on the No. 4 screen.

The Asphalt cement shall be heated to 325°F. The aggregate shall be heated to 180°F. Mixing time shall be three (3) minutes. In making up the mix, 500 grams of aggregate, and asphalt cement amounting to 5.5% of total mix, shall be used.

**Stripping Test:**

The mixture produced in the stone coating test

shall be spread out in a loose layer, approximately  $\frac{3}{4}$  of an inch thick and allowed to cure for 5 hours at 100°F. A suitable size sample of the seasoned material shall then be placed in a glass jar, completely covered with distilled water and fitted with a tight cover. The jar and contents shall then be allowed to stand for a period of sixteen (16) hours at normal laboratory room temperature. The sample shall then be vigorously shaken for a period of fifteen minutes. The sample shall then be examined for stripping of the bituminous film from the aggregate.

**Test Requirements:**

The stone surface shall be coated to not less than 95% with a bituminous film in coating test outlined above.

When subjected to the Stripping Test given above, the stone surfaces shall not strip to less than 95%.

Any treated bituminous materials, acceptable at the time of delivery, and which fail to meet the above coating and stripping requirements over any six months storage period, shall be replaced with acceptable material by the contractor, at no additional cost to the Department.

**ASPHALT MINERAL POURED JOINT  
FILLER—M-6:**

The filler shall be homogeneous and shall be composed of bitumen and mineral filler. The bitumen shall be free from impurities. The asphalt mineral filler shall conform to the following requirements:

	Min.	Max.
1. Melting Point Ring & Ball °F .....	125	145
2. Penetration at 32° F, 200g, 1 min.....	22	
3. Penetration at 77° F, 100g, 5 sec.....	50	65
4. Ductility at 100°F, Cm. ....	20	
5. Bitumen Soluble in Carbon		
Disulphide, per cent .....	40	50
6. Mineral Filler, per cent .....	50	60
7. Water (By Distillation), per cent .....		2

**ASPHALT PLANK—M-7:**

These specifications cover plain asphalt plank.

**Manufacture:**

Asphalt plank shall be a mixture of asphalt, fiber and mineral aggregate formed by extrusion under sufficient pressure to expel the air and form a dense mass.

**Workmanship:**

The plank shall be free from defects affecting its serviceability or appearance; it shall have straight edges and square corners.

**Asphalt Cement:**

The asphalt cement shall have such characteristics that, when combined with the other ingredients, a plank of desired quality will result.

**Fiber:**

This material shall be free from lumps and be in flocculent condition when used and shall be finely divided whole threads of fiber. This fabric and fibrous material shall be free from all foreign material such as metal, leather, straw, sawdust, cornstalks, or other deleterious materials.

**Mineral Filler:**

The mineral filler shall be finely crushed slate, limestone, asbestos, silica or other aggregate which has been approved suitable for use with asphalt cement in constructing pavement wearing surfaces.

**Dimensions:**

Asphalt plank shall have the dimensions specified or shown on the plans. Tolerance of plus or minus 1/16 inch thickness, 1/8 inch width and 1/4 inch length will be permitted.

**Absorption:**

The asphalt plank shall have an absorption of not more than 1.0 per cent by weight.

**Brittleness:**

At least 80 per cent of the specimens of plank tested shall not have any detrimental cracking when tested in accordance with the method specified in the Standard Methods of Sampling and Testing Asphalt Plank (A.A.S.H.O. Designation: T 77).

**Indentation:**

Asphalt Plank, irrespective of thickness, shall have, when subjected to a load as prescribed in the Standard Method of Sampling and Testing Asphalt Plank (A.A.S.H.O. Designation: T 77), indentations within the following limits:

(a) At 77°F, at the end of 1 minute: Not less than 12 mils nor more than 27 mils.

(b) At 77°F, at the end of 10 minutes: Not more than that specified in Table I corresponding to the indentation at 1 minute.

TABLE I.

Indentation recorded at 1 minute nearest mil	Maximum indentation at 10 minutes nearest 1/2 mil
12	21.5
13	23.0
14	24.0
15	25.5
16	27.0
17	28.5
18	30.0
19	31.0
20	32.5
21	33.5
22	35.0
23	36.5
24	37.5
25	39.0
26	40.0
27	41.5

(c) At 125°F, at the end of 30 seconds: Not less than 35 mils nor more than 70 mils.

(b) At 125°F, at the end of 300 seconds: Not more than that specified in Table II (or interpolated therefrom) corresponding to the indentation at 30 seconds.

TABLE II

Indentation recorded at 30 seconds, nearest mil	Maximum indentation at 300 seconds, nearest 1/2 mil
35	70.0
40	77.0
45	85.0
50	93.0
55	100.0
60	108.0
65	116.0
70	125.0

Sampling and Testing: Sampling and testing of premoulded asphalt plank shall be in accordance with the standard method of Sampling and Testing asphalt plank A.A.S.H.O., Method T77-38.

**ASPHALT WATERPROOFING:—M-8**

Waterproofing asphalt shall be the product of the distillation and refining of crude asphaltic petroleum. It shall be free from coal tar pitch or any of its derivatives and shall conform to the following requirements:

	Min.	Max.
1. Flash Point C.O.C. °F. ....	392	
2. Softening Point °F. ....	150	170
3. Penetration at 32°F., 200 g, 1 min.	10	
77° F., 100 g, 5 sec. ....	25	50
115°F., 50 g, 5 sec. ....		100
4. Loss on heating at 325°F., 50 gms., 5 hours.....		1.0
5. Penetration of residue after heating at 77°F., 100 gms., 5 sec., as compared to penetration before heating, per cent.....	80	
6. Ductility at 77°F., 5 cm., per min.	10	
at 40°F., 1 cm., per min .....	4	
7. Total Bitumen (soluble in carbon disulphide), per cent.....	99.5	

**ADDITIONAL REQUIREMENTS:**

A "wetting agent" shall be incorporated with the bituminous materials called for under this specification which gives the bituminous materials the property of readily coating the wet or dry stone, when mixed with such stone. The character of the wetting agent shall be such that it will not appreciably alter the normal mixing, setting and binding qualities of the bituminous materials, when the treated bituminous materials are used in field service as a coating of wet or dry stone, and the coating shall resist the stripping action of water.

The treated bituminous materials shall be capable of indefinite storage without detriment to the above properties.

## **TESTS FOR WETTING AGENT:**

### **Coating Test:**

The aggregate used to determine stone coating qualities of the bituminous material shall be dry Standard Massachusetts Rhyolite (Standard Massachusetts Rhyolite is a hydrophilic ledge rock which may be obtained from the "CENTRAL SCIENTIFIC COMPANY, CAMBRIDGE, MASSACHUSETTS"). The gradation of the stone used shall be 100% passing the  $\frac{1}{2}$ " and retained on the No. 4 screen.

The asphalt cement shall be heated to 325°F. The aggregate shall be heated to 180°F. Mixing time shall be three (3) minutes. In making up the mix, 500 grams of aggregate, and asphalt cement amounting to 5.5% of the total mix, shall be used.

### **Stripping Test:**

The mixture produced in the stone coating test shall be spread out in a loose layer, approximately  $\frac{3}{4}$  of an inch thick and allowed to cure for 5 hours at 100°F. A suitable size sample of the seasoned material shall then be placed in a glass jar, completely covered with distilled water and fitted with a tight cover. The jar and contents shall then be allowed to stand for a period of sixteen (16) hours at normal laboratory room temperature. The sample shall then be vigorously shaken for a period of fifteen minutes. The sample shall then be examined for stripping of the bituminous film from the aggregate.

### **Test Requirements:**

The stone surface shall be coated to not less than 95% with a bituminous film in coating test outlined above.

When subjected to the Stripping Test given above, the stone surfaces shall not strip to less than 95%.

Any treated bituminous materials, acceptable at the time of delivery, and which fail to meet the above coating and stripping requirements over any six months storage period, shall be replaced with accept-

able material by the contractor, at no additional cost to the Department.

**BITUMINOUS MIXTURE FOR COLD APPLICATION  
CUT-BACK ASPHALT TYPE:—M-9**

**Description:**

This material shall consist of a mixture of mineral aggregate and bituminous material meeting the requirements of these specifications for binder course and/or wearing course.

**Composition and Proportioning:**

The mineral aggregate and bituminous material shall be combined in such proportions that the mixture shall meet the following requirements by weight:

Material	Binder Course		Wearing Course	
	Min.	Max.	Min.	Max.
Total Mineral Aggregate, %.....	93.5	95.0	92.5	94.5
Total Bitumen, %.....	5.0	6.5	5.5	7.5

Volumetric proportioning may be substituted for weight proportioning. The mixer may be the pug mill, drum, or continuous type.

The percentage of bitumen may vary between extreme limits herein set forth, however, the exact percentage will be fixed by the Project Engineer, depending on the gradation and type of aggregate used.

The finished material is intended for immediate use upon arrival at destination and shall be in a workable condition.

**Plant and Machinery:**

The mixing plant used in the preparation of the bituminous material shall be stationary and shall comply with the following requirements. The plant shall have a storage bin of sufficient capacity to furnish the necessary amount of aggregate up to the maxi-

mum rated capacity of the plant with no undue periods of waiting for material.

The plant shall so operate that the aggregate shall be completely coated with no "balling" of the fines or separation of coarse and fine aggregate. The drum or housing of the mixer shall be so constructed that leaking of the bituminous material will be avoided. The plant shall contain a drier suitably designed to heat and dry the aggregate and to agitate it continuously during heating. The bituminous material shall be heated, preferably by steam coils, and in any case the equipment shall be of such design that steam will not be introduced directly into the bituminous materials. Accurate thermometers shall be furnished, suitable for determining the temperature of the mix.

**MATERIALS:**

**Aggregate:**

The mineral aggregate shall consist of crushed gravel and sand, crushed stone, crushed stone and sand, crushed slag and sand or any combination of the foregoing materials, which, when meeting requirements hereinafter set forth and so combined, will comply with the following mechanical analysis:

Square Opening Sieves	Binder Course		Wearing Course	
	Min.	Max.	Min.	Max.
Passing 1 1/4" .....	100			
Passing 3/4" .....	80	95		
Passing 1/2" .....			100	
Passing No. 4 .....	50	70	80	95
Passing No. 10 .....	35	60	40	65
Passing No. 40 .....	10	30	15	30
Passing No. 80 .....	2	10	3	15
Passing No. 200 Mesh.....	0	7	0	10

Crushed gravel shall consist of clean, hard, tough, durable fragments and shall be screened and crushed to sizes as necessary to meet the grading requirements. At least 80 percent of the gravel retained on a ten mesh sieve shall have more than one crushed face. Gravel shall have a percent of wear of not more than fifteen (Deval Abrasion Test).



Crushed stone shall consist of clean, hard, tough, durable fragments, reasonably free from flat, elongated, soft or disintegrated pieces, dirt or other objectionable matter. Crushed stone shall show a percent of wear of not more than seven (Deval Abrasion Test).

Crushed slag shall be air cooled, blast furnace slag, and shall consist of angular fragments reasonably free from flat or elongated pieces, dirt or other objectionable matter. Crushed slag shall show a percent of wear of not more than fifteen (Deval Abrasion Test). It shall weigh not less than seventy lbs. per cubic foot, dry rodded.

Sand shall consist of clean, hard, durable grains graded from coarse to fine, free from clay lumps, vegetable matter or any deleterious substance.

The moisture content of the aggregate at the time of mixing shall not exceed one percent by weight.

Cut-back asphalt shall conform to the requirements specified in M-1, Type RC-2.

**Note:**

This material is not intended for stock piling. Cannot be shipped by Railroad Cars except during the months of June, July and August. It must be used immediately when loaded directly from plant or cars.

**BITUMINOUS MIXTURE FOR COLD APPLICATION  
EMULSIFIED ASPHALT TYPE: M-10**

**DESCRIPTION:**

This material shall consist of a mixture of mineral aggregate, portland cement, hydrated lime and bituminous material meeting the requirements of these specifications for binder course and/or wearing course.

**Composition and Proportioning:**

The mineral aggregate, Portland cement, hydrated lime and bituminous material shall be combined in such proportions that the mixture shall meet the following requirements by weight:

Material	Binder Course		Wearing Course	
	Min.	Max.	Min.	Max.
Total Mineral Agregate %.....	92.4	93.9	91.4	93.4
Total Portland Cement %.....	1.0	1.5	1.0	1.5
Total Hydrated Lime %.....	0.1	0.2	0.1	0.2
Total Bitumen % .....	5.0	6.5	5.5	7.0

Volumetric proportioning may be substituted for weight proportioning. The mixer may be of the pug mill or drum type.

The percentage of bitumen may vary between extreme limits herein set forth, however, the exact percentage will be fixed by the Project Engineer, depending on the gradation and type of aggregate used.

The finished material is intended for immediate use or stockpiling upon arrival at destination and must be in a workable condition. If hauled by truck, the material shall be stockpiled a minimum of 48 hours before use.

#### Plant and Machinery:

The mixing plant used in the preparation of the bituminous material shall be stationary and shall comply with the following requirements. The plant shall have a storage bin of sufficient capacity to furnish the necessary amount of aggregate up to the maximum rated capacity of the plant with no undue periods of waiting for material, when the material is to be hauled by trucks. It is not necessary that the plant be equipped with a drier or heater to dry or heat the aggregate. The emulsified asphalt is not to be heated. In some instances, particularly dry aggregate, may have to be wetted with water to insure a uniform covering with the bituminous material.

The plant shall so operate that the aggregate shall be completely coated with no "balling" of the fines or separation of coarse and fine aggregate. The drum or housing of the mixer shall be so constructed that leaking of the emulsified asphalt will be avoided.

To obtain good mixing results, insuring a thorough coating of the aggregate, it is recommended that the following routine of adding the materials entering into the mix be carried out; the mixer to be operating while

all items are being added. First, dump the coarse or larger of the aggregates in the mixer (if the coarse aggregate is dry, add a small amount of water only sufficient to coat same) then add the emulsion, or this operation of introducing the aggregate and emulsion may be reversed, dependent on the type of mixer, followed by the hydrated lime after the aggregate has been thoroughly coated with emulsion, then dump the fine aggregate (sand) after completely coating all aggregate, add Portland cement then continue mixing until the Portland cement is thoroughly coated, then dump immediately.

**MATERIALS:**

**Aggregate:**

The mineral aggregate shall consist of crushed gravel and sand, crushed stone, crushed stone and sand, crushed slag and sand or any combination of the foregoing materials, which, when meeting requirements hereinafter set forth and so combined will comply with the following mechanical analysis:

Square Opening Sieves	Binder Course		Wearing Course	
	Min.	Max.	Min.	Max.
Passing 1 1/4".....	100			
Passing 3/4".....	80	95		
Passing 1/2".....			100	
Passing No. 4.....	50	70	80	95
Passing No. 10.....	35	60	40	60
Passing No. 40.....	10	30	15	30
Passing No. 80.....	2	10	3	15
Passing No. 200 Mesh.....	0	7	0	10

Crushed gravel shall consist of clean, hard, tough, durable stone fragments and shall be screened and crushed to sizes as necessary to meet the grading requirements. At least 80 percent of the gravel retained on a ten mesh sieve shall have more than one crushed face. Gravel shall have a percent of wear of not more than fifteen (Deval Abrasion Test).

Crushed slag shall be air cooled blast furnace slag, and shall consist of angular fragments reasonably free from flat or elongated pieces, dirt or other objectionable matter. Crushed slag shall show a percent of wear

of not more than fifteen (Deval Abrasion Test). It shall weigh not less than seventy lbs. per cubic foot, dry rodded.

Crushed stone shall consist of clean, hard, tough, durable fragments, reasonably free from flat, elongated, soft or disintegrated pieces, dirt or other objectionable matter. Crushed stone shall show a percent of wear of not more than seven (Deval Abrasion Test).

Sand shall consist of clean, hard, durable grains graded from coarse to fine, free from clay lumps, vegetable matter or any deleterious substance.

**Portland Cement:**

Portland cement shall meet the requirements specified in M-24.

**Hydrated Lime:**

Hydrated lime shall be composed of not less than 95% calcium and magnesium oxides.

Emulsified asphalt shall conform to the requirements specified in M-4, Type EA-4.

**COARSE AGGREGATE: M-13**

Types A, B, C, D, E and F: This aggregate shall consist of gravel and/or crushed stone. Gravel shall consist of clean, tough, durable stone, free from sticks and clay coating. Gravel shall not contain more than fifteen per cent of thin or elongated particles of stone and shall have a per cent of wear of not more than fifteen by the Deval abrasion test. Any piece of gravel or stone whose greatest dimension is more than four times its least dimension shall be considered thin or elongated. The maximum amounts of deleterious substances shall be as follows:

	Per cent by weight
Removed by Washing .....	0.5
Clay Lumps.....	0.5
Soft Fragments.....	0.5
Iron Ore (included in soft fragments) re-	

tained on 3/4 inch square opening sieve....	0.5
Passing 3/4 inch square opening sieve.....	1.0
Coal and Lignite.....	1.0
Total Clay Lumps, Soft Fragments, Coal and Lignite .....	5.0

**Crushed Stone:**

Crushed stone shall be obtained from clean, tough, sound durable stone. The particles of stone shall be free from dust, vegetable or other deleterious matter, and shall have a per cent of wear of not more than eight by the Deval abrasion test. The stone shall not contain more than fifteen per cent of thin, elongated particles and not more than three per cent by weight shall be removed by washing over a number eight sieve.

Coarse aggregate shall be uniformly graded from coarse to fine, and when tested by means of laboratory sieves shall conform to the following gradation requirements for the type specified:

Per cent of coarse aggregate passing square opening laboratory sieves.

**TYPE "A"**

1 1/2" .....	100%
1" .....	90-100%
3/4" .....	40- 85%
No. 4.....	0- 5%

**TYPE "B"**

2" .....	100%
1 1/2" .....	85-100%
3/4" .....	40- 85%
No. 4.....	0- 5%

Types C and E: Types C and E may be composed of a mixture of two sizes of aggregates and individual gradings of the two sizes of aggregate shall conform to the gradation specified for the combined mix, and the two sizes of aggregate shall be stockpiled and binned separately. When tested by square opening laboratory sieves, the combined mixture shall conform to the following requirements:

TYPE "C"	TYPE "E"	Per cent
Passing 2¼"	Passing 2½"	100
2¼" to 1"	2½" to 1½"	25-40
1" to ½"	1½" to ¾"	20-45
½" to No. 4	¾" to No. 4	20-35
Passing No. 4	Passing No. 4	0- 5

The individual sizes of aggregate for type C and E aggregate, unless otherwise specified by the Project Engineer, shall be restricted as follows: The smaller size aggregate, for Type "C" shall not have more than 10 per cent retained on the ¾ inch square sieve, and for Type "E" shall not have more than 10 per cent retained on the 1 inch square sieve, not less than 5 per cent on the ¾ inch square sieve and not more than 8 per cent passing the No. 4 square opening sieve. The larger size aggregate for Type "C" shall not have more than 20 per cent passing the ¾ inch square sieve, and for Type "E" shall have 45 to 60 per cent retained on the 1½ inch square sieve and shall not have more than 20 per cent passing the 1 inch square sieve.

#### TYPE "D"

2½" .....	100%
2" .....	90-100%
1" .....	40- 80%
No. 4.....	0- 5%

#### TYPE "F"

2¾" .....	100%
2½" .....	90-100%
1½" .....	40- 70%
¾" .....	0- 25%
No. 4.....	0- 5%

Types J, K, L, M: The aggregate shall consist of crushed gravel or crushed stone.

Gravel shall consist of clean, tough, durable stone and shall be crushed and screened to conform to the gradations specified. A minimum of 80 per cent of the gravel retained on the No. 10 sieve shall have one or more fractured faces. Gravel shall have a per cent of wear of not more than 15 by the Deval abrasion test.

Crushed stone shall consist of clean, tough, sound, durable particles of stone. The particles of stone shall be free from dust, vegetable or other deleterious matter and shall have a per cent of wear of not more than 8 by the Deval abrasion test. The stone shall not contain more than 15 per cent of thin, elongated particles. Crushed gravel or crushed stone, when tested by means of square opening laboratory sieves, shall conform to the following requirements for the type specified:

The maximum amounts of deleterious substances shall be as specified for Types A, B, C, D, E and F.

#### TYPE "J"

	Per cent
Passing 1½, retained on ¾.....	20-30
Passing ¾, retained on No. 4.....	24-40
Passing No. 4, retained on No. 10.....	5-15
Passing No. 10.....	20-35

#### TYPE "K"

	Per cent
Passing ⅝.....	95-100
Passing ⅝, retained on No. 4.....	40-80
Passing No. 10.....	0-15

#### TYPE "L"

	Per cent
Passing ¾, retained ½.....	15-25
Passing ½, retained No. 4.....	20-35
Passing No. 4, retained No. 10.....	10-25
Passing No. 10, retained No. 200.....	25-40
Passing No. 200.....	4-10

#### TYPE "M"

	Per cent
Passing ⅝, retained No. 10.....	20-35
Passing No. 10, retained No. 40.....	7-30
Passing No. 40, retained No. 80.....	11-40
Passing No. 80, retained No. 200.....	10-30
Passing No. 200.....	7-12

Types R-1, R-2, and R-3: Crushed gravel shall conform to the following requirements: Crushed gravel

shall consist of clean, tough, durable stone and shall be crushed and screened to conform to the gradation specified. A minimum of 80 per cent of the crushed gravel retained on the No. 10 sieve shall have one or more fractured faces. Crushed gravel shall have a per cent of wear of not more than 15 by the Deval Abrasion Test.

Crushed gravel, when tested by square opening laboratory sieves, shall conform to the following gradation requirements.

R-1

Passing	Per Cent
1 1/4" .....	100
1" .....	90-100
3/4" .....	20- 60
1/2" .....	0- 10
No. 4.....	0- 2

R-2

Passing	Per Cent
5/8" .....	100
1/2" .....	90-100
3/8" .....	40- 80
No. 4.....	0- 15
No. 10.....	0- 3

R-3

Passing	Per Cent
1/2" .....	100
3/8" .....	95-100
No. 4.....	40- 70
No. 10.....	0- 15
No. 16.....	0- 5

Types S-1, S-2 and S-3: Crushed stone shall conform to the following requirements: Crushed stone shall consist of clean, tough, sound, durable particles of stone. The particles of stone shall be free from dust, vegetable or other deleterious matter and shall have a per cent of wear of not more than 8 by the Deval Abrasion Test. The stone shall not contain more than 15 per cent of thin, elongated particles (particles whose greatest dimension is more than 4 times its least dimension).



Crushed stone, when tested with square opening laboratory sieves, shall conform to the following gradation requirements:

S-1

Passing	Per Cent
1 1/4" .....	100
1" .....	90-100
3/4" .....	20- 60
1/2" .....	0- 10
No. 4 .....	0- 2

S-2

Passing	Per Cent
5/8" .....	100
1/2" .....	90-100
3/8" .....	40- 80
No. 4 .....	0- 15
No. 10 .....	0- 3

S-3

Passing	Per Cent
1/2" .....	100
3/8" .....	95-100
No. 4 .....	40- 70
No. 10 .....	0- 15
No. 16 .....	0- 5

Types T-1, T-2 and T-3. Crushed slag shall conform to the following requirements: Crushed slag shall be air-cooled, blast-furnace slag, and shall consist of angular fragments reasonably uniform in density and quality and reasonably free from flat or elongated particles, dirt or other deleterious substances. The crushed slag shall have a weight per cubic foot of not less than 70 pounds, using A.A.S.H.O. Method T-19. Slag shall have a per cent of wear of not more than 15 by the Deval Abrasion Test.

Crushed slag, when tested with square opening laboratory sieves, shall conform to the following gradation requirements:

### T-1

Passing	Per Cent
1¼" .....	100
1" .....	90-100
¾" .....	20- 60
½" .....	0- 10
No. 4 .....	0- 2

### T-2

Passing	Per Cent
⅝" .....	100
½" .....	90-100
⅜" .....	40- 80
No. 4 .....	0- 15
No. 10 .....	0- 3

### T-3

Passing	Per Cent
½" .....	100
⅜" .....	95-100
No. 4 .....	40- 70
No. 10 .....	0- 15
No. 16 .....	0- 5

### Type "Q"

Coarse Aggregate for White Concrete: The aggregate shall be light colored gravel, limestone or granite and shall be sound, hard, durable and free from loam, clay, organic or other foreign matter. It shall contain not more than 5 per cent of slate, shale or soft sandstone pieces. When tested by means of square opening laboratory sieves, the aggregate shall conform to the following gradation requirements:

Passing	Per Cent
¾" .....	100
½" .....	40- 75
No. 4 .....	0- 5

### FINE AGGREGATE:—M-14

Fine aggregate shall consist of clean, hard, sound

durable particles of stone or sand, and shall be free from clay, loam or other foreign matter.

Type A, B, K: These types shall be subjected to the colorimetric tests for organic impurities and those producing a color darker than figure three of A.S.T.M. Designation C-40 shall be rejected. These types shall be subjected to the A.S.T.M. Designation C-109 for mortar strength and shall have a minimum strength of ninety-five per cent of the standard mortar strength. Types A and B shall not exceed the following percentages by weight of deleterious substances:

Removed by decantation .....	3.0
Coal or Lignite .....	0.25
Clay Lumps .....	0.5

Fine aggregates, when tested with square opening laboratory sieves shall conform to the following gradation requirements for per cent passing:

Type "A"

Passing	Per Cent
3/8" .....	100
No. 4 .....	95-100
No. 16 .....	65- 90
No. 50 .....	7- 30
No. 100 .....	0- 7

Type "B"

Passing	Per Cent
No. 8 .....	100
No. 50 .....	15- 40
No. 100 .....	0- 10

Type "K"

Sieve	Per Cent
Passing No. 10, retained No. 40.....	10-40
Passing No. 40, retained No. 80.....	20-45
Passing No. 80, retained No. 200....	12-32
Passing No. 200.....	10-20

Type "L": Mineral filler shall consist of thoroughly dry limestone dust or other mineral dust approved by the Project Engineer. When tested with standard laboratory sieves, the filler shall conform to the following requirements:

Passing	Per Cent
No. 40 mesh .....	85-100
No. 80 mesh .....	not less than 80
No. 200 mesh .....	not less than 65

Type "M", Fine Aggregate for White Concrete and White Mortar: Sand shall be white quartz, crushed white limestone, white marble or white granite which shall contain no discoloring material, clay, loam or other foreign matter. White quartz sand shall contain not more than 0.5% of material which can be removed by elutriation. Crushed white limestone, white marble, or white granite shall contain not more than 1% of material which can be removed by elutriation. By visual comparison fine aggregates shall be, in the opinion of the Project Engineer, at least as white as a standard sample on file in the Department's Laboratory. The gradation of fine aggregate used for white concrete and mortar shall be the same as Type "A."

#### FLUX OIL—M-15:

Bituminous material to be used for fluxing shall be an asphaltic base oil, having the following characteristics:

It shall be free from foreign matter and practically free from water.

Specific Gravity @ 77° F. ....	0.920 to 0.950
Viscosity Sayvolt Furol @ 122° F. 60 cc, (Sec.).....	50 to 100
Flash Point (Open Cup Cleve- land) .....	Min. 350° F
Evaporation loss—50 grams, 5 hrs. @ 325° F. ....	Max. 5.0%

#### SPECIAL BINDER:—M-17:

Special binder shall meet the following requirements:

Passing No. 10 square mesh sieve, %	90-100
Passing No. 40 square mesh sieve, %	70-100
Special binder, when mixed with sand in base courses in the amount specified on the plans or speci-	

fied by the Project Engineer, shall conform to the following physical characteristics:

Liquid Limit (Maximum) .....	25
Plastic Index .....	0-6

**BRICK:—M-18**

Brick shall conform to the requirements of, and shall be sampled and tested in accordance with, the A.S.T.M. Tentative Standard Specifications for Sewer Brick, Serial Designation C-32-37T. Unless otherwise specified on the plans or in the special provisions, brick shall conform to the requirements of grade MA and size No. 1.

**COTTON FABRIC—M-19**

Cotton fabric for curing concrete surfaces shall weigh not less than 10 ounces to the square yard when new and not less than 13 ounces after its first saturation. Cotton fabric shall have a minimum number of threads per square inch when new, of 6 x 11.

Worn fabric, fabric with holes and fabric reclaimed from uses other than that of curing concrete, shall not be permitted. If fabric is furnished in strips, the strips shall be a minimum of 3 feet in width, when new.

Cotton fabric shall be thoroughly pre-shrunk before placing it on finished surfaces as this material will attain as high as 30% shrinkage with its first saturation.

**BRONZE CASTINGS—M-20**

Bronze castings shall conform to the requirements of the Tentative Specifications for Bronze Castings for Turntables and Movable Bridges, A.S.T.M. Designation B 22-36T, Class C.

**GRAY-IRON CASTINGS—M-21**

(a) General: Iron castings shall conform to the requirements of the Standard Specifications for Gray-Iron Castings, A.S.T.M. Designation A 48-36, with subsequent amendments and additions thereto adopted by the A.S.T.M.

Castings shall be boldly filleted at angles, and the arrises shall be sharp and perfect.

(b) Structural Defects: Iron castings shall be true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow holes, and other defects in positions affecting their strength and value for service intended.

#### **MALLEABLE IRON CASTINGS:—M-22**

(a) General: Malleable castings shall conform to the requirements of the Standard Specifications for Malleable Castings, A.S.T.M. Designation A 47-33, with subsequent amendments and additions thereto adopted by the A.S.T.M.

The castings shall be boldly filleted at angles and arrises shall be sharp and perfect. The surfaces shall have a workmanlike finish.

(b) Structural Defects: Malleable castings shall be true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow holes and other defects in positions affecting their strength and value for the service intended.

#### **STEEL CASTINGS:—M-23**

(a) Process: The steel shall be made by one or more of the following processes: Open-hearth, electric furnace, converter, or crucible.

(b) Chemical Composition and Tests:

1. Composition: The steel shall conform to the following requirements as to chemical composition:

Manganese, per cent .....	0.50 to 1.00
Phosphorus, per cent .....	not over 0.05
Sulphur, per cent .....	not over 0.06
Silicon, per cent .....	0.20 to 0.75

2. Ladle Analyses: An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus, sulphur and silicon. This analysis shall be made from drillings taken at least  $\frac{1}{4}$  inch beneath the surface of a test ingot secured during the pouring of the melt. The chemical composition thus determined shall be re-

ported to the Project Engineer and, if it fails to conform to the required chemical composition, the melt shall be rejected.

3. Check Analyses: An analysis may be made by the Project Engineer from a broken tension test specimen or from a casting representing each melt. The chemical composition thus determined shall conform to the requirements specified. Drillings for analysis shall be taken at least  $\frac{1}{4}$  inch beneath the surface.

(c) Annealing:

1. Process: All castings shall be annealed unless otherwise provided. The procedure shall be as follows: after pouring, allow the castings to cool to a temperature below the critical range, then reheat uniformly to a proper temperature and for the required time, to refine the grain, and allow to cool slowly in the furnace until the pyrometer shows that the furnace temperature has fallen to 500°F. The furnace temperature shall be controlled effectively by pyrometers.

2. Record of Annealing: A record of the annealing charges shall be furnished the Project Engineer showing the castings in each charge, the melt or melts from which they were secured, and the treatment they received.

(d) Physical Properties and Tests:

1. Tensile Properties: The castings, after annealing, shall conform to the following requirements:

Tensile strength, pounds per square inch....	70,000
Yield point, minimum pounds per square inch .....	38,000
Elongation in 2 inches, minimum per cent	24
Reduction of area, minimum per cent .....	36

2. Speed of Testing Machines: The requirements of this article shall be the same as for steel forgings, of these specifications.

3. Tension Test Specimens: Tension test specimens shall be taken from test bars cast attached to the castings, or, in the judgment of the manufacturer, the design of the castings is such that test bars attached directly to the castings might affect the castings or

the test specimens injuriously, the test bars shall be cast attached to special blocks. Test bars from which tension test specimens are to be taken shall remain attached to the castings or blocks while being annealed and until presented for inspection.

Test bars shall be provided in sufficient numbers to fulfill the requirements as given below.

Tension test specimens shall conform to the dimensions shown in Figure 9, Standard 2-inch Gage Length Tension Test Specimen, Methods of Tension Testing of Metallic Materials, A.S.T.M. Designation E 8-36.

4. Number of Tests: Tests shall be made as follows: One tension test shall be made from each annealing charge, except that when more than one melt is involved in an annealing charge, one test shall be made from each melt. When so specified, one tension test shall be made from each casting weighing 500 pounds or more.

When a test specimen shows defective machining or develops flaws, it may be discarded and another specimen from the same charge and melt substituted.

5. Retests: When the percentage of elongation of a test specimen is less than that specified and any part of the fracture is more than  $\frac{3}{4}$  inch from the center of the gage length, as indicated by scribe scratches marked upon the specimen before testing, a retest shall be made.

When the results of the test of an annealing charge fail to conform to the requirements specified, the manufacturer may reanneal the charge, but not more than twice; and following each annealing treatment, test specimens shall be made and tested as hereinbefore described.

(e) Workmanship and Finish: Steel castings shall be true to pattern in form and dimensions without sharp, unfilleted angles or corners, and shall be free from pouring faults, sponginess, cracks, blow holes, and other defects in positions affecting their strength and value for the service intended.

Blow holes appearing upon finished castings shall be so located that a straight line laid in any direction



will not cut a total length of cavity greater than 1 inch in any 1 foot, nor shall any single blow hole exceed 1 inch in any dimension or have an area greater than  $\frac{1}{2}$  square inch.

Blow holes shall not have a depth injuriously affecting the strength of the castings. Minor defects which do not impair the strength may, with the approval of the Project Engineer, be welded by an approved process. The defects shall be removed to solid metal by chipping, drilling, or other satisfactory methods and, after welding the casting shall be annealed, if required by the Project Engineer. Castings which have been welded without the permission of the Project Engineer shall be rejected.

If required by the Project Engineer, large castings shall be suspended and hammered all over. No cracks, flaws, or other defects shall appear after such treatment.

(f) Identification Marks: The name or brand of the manufacturer and the pattern number shall be cast, when practicable, in each casting. The melt number shall be stamped lightly on each casting and each test specimen.

(g) Inspection: The Project Engineer shall be allowed free access at all times to the parts of the works involved in the manufacture of the castings, while the work thereon is in progress. The manufacturer shall, without charge, provide the facilities for making inspections, shall furnish the required number of test specimens and unless otherwise provided, shall provide the testing laboratory facilities, including labor, necessary to make the tests.

Inspections and tests (except check analysis) shall be made at the place of manufacture before shipment, unless otherwise provided and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Tests made by the Department in its laboratory or elsewhere shall be made without expense to the contractor.

(h) Rejection: Unless otherwise provided, any rejection based upon tests made by the Department in its laboratory or elsewhere shall be reported within five days from the receipt of the specimen.

Specimens representing castings rejected as a result of tests made by the Department in its laboratory or elsewhere shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the result, the manufacturer shall be allowed a rehearing within the time.

Castings in which injurious defects are discovered subsequent to their acceptance at the work shall be rejected and the manufacturer so notified.

## PORTLAND CEMENT:—M-24

### SCOPE:

1. These specifications cover six types of Portland cement, as follows:

Type I—For use in general concrete construction when the special properties specified for types II, III, IV, and V are not required.

Type II—For use in general concrete construction exposed to moderate sulfate action, or where moderate heat of hydration is required.

Type III—For use when high early strength is required.

Type IV—For use when a low heat of hydration is required.

Type V—For use when high sulfate resistance is required.

Type "White"—For use in white concrete and white mortar.

### BASIS OF PURCHASE:

2. The purchaser should specify the type or types desired. When no type is specified, the requirements of type I shall govern.

### DEFINITION:

3. Portland Cement—Portland cement is the prod-

uct obtained by pulverizing clinker consisting essentially of hydraulic calcium silicates, to which no additions have been made subsequent to calcination other than water and/or untreated calcium sulfate, except that additions not to exceed 1.0 per cent of other materials may be interground with the clinker at the option of the manufacturer, provided such materials in the amounts indicated have been shown to be not harmful by tests carried out or reviewed by ASTM Committee C-1 on Cement.

#### **CHEMICAL REQUIREMENTS:**

4. Portland cement of each of the six types shown in Section 1 shall conform to the chemical requirements prescribed in Table I.

#### **PHYSICAL REQUIREMENTS:**

5. Portland cement of each of the six types shown in Section 1 shall conform to the physical requirements prescribed in Table II.

#### **PACKAGING AND MARKING:**

6. When cement is delivered in packages, the name and brand of the manufacturer shall be plainly marked thereon. The type and A.S.T.M. specification number C 150, and the amount and kind of any acceptable interground addition that may be present shall be clearly stated in the shipping advices accompanying the shipment of packaged or bulk cement. A bag shall contain 94 lb. net. A barrel shall consist of 376 lb. net. All packages shall be in good condition at the time of inspection.

#### **STORAGE:**

7. The cement shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment, and in a suitable weather-tight building that will protect the cement from dampness and minimize warehouse set.

**INSPECTION:**

8. Every facility shall be provided the purchaser for careful sampling and inspection at either the mill or at the site of the work, as may be specified by the purchaser. The following periods from time of sampling shall be allowed for completion of testing:

1-day test .....	6 days
3-day test .....	8 days
7-day test .....	12 days
28-day test .....	33 days

**REJECTION:**

9. (a) The cement may be rejected if it fails to meet any of the requirements of these specifications.

(b) Cement remaining in bulk storage at the mill, prior to shipment, for a period greater than 6 months after completion of the tests may be retested and may be rejected if it fails to conform to any of the requirements of these specifications.

(c) Packages varying more than 5 per cent from the specified weight may be rejected; and if the average weight of packages in any shipment, as shown by weighing 50 packages taken at random, is less than that specified, the entire shipment may be rejected.

**Methods of Testing:**

10. The cement shall be sampled and the properties enumerated in these specifications shall be determined in accordance with the following methods of the American Society for Testing Materials:

(a) Chemical Analysis.—Standard Methods of Chemical Analysis of Portland Cement (A.S.T.M. Designation: C 114—42) and Tentative Methods of Chemical Analysis of Portland Cement (A.S.T.M. Designation: C 114—42 T).

(b) Sampling and Physical Tests.—Standard Methods of Sampling and Physical Testing of Portland Cement (A.S.T.M. Designation: C 77).

(c) Compressive Strength.—Tentative Method of Test for Compressive Strength of Portland-Cement Mortars (A.S.T.M. Designation: C 109), when specified.

(d) Fineness.—Standard Method of Test for Fineness of Portland Cement by Means of the Turbidimeter (A.S.T.M. Designation: C 115).

(e) Autoclave Expansion.—Tentative Method of Test for Autoclave Expansion of Portland Cement (A.S.T.M. Designation: C 151).

TABLE I.—CHEMICAL REQUIREMENTS

	Type I & Type White	Type II	Type III	Type IV	Type V
°					
Silicon dioxide (SiO <sub>2</sub> ), min., per cent.....		21.0			24.0
Aluminum oxide (Al <sub>2</sub> O <sub>3</sub> ), max., per cent.....		6.0			4.0
Ferric oxide (Fe <sub>2</sub> O <sub>3</sub> ), max., per cent.....		6.0		6.5	4.0
Magnesium oxide (MgO), per cent.....	5.0	5.0	5.0	5.0	4.0
Sulfur trioxide (SO <sub>3</sub> ), max., per cent.....	2.0	2.0	2.5	2.0	2.0
Loss on ignition, max., per cent.....	3.0	3.0	3.0	2.3	3.0
Insoluble residue, max., per cent.....	0.75	0.75	0.75	0.75	0.75
Ratio of Al <sub>2</sub> O <sub>3</sub> to Fe <sub>2</sub> O <sub>3</sub> ..		0.7 to 2.0			0.7 to 2.0
Tricalcium silicate (3CaO:SiO <sub>2</sub> , max., per cent.....		50		35	
Dicalcium silicate (2CaO:SiO <sub>2</sub> ), min., per cent.....				40	
Tricalcium aluminate (3CaO:Al <sub>2</sub> O <sub>3</sub> ), max., per cent.....		8	15	7	5

The percentages of tricalcium silicate, dicalcium silicate, and tricalcium aluminate shall be calculated from the chemical analysis as follows:

Tricalcium silicate=

$$(4.07 \times \text{per cent CaO}) - (7.60 \times \text{per cent SiO}_2) \\ - (6.72 \times \text{per cent Al}_2\text{O}_3) - (1.43 \times \text{per cent Fe}_2\text{O}_3) \\ - (2.85 \times \text{per cent SO}_3)$$

Dicalcium Silicate=

$$(2.87 \times \text{per cent SiO}_2) - (0.754 \times \text{per cent 3CaO} \cdot \text{SiO}_2)$$

Tricalcium aluminate=

$$(2.65 \times \text{per cent Al}_2\text{O}_3) - (1.69 \times \text{per cent Fe}_2\text{O}_3)$$

Oxide determinations calculated to the nearest 0.1 per cent shall be used in the calculations. Compound percentages shall be calculated to the nearest 0.1 per cent and reported to the nearest 1 per cent.

TABLE II.—PHYSICAL REQUIREMENTS

	TYPE I & WHITE	TYPE II	TYPE III	TYPE IV	TYPE V
Fineness, Specific surface, sq. cm. per g.: Average value, min., .....	1600	1700	.....	1800	1800
Minimum value, any one sample .....	1500	1600	.....	1700	1700
Soundness:					
Autoclave expansion, max., per cent .....	0.50	0.50	0.50	0.50	0.50
Time of setting (alt. methods):					
Gillmore test:					
Initial set, min., not less than .....	60	60	60	60	60
Final set, hr., not more than .....	10	10	10	10	10
Vicat test:					
Initial set, min., not less than .....	45	45	45	45	45
Final set, hr., not more than .....	10	10	10	10	10
Tensile strength, psi.:					
The avg. tensile strength of not less than 3 standard mortar briquets composed of one part cement and 3 parts standard sand, by weight, prepared in accordance with A.S.T.M. Method C 77, shall be equal to or higher than the values specified for the ages indicated below:					
1 day in moist air .....	.....	.....	275	.....	.....
1 day in moist air, 2 days in water .....	150	125	375	.....	.....
1 day in moist air, 6 days in water .....	275	250	.....	175	175
1 day in moist air, 27 days in water .....	350	325	.....	300	300
Compressive strength, psi.:					
The average compressive strength of not less than 3 mortar cubes composed of 1 part cement and 2.75 parts graded standard sand, by weight, prepared in accordance with A.S.T.M. Method C 109, shall be equal to or higher than the values specified for the ages indicated below:					
1 day in moist air .....	.....	.....	1300	.....	.....
1 day in moist air, 2 days in water .....	1000	750	3000	.....	.....
1 day in moist air, 6 days in water .....	2000	1500	.....	800	1000
1 day in moist air, 27 days in water .....	3000	3000	.....	2000	2200

**Type White:**

White Portland cement shall conform to the requirements specified for Type I, except that the color shall be white.

## COTTON MATS—M-26

Cotton mats shall have a width of approximately five and one half feet and shall have a length exceeding the slab width by two feet. The mats shall be composed of a single layer of cotton filler covered on both sides with approved burlap or the cotton cloth known as "Osnaburg." The mats shall contain not less than eight ounces (dry weight) of cotton filler per square yard, and the cover shall weigh (dry weight) not less than seven ounces per square yard. Cotton mats shall be substantially stitched and shall be quilted in squares not to exceed four inches square. The mat shall have a six inch flap of cover material extending along one edge for lapping adjacent mats.

## CHROMATED ZINC CHLORIDE:—M-29

Chromated zinc chloride shall contain not less than 81.5 per cent of zinc chloride as defined above, and not more than 18.5 per cent sodium bichromate, which shall be commercial bichromate of sodium ( $\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$ ). Concentrated chromated zinc chloride shall contain not less than 50 per cent of chromated zinc chloride.

Chromated zinc chloride shall be tested for determination of zinc using A.S.T.M. Standard Method D-199-27. For the determination of sodium bichromate the method shall be as follows:

Solutions required:

Standard N/10 sodium Thiosulphate.

20% solution c.p. potassium iodide.

Starch solution.

Concentrated c.p. hydrochloric acid.

The starch solution is best prepared by mixing 1 gm. of soluble starch to a paste with a little distilled water and adding it to 200 cc. of boiling distilled water. In case of solid chromate zinc chloride a sample of approximately 6 gm., and in case of 50 per cent chromated zinc chloride a sample of about 12 gm., should be taken. The sample should be weighed accurately

in a closed weighing bottle, dissolved in distilled water, the volume made up to 500 cc. in a standard flask and a little hydrochloric acid added to remove any turbidity, and a 25 cc. aliquot taken for titration. In case of treating solutions (2 to 6 per cent) a sample of 5 to 10 grams is weighed and taken directly for titration. The precision of the method is highest with a titration of 10 cc. to 15 cc. of N/10 thiosulphate. The aliquot or sample taken for titration is diluted to approximately 300 cc. in a beaker or Erlenmeyer flask. Five cc. of concentrated hydrochloric acid are added and the solution cooled a little below room temperature. Ten cc. of the 20 per cent potassium iodide solution are added and the sample allowed to stand 10 minutes. The liberated iodine is then titrated with the N/10 thiosulphate until the yellow color of iodine almost disappears. Two cc. of starch solution are added and titration continued until the blue color just disappears. The percentage of sodium bichromate in the original sample is calculated as follows:

cc.'s of N/10 thiosulphate X 0.4966 = percentage  
 $\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$ . Weight of aliquot sample.

#### DOWEL ASSEMBLY:—M-30

FABRICATED METALLIC DOWEL BARS SUPPORTING FRAMES: Fabricated metallic dowel bar supporting frames for use in dowel assemblies for concrete pavement shall conform to the following requirements:

- (1) At a point not more than three (3) inches from its end, each end of each dowel shall be supported by a leg or chair resting on the subgrade.
- (2) The effective area of support for each such leg or chair shall be not less than six (6) square inches (sand plate).
- (3) The legs or chairs shall be rigidly fabricated together to form a frame either by welding or by punching and bradding. Fabrication which depends upon friction for rigidity is not acceptable.
- (4) Dowel bars may be attached to the support



framework by any means which provides reasonably positive resistance to movement in any direction, except longitudinal movement.

(5) Dowel bar support frame shall not occupy an unreasonable amount of space and shall not be constructed so as to prevent placing and consolidation of concrete.

(6) The dowel bar support frame shall be so constructed that no dangerous planes of weakness such as wide flat members shall be formed, particularly planes which are parallel to the joint.

(7) The dowel bar assembly shall be constructed so that the members will not restrict the free opening and closing of the joint.

**BITUMINOUS EXPANSION JOINT FILLER:—M-32**

Bituminous filler shall consist of asphalt or tar composition of an approved quality formed into strips of the dimensions specified. The strips shall be of such characteristics that it shall not be deformed or broken by ordinary handling under atmospheric conditions. Thin strips of non-metallic stiffener will be allowed, provided that the filler is the required thickness exclusive of the stiffener. The filler may be impregnated with particles of non-metallic material uniformly distributed throughout the filler. When tested by methods of A.A.S.H.O. Designation T-42 the filler shall conform to the following requirements:

(a) Absorption, not to exceed the following percentages:

Joint Thickness	Max. Absorption
1 inch .....	2.5
$\frac{3}{4}$ inch .....	3.0
$\frac{1}{2}$ inch .....	4.0
$\frac{3}{8}$ inch .....	5.0
$\frac{1}{4}$ inch .....	7.0

(b) Distortion, not to exceed one inch.

(c) Brittleness, the filler shall not crack or shatter.

## **EXPANSION JOINT FILLER FOR CONCRETE PAVEMENT—M-33**

Expansion joint filler for concrete pavement shall comply with the following requirements:

1. **ABSORPTION:** A sample 5"x5", cut from the joint material in such a manner that all edges are freshly cut, is weighed and immersed in water for 24 hours, removed and surface water wiped off with a slightly dampened cloth, then immediately weighed. The material shall not have an expansion of more than 15% by volume.
2. **RESILIENCE:** The same sample used to conduct Test 1 without encasement, cut 4"x4" in size and not to exceed 1" in thickness, while still wet, shall be compressed at a rate of 0.05 inches per minute to  $\frac{1}{2}$  of its original thickness. Upon being reduced to 50% of its original thickness the pressure shall be released, following which the sample shall return to not less than 70% of its original thickness within one hour. This test shall be repeated 3 consecutive times, at one-hour intervals, and the sample shall return to not less than 70% of its original thickness within one hour after the expiration of each test.
3. **COMPRESSION:** This test shall follow the same procedure followed in Test 2, and conducted with the specimen used in Test 2, instead of wet, at a temperature of 77°F. The pressure necessary for compression to 50% its original thickness shall not exceed 1500 pounds per square inch, and for compression to 75% its original thickness shall not be less than 300 pounds per square inch.
4. **EXTRUSION:** A sample of the expansion joint filler, 4"x4" in size and not to exceed 1" in thickness, when confined on 3 edges by a suitable mold, shall show an extension on the free edge of not more than  $\frac{1}{4}$ " when compressed to 50% its original thickness.

## **ASPHALTIC LIQUEFIER—M-34:**

Liquefier to be used as an admixture to asphalt cement shall be a petroleum distillate conforming to

the following requirements when distilled in accordance with A.S.T.M. Designation D 86-40.

Initial Boiling Point—Min. °F.....	200
Total distillate at 282°F.....	Not more than 55%
Total distillate at 374°F.....	Not less than 85%
End Point—Max. °F.....	460

### STEEL FORGINGS:—M-39

(a) Process: Steel for forgings from which pins, rollers, trunnions or other forged parts are to be fabricated, shall be made by either or both the following processes: Open hearth or electric furnace.

(b) Discard: A discard shall be made from each ingot sufficient to secure freedom from injurious piping and undue segregation.

(c) Prolongation for Tests: Unless otherwise specified, not less than 20 per cent of the forgings shall be provided with elongations for test purposes or, at the manufacturer's option, a forging may be selected.

#### (d) Chemical Composition and Tests:

1. Composition: The steel shall conform to the following requirements as to chemical composition:

Manganese, per cent.....	0.40 to 0.80
Phosphorous, per cent (Acid, not over.....	0.05
(Basic, not over.....	0.05
Sulphur, per cent, not over.....	0.05

2. Ladle Analyses: An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorous and sulphur. This analysis shall be made from a test ingot secured during the pouring of the melt. The chemical composition thus determined shall be reported to the Project Engineer and, if it fails to conform to the required chemical composition, the melt shall be rejected.

3. Check Analysis: An analysis may be made by the Project Engineer from a forging representing each melt. The chemical composition thus determined shall conform to the requirements specified. Drillings for analysis may be taken from the forgings or from a fullsize prolongation thereof, at any point midway be-

tween the inner and the outer surfacing of the wall of bored forgings, or turnings may be taken from a test specimen.

(e) Annealing:

1. Process: Forgings shall be annealed. The procedure shall be as follows: Allow the objects, immediately after forging, to cool to a temperature below the critical range under suitable conditions to prevent injury by too rapid cooling; then reheat uniformly to a proper temperature to refine the grain and allow to cool uniformly. A group of objects thus simultaneously reheated and cooled constitutes an annealing charge.

2. Record of Annealing: A record of the annealing charges shall be furnished the Project Engineer showing the forgings in each charge, the melt or melts from which they were secured, and the treatment they received.

(f) Physical Properties and Tests:

1. Tensile Properties: The forgings, after annealing, shall conform to the following requirements:

Tensile strength, minimum pounds	
per sq. in. ....	60,000
Yield point, pounds per sq. in. ....	0.5 tensile strength
but not less than.....	33,000
	Elongation in 2 in., min.,
	per cent

Forgings having a maximum outside diameter or over-all thickness of not over 12 in.	1,700,000	not under 25
	Ten. Str.	

Forgings having a maximum outside diameter or over-all thickness over 12 in. to 20 in., inclusive....	1,600,000	not under 24
	Ten. Str.	
	Reduction of Area, Min.,	
	per cent	

Forgings having a maximum outside diameter or over-all thickness of not over 12 in.	2,700,000	not under 38
	Ten. Str.	

Forgings having a maximum  
 outside diameter or over-all  
 thickness over 12 in. to 20 2,500,000  
 in., inclusive..... ————— not under 36  
 Ten. Str.

2. Classification: The classification of forgings by size shall be determined by the diameter or thickness of the prolongation from which the test specimen is taken.

Tests of forgings shall be made only after the final treatment.

3. Speed of Testing Machine: The crosshead of the testing machine shall move at a speed insuring uniformity in the application of the load and accuracy in its determination. It shall not exceed the limits specified in Methods of Tension Testing of Metallic Material, A.S.T.M. Designation E 8-36.

The yield point shall be determined by the drop of the beam or the halt in the gage of the machine.

4. Tension Test Specimens: Tension test specimens shall be taken from a full-size prolongation of a forging. For forgings with large ends or collars, the prolongation may be of the same cross section as that of the forging back of the end or collar. Specimens may be taken from the forging itself with a hollow drill, if approved by the Project Engineer.

The axis of the specimen may be located at any point midway between the center and at any point midway between the inner and the outer surfaces of the wall of a bored forging, and shall be parallel to the direction in which the metal of the forging is most drawn out.

Tension test specimens shall conform to the dimensions shown in figure 9, Standard 2-inch Gage Length Tension Test Specimen, Methods of Tension Testing of Metallic Materials, A.S.T.M. Designation E 8-36.

5. Number of Tests: Tests shall be made as follows: One tension test shall be made from each annealing charge, except that when more than one melt is in-

volved in an annealing charge, one tension test shall be made from each melt.

When more than one class of forgings by size is involved in an annealing charge, one tension test from a forging of each class shall be made.

When a test specimen shows defective machining or develops flaws it may be discarded and another specimen substituted.

Retests: When the percentage of elongation of a test specimen is less than that specified and any part of the fracture is more than  $\frac{3}{4}$  inch from the center of the gage length, as indicated by scribe scratches marked upon the specimen before testing, a retest shall be made.

When the result of the test of annealing charge fails to conform to the requirements specified, the manufacturer may reanneal the charge one or more times and following each annealing treatment, test specimens shall be made and tested as hereinbefore described.

(g) Workmanship and Finish: The forgings shall be free from injurious defects, shall conform to the required sizes and shapes and shall have a workmanlike finish.

(h) Identification Marks: Identification marks shall be stamped legibly on each forging and on each test specimen.

(i) Inspection: The Project Engineer shall be allowed free access at all times to the parts of the works involved in the manufacture of material ordered, while work thereon is in progress. The manufacturer shall without charge, provide the facilities for making inspections, shall furnish the required number of test specimens and, unless otherwise provided, shall provide the testing laboratory facilities, including labor, necessary to make the tests.

Inspection and tests (except check analyses) shall be made at the place of manufacture before shipment unless otherwise provided, and shall be so conducted

as not to interfere unnecessarily with the operation of the works.

Tests made by the Department in its laboratory or elsewhere shall be made without expense to the contractor.

(j) Rejection: Unless otherwise provided, any rejection based upon tests made by the Department in its laboratory or elsewhere shall be reported within five days from the receipt of the specimens.

Specimens representing forgings rejected as a result of tests made by the Department in its laboratory or elsewhere shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results, the manufacturer shall be allowed a rehearing within that time.

Forgings in which injurious defects are discovered subsequent to their acceptance at the works will be rejected and the manufacturer so notified.

#### **POSTS, FENCE:—M-40**

Posts may be of creosoted or untreated timber and shall be of the dimensions indicated on the plans. They shall be straight and free from defects which will impair their life or materially reduce their strength and usefulness as fence posts. Unless otherwise shown on the plans, posts shall be sawed off square at both ends.

(a) Creosoted Posts: Creosoted posts shall be sawn halves from round posts which shall not be less than five and one-half inches in diameter at any point and shall be air or artificially seasoned yellow pine, impregnated by the full cell process as specified in M-117. The post shall retain not less than five pounds of grade 1 creosote oil per cubic foot of material. Posts to carry braces shall be full round a minimum of 5½" in diameter.

(b) Untreated Posts: Untreated posts may be round posts or sawn square edge posts as indicated on the plans and may be black locust, cypress, catalpa, white oak or post oak. Cypress posts may be sound or pecky. Round posts shall be peeled and trimmed of all

knots and knobs. The ground end of untreated posts shall be dipped in hot tar pitch, which coating shall extend to a point one-half foot above the ground line.

#### FABRIC WATERPROOFING—M-41

The waterproofing fabric shall be a woven cotton fabric having a thread count of not less than 18 and not more than 26 per inch, both in the warp and in the filling. No selvage shall be wider than  $\frac{1}{4}$  inch. Before being delivered on the work, it shall have been thoroughly saturated with an asphalt or tar meeting all requirements for waterproofing asphalt or tar as specified, and of the same manufacture as that with which it is to be applied. The saturation shall be obtained without the use of bitumen solvents, and the process shall be such that every thread shall be both coated and saturated. The meshes of the fabric shall not be closed or sealed by the process of saturation; there shall be sufficient porosity maintained to allow successive moppings to seep through. The average weight of the treated fabric shall be not less than two and a half nor more than three times the weight of the untreated fabric.

The tensile strength of the treated fabric shall be not less than 50 pounds per inch of width and the elongation at rupture shall be not less than 10 per cent, both in warp and in the filling. The tensile strength and elongation shall be determined by the Grab Test as specified in the Standard Methods of Testing Cotton Fabrics, Designation D 39-38, of the A.S.T.M.

The finished fabric shall not be coated with talc, Portland cement, or other substances which would tend to prevent adhesion between successive plies.

#### FERTILIZER—M-42

The amount and kind of fertilizer to be used shall be shown on the plans or special provisions. Commercial fertilizer shall conform to the requirements of the Louisiana Department of Agriculture, Fertilizer Division. Domestic fertilizer, such as manure, shall be approved by the Project Engineer.



### SAND CLAY GRAVEL:—M-43

Sand clay gravel shall be composed of either a natural or artificially prepared mixture of sand, clay and gravel. This mixture shall not contain more than five percent of mica, feldspar and schist, and shall be free from vegetable or other injurious matter. When tested by means of square opening laboratory sieves the material shall conform to the following requirements:

Sieve Size	Grade "A" & "C" Percent	Grade "B" Percent	Grade "D" Percent
Passing 1½.....	95-100	95-100	95-100
Passing No. 4.....	35- 50	45- 60	55- 70
Passing No. 10.....	25- 45	30- 45	45- 60
Passing No. 40.....	15- 35	20- 40	25- 45
Passing No. 200.....	7- 17	7- 17	7- 17

The material passing the number forty sieve shall conform to the following physical characteristics:

	Grade "A"	Grade "B", "C" & "D"
Liquid Limit (Maximum).....	25	35
Plastic Index.....	0-6	4-10

When Grades "B" or "C" sand clay gravel is deficient in gradation, sufficient material shall be added to supply the deficiency and the combined mixture shall conform to the specified gradation for the particular grade specified.

### WASHED GRAVEL:—M-44

Washed or screened gravel shall consist of hard, durable particles of stone, having a per cent of wear of not more than fifteen by the Deval abrasion test, and when tested by square opening laboratory sieves, shall conform to the following gradation:

Sieve	Per cent
passing 2½.....	100
passing 1½.....	95-100
passing No. 4.....	0- 15
passing No. 4 (foreign matter).....	0- 2

### WASHED SAND GRAVEL:—M-45

Washed or screened sand gravel shall consist of clean, hard, durable particles of stone having a per cent of wear of not more than fifteen by the Deval abrasion test, and when tested by square opening laboratory sieves, shall conform to the following gradation.

Sieve	Per cent
passing 1½ .....	95-100
passing No. 4 .....	24-40
Passing No. 100.....	0-8
Clay (by Elutriation).....	0-3

### HARDWARE—M-46

Machine bolts, drift bolts and dowels may be either wrought iron or medium steel. Washers shall be cast ogee gray iron or malleable castings, unless washers cut from medium steel or wrought iron plate are called for on the plans. A standard circular washer shall be used under the heads of all lag screws.

Machine bolts shall have square heads and nuts unless otherwise called for. Nails shall be cut or round of standard form. Spikes shall be cut, wire, or boat spikes.

### IRON ORE:—M-47

2.57 Iron ore shall consist of ferruginous sandy or gravelly material. Gravel or hard pieces of ore over two inches in largest dimensions which will not be broken up during construction, or will not become compacted into the surface, shall be removed. The iron ore shall have forty to seventy per cent retained on the ten mesh sieve, and shall contain not more than twenty-five per cent clay.

The physical characteristics of the material passing the 40 mesh sieve, if used as a base course, shall have a liquid limit of not more than 25 and a plastic index of not more than 6. If used as a surface or wearing course, it shall have a liquid limit of not more than 35 and a plastic index of not more than 10.

**METAL PARTING STRIP:—M-49**

Metal parting strips shall be shaped from metal of a gauge shown on the plans and shall be free from bends and kinks. It shall conform to the dimensions and shall be punched for pins and tie bars as shown on the plans. Sections of metal parting strips shall be so designed that adjoining sections may be securely fastened together by lapping and pinning, by means of a slip joint, or other approved methods.

**ALUMINUM PAINT (POWDERED  
PIGMENT):—M-50:**

This paint shall meet the following requirements:

Aluminum Powder.....	2.0 pounds
Varnish .....	1.0 gallon

The powder and the vehicle shall be delivered separately, the powder in bulk and the varnish in 5 gallon cans or barrels. The paint shall be mixed at the place where it is to be used, and no more paint shall be mixed at any time than the amount that can be used on that particular day. The contractor shall equip himself with a reliable, accurate set of scales, graduated to the tenth part of an ounce.

**Aluminum Powder:**

This material shall consist of aluminum powder in the form of polished flakes; shall contain no filler or adulterant such as mica, magnesium silicate, etc. A sample of the powder, when tested on standard mesh sieve shall meet the following requirements:

Coarse particles using alcohol or Mineral Spirits as wash liquid	
Total residue retained on No. 200 sieve, max., per cent.....	0.5
Total residue on No. 325 sieve, max., per cent .....	3.0
Extracted fatty or oily matter (polishing lubricant), max., per cent.....	3.0

**Vehicle for Aluminum Paint:**

The vehicle shall be a varnish and shall fulfill the following requirements:

- Appearance—clear and transparent.
- Non-volatile matter—not less than 50 per cent by weight.
- Set to touch—in not less than 30 minutes and not more than 6 hours.
- Dry hard and tough—in not more than 24 hours.
- Viscosity—consistency to correspond to tubes A to D—Gardner-Holdt Air Bubble Viscositymeter.
- Toughness—shall pass a 60 per cent Kauri Reduction Test at 75°F.

Working Properties: When mixed with aluminum powder in the proportion of two lbs. of powder to one gallon of vehicle, the resulting paint shall give a free flowing, smooth continuous coating, free from breaks and sags when applied to a smooth vertical surface.

Method of Analysis: The method of analysis shall be as given by the Federal Specification Board under Specifications TT-V-81.

**ALUMINUM PAINT (PASTE PIGMENT):—M-51:**

This paint shall meet the following requirements:

- Aluminum Paste..... 2.0 pounds
- Varnish ..... 1.0 gallon

The paste and the vehicle shall be delivered separately, the paste in bulk and the varnish in 5 gallon cans or barrels. The paint shall be mixed at the place where it is to be used, and no more paint shall be mixed at any time than the amount that can be used on that particular day. The contractor shall equip himself with a reliable, accurate set of scales, graduated to the tenth part of an ounce.

**Aluminum Paste:**

The aluminum paste shall consist of:

- Pigment, min., per cent..... 63.0

Liquid, max., per cent..... 37.0

Moisture, max., per cent..... 0.5

Liquid portion with which the aluminum bronze powder is compounded to form the paste shall be completely volatile at 105°C. (221°F.).

**Vehicle for Aluminum Paint:**

The vehicle shall be a varnish and shall fulfill the following requirements:

Appearance—clear and transparent.

Non-volatile matter—not less than 50 per cent by weight.

Set to touch—in not less than 30 minutes and not more than 6 hours.

Dry hard and tough—in not more than 24 hours.

Viscosity—consistency to correspond to tubes A to D—Gardner-Holdt Air Bubble Viscosimeter.

Toughness—shall pass a 60 per cent Kauri Reduction test at 75°F.

Working Properties: When mixed with aluminum powder in the proportion of two pounds of powder to one gallon of vehicle, the resulting paint shall give a free flowing, smooth continuous coating, free from breaks and sags when applied to a smooth vertical surface.

Method of Analysis: The method of analysis shall be as given by the Federal Specification Board under Specifications TT-V-81.

**BITUMINOUS PAINT (BLAST PLATE):—M-52:**

This paint shall be made to meet the following requirements:

	Min.	Max.
Water (by evaporation at 100°C.), per cent.....	45.0	50.0
Inert Mineral Ash, per cent.....	5.5	6.5
Bitumen (by differences), per cent.....	44.0	49.0

### **Ash:**

Type A—Lead Type: The ash must not contain less than 100 per cent lead.

Type B—Lead Free: The ash must contain no lead.

Action with Linseed Oil: Shall mix with Linseed Oil (1:19) without curdling.

Drying Properties: A mixture with linseed oil(1:19) shall dry within 8 hours.

The method of test shall be in accordance with Gardiners' Laboratory Manual, Standard Methods Fifth Edition, Institute of Paint and Varnish Research, Chapter 26, Page 614.

### **Bituminous Paint Pigment (Blast Plate):**

1. The bitumen shall be a pure, highly adhesive asphalt dispersed in water and, after drying, shall be incapable of becoming colloidal, dissolving, swelling, softening or gelatenizing in water.

2. Asphalt emulsions in which soap or clay is used as a dispersing agent are not acceptable under this specification. The use of hydrated lime or asphaltic solvents in the preparation will not be acceptable.

3. The dispersion shall be capable of sustaining, without clotting, dilution with water and shall not coagulate on additions of acids, alkalis or saline solutions.

4. The emulsion when spread upon a glass or steel plate in film thickness of approximately 1/16 inch and allowed to dry, shall not crack or check. It shall adhere to the plate so that it cannot be readily detached or stripped therefrom.

5. Any material shall be rejected which, when coated on glass or steel, to a thickness of 1/16 inch to 1/8 inch and allowed to dry for 48 hours in air at room temperature, shall, thereafter, on continuous immersion in water and in a 5 per cent solution of sodium chloride (common salt) each for a period of 30 days, fail to retain its bond to the surface and its tenacity of body.

6. The emulsion shall be of heavy painting consistency, and such as may be applied by brush or spray.

7. Any sedimentation of emulsion solids occurring shall be of such character as to permit of ready redistribution by manual agitation to give a homogeneous product.

**BLACK TRAFFIC PAINT (TAR BASE):—M-53**

**DESCRIPTION:** This specification covers black traffic paint for use on concrete surfaces. The paint shall consist of a properly blended mixture of tar pitch and light distillate tar oils and shall be free from extraneous matter or sediment which cannot be readily incorporated by stirring. The mixture shall conform to the following requirements:

1. Specific Gravity 25°C/25°C..... 1.04 to 1.16
2. Water, per cent.....not more than 1.0
3. Viscosity, Saybolt Furol at 122°F  
60cc., Sec. .... 12 to 21
4. Total Bitumen, soluble in carbon  
disulphide, per cent..... 85 to 97
5. Distillation, per cent by weight  
to 200°C. .... not less than 22  
to 300°C. .... 30 to 50
6. Softening Point (R+B) of Distillation  
Residue, °C. .... 55 to 75

**DRYING TIME:** When brushed on a metal panel at the rate of 400 square feet per gallon and exposed to a temperature of not less than 70°F. in a well ventilated room, the film shall set to light touch within 30 minutes, and shall be firm and substantially free from tackiness within 60 minutes after application.

**COLOR:** The color of the dried film shall be a dense, lustrous black.

**PACKING:** Paint shall be delivered in containers not larger than 55 gallons capacity.

**IDENTIFICATION:** Each container shall bear a label with the following information thereon: Name and address of the manufacturer, trade name or trade mark, kind of paint, and number of gallons.

**ANALYSIS:** A one quart sample shall be taken at

random from any or all deliveries and acceptance or rejection of shipments, shall be based on the analysis of these samples.

**GRAPHITE PAINT:—M-54:**

This paint shall be made to meet the following requirements:

	Min.	Max.
Pigment, by weight, per cent .....	30.0	35.0
Vehicle, by weight, per cent.....	65.0	70.0
The vehicle shall be composed of:		
Boiled Linseed Oil, per cent.....	88.0	92.0
Drier, per cent.....	5.0	6.0
Turpentine and Volatile Matter, per cent.....	3.0	6.0

The resulting paint when mixed in the proportions given above and brushed on a smooth vertical metal surface shall dry hard and elastic without running, streaking, or sagging.

**Graphite, Dry Pigment:**

The dry pigment shall be a pure amorphous and silicate rock to which may be added a small percentage of carbon black, iron oxide, or other oxides needed to secure a desired tint or color. The pigment shall be so ground that it will all pass a 200-mesh sieve, and contain not more than three per cent of material retained on a 325-mesh sieve. The prepared pigment must contain not less than thirty-five per cent or more than fifty per cent of graphite in the form of graphite carbon.

**Boiled Linseed Oil:**

Boiled linseed oil shall be pure linseed oil that has been treated by heating and incorporating compounds of lead and, at the option of the manufacturer, suitable compounds of other drying metals so as to produce a product that will dry rapidly. It shall be clear, free from sediment, and shall conform to the following requirements:

	Min.	Max.
Time of drying on glass, hours.....	.....	18.0



Specific Gravity, 15.5°/15.5°C.....	0.931	0.945
Acid Number .....		7.5
Saponification Number.....	189.0	195.0
Unsaponifiable Matter, per cent.....		1.50
Iodine Number (Wijs).....	170.0	.....
Loss on Heating at 105 to 110°C., per cent.....		0.2
Ash, per cent.....		0.50
Lead, per cent.....	0.05	.....

The method of test shall be in accordance with A.S.T.M. Serial Designation D 260-33.

**Turpentine:**

This material shall be reasonably free from suspended matter, entirely free from water, and conform to the following additional requirements: .....

	Min.	Max.
Specific Gravity 15.5°/15.5° C.....	0.860	0.875
Residue after polymerization with 38 NH <sub>2</sub> SO <sub>4</sub> , volume, per cent .....		2.0
Consistency shall be viscous		
Color shall be straw or darker		
Initial boiling point at 760 mm. pressure, per cent.....	.90	.....

The method of test shall be in accordance with A.S.T.M. Serial Designation D 233-36.

**Drier:**

This material shall be a resin free drier, composed of lead, manganese or cobalt, or a mixture of any of these elements combined with a suitable fatty oil and mineral spirits or turpentine, or a mixture of these solvents. It shall be reasonably free from sediment and suspended matter and shall otherwise conform to the following:

Appearance—clear.

Color—a mixture with linseed oil (1:8) shall not be darker than a solution of 3 grams of K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> in 100 cc H<sub>2</sub>SO<sub>4</sub> (1.84).

Flash Point—not lower than 30°C. (86°F.) (Tag. closed cup).

## RED LEAD PAINT:—M-55:

This paint shall be made to meet the following requirements:

	Min.	Max.
*Pigment, by weight, per cent.....	77.5	.....
Vehicle, by weight, per cent.....	.....	22.5
Water, per cent.....	.....	0.2
Coarse particles and skins (total residue retained on No. 325 screen; based on pigment) per cent.....	.....	1.5
Weight per gallon—lbs. ....	24.0	.....

The pigment shall be composed of lead oxides, free from all adulterants and shall contain not less than 95.0 per cent pure lead oxide ( $Pb_3O_4$ ).

The vehicle shall be composed of raw or boiled linseed oil and volatile thinner with or without drier, processed and blended into a homogeneous liquid. The non-volatile content @ 221°F. for three hours shall not be less than 65.0 per cent nor more than 70.0 per cent by weight. The acid number of the non-volatile vehicle shall not exceed 8.

The paint shall be well ground; shall not cake, thicken, curdle, nor show any objectionable properties and shall be readily broken up with a paddle to a smooth, uniform paint of satisfactory consistency. The paint, when brushed on a smooth vertical metal surface, shall dry within eighteen (18) hours to a smooth, semi-gloss finish, without streaking, running or sagging.

NOTE: Tinting may be required by the Project Engineer to the extent of one oz. lamp black, paste form, to one gallon finished paint.

### Red Lead:

The red lead pigment shall consist entirely of lead oxide, free from all adulterants, and shall meet the following requirements:

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\* The inclusion of aluminum stearate in an amount not to exceed 0.3% by weight of pigment is permitted in order to keep the red lead pigment in loose suspension.

True red lead, $Pb_3O_4$ , minimum, per cent.....	95.0
Total impurities, including moisture, soluble matter, water, and matter insoluble in a mixture of nitric acid and hydrogen peroxide, maximum, per cent.....	1.0
Lead monoxide (PbO).....	remainder
Coarse particles retained on a No. 325 sieve, max., per cent.....	1.0

The method of test shall be in accordance with A.S.T.M. Serial Designation D 49-37.

**Boiled Linseed Oil:**

Boiled linseed oil shall be pure linseed oil that has been treated by heating and incorporating compounds of lead and, at the option of the manufacturer, suitable compounds of other drying metals so as to produce a product that will dry rapidly. It shall be clear, free from sediment, and shall conform to the following requirements:

	Min.	Max.
Time of drying on glass, hours.....	.....	18.0
Specific Gravity, 15.5°/15.5°C. ....	0.931	0.945
Acid number .....	.....	7.5
Saponification number .....	189.0	195.0
Unsaponifiable matter, per cent.....	.....	1.50
Iodine number (Wijs).....	170.0	.....
Loss on heating at 105 to 110°C., per cent.....	.....	0.2
Ash, per cent.....	.....	0.50
Lead, per cent.....	0.05	.....

The method of test shall be in accordance with A.S.T.M. Serial Designation D 260-33.

**Raw Linseed Oil:**

Linseed oil shall be the pure oil pressed from flaxseed and shall conform to the following requirements:

	Min.	Max.
Specific Gravity 15.5°/15.5°C. ....	0.931	0.936
Acid number .....	.....	4.0
Saponification number .....	189.0	195.0
Unsaponifiable matter, per cent.....	.....	1.50
Iodine number (Wijs).....	177.0	.....

Loss on heating at 105 to 110°C., per cent.....	0.2
Color—not darker than a freshly prepared solution of 1.0 gram potassium dichormate in 100 cc. pure sulphuric acid (Sp.Gr.1.84)	
Foots, per cent	
Heated Oil .....	1.0
Chilled oil .....	4.0

The method of test shall be in accordance with A.S.T.M. Serial Designation D 234-28.

**Drier:**

This material shall be a resin free drier, composed of lead, manganese or cobalt, or a mixture of any of these elements combined with a suitable fatty oil and mineral spirits or turpentine, or a mixture of these solvents. It shall be reasonably free from sediment and suspended matter and shall otherwise conform to the following:

Appearance—clear.

Color—a mixture with linseed oil (1:8) shall not be darker than a solution of 3 grams of  $K_2Cr_2O_7$  in 100 cc  $H_2SO_4$  (1.84).

Flash point—not lower than 30°C. (86°F.) (Tag. closed cup).

**WHITE TRAFFIC PAINT:—M-57**

**DESCRIPTION:** This specification covers ready mixed white traffic paint for use on bituminous surfaces. The paint as received shall be suitable for use with the usual paint brush or paint machine. It shall be well made, shall not “liver” or settle badly, and shall not cake, thicken or thin in the container within 3 months of delivery. It shall flow evenly and smoothly and cover solidly in one coat on bituminous pavements. It shall not cause the bitumen to “bleed” either during application or while it is drying. It shall give a brilliant white finish, free from laps or brush marks, and shall not turn gray in sunlight; nor show appreciable discoloration with age.

COMPOSITION: The paint shall have the following composition:

	Min.	Max.
Pigment, per cent.....	60.0	65.0
Vehicle, per cent.....	35.0	40.0

PIGMENT: The pigment shall consist of:

	Min.	Max.
Titanium-Barium, per cent .....	55.0	57.0
*Zinc Oxide (Lead free), per cent.....	23.0	26.0
Diatomaceous Silica, per cent.....	5.0	10.0
Magnesium Silicate.....	Remainder	

\*NOTE: The zinc oxide used shall be the acicular type recommended for exterior exposure.

VEHICLE: The vehicle shall be a properly cooked, quick drying, pale colored varnish composed of vegetable drying oils, resins, drier and petroleum thinner. The oil portion shall be a mixture of properly processed tung oil and boiled linseed oil, in the proportion of 60 parts tung oil to 40 parts of linseed oil. The resin shall be an approved modified phenolic resin. The drier (free from lead) and petroleum thinner shall give a quick drying varnish, which shall contain not less than 40 per cent of non-volatile matter. The varnish shall contain 15 to 20 gallons of the above oils to each 100 pounds of resin.

DRYING TIME: A single coat shall set to touch in not less than 15 minutes or more than 45 minutes so that there will be no pick-up under traffic; and thoroughly dry with 1½ hours, free from tackiness, to an elastic, opaque, adherent finish when applied at temperature between 50° and 100°F.

PACKING: Paint shall be delivered in containers not larger than 5 gallon capacity unless otherwise specified.

IDENTIFICATION: Each container shall bear a label with the following information thereon: Name and address of the manufacturer, trade name or trade mark, kind of paint, and number of gallons.

ANALYSIS: A one quart sample shall be taken at random from any or all deliveries and acceptance or rejection of shipments shall be based on the analysis of these samples.

**WHITE LEAD PAINT:—M-58:**

This paint shall be made to meet the following requirements:

	Min.	Max.
Pigment, by weight, per cent.....	68.0	72.0
Vehicle, by weight, per cent.....	28.0	32.0

The pigment shall be composed of basic carbonate, white lead one hundred (100) per cent.

The vehicle shall be composed of raw or boiled linseed oil, and volatile thinner with drier, processed and blended into a homogeneous liquid. The acid number shall be not more than 8, based on the non-volatile content. The non-volatile content @ 221°F. for three hours, shall be not less than 65.0 per cent nor more than 70.0 per cent by weight.

One gallon of finished paint shall weigh not less than 18.0 pounds.

**Gray (White Lead) Paint:**

This paint shall be made to meet the following requirements:

	Min.	Max.
Pigment, by weight, per cent.....	68.0	72.0
Vehicle, by weight, per cent.....	28.0	32.0

The pigment shall be composed of basic carbonate, white lead 99.8 per cent and lamp black 0.2 per cent in paste form, to result in a medium gray color.

The vehicle shall be composed of raw or boiled linseed oil, and volatile thinner with drier, processed and blended into a homogeneous liquid. The acid number shall be not more than 8, based on the non-volatile content. The non-volatile content @ 221°F. for three hours, shall be not less than 65.0 per cent nor more than 70.0 per cent by weight.

One gallon of finished paint shall weigh not less than 18.0 pounds.

**White Lead:**

Basic Carbonate of Lead: The material shall approximately conform to the formula  $2 \text{PbCO}_3 \cdot \text{Pb}(\text{OH})_2$ , and the pigment shall conform to the following requirements:

Lead Carbonate, per cent.....	65.0 to 75.0
Moisture and other volatile matter, max, per cent .....	0.7
Total other impurities, max., per cent.....	1.0
Coarse particles (total residue retained on a No. 325 sieve), max., per cent.....	1.0

The method of test shall be in accordance with A.S.T.M. Serial Designation D 34-33.

**Boiled Linseed Oil:**

Boiled linseed oil shall be pure linseed oil that has been treated by heating and incorporating compounds of lead, and, at the option of the manufacturer, suitable compounds of other drying metals so as to produce a product that will dry rapidly. It shall be clear, free from sediment, and shall conform to the following requirements:

	Min.	Max.
Time of drying on glass, hours.....	.....	18.0
Specific Gravity, 15.5°/15.5°C. ....	0.931	0.945
Acid number .....	.....	7.5
Saponification number .....	189.0	195.0
Unsaponifiable matter, per cent.....	.....	1.50
Iodine number (Wijs).....	170.0	.....
Loss on heating at 105 to 110°C., per cent.....	.....	0.2
Ash, per cent.....	.....	0.50
Lead, per cent.....	0.05	.....

The method of test shall be in accordance with A.S.T.M. Serial Designation D 260-33.

**Raw Linseed Oil:**

Linseed oil shall be the pure oil pressed from flaxseed and shall conform to the following requirements:

	Min.	Max.
Specific gravity 15.5°/15.5°C. ....	0.931	0.936
Acid number .....	.....	4.0

Saponification number .....	189.0	195.0
Unsaponifiable matter, per cent.....	.....	1.50
Iodine number (Wijs).....	177.0	.....
Loss on heating at 105 to 110°C., per cent.....	.....	0.2
Color—not darker than a freshly prepared solution of 1.0 gram potassium dichromate in 100 cc. pure sulphuric acid (Sp.Gr. 1.84)		
Foots, per cent		
Heated oil.....	.....	1.0
Chilled oil .....	.....	4.0

The method of test shall be in accordance with A.S.T.M. Serial Designation D 234-28.

**Lamp Black:**

This material shall be the fully calcined product of oils or tars free from acid or grit. In addition it shall meet the following requirements:

	Min.	Max.
Total carbon, per cent.....	98.0	
Benzol extract (which shall be colorless), per cent .....		0.5
Ash, per cent .....		1.0

**Drier:**

This material shall be a resin free drier, composed of lead, manganese or cobalt, or a mixture of any of these elements combined with a suitable fatty oil and mineral spirits or turpentine, or a mixture of these solvents. It shall be reasonably free from sediment and suspended matter and shall otherwise conform to the following:

Appearance—clear.

Color—a mixture with linseed oil (1:8) shall not be darker than a solution of 3 grams of  $K_2Cr_2O_7$  in 100 cc.  $H_2SO_4$  (1.84).

Flash point—not lower than 30°C. (86°F.) (Tag. closed cup).

**YELLOW TRAFFIC PAINT—M-59**

DESCRIPTION: This specification covers ready



mixed yellow traffic paint for use on bituminous or concrete surfaces. The paint as received shall be suitable for use with the usual paint brush or paint machine. It shall be well made, shall not "liver" or settle badly, and shall not cake, thicken or thin in the container within 3 months of delivery. It shall flow evenly and smoothly and cover solidly in one coat on bituminous or concrete pavements. It shall not cause the bitumen on bituminous pavement to "bleed" either during application or while it is drying. It shall give a brilliant finish, free from laps or marks, and shall not show appreciable discoloration with age.

COMPOSITION: The paint shall have the following composition:

	Min.	Max.
Pigment, per cent .....	60.0	65.0
Vehicle, per cent.....	35.0	40.0
PIGMENT: The pigment shall consist of:		
	Min.	Max.
Chrome yellow (C. P. Grade), per cent	40.0	
*Zinc Oxide (American Process, Lead free), per cent.....	20.0	25.0
Diatomaceous Silica, per cent.....	5.0	10.0
Magnesium Silicate .....	Remainder	

\* NOTE: The zinc oxide used shall be the acicular type recommended for exterior exposure.

VEHICLE: The vehicle shall be a properly cooked, quick drying, pale colored varnish composed of vegetable drying oils, resins, drier and petroleum thinner. The oil portion shall be a mixture of properly processed tung oil and boiled linseed oil, in the proportion of 60 parts tung oil to 40 parts of linseed oil. The resin shall be an approved modified phenolic resin. The drier and petroleum thinner shall give a quick drying varnish, which shall contain not less than 40 per cent of non-volatile matter. The varnish shall contain 15 to 20 gallons of the above oils to each 100 pounds resin.

DRYING TIME: A single coat shall set to touch in not less than 15 minutes nor more than 45 minutes so that there will be no pick-up under traffic; and thoroughly dry within 1½ hours, free from tackiness, to an

elastic, opaque, adherent finish when applied at temperatures between 50° and 100°F.

**PACKING:** Paint shall be delivered in containers not larger than 5 gallon capacity unless otherwise specified.

**IDENTIFICATION:** Each container shall bear a label with the following information thereon: Name and address of the manufacturer, trade name or trade mark, kind of paint, and number of gallons.

**ANALYSIS:** A one quart sample shall be taken at random from any or all deliveries and acceptance or rejection of shipments shall be based on the analysis of these samples.

#### **WATERPROOFED PAPER FOR CURING CONCRETE:—M-73**

Paper to be used for the curing of concrete pavement shall be of a type and quality approved by the Project Engineer. It shall be sufficiently strong and tough to permit its use under the conditions existing on concrete construction. Paper shall be tested by the following method and shall insure the following results before it shall be approved for use. A test specimen composed of one part Portland cement, 1.71 parts of sand, and 0.346 parts of water, all by weight, shall be cast in a non-absorbent, water tight mold, fifteen inches square and two inches thick. The paper to be tested shall be applied over the test specimen within two hours after the specimen is cast. The mortar specimen shall retain a minimum of ninety-three per cent of the original mixing water after exposure for one hundred forty-four hours to a temperature of 90°F. at a relative humidity of thirty to fifty per cent.

#### **BLACK AND GALVANIZED STEEL PIPE: M-75**

Black and galvanized steel pipe shall be Standard Weight, conforming to the requirements of the Standard Specifications for Welded and Seamless Steel Pipe, A.S.T.M. Designation A 120-36.

#### **BITUMINOUS COATED CORRUGATED METAL CULVERT PIPE:—M-76**

The metal pipe shall conform to the requirements

of A.A.S.H.O. Specification M-36 and shall be completely and uniformly coated inside and outside with an asphalt cement as herein specified, to a minimum thickness of 0.03 inch, measured on the crests of the corrugations.

The asphalt cement shall adhere to the metal tenaciously, shall not chip off in handling, and shall protect the pipe from deterioration as evidenced by meeting the following performance requirement tests:

(a) Solubility Test: The asphalt cement shall be 99.5 per cent soluble in Carbon Bisulphide.

(b) Stability Test: Parallel lines shall be drawn along the valleys of the corrugations of a representative sample of coated pipe and the specimen placed on end in a constant temperature oven, with the parallel lines in a horizontal position. The temperature of the specimen shall be maintained within 2°F. of 150°F. for a period of four hours. At the end of this time no part of any line shall have dropped more than ¼ inch.

(c) Imperviousness Test: A 25% solution of sulphuric acid, or a 25% solution of sodium hydroxide, or a saturated salt solution (such as sodium chloride) shall be held in the valley of a corrugation for a period of 48 hours, during which time no loosening or separation of the bituminous material from the galvanizing shall have taken place.

(d) Erosion Test: A representative sample consisting of a two-foot length of a fully coated pipe (with ends closed by suitable bulkheads) shall be revolved end over end about its transverse axis at a speed of 3.7 revolutions per minute and in such a manner that the erosive charge shall alternately roll along the inner surface of opposite sides of the pipe. At least 75% of the sample shall be immersed, as it revolves, in a bath of water maintained at a temperature of 50°-55°F. The pipe shall not show areas of bare metal more than two inches in length on four of the seven central corrugations after 5 hours of continuous testing. The erosive charge shall be 50 pounds of grade MW building brick, conforming to the requirements of the A.S.T.M.

Serial Designation C62-40T, broken up into pieces 2 to 3 inches in diameter and 3 gallons of water.

**METAL PIPE ENDS:—M-77**

This specification covers metal pipe ends to be attached to the inlet and outlet ends of metal pipe.

**Materials:**

The materials to be used for metal pipe ends shall conform to the requirements specified for Corrugated Metal Pipe, M-79, except that 1.25 ounces of spelter coating shall be required. The metal pipe ends shall have a bituminous coating when specified and shall be coated as specified for Bituminous Coated Corrugated Metal Pipe, M-76.

**Specification:**

The units fabricated under this specification shall be made to conform to the shape and dimensions and of the design shown on the plans. They shall be manufactured as integral units so that they can be assembled and erected in place. Wherever welding or torch cutting is used in the fabrication, the affected parts shall be re-galvanized.

Rivets shall be of the following diameters for the gages specified:

16 gage .....	3/16" diameter
14 gage .....	5/16" diameter
12 gage .....	3/8" diameter
10 gage .....	3/8" diameter
8 gage .....	1/2" diameter

All rivets shall be driven cold in such a manner that the plates shall be drawn tightly together throughout the entire lap. Rivets shall not be driven any closer to the edge of the metal than twice the diameter of the rivet. All rivets shall have neat, workmanlike and full hemispherical heads, or heads acceptable to the Project Engineer, shall be driven without bending and shall completely fill the hole. For shop riveted seams the maximum rivet spacing shall be six (6) inches.

**Workmanship:**

The completed unit shall show full completed work-

manship in all particulars. The following defects are specified as constituting poor workmanship and the presence of any of them in any individual units shall constitute sufficient cause for rejection:

- Not meeting specified dimensions.
- Not of the specified shape.
- Uneven laps.
- Ragged sheared edges.
- Loose, unevenly lined or spaced rivets.
- Poorly formed rivet heads.
- Illegible brands.
- Lack of rigidity.
- Dents or bends in the metal itself.

**STEEL CASINGS FOR CAST IN PLACE CONCRETE  
PILES: M-78:**

The material in the steel casings for cast in place concrete piles shall conform to the requirements of the Standard Specifications for Low Tensile Strength Carbon Steel Plates of Flange and Firebox Qualities, A.S.T.M. Designation A-89-39. Forged steel in pile point shall conform to the requirements of the Standard Specifications for Carbon Steel and Alloy Steel Blooms, Billets and Slabs for Forgings, A.S.T.M. Designation A 273-44T, AISI No. CQ1016.

The design and shape of casings shall be as shown on the plans and shall be furnished in the lengths specified.

**CORRUGATED METAL CULVERT PIPE:—M-79**

(a) Material Covered: These specifications cover corrugated metal pipe for use in the construction of pipe culverts, up to and including 60 inches in diameter.

(b) Requirements: Corrugated metal pipe shall conform to the requirements of the A.A.S.H.O. Standard Specifications for Corrugated Metal Pipe, Specifications M-36. With the exception that pipe may be of the pipe arch type, having a hypocycloidal shape of the dimensions shown on the plans, with an allowable variation in dimensions of plus or minus one inch.

(c) Sampling and Testing: Sampling and testing

shall be done in accordance with the A.A.S.H.O. Specification M-36.

**MALLEABLE IRON PIPE FITTINGS:—M-80**

Fittings for pipe railings shall be of malleable iron and shall comply with the Standard Specifications for Malleable Iron Castings, A.S.T.M. Designation A 47-33. Unless otherwise specified fittings shall be of the ball pattern, made especially for railings. Fittings used with galvanized pipe shall be galvanized. The galvanizing shall comply with the specifications for the galvanized pipe.

**PERFORATED CORRUGATED METAL PIPE  
UNDERDRAINS:—M-81.**

This specification covers corrugated metal pipe for use in the construction of underdrains.

General Requirements: The metal pipe shall conform to the requirements of A.A.S.H.O. M-36-42, Specifications for Corrugated Metal Pipe, except as herein modified: when pipe 21 inches or smaller is specified, the pipe may be riveted pipe or pipe having helical corrugations which are continuous from end to end of each length of pipe, with a continuous lock seam paralleling the corrugations, or a continuous welded seam. The seam shall be so constructed as not to affect the shape or nominal diameter of the pipe, nor shall it reduce the strength of the pipe.

Corrugations: When helically corrugated pipe is furnished in diameters 10 inches and smaller, the corrugations shall have a pitch of not less than 1-3/8 inches nor more than 1-7/8 inches center to center, measured at right angles to the direction of the corrugations, and a depth of not less than 1/4 inch. When helically corrugated pipe is furnished in diameters larger than 10 inches, the pitch of the corrugations shall be not less than 1-7/8 inches nor more than 2 1/4 inches, center to center, and the depth shall be not less than 7/16 inch. The helical angle shall not be less than 45°.

Perforations: Where specified, helically corrugated

pipe and riveted pipe shall be perforated according to the following requirements.

Perforations shall be located in the inside crests of the corrugations and shall have a diameter of 5/16 inch with an allowable variation of plus or minus 1/16 inch. Perforations shall be in longitudinal rows, spaced approximately on 1 inch centers and extending to within 4 inches of each end of each length of pipe.

Perforations may be made after the pipe is galvanized, and the rows of perforations shall be in two groups with half the number of rows on either side of an unperforated segment.

The minimum number of rows of perforations and the minimum width of the unperforated segment, shall be as given in Table I. The top row of holes shall be not less than 22½ degrees below the horizontal axis.

Gage and Weight: The average weight per linear foot of finished helically corrugated and riveted pipe shall not underrun the computed weight as given in Table I by more than 5 per cent.

TABLE I—DIMENSIONS, WEIGHT AND SPACING OF PERFORATIONS

Nominal Internal Diameter (Inches)	Minimum No. of Rows of Perforations	Minimum Width of Unperforated Segment.	Gage	Helically Corrugated Pipe Weight per Linear Foot of Pipe (lbs.)
4	4	2	18	2.8
6	4	4½	18	4.0
8	4	7	18	5.2
10	4	9	18	6.4
12	6	9½	16	10.1
15	6	13	16	12.6
18	6	16½	16	15.0
21	6	20	16	17.4

Coupling Bands: Unless otherwise specified, field joints shall be made with band couplers. The sheets shall be galvanized and of the same base metal as that in the pipe. Bands for pipe shall be of number 18 gage. Band couplers shall be at least 7 inches wide.

Band couplers for helically corrugated pipe shall have corrugations that mesh with the corrugations of the pipe. If a 1-piece band coupler is supplied for heli-

cally corrugated pipe, it shall be fastened by two  $\frac{3}{8}$  inch diameter galvanized bolts; if a 2-piece coupler is supplied, it shall be fastened by four  $\frac{3}{8}$  inch diameter galvanized bolts.

**PLAIN CONCRETE CULVERT PIPE:—M-82**

(a) Material Covered: These specifications cover concrete pipe intended for use in the construction of pipe culverts and pipe storm sewers.

(b) Concrete: The concrete shall consist of Portland cement, mineral aggregate and water.

(c) Cement, Aggregates, Mixture, Joints and Curing: The cement, aggregates, mixture, joints and curing shall conform to the requirements specified for, "Reinforced Concrete Culvert Pipe M-84."

(d) Minimum Design: The ultimate load, as determined by the Three-Edge-Bearing Method, shall not be less than the ultimate load specified in the table herein, which shall be determined by failure of the pipe.

The absorption, as determined by the Absorption Test, shall not exceed 8 per cent of the dry weight. Pipe shall be considered as conforming to these specifications for absorption when not less than 80 per cent of the number of specimens tested, including any retested, conform to the test requirements. When the initial absorption specimen from a pipe fails to conform to these specifications, the absorption test shall be made on another specimen from the same pipe and the results of the retest shall be substituted for the original test results.

The pipe shall be circular and the shell thickness shall not be less than that given in the table herein for the sizes of pipe therein specified.

PLAIN CONCRETE CULVERT PIPE (CIRCULAR)

Internal Diameter of Pipe Inches	Standard Minimum Shell Thicknesses In Inches	Ultimate Strength Test Requirements, Three-Edge-Bearing, lbs. per linear foot of pipe
12	1	1500
15	1 $\frac{1}{4}$	1750
18	1 $\frac{1}{2}$	2000
24	2 $\frac{1}{8}$	2400



(e) Permissible Variations in Dimensions: Variations of the internal diameter shall not exceed plus 1 per cent or minus 3 per cent. The shell thickness shall not be less than that intended in the design by more than 5 per cent at any point. When the lengths of pipe sections are specified, the under-run in length of pipe from that specified shall not be more than  $\frac{1}{8}$  in. per ft. with a maximum of  $\frac{1}{2}$  in. in any length of pipe.

(f) General: Test Specimens, Measurement and Observation of Specimens, Crushing Strength Tests, Number of Tests, Apparatus and Application of Load, Three-Edge-Bearing Method, Absorption Test, Acceptance or Rejection, Absence of Defects, Finish of Ends, Marking, Inspection, Rejection, and Marking of Rejected Specimens, shall all comply with the requirements of A.S.T.M. Designation C 14-41, except that paragraph 20(a) under "Acceptance or Rejection" shall be construed to apply only to such tests as are specified herein and paragraph 28(a) under "Rejection" shall read as follows: "Variations in any dimensions exceeding the permissible variations specified."

#### **REINFORCED CONCRETE CULVERT PIPE:—M-84**

(a) Material Covered: These specifications cover reinforced concrete pipe intended for use in the construction of pipe culverts and pipe storm sewers. Unless otherwise specified in the special provisions standard strength pipe shall be furnished.

(b) Reinforced Concrete: The reinforced concrete shall consist of Portland cement, mineral aggregate and water, in which steel has been embedded in such a manner that the steel and concrete act together.

(c) Cement: Portland cement shall conform to the requirements specified in M-24.

(d) Steel: Reinforcement may consist of either wire which conforms to the requirements for cold drawn steel wire for concrete reinforcement, or of bars of structural or intermediate grade which conform to the requirements of billet steel concrete reinforcement bars, structural or intermediate grade. Specific reference is made to M-107 or M-110.

(e) Aggregates: Sand shall be composed of clean, hard, durable, uncoated grains, free from lumps of clay, soft or flaky particles, salt, alkali, loam, organic matter or other objectionable matter.

The coarse aggregate shall consist of clean, hard, tough and durable stone fragments, free from dust, thin or elongated pieces or other objectionable matter.

(f) Mixture: The aggregates shall be so graded and proportioned and thoroughly mixed in a batch mixer with such proportions of cement and water as will produce a homogeneous concrete mixture of such quality that the pipe will conform to the test and design requirements of these specifications.

(g) Placing Reinforcement: In pipe having one line of reinforcement, the reinforcement shall be placed equally distant from the inner and outer surfaces of the pipe. In pipe having two lines of reinforcement, each line shall be placed so that the net protective covering of concrete over the reinforcement shall be one inch.

(h) Minimum Designs: The ultimate load, as determined by the Three-Edge-Bearing Method or the Sand-Bearing Method, shall be not less than the ultimate load specified in Tables I and II. When the test load reaches the cracking load given in tables for the size and class of pipe tested, there shall be in the barrel of the pipe no cracks having a width of 0.01 inch or more for a length of 1 foot or more. The cracks shall be considered 0.01 inch in width when the point of measuring gage will, without force, penetrate it 1/16 inch at close intervals throughout the specified distance of 1 foot. The width of crack shall be measured by means of a gage made from a leaf 0.01 inch in thickness (as in a set of standard machinists gages), ground to a point 1/16 inch in width with corners rounded, and a taper of 1/4 inch per inch. The ultimate load is reached when the pipe will sustain no greater load.

The absorption, as determined by the Absorption Test, shall not exceed 8 per cent of the dry weight. Pipe shall be considered as conforming to these specifications for absorption when not less than 80 per cent

of the number of specimens tested, including any retested, conform to the test requirements. When the initial absorption specimen from a pipe fails to conform to these specifications, the absorption test shall be made on another specimen from the same pipe and the results of the retest shall be substituted for the original test results.

The shell thickness and amount of circumferential reinforcement shall not be less than given in Tables I and II for the classes and sizes of pipe therein specified. (Note: See Table I.)

The acceptability of pipe shall be determined by the results of the strength and absorption tests specified herein and by inspection to determine whether the pipe conforms to the specifications in design and freedom from defects. (Note: See Table II.)

(i) Joints: The ends of the pipe shall be of such design that the pipe when laid shall form a continuous conduit with a smooth and uniform interior surface.

(j) Longitudinals: Each line of circumferential reinforcement shall be assembled into a cage which shall contain sufficient longitudinal bars or members, extending through the barrel of the pipe; to maintain the reinforcement rigidly in exact shape and correct position within the form.

(k) Laps, Welds and Spacing: If the splices are not welded, the reinforcement shall be lapped not less than 30 diameters for bars, and 40 diameters for coldrawn wire. If welded, the member at either a welded splice or intersection shall develop a tensile strength not less than the minimum strength required for the reinforcement by the applicable specifications cited in paragraph (d). The spacing center to center of adjacent rings of circumferential reinforcement in a cage shall not exceed 4 inches for pipe up to and including 48 inches in diameter, and shall not exceed the shell thickness for larger pipe, and shall in no case exceed 6 inches.

(l) Joint Reinforcement: The joint shall have a circumferential reinforcement equal in unit area to that of a single line within the barrel of the pipe.

TABLE I.—DESIGN AND STRENGTH TEST REQUIREMENTS OF STANDARD-STRENGTH REINFORCED CONCRETE CULVERT PIPE

Internal Diameter of Pipe, in.	Concrete, 3500 psi.			Concrete, 4500 psi.			Strength Test Requirements lb. per linear ft. Of pipe	
	Minimum Shell Thickness, in.	Minimum Reinforcement <sup>a</sup> , sq. in. per linear ft. of pipe barrel		Minimum Shell Thickness, in.	Minimum Reinforcement <sup>a</sup> , sq. in. per linear ft. of pipe barrel		Three-Edge-Bearing Method <sup>b</sup>	
		Circular Reinforcement in Circular Pipe	Elliptical Reinforcement in Circular Pipe		Circular Reinforcement in Circular Pipe	Elliptical Reinforcement in Circular Pipe	Load to Produce a 0.01-in. Crack	Ultimate Load
12.....	2	1 line 0.07	.....	1 <sup>3</sup> / <sub>4</sub>	1 line 0.08	.....	2250	3500
15.....	2 <sup>1</sup> / <sub>4</sub>	1 line 0.09	.....	2	1 line 0.11	.....	2625	4065
18.....	2 <sup>1</sup> / <sub>2</sub>	1 line 0.12	1 line 0.10	2	1 line 0.14	.....	3000	4500
24.....	3	1 line 0.17	1 line 0.13	2 <sup>1</sup> / <sub>2</sub>	1 line 0.20	1 line 0.17	3000	5000
30.....	3 <sup>1</sup> / <sub>2</sub>	1 line 0.22	1 line 0.17	3	1 line 0.28	1 line 0.21	3375	5750
36.....	4	2 lines, each 0.18	1 line 0.18	3 <sup>3</sup> / <sub>8</sub>	2 lines, each 0.22	1 line 0.22	4050	6600
42.....	4 <sup>1</sup> / <sub>2</sub>	2 lines, each 0.21	1 line 0.21	3 <sup>3</sup> / <sub>4</sub>	2 lines, each 0.25	1 line 0.25	4725	7350
48.....	5	2 lines, each 0.25	1 line 0.25	4 <sup>1</sup> / <sub>4</sub>	2 lines, each 0.31	1 line 0.31	5400	8000
54.....	5 <sup>1</sup> / <sub>2</sub>	2 lines, each 0.30	1 line 0.30	4 <sup>5</sup> / <sub>8</sub>	2 lines, each 0.37	1 line 0.37	5850	9000
60.....	6	2 lines, each 0.33	1 line 0.33	5	2 lines, each 0.41	1 line 0.41	6000	10000
66.....	6 <sup>1</sup> / <sub>2</sub>	2 lines, each 0.37	1 line 0.37	5 <sup>1</sup> / <sub>2</sub>	2 lines, each 0.45	1 line 0.45	6300	11000
72.....	7	2 lines, each 0.40	1 line 0.40	6	2 lines, each 0.48	1 line 0.48	6600	12000
84.....	8	2 lines, each 0.46	1 line 0.46	7	2 lines, each 0.54	1 line 0.54	7000	14000

<sup>a</sup>The distance from the center line of the reinforcement to the nearest surface of the concrete has been assumed in the design tables as 1<sup>1</sup>/<sub>4</sub> in. for pipe with a shell 2<sup>1</sup>/<sub>2</sub> in. or more in thickness.

<sup>b</sup>Test loads for sand-bearing tests shall be one and one-half times those specified in this table for the three-edge-bearing tests.

TABLE II.—DESIGN AND STRENGTH TEST REQUIREMENTS OF EXTRA-STRENGTH REINFORCED CONCRETE CULVERT PIPE.

Internal Diameter of Pipe, in.	Concrete, 4500 psi.		Strength Test Requirements, lb. per linear ft. of pipe		
	Minimum Shell Thickness, in.	Minimum Reinforcement, sq. in. per linear ft. of pipe barrel <i>a</i>		Three-Edge-Bearing Method <sup>b</sup>	
		Circular Reinforcement in Circular Pipe	Elliptical Reinforcement in Circular Pipe	Load to Produce a 0.01 in. Crack	Ultimate Load
24.....	3	1 line 0.26	1 line 0.20	4000	6000
30.....	3½	1 line 0.31	1 line 0.24	5000	7500
36.....	4	2 lines, each 0.28	1 line 0.28	6000	9000
42.....	4½	2 lines, each 0.33	1 line 0.33	7000	10500
48.....	5	2 lines, each 0.38	1 line 0.38	8000	12000
54.....	5½	2 lines, each 0.44	1 line 0.44	9000	13500
60.....	6	2 lines, each 0.50	1 line 0.50	9000	15000
66.....	6½	2 lines, each 0.56	1 line 0.56	9500	16500
72.....	7	2 lines, each 0.60	1 line 0.60	9900	18000
84.....	8	2 lines, each 0.72	1 line 0.72	10500	21000

<sup>a</sup>The distance from the center line of the reinforcement to the nearest surface of the concrete has been assumed in the design tables as 1¼ in. for pipe with a shell 2½ in. or more in thickness.

<sup>b</sup>Test loads for sand-bearing tests shall be one and one-half times those specified in this table for the three-edge-bearing tests.

(m) Curing: The pipe shall be properly cured by any approved method.

(n) Testing: All physical tests shall be made in accordance with the requirements of A.S.T.M. Designation C 76-42 and the contractor shall be required to furnish the specified number of pipe for the purpose of tests without charge.

(o) General: Size and Permissible Variations, Workmanship, Finish, Inspection and Rejection shall all comply with the requirements of A.S.T.M. Designation C 76-42.

(p) Marking: The following shall be clearly stenciled on the pipe with indelible ink:

1. Standard strength pipe shall be marked with a "C."
2. Extra strength pipe shall be marked with "X-C."
3. The date of manufacture.
4. The name or trade-mark of the manufacturer.
5. Circular pipe with elliptical reinforcement shall have the word "top" or "bottom" clearly stenciled on the inside of the pipe in the correct place to indicate the proper position when being laid. In addition to stenciling, circular pipe with elliptical reinforcement shall have an indentation manufactured within the pipe on the spigot end on the inside diameter clearly indicating the top and bottom of the pipe. This indentation shall be  $\frac{1}{4}$  inch deep,  $\frac{1}{2}$  inch wide and 2 inches long.

#### REINFORCED CONCRETE SEWER PIPE: M-85

(a) Material Covered: These specifications cover reinforced concrete sewer pipe for use in construction of sewers, when the use of this material is specified. This material shall not be used for culvert pipe.

(b) Requirements: Reinforced concrete sewer pipe shall conform to the requirements of the A.S.T.M. Standard Specifications for Reinforced Concrete Sewer Pipe, Serial Designation C 75-41, except that elliptical pipe shall not be permitted.

(c) Sampling and Testing: Sampling and testing

Reinforced Concrete Sewer Pipe shall be done in accordance with methods prescribed in A.S.T.M. Standard Specifications for Reinforced Concrete Sewer Pipe, Serial Designation C 75-41.

**WROUGHT IRON PIPE: M-86**

Wrought iron pipe shall be Standard Weight, conforming to the requirements of the Standard Specifications for Welded Wrought Iron Pipe, A.S.T.M. Designation A 72-38.

**PITCH, WATERPROOFING:—M-87**

Waterproofing pitch shall be a straight run coal tar pitch derived entirely from high temperature coal tar and shall conform to the following requirements:

	Min	Max.
1. Water, per cent.....		0.0
2. Specific Gravity at 77°/77°F. ....	1.22	1.34
3. Softening Point (cube in Water Method) °F. (a).....	130	140
(b).....	140	150
4. Total bitumen (soluble in carbon disulphide) per cent (a).....	75	88
(b).....	73	85
5. Distillation test: Total distillate, per cent by weight to 572°F.....	12.0	
Residue, per cent by weight.....	88.0	
6. Specific Gravity of total distillate to 572°F. at 100°F/77°F.....		1.03
7. Ductility at 77°F., 5 cm. per min., cm .....	50	

Note: Pitch with a softening point at 130°F-140°F. should generally be used on flat surfaces. Pitch with a softening point at 140°-150°F. should generally be used on vertical surfaces or on all surfaces of small structures.

**CREOSOTED TIMBER PILES:—M-88**

Creosoted timber piles shall be Southern Yellow Pine unless otherwise specified. They shall be creos-

soted with a sixteen pound treatment, except where they are to be driven in coastal waters, in which case they shall be creosoted with a twenty pound treatment, in accordance with the specification requirements.

All timber piles shall be cut from sound, live trees, preferably during the winter season. They shall contain no unsound knots. Sound knots shall be permitted, provided the diameter of the knot does not exceed four inches or one-third of the diameter of the pile at the point where it occurs. Where not more than three knots greater than one inch occur in a circumference of the pile and the character of the knots do not weaken the pile excessively in the opinion of the Project Engineer, they shall be permitted. Any defect or combination of defects which will impair the strength of the pile more than the maximum allowable knot shall not be permitted. The pile butts shall be sawed square and the pile tips shall be sawed square or tapered to a tip not less than four inches in diameter as directed by the Project Engineer.

Unless otherwise specified, all piles shall be peeled by removing all of the rough bark and at least eighty per cent of the inner bark. No strip of inner bark remaining on the pile shall be over  $\frac{3}{4}$  inch wide or over eight inches long and there shall be at least one inch of clean wood surface between any strips. Not less than eighty per cent of the surface on any circumference shall be clean wood.

Piles shall be cut above the ground swell and shall taper from butt to unsharpened tip. A line drawn from the center of the tip to the center of the butt shall not fall outside of the center of the pile, at any point, more than one per cent of the length of the pile. In short bends, the distance from the center of the pile to a line stretched from the center of the pile above the bend to the center of the pile below the bend shall not exceed four per cent of the length of the bend or a maximum of  $2\frac{1}{2}$  inches. All knots shall be trimmed close to the body of the pile.

Dimensions: Round piles shall have a minimum



diameter at the tip, measured under the bark, as follows:

Length of Pile	Tip Diameter
Less than 40 feet.....	8 inches
40 to 60 feet.....	7 inches
Over 60 feet.....	6 inches

The minimum diameter of the piles at a section 4 feet from the butt, measured under the bark, shall be as follows:

Length of Pile	Diameter in inches	
	Douglas Fir Southern Yellow Pine Southern Cypress	All Other Species
20 feet and under.....	11	11
Above 20 to 30 feet.....	12	12
Above 30 to 40 feet.....	12	13
Over 40 feet.....	13	14

The diameter of the pile at the butt shall not exceed 20 inches. Square piles shall have the dimension shown on the plans.

**UNTREATED TIMBER PILES:—M-89**

Untreated piles may be any species of wood which will satisfactorily withstand driving.

**RED HIGHWAY IRON:—M-90**

The dust shake shall consist of 8% to 10% of red metallic oxides combined with 90% to 92%, by weight, of highway iron.

The highway iron used in the dust shake shall be an approved metallic aggregate, free from non-ferrous particles and shall be water absorbent. It shall not contain more than 0.02% of oil or grease and shall be combined with suitable proportions (not over 2% and not less than 1½%) of a reagent which promotes oxidation of the metallic particles in an alkaline medium. The metallic aggregate shall also be combined with a reagent (not over ½%) which increases the flow by not less than 25% with a mortar made of one part cement, one part highway iron, one part sand (all weight) at the same water content.

The dust shake shall have the following gradation:

	Per Cent
Passing No. 4 Sieve.....	100-
Passing No. 20 Sieve.....	75-85
Passing No. 40 Sieve.....	15-50
Passing No. 60 Sieve.....	5-25
Passing No. 100 Sieve.....	1- 5

#### **RIPRAP STONE:—M-92**

Riprap stone shall be durable field or quarry stone. It shall be dense, resistant to the action of air and water, and suitable in all respects for riprap purposes. Stone used for hand placed riprap and grouted riprap shall be approximately rectangular in shape. The volume of the individual stones, except those used for chinking, shall be not less than one-fourth of a cubic foot.

Waste concrete may be substituted for the stone, if it is sound and meets the size requirements for stone.

#### **CRUSHED STONE:—M-93**

Crushed stone shall be obtained from clean, tough, sound, durable stone, having a per cent of wear of not more than eight by the Deval abrasion test, and when tested by means of square opening laboratory sieves, shall conform to the following gradation:

Sieve	Per Cent
Passing 2¼ .....	100
Passing 1½.....	95-100
Passing No. 4.....	0-15

#### **CANNERY SHELL:—M-94**

This material shall consist of cannery or live oyster shell. The shell shall not contain more than three per cent by dry weight of foreign matter by decantation.

#### **CLAM SHELL:—M-95**

This material shall consist of dead clam shell. A rotary type screen washer, the mesh of which shall not be smaller than ¼ inch, shall be used for washing the shell. The shell shall not contain more than three per cent by dry weight of foreign matter by decantation.

#### **NATIVE PIT-RUN SHELL: M-96**

This material shall consist of pit-run shell obtained from local deposits or pits. The shell shall be free from sticks and roots and shall not contain more than fifteen per cent by dry weight of foreign matter by decantation.

#### **REEF SHELL:—M-97**

This material shall consist of dead oyster shell and shall not contain cannery or live shell. A rotary type screen washer, the mesh of which shall not be smaller than  $\frac{1}{4}$  inch, shall be used for washing the shell. The shell shall not contain more than three per cent by dry weight of foreign matter by decantation.

#### **SHELL SURFACING:—M-98**

This material shall be composed of dead clam shell and/or dead oyster shell and shall not contain cannery or live shell. The shell shall not contain more than fifteen per cent by dry weight of foreign matter by decantation.

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#### **CRUSHED SLAG:—M-99**

Crushed slag shall be air cooled, blast furnace slag, and shall consist of angular fragments reasonably free from flat or elongated pieces, dirt or other objectionable matter. Crushed slag shall show not more than fifteen per cent of wear by the Deval abrasion test.

#### **STAPLES:—M-100**

Staples shall be made of galvanized steel wire and shall be of the size and dimensions shown on the plans.

#### **SHEET PACKING:—M-101**

Sheet packing for use between expansion plates shall be made of a selected long fibre asbestos and special heat resisting compound bonded together under pressure into a sheet that is pliable and resilient. The packing shall contain a minimum of seventy per cent asbestos, not more than a trace of rubber and the balance filler, and shall be graphited on one side only. The sheet packing shall be a minimum of one sixteenth inch thick, unless otherwise specified.

### **STEEL GUARD RAIL PLATES:—M-102**

Rail plates shall be of metal and shall be galvanized by the hot dip method. They shall have a continuous coating of prime virgin spelter so applied that it will adhere firmly to the surface of the metal. The metal shall have a coating of not less than one and four-tenths ounces of zinc per square foot and the thickness of the coating shall be determined by its ability to withstand four immersions in a testing solution of copper sulphate without showing any trace of metallic copper on the metal. The first three immersions shall be for a period of one minute each, and the fourth immersion for a period of one-half minute.

Rail plates shall be fabricated to meet the following requirements:

1. The rail plates shall be rolled or crimped or otherwise shaped to provide rigidity in the finished plates.
2. The rail plates shall be fabricated so that the section will drain readily.
3. The traffic face of the rail plate shall be smooth longitudinally.
4. Traffic face depth shall be a minimum of ten inches.
5. Rail plates shall be of such shape and design, that when tested as a free beam, center loaded, over a sixty inch span, it shall, without exceeding the elastic limit, require a minimum load of 7,000 pounds to produce a maximum deflection of one inch.

### **STEEL PLATE FOR RAILROAD CROSSING:—M-103**

The traffic tread plates shall be rolled steel plates of the size and dimensions shown on the plans and shall weigh not less than 11.2 pounds per square foot. The plates shall have a diamond or other pattern tread acceptable to the Project Engineer.

### **BARBED WIRE:—M-105**

Barbed wire shall be four point hog wire consisting of tough annealed strands heavily galvanized of the gauge shown on the plans.

### MESH WIRE:—M-106

Mesh wire shall be constructed on the hinged joint principle. The stays or uprights shall be separate pieces of wire which connect with the horizontal or strand bars and shall be wrapped securely around the strand, forming a complete joint or lock. All wire shall be basic Open Hearth Steel, heavily galvanized.

### COLD DRAWN STEEL WIRE REINFORCING:—M-107

(a) Material Covered: These specifications cover cold drawn steel wire to be used as such, or in fabricated form, for the reinforcement of concrete, in gages not less than 0.080 inch nor greater than 0.625 inch.

Where wire is ordered by gage number the following relation between number and diameter, in inches, shall apply unless otherwise specified:

Gage Number	Diameter in Decimals of Inch	Gage Number	Diameter in Decimals of Inch
0000000.....	0.4900	5.....	0.2070
000000.....	0.4615	6.....	0.1920
00000.....	0.4305	7.....	0.1770
0000.....	0.3938	8.....	0.1620
000.....	0.3625	9.....	0.1483
00.....	0.3310	10.....	0.1350
0.....	0.3065	11.....	0.1205
1.....	0.2830	12.....	0.1055
2.....	0.2625	13.....	0.0915
3.....	0.2437	14.....	0.0800
4.....	0.2253		

(b) Manufacture: The steel shall be made by one or more of the following processes: open-hearth, electric furnace or acid bessemer.

The wire shall be cold drawn from rods hot-rolled from billets.

(c) Physical Properties and Tests:

1. Tensile Properties: The wire, except as specified below under wire for mesh and wire testing over 100,000 pounds per square inch tensile strength shall

conform to the following minimum requirements as to tensile properties:

Tensile strength, pounds per square inch	80,000
Yield point, per cent observed tensile strength.....	80
Reduction of area, per cent.....	30

For wire to be used in the fabrication of mesh a minimum tensile strength of 70,000 pounds per square inch shall be permitted.

The yield points shall be determined by the drop of the beam or halt in the gage of the testing machine. In case no definite drop of the beam or halt in the gage is observed until final rupture occurs, the test shall be construed as meeting the requirement for yield point shown in above table.

For wire testing over 100,000 pounds per square inch tensile strength, the reduction of area shall be no less than 25 per cent.

2. Bending Properties: The test specimen shall stand being bent cold through 180 degrees without cracking on the outside of the bent portion, as follows:

For wire 0.3 inch in diameter or under, around pin the diameter of which is equal to the diameter of the specimen.

For wire over 0.3 inch in diameter, around a pin the diameter of which is equal to twice the diameter of the specimen.

3. Tension and Bend Test Specimens: Tension and bend test specimens shall be of the full size section of the wire as drawn.

4. Permissible Variations in Gage: The dimensions of the wire, on any diameter, shall not vary more than 0.003 inch from the specified nominal diameter. The difference between the maximum and minimum diameters, as measured on any given cross section of the wire, shall not be greater than 0.003 inch.

5. Finish: The finished wire shall be free from injurious defects and shall have a workmanlike finish with smooth surface.

6. Testing: Tests of steel wire shall be made at the laboratory of the Department, unless otherwise specified.

After the steel is delivered to the site, the Project Engineer shall select one sample, 36 inches by 36 inches from each carload or less, and forward to the Department testing laboratory for testing purposes.

If any specimen shows defects or develops flaws, it may be discarded and another specimen substituted.

(d) Fabrication: Wire fabric reinforcement shall be of a series of longitudinal wires combined with a series of transverse wires arranged at right angles thereto and electrically welded at all points of intersection. The size and spacing of wires in the fabric shall be as shown on the plans. Welds shall be of sufficient strength that they will not be broken during handling or placing.

Reinforcing fabric shall be furnished in flat sheets. Any sheets that may have become bent or distorted shall be straightened and otherwise put in proper condition before using. When placed in the work, the fabric shall be free from excessive rust, scale or coating of any character which will impair its bond with the concrete.

#### **STRUCTURAL AND RIVET STEEL:—M-108**

Except where otherwise provided, all members of steel structures shall be of structural steel and rivets shall be of rivet steel. All structural steel, except where alloy steel is specified, shall conform to the requirements of the Standard Specifications for Steel for Bridges, A.S.T.M. Designation A 7-36, and all rivet steel shall conform to the requirements of the Standard Specifications for Structural Rivet Steel, A.S.T.M. Designation A 141-36. These requirements shall apply with the subsequent amendments and additions thereto adopted by the A.S.T.M., but are supplemented by the following requirements:

(a) Character of Fracture: Test specimens of structural or rivet steel shall show a fracture having a silky or fine granular structure throughout, with a

bluish gray or dove color, and shall be entirely free from granular black and brilliant specks.

(b) Defects in Material: Finished rolled material shall be free from cracks, flaws, injurious seams, laps, blisters, ragged and imperfect edges, and other defects, provided, however, that surface imperfections in material  $\frac{3}{8}$  inch or more in thickness may be corrected in the following manner.

When the imperfections are less than  $\frac{1}{16}$  inch in depth, they may be removed by grinding. When the imperfections are  $\frac{1}{16}$  inch or more in depth, they shall be chipped and, unless otherwise permitted by the Project Engineer, they shall be welded in accordance with this specification.

The maximum depth of any depression after chipping shall not exceed the following:

$\frac{1}{16}$  inch in metal from 0.375 to 0.499 inch in thickness.

$\frac{1}{8}$  inch in metal from 0.500 to 0.999 inch in thickness.

$\frac{3}{16}$  inch in metal from 1.000 to 1.499 inches in thickness.

$\frac{1}{4}$  inch in metal from 1.500 to 2.249 inches in thickness.

$\frac{3}{8}$  inch in metal from 2.250 to 3.500 inches in thickness.

The cross-sectional area shall not be reduced at any point in its length more than 1.5 per cent by the removal of the defects.

After removal of the defects and before any welding is done, the material shall be subject to inspection by the Project Engineer. All welding shall be done in the presence of the Project Engineer. This inspection may be waived only upon written authorization of the Project Engineer.

Upon approval of the chipped areas or upon written waiver of inspection by the Project Engineer, weld metal shall be deposited in the depression to a thickness extending at least  $\frac{1}{16}$  inch above the rolled surface. The welders shall be qualified for the work and



flux coated welding rods suitable to the grade of steel shall be used.

The deposited weld metal shall be sound and free from excessive oxides, non-metallic inclusions and gas pockets. It shall penetrate every recess in the rolled metal and shall be thoroughly fused with it on all surfaces and edges of fusion. Along the edge of the deposit, the weld metal shall merge into the metal with a gradual taper and shall have no re-entrant projection or overlap.

In the welding operation, the metal shall not be undercut along the edges of the welded area. All metal projections above the rolled surface after welding shall be removed by chipping or grinding to produce a workmanlike finish.

All material shall be free from loose mill scale, rust pits or other defects affecting its strength.

#### **STRUCTURAL SILICON STEEL:—M-109**

Silicon steel shall conform to the requirements of the Standard Specifications for Structural Silicon Steel, A.S.T.M. Designation A 94-36 with subsequent amendments and additions thereto adopted by the A.S.T.M.

#### **STEEL, BILLET, REINFORCING:—M-110**

(a) Material Covered: These specifications cover two classes of billet steel concrete reinforcement bars: namely, plain and deformed.

Plain and deformed bars are of two grades; namely, structural steel and intermediate.

(b) Manufacture: The steel shall be made by one or more of the following processes: open-hearth, electric furnace or acid bessemer.

The bars shall be rolled from new billets of properly identified heats of open-hearth or electric furnace steel, or lots of acid bessemer steel. No rerolled material will be accepted.

(c) Chemical Properties and Tests:

1. Composition: The steel shall conform to the

following requirements as to chemical composition.

Phosphorus, max., per cent:

Acid-bessemer .....	0.10
Open-hearth or electric furnace—	
Basic .....	0.05
Acid .....	0.08

2. Analysis: An analysis of each melt of steel shall be made by the manufacturer to determine the percentage of carbon, manganese, phosphorous and sulfur. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and the percentage of phosphorous shall conform to the requirements specified in paragraph 1. Analysis may be made by the purchaser from finished bars representing each melt of open-hearth or electric furnace steel, and each melt or lot of ten tons of bessemer steel. The phosphorous content thus determined shall not exceed that specified in paragraph 1 by more than 25 per cent.

3. Rejection: Unless otherwise specified, any rejection based on the above tests shall be reported within five days from receipt of sample. Samples which represent rejected bars shall be preserved for two weeks from the date of the test report. In case the results of the tests are not satisfactory, the manufacturer may make claim for a rehearing within that time.

(d) Physical Properties and Tests:

1. The bars shall conform to the following requirements as to tensile properties:

(NOTE: See Table I.)

The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine.

2. Modification in Elongation: For plain and deformed bars over  $\frac{3}{4}$  inch in thickness or diameter, a deduction from the percentages of elongation specified in paragraph 1 of 0.25 per cent shall be made for each increase of  $\frac{1}{32}$  inch of the specified thickness or diameter above  $\frac{3}{4}$  inch.

TENSILE REQUIREMENTS

Properties Considered	Plain Bars			Deformed Bars		
	Structural Steel Grade	Intermediate Grade	Hard Grade	Structural Steel Grade	Intermediate Grade	Hard Grade
Tensile strength lb. per sq. in.....	55,000 to 70,000	70,000 to 90,000	80,000 min.	55,000 to 70,000	70,000 to 90,000	80,000 min.
Yield point, min. lbs. per sq. in.....	33,000	40,000	50,000	33,000	40,000	50,000
Elongation in 8 in. min. per cent.....	1,400,000*	1,300,000*	1,800,000*	1,250,000*	1,125,000*	1,000,000*
	Tensile Strength	Tensile Strength but not less than 16%	Tensile Strength	Tensile Strength	Tensile Strength but not less than 14%	Tensile Strength

\*See paragraph 2.

### BEND TEST REQUIREMENTS

Thickness or Diameter of Bar	Plain Bars			Deformed Bars		
	Structural Steel Grade	Intermediate Grade	Hard Grade	Structural Steel Grade	Intermediate Grade	Hard Grade
Under 3/4 In. ....	180° d = t	180° d = 2t	180° d = 3t	180° d = t	180° d = 3t	180° d = 4t
3/4 Inch or Over ....	180° d = t	90° d = 2t	90° d = 3t	180° d = 2t	90° d = 3t	90° d = 4t

Explanatory Note: d = the diameter of pin about which the specimen is bent.  
t = the thickness or diameter of the specimen.

For plain and deformed bars under 7/16 inch in thickness or diameter, a deduction from the percentages of elongation specified in paragraph 1 of 0.5 per cent shall be made for each decrease of 1/32 inch of the specified thickness or diameter below 7/16 inch.

3. Bending Properties: The test specimen shall stand being bent cold around a pin without cracking. The following requirements for degree of bending and sizes of pins shall be observed:

(NOTE: See Table II.)

Bend tests shall be made on specimens of sufficient length to insure free bending and with apparatus which provides:

Continuous and uniform application of force throughout the duration of the bending operation.

Unrestricted movement of the specimen at points of contact with the apparatus.

Close wrapping of the specimen about the pin or mandrel during the bending operation.

Other methods of bend testing may be used but failure due to such methods shall not constitute a basis for rejection.

4. Tension and Bend Test Specimens: Tension and bend test specimens from plain or deformed bars shall be of the full section of bars as rolled. For tension tests of deformed bars the sectional area used for unit stress determination shall be calculated from the length and weight of the test piece. Note: The area in square inches may be calculated by dividing the weight per linear inch of specimen in pounds by 0.2833 (weight of 1 cubic inch of steel), or by dividing the weight per linear foot of specimen in pounds by 3.4 (weight of steel 1 inch square, 1 foot long).

5. Permissible Variations in Weight: The weight of any lot (see note) of bars shall not vary more than 3½ per cent over or under the theoretical weight for bars ⅜ inch and over in diameter; nor more than 5 per cent over or under for bars under ⅜ inch in diameter. The weight of any individual bar shall not vary more

than 6 per cent under the theoretical weight for bars  $\frac{3}{8}$  inch and over in diameter; nor more than 10 per cent under the theoretical weight for bars under  $\frac{3}{8}$  inch in diameter. The theoretical weight of deformed bars shall be the theoretical weight of plain round or square bars of the same nominal size.

6. Finish: The finished bars shall be free from injurious defects and shall have a workmanlike finish.

7. Marking: The brand of the manufacturer shall be legibly rolled on all deformed bars, and when loaded for mill shipment, all bars shall be properly separated and tagged with the manufacturer's test identification number.

8. Testing: All physical tests of bars shall be made at the laboratories of the Department unless otherwise specified. Testing of billet steel bars shall be in accordance with A.S.T.M. Designation E 8-36.

After the steel is delivered to the site, the engineer shall select one sample, 36 inches long of each size and type bar from each consignment of 30 tons or less, and forward to the Department testing laboratory for testing purposes. Contractor shall ship one extra main girder bar, of each size with each 30 ton consignment containing these bars, to provide test specimens, as no splicing of these bars is permitted.

If any specimen develops flaws, it may be discarded and another specimen substituted.

(Note: The term "lot" used in this paragraph means all the bars of the same nominal weight per linear foot in a carload.)

If the percentage of elongation of any tension test specimen is less than that specified in paragraph 1 and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

#### **STEEL, RAIL, REINFORCING:—M-111**

(a) Material Covered: These specifications cover two classes of rail steel concrete reinforcement bars: namely, plain and deformed.

(b) Manufacture: The bars shall be rolled from standard section Tee rails. No other materials, such as those known by terms of "rerolled," "rail steel equivalent," and "rail steel quality," shall be substituted.

(c) Physical Properties and Tests:

1. Tensile Properties: The bars shall conform to the following minimum requirements as to tensile properties:

	Plain Bars	Deformed Bars
Tensile strength, lbs. per square inch.....	80,000	80,000
Yield points, lbs. per square inch.....	50,000	50,000
Elongation in 8 inches, per cent.....	1,200,000*	1,000,000*
	tens str.	tens. str.

\*See paragraph 2 following.

The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine.

2. Modification in Elongation: For bars over 3/4 inch in thickness or diameter, a deduction from the percentages of elongation specified in paragraph 1 of 0.25 per cent shall be made for each increase of 1/32 inch of one specified thickness or diameter above 3/4 inch.

For bars under 7/16 inch in thickness or diameter, a deduction from the percentages of elongation specified in paragraph 1 of 0.5 per cent shall be made for each decrease of 1/32 inch of the specified thickness of diameter below 7/16 inch.

3. Bending Properties: The test specimen shall stand being bent cold around a pin without cracking. The following requirements for degree of bending and sizes of pins shall be observed:

	Plain Bars	Deformed Bars
Thickness or Diameter of Bar Under 3/4 inch.....	180°d=3t	180°d=4t
3/4 inch or over.....	90°d=3t	90°d=4t

( $d$ =the diameter of pin about which the specimen is bent;  $t$ =the thickness or diameter of the specimen.)

Bend test shall be made on specimens of sufficient length to insure free bending and with apparatus which provides:

Continuous and uniform application of force throughout the duration of the bending operation.

Unrestricted movement of the specimen at points of contact with the apparatus.

Close wrapping of the specimen about the pin or mandrel during the bending operation.

Other methods of bend testing may be used but failure due to such methods shall not constitute a basis for rejection.

4. Tension and Bend Test Specimens: Tension and bend test specimens from plain or deformed bars shall be of the full section of bars as rolled. For tension test of deformed bars of the sectional area used for unit stress determination shall be calculated from the length and weight of the test piece.

(Note: The area in square inches may be calculated by dividing the weight per linear inch of specimen in pounds by 0.2833 (weight of 1 cubic inch steel), or by dividing the weight per linear foot of specimen in pounds by 3.4 (weight of steel 1 inch square, 1 foot long).

5. Permissible Variations in Weight: The weight of any lot (see note) of bars shall not vary more than  $3\frac{1}{2}$  per cent over or under the theoretical weight for bars  $\frac{3}{8}$  inch and over in diameter; nor more than 5 per cent over or under for bars under  $\frac{3}{8}$  inch in diameter. The weight of any individual bar shall not vary more than 6 per cent under the theoretical weight for bars  $\frac{3}{8}$  inch and over in diameter; nor more than 10 per cent under the theoretical weight for bars under  $\frac{3}{8}$  inch in diameter. The theoretical weight of deformed bars shall be the theoretical weight of plain round or square bars of the same nominal size.

(Note: The term "lot" used in this paragraph means



all the bars of the same nominal weight per linear foot in a carload.)

6. Finish: The finished bars shall be free from injurious defects and shall have a workmanlike finish.

7. Testing: All physical tests of bars shall be made at the laboratory of the Department, unless otherwise specified. Testing of bars shall be in accordance with A.S.T.M. Designation E 8-36.

After the steel is delivered to the site, the engineer shall select one sample, 36 inches long of each size and type of bar from each consignment of 30 tons or less and forward to the Department testing laboratory for testing purposes.

If any specimen develops flaws, it may be discarded and another specimen substituted.

If the percentage of elongation of any tension test specimen is less than that specified in paragraph 1 and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

### **TREES, SHRUBS, VINES AND OTHER PLANTS:—M-112**

#### **State and Federal Regulations:**

Plant material shall be free from injurious insect pests and plant diseases and subject to all regulations of the Federal and State Departments of Agriculture. The contractor shall obtain the proper certificates for the movement of nursery stock, intra-state or inter-state, and shall comply with all other requirements before and during movement or shipment of plants.

#### **Adopted Standards for Nursery Stock:**

Plant material shall conform in size and grade with the "Standard Rules and Tables for Growing and Grading Ornamental and Fruit Nursery Stock," of the American Association of Nurserymen, insofar as applicable hereto, and as further specified in the itemized Summary Plant List in the special provisions. Each plant shall be true to name and legibly tagged with

the name and size of the material according to general standards of nursery practice, except in the case where many plants of the same kind, as small vines or small shrubs, are furnished in quantity lots and which are easily distinguishable. In such cases the containers or a few plants in the lot shall be marked.

**Source of Plant Material:**

All plant material shall be nursery grown unless written permission is obtained from the Project Engineer to use selected native stock which permission will be granted only in case the contractor demonstrates that it is impracticable to obtain nursery grown plant material or if, in the opinion of the Project Engineer, selected native stock will be better suited or superior in quality to that obtained from a nursery.

If permission is given to use selected native stock, the Project Engineer will inspect the materials before digging and the contractor shall tag or label each plant so selected and dig the plants as directed. In the event any selected plant does not show a sufficient root system after being dug, it will be rejected. The handling, care, and other requirements of collected plants will be the same as that described for nursery grown stock.

**Grades and Sizes:**

All plants shall be a first class representative of its normal species and shall be grade XX (extra heavy) unless otherwise specified. Trees shall have average and normal well developed branch systems together with vigorous root systems according to the species and grade.

All trees shall have reasonably straight trunks. Deciduous trees which normally produce "leaders," such as sycamores, willow, oaks, water oak and elms, shall have "leaders" and they shall not be removed or cut back. Evergreen trees, such as live oaks, and magnolias, will be acceptable without strict "leaders," providing the branching system of each conforms to or represents the natural growth and provided further that they do not show unnatural growth caused by severe pruning or cutting back.

The sizes of plants shown on the Summary Plant List in the special provisions are the minimum acceptable sizes. If the contractor desires to furnish material which is oversize, he shall obtain permission from the Project Engineer and the handling, care, and planting of such oversize stock shall be as directed.

**Substitutions:**

No substitutions of plant material shall be made without the written permission of the Project Engineer and then only when sufficient evidence has been presented by the contractor that the plant cannot be obtained. Permission will be given to substitute only such plants as are equal to or better than the original plant.

**Balled and Burlapped Plants:**

Plants designated "B" in the planting list and summary plant list shall be carefully dug with balls of dirt sufficiently large to include enough roots at the sides and the bottom of the plant to insure proper growth. These balls shall be dug by "Cutting" in a workman-like manner and not by "spading out" or "lifting" from the ground. The burlap shall be securely fastened around the ball by an approved method such as pinning with nails or tying with cord. Large balls one and one-half feet or more in diameter shall be tied with small rope to insure against settling or cracking. Balled plants shall be handled only by the balls of dirt.

Where balled and burlapped plants are called for, the contractor shall ascertain from the Project Engineer the sizes of the balls of dirt to be dug with each variety of plant. The following diameter of balls with relation to the height or caliper will apply:

**Small Trees, Shrubs and Vines**

Height	Minimum Diameter of Ball
2 feet to 3 feet.....	10 inches
3 feet to 4 feet.....	12 inches
4 feet to 5 feet.....	15 inches
5 feet to 6 feet.....	16 inches
6 feet to 7 feet.....	18 inches

## Larger Trees—Evergreen

Caliper	Minimum Diameter of Ball
1 inch to 1½ inches.....	18 inches
1½ inches to 1¾ inches.....	20 inches
1¾ inches to 2 inches.....	24 inches
2 inches to 2½ inches.....	30 inches
2½ inches to 3 inches.....	33 inches

The depth of balls of dirt shall be determined by the root showing as digging progresses, but in no case will plants be accepted which have flat, shallow balls of dirt when such plants are known to have deep root systems. Extreme care shall be used in digging large trees as magnolia and live oak.

### Bare Rooted Plants:

Plants designated "A" in the planting list and summary plant list shall be furnished with roots bare. They shall be dug with sufficient root systems to insure their growth and the roots shall not be exposed to wind or sun during digging. Small shrubs dug bare rooted shall be taken up with a majority of roots intact but large deciduous trees may have some of their roots removed. The following table shows the minimum acceptable sizes of root systems which will govern the digging of large deciduous trees.

Caliper	Minimum Diameter of Root System
1 inch to 1½ inches.....	24 inches
1½ inches to 2 inches.....	30 inches
2 inches to 2½ inches.....	33 inches
2½ inches to 3 inches.....	36 inches
3 inches to 4 inches.....	48 inches

### Notification by Contractor:

As soon as the contractor has determined where the different plant materials will be obtained, he shall notify the Project Engineer. The Project Engineer may inspect any or all plant material at the point of origin before same has been dug and prepared for shipment.

If the material selected by the contractor is not suitable as to grade, type, size, or in any other manner does not conform to the specifications or special provisions, same will be rejected.

**Notification of Delivery:**

The contractor shall give the Project Engineer at least twenty-four hours notice before making any delivery of plant material to the project. Each shipment shall be accompanied by an invoice showing the sizes and varieties of plants included.

**Receipt of Nursery Stock:**

On delivery of the nursery stock, the contractor shall assist the Project Engineer in the inspection of the plant material. No plant shall be planted until it shall have been inspected and accepted by the Project Engineer.

Freshly dug stock shall be used. Plants showing a storage damage will be rejected. All precautions that are customary in good trade practice shall be taken to insure the arrival of all plants at the project in good condition for successful growth.

**Rejection of Plant Material:**

All plants which do not strictly comply with these specifications and special provisions will be rejected.

Any plant having any of the following unnatural or objectionable features shall be rejected. Excessive abrasions of the bark; dried out root system; excessive dead wood; dried up wood; excessive sunscald injuries; undeveloped and weak top or roots or both; crooked or one-sided development of tops; no straight leaders on trees naturally and normally having them; broken or removed leaders; untrue types of sizes; not complying with Federal and State laws or regulations bearing on inspections and certificates; excessively damaged balls of dirt; balls of dirt dug from loose soil which could not be expected to properly ball and hold in handling; and plants actually dead.

The rejected material shall be replaced as quickly as possible with other material meeting the requirements and at the expense of the contractor.

**TAR FOR ABSORPTIVE TREATMENT: M-114**

Tar for absorptive treatment shall be a liquid water gas tar which conforms to the following requirements:

	Min.	Max.
Specific Gravity 77°/77°F.....	1.030	1.100
Specific Viscosity at 104°F., Engler....		3.0
Total Distillate, per cent by weight to 572°F .....		50
Bitumen (soluble in carbon disul- phide), per cent.....	98	
Water, per cent.....		3.0

**TAR SEAL COAT FOR ABSORPTIVE  
TREATMENT:—M-115**

Tar seal coat for absorptive treatment shall conform to the following requirements:

	Min.	Max.
Specific Gravity at 77°/77°F. ....	1.090	1.190
Specific Viscosity at 104°F., Engler....	8.0	20.0
Total distillate, by weight		
To 338°F. ....	2.0	8.0
To 455°F. ....	8.0	20.0
To 518°F. ....	16.0	28.0
To 572°F. ....		36.0
Softening Point of residue °F. ....		149
Bitumen (soluble in carbon disul- phide), per cent.....	80	
Water, per cent.....		2.0

**TIMBER, PECKY CYPRESS:—M-116**

Pecky cypress timber shall be free from excess peck and of sufficient strength to withstand driving where required.

**TIMBER, TREATED, STRUCTURAL:—M-117**

Timber to be treated with a preservative treatment shall be of the grade specified and shall be treated in accordance with the specification requirements.

Treatment shall be according to section "Creosoted Treatment for Timber," or "Water Borne Salts Treatment of Timber," as specified on the plans.

**TIMBER, UNTREATED, STRUCTURAL:—M-118**

The common and botanical names of the species of woods recognized in these specifications are described as follows:

Common Names	Botanical Names
Cypress, Tidewater Red Fir, Douglas (Coast) Southern Yellow Pine, includes Loblolly Pine Longleaf Pine Pitch Pine Pond Pine Shortleaf Pine Slash Pine	Toxadium distichum Paseudotsuga toxifolia Pinus taeds  Pinus palustris Pinus rigida Pinus serotina Pinus echinata Pinus Caribaea Pinus lambertiana

Southern Yellow Pine, Douglas Fir and Cypress, if required, shall meet the following requirements as to grading:

Structural Purpose	Size of member	Species	Standard Stress Grade
Stringers, floorbeams, caps, mudsills, posts, fender timbers, bulkhead timbers, pair tops, ties, etc.	5" thickness and larger	Pine	1600 lb. f Structural Beams and Stringers
		Douglas Fir	1600 lb. f Structural Beams and Stringers.
		Cypress	1400 lb. f Structural Beams and Stringers.
Stringers, decking, bulkhead planks, sway bracing, and smaller felloe guards, pier bracing, nailing strips, bridging, fender and bulkhead timbers, handrails, posts and culvert timbers.	4" thickness and smaller	Pine	1600 lb. f Structural Joists and Plank.
		Douglas Fir	1600 lb. f Structural Joist and Plank.
		Cypress	1400 lb. f Structural Joist and Plank.

f = Extreme fibre stress in bending in pounds per square inch for continuously dry locations.

**Grading of Structural Timber:**

(a) General Requirements: The following general provisions apply to all stress-grades: All material shall

be well manufactured. All sizes prescribed in the specifications applying to lumber and timber refer to nominal sizes, and the American Standard rough and dressed sizes hereinafter enumerated shall be accepted as conforming thereto.

All timber to be used without preservative treatment shall contain not less than 85 per cent heartwood on the girth, or on each face, side or edge, measured at the point where the greatest amount of sapwood occurs.

For all timber to be pressure treated, there shall be no heartwood requirement, and the amount of sapwood shall not be limited.

Where wane is not desired, the specifications should state "Square Edge."

No piece of exceptionally light weight is permitted.

Only pieces consisting of sound wood, free from any form of decay are acceptable.

Slope of grain shall be measured over a distance sufficiently great to determine the general slope, disregarding slight local deviations. Within the middle half of the length of the piece the slope of grain shall not be steeper than specified.

Knot holes and holes from causes other than knots are measured and limited as provided for knots.

Cluster knots and knots in groups are not permitted.

(b) Knots in Joist and Plank: The size of a knot on a narrow face is taken as the width between lines enclosing the knot and parallel to the edges of the piece. The only knots measured on narrow faces, except spike knots which cross the corners of side-cut piece and contains the intersection of the adjacent faces, or which extends entirely across a face of a piece, shall be measured only on its end or ends, between lines parallel to the edges of the piece.

The sizes of knots on narrow faces and at the edges of wide faces may increase proportionately from the size permitted in the middle third of the length to twice



that size at the ends of the piece. The size of knots on wide faces may increase proportionately from the size permitted at the edge to the size permitted along the center line.

The sum of the sizes of all the knots within the middle half of the length of any face, measured as specified above for the face under consideration, shall not exceed four and one-half times the size of the largest knot allowed on that face.

(c) Knots in Beams and Stringers: The size of a knot on a narrow face is taken as the width between lines enclosing the knot and parallel to the edges of the piece, except that when a knot on a narrow face extends into the adjacent one-fourth of the width of a wide face its least dimension is taken as its size.

The size of a knot on a wide face is its smallest diameter. Knots at the edges of wide faces are limited to the same sizes as on narrow faces but are measured according to this article.

The sizes of knots on narrow faces and at the edge of wide faces may increase proportionately from the size permitted in the middle third of the length to twice that size at the ends of the piece, except that the size of knot shall not exceed the size permitted along the center line of the wide face. The sizes of knots on wide faces may increase proportionately from the size permitted at the edge to the size permitted along the center line.

The sum of the sizes of all knots within the middle half of the length of any faces, measured as specified above for the face under consideration, shall not exceed four times the size of the largest knot allowed on that face.

(d) Shakes, Checks and Splits: Shakes, checks, and splits, where permitted in the grade specified herein, are measured at the ends of the piece. Only those within the middle half of the height are considered. (Height equals the width of the wide face.) The size of the shake is the distance between lines enclosing the shake and parallel to the wide faces of the piece.

Checks and splits are measured and limited in the same way as shakes. The following limitations apply to both ends, but only within the middle half of the height of the piece and within three times the height from the end. (Height equals the width of the wide face.) The size of the checks within this portion of the piece shall be taken as their estimated area, along the horizontal section showing the maximum area, divided by three times the height of the piece. (See Note.) When the checks on two parallel faces are opposite or approximately so, the sum of their sizes is taken. The sum of the sizes of shakes, checks and splits shall not exceed the permissible size of the shake.

Note: A practical method of inspection in the field to determine the size of checks and splits under the above specifications is as follows:

The size of checks within the specified portion of the piece shall be taken as the sum of seven depth measurements, one on the end and three on each side, divided by three. Each measurement shall represent the greatest depth of any check within the center half of the height; the measurement on the end shall be taken at the center of the width, and the three measurements on each side shall be taken at distances of 1, 2 and 3 times the height of the piece from the end in joist, plank, beams and stringers and the width of the piece from the end in posts and timbers. Each measurement shall be determined by the penetration into the piece of a probe  $1/64$  inch thick and  $1/4$  inch wide.

Checks extending entirely across the end within the middle half of the height shall not extend into the piece at the center of the width of the end a distance greater than the size of the allowable shake.

(e) Density, Douglas Fir: Dense Douglas Fir shall average on either one end or the other of each piece not less than six annual rings per inch in Douglas Fir, and, in addition, one-third or more summerwood (the dark portion of the annual ring), measured over 3 inches on a line at a right angle to the annual rings, located as described below. The contrast in color between summerwood and springwood shall be distinct.

Coarse-grained material excluded by this rule shall be accepted as dense if averaged one-half or more summerwood.

In boxed heart pieces, the line shall run from the pith to the corner farthest from the pith except, when the line is not representative, it shall be shifted sufficiently to present a fair average, but the distance from the pith to the beginning of the 3-inch portion of the line shall not be changed. When the least dimension is 6 inches or less, the 3-inch portion of the line shall begin at a distance of 1 inch from the pith. When the least dimension is more than 6 inches, the 3-inch portion of the line shall begin at a distance from the pith equal to one-quarter the least dimension of the piece.

In side-cut pieces (pith not present), the center of the 3-inch portion of the line shall be at the center of the end of the piece.

If a 3-inch portion of the line cannot be obtained, the measurement shall be made over as much of a 3-inch portion as is available.

In case of disagreement, two radial lines shall be chosen, and the summerwood and number of rings shall be taken as the average on these lines.

(f) Close Grain Douglas Fir: Close-grained Douglas Fir shall average on either one end or the other of each piece not less than six nor more than 20 annual rings per inch in Douglas Fir, measured over 3 inches on a line at right angles to the annual rings located as described below.

In boxed-heart pieces the line shall run from the pith to the corner farthest from the pith except, when the line is not representative, it shall be shifted sufficiently to present a fair average but the distance from the pith to the beginning of the 3-inch portion of the line shall not be changed. When the least dimension is 6 inches or less, the 3-inch portion of the line shall begin at a distance of 1 inch from the pith. When the least dimension is more than 6 inches, the 3-inch portion of the line shall begin at a distance from

the pith equal to one-fourth the least dimension of the piece.

In side-cut pieces (pith not present), the center of the 3-inch portion of the line shall be at the center of the end of the piece.

If a 3-inch portion of the line cannot be obtained, the measurement shall be made over as much of a 3-inch portion as is available.

In case of disagreement, two radial lines shall be chosen and the number of rings shall be taken as the average on these lines.

Pieces of Douglas Fir averaging five rings or more than 20 shall be accepted if containing one-third or more summerwood.

(g) Density, Southern Yellow Pine: Dense longleaf or shortleaf yellow pine shall average on either one end or the other of each piece not less than six annual rings per inch, and, in addition, one-third or more summerwood, the darker, harder portion of the annual ring, measured over the third, fourth, and fifth inches of a radial line from the pith. The contrast in color between summerwood and springwood shall be sharp, and the summerwood shall be dark in color, except in pieces having considerably above the minimum requirement for summerwood.

Coarse-grained material excluded by this rule shall be accepted as dense if averaging one-half or more summerwood.

The radial line shall be representative of the average growth of the cross section. In case of disagreement, two radial lines shall be chosen, and the number of rings per inch and percentage of summerwood shall be taken as the average determined on these lines.

In boxed heart pieces the measurement shall be made over the third, fourth and fifth inches from the pith along the radial line.

In material containing the pith, but not a 5-inch radial line, which is less than 2 by 8 inches in section or less than 8 inches in width, that does not show over 16 square inches on the cross section, the inspection

shall apply to the second inch from the pith. In larger material that does not show a 5-inch radial line, the inspection shall apply to the 3 inches farthest from the pith.

In cases where timbers do not contain the pith and it is impossible to locate it with any degree of accuracy, the same inspection shall be made over 3 inches on an approximate radial line beginning at the edge nearest the pith in timbers over 3 inches in thickness and on the second inch nearest the pith in timbers 3 inches or less in thickness.

(h) Structural Joist and Plank with Load Applied to Either the Wide Face or the Narrow Face:

1. Standard Sizes:

Nominal thicknesses, 2 inches, 3 inches and 4 inches.

Permissible minimum rough thicknesses in not to exceed 20 per cent of pieces in any one shipment:

- 2 inches.....  $\frac{1}{8}$  inch off
- 3 inches and 4 inches.....  $\frac{3}{16}$  inch off
- Dressed thicknesses, S1S or S2S.....  $\frac{3}{8}$  inch off
- Nominal widths 4 inches and wider.

Permissible minimum rough widths in not to exceed 20 per cent of pieces in any one shipment:

- 4 inches and 6 inches.....  $\frac{3}{16}$  inch off
- 8 inches and wider.....  $\frac{1}{4}$  inch off
- Dressed widths, S1E or S2E;
- 4 inches and 6 inches.....  $\frac{3}{8}$  inch off
- 8 inches and wider.....  $\frac{1}{2}$  inch off

2. 1600 lb. f Structural Joist and Plank (Structural Square Edge and Sound): Dense longleaf southern pine. Dense shortleaf southern pine.

Slope of Grain.—1 in 12.

Knots—Maximum permissible size in inches:

Nominal Width of Face, In.	On Narrow Face, Or at Edge of Wide Face, Middle Third of Length	At Center Line Of Wide Face
	On Narrow Face	
2.....	$\frac{3}{4}$ in.	.....
3.....	$1\frac{1}{8}$ in.	.....
4.....	$1\frac{1}{2}$ in.	.....
	At Edge of Wide Face	
4.....	$\frac{7}{8}$ in.	$1\frac{1}{2}$ in.
6.....	$1\frac{1}{4}$ in.	$2\frac{1}{4}$ in.
8.....	$1\frac{5}{8}$ in.	3 in.
10.....	$2\frac{1}{8}$ in.	$3\frac{3}{4}$ in.
12.....	$2\frac{1}{2}$ in.	$4\frac{1}{2}$ in.
14.....	$2\frac{3}{4}$ in.	$4\frac{7}{8}$ in.
16.....	$2\frac{7}{8}$ in.	$5\frac{1}{8}$ in.

Width of Narrow Face

Shakes, Checks, Splits:      When green      When seasoned

120 lb. Shear Grade.....       $\frac{3}{10}$        $\frac{3}{8}$

Wane .....       $\frac{1}{5}$  width of any face

3. 1600 lb. f Structural Joist and Plank: Close-grained Douglas Fir (Coast region).

Slope of Grain.—1 in 12.

Knots.—Maximum permissible size in inches:

Nominal Width of Face, In.	On Narrow Face, Or at Edge of Wide Face, Middle Third of Length	At Center Line Of Wide Face
	On Narrow Face	
2.....	$\frac{5}{8}$ in.	.....
3.....	1 in.	.....
4.....	$1\frac{1}{4}$ in.	.....
	At Edge of Wide Face	
4.....	$\frac{3}{4}$ in.	$1\frac{1}{4}$ in.
6.....	1 in.	$1\frac{7}{8}$ in.
8.....	$1\frac{3}{8}$ in.	$2\frac{1}{2}$ in.
10.....	$1\frac{3}{4}$ in.	$3\frac{1}{4}$ in.
12.....	$2\frac{1}{8}$ in.	$3\frac{7}{8}$ in.
14.....	$2\frac{1}{4}$ in.	$4\frac{1}{8}$ in.
16.....	$2\frac{1}{2}$ in.	$4\frac{1}{2}$ in.

Width of Narrow Face

Shakes, Checks, Splits:      When green      When seasoned

100 lb. Shear Grade.....       $\frac{1}{6}$        $\frac{1}{4}$

Wane .....       $\frac{1}{6}$  width of any face

4. 1400 lb. f Structural Joist and Plank: Tidewater red cypress.

Slope of Grain.—1 in 14.

Knots and Peck.—Maximum permissible size in inches:

Nominal Width of Face, In.	On Narrow Face, Or at Edge of Wide Face, Middle Third of Length	At Center Line Of Wide Face
	On Narrow Face	
2.....	$\frac{5}{8}$ in.	.....
3.....	$\frac{7}{8}$ in.	.....
4.....	$1\frac{1}{8}$ in.	.....
	At Edge of Wide Face	
4.....	$\frac{5}{8}$ in.	$1\frac{1}{8}$ in.
6.....	1 in.	$1\frac{3}{4}$ in.
8.....	$1\frac{1}{4}$ in.	$2\frac{3}{8}$ in.
10.....	$1\frac{3}{8}$ in.	$2\frac{7}{8}$ in.
12.....	$1\frac{7}{8}$ in.	$3\frac{1}{2}$ in.
14.....	2 in.	$3\frac{3}{4}$ in.
16.....	$2\frac{1}{4}$ in.	$4\frac{1}{8}$ in.

Shakes, Checks, Splits:	Width of Narrow Face	
	When green	When seasoned
120 lb. Shear Grade.....	$\frac{1}{10}$	$\frac{1}{5}$
Wane .....	$\frac{1}{6}$ width of any face	

(i) Structural Beams and Stringers with Load Applied to the Narrow Face:

1. Standard Sizes:

Nominal thickness 5 inches and thicker.

Permissible minimum rough thicknesses in not to exceed 20 per cent of pieces in any one shipment:

5-inch and 6-inch.....	$\frac{3}{16}$ inch off
8-inch and wider.....	$\frac{1}{4}$ inch off
Dressed thicknesses, S1S or S2S	$\frac{1}{2}$ inch off
Nominal Widths, 8 inches and wider.	

Permissible minimum rough widths in not to exceed 20 per cent of pieces in any one shipment .....

Dressed widths, S1E or S2E.....	$\frac{1}{2}$ inch off
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2. 1600 lb. f Structural Beams and Stringers (Structural Square Edge and Sound): Dense longleaf southern pine. Dense shortleaf southern pine.

Slope of Grain.—1 in 12.

Knots.—Maximum permissible size in inches:

Nominal Width of Face, In.	On Narrow Face, Middle Third of Length	At Center Line Of Wide Face
5.....	1½ in.	.....
6.....	1⅞ in.	.....
8.....	2⅛ in.	2½ in.
10.....	2⅜ in.	3⅛ in.
12.....	2⅝ in.	3¾ in.
14.....	2⅞ in.	4 in.
16.....	3 in.	4⅜ in.
18.....	.....	4⅝ in.
20.....	.....	4⅞ in.

Width of Narrow Face

Shakes, Checks, Splits:      When green      When seasoned

120 lb. Shear Grade.....      3/10      3/8

Wane .....      1/6 width of any face

3. 1600 lb. f Structural Beams and Stringers: Close-grained Douglas Fir (Coast region).

Slope of Grain.—1 in 15.

Knots.—Maximum permissible size in inches:

Nominal Width of Face, In.	On Narrow Face Middle Third of Length	At Center Line Of Wide Face
5.....	1⅛ in.	.....
6.....	1⅜ in.	.....
8.....	1⅝ in.	1⅞ in.
10.....	1¾ in.	2¼ in.
12.....	1⅞ in.	2⅝ in.
14.....	2 in.	2⅞ in.
16.....	2¼ in.	3⅛ in.
18.....	.....	3⅜ in.
20.....	.....	3½ in.

Width of Narrow Face

Shakes, Checks, Splits:      When green      When seasoned

100 lb. Shear Grade.....      1/6      1/4

Wane .....      1/6 width of any face

4. 1400 lb. f Structural Beams and Stringers: Tide-water red cypress.



Slope of Grain.—1 in 16.

Knots and Peck.—Maximum permissible size in inches:

Nominal Width of Face, In.	On Narrow Face, Middle Third of Length	At Center Line Of Wide Face
5.....	1 in.	.....
6.....	1 <sup>1</sup> / <sub>8</sub> in.	.....
8.....	1 <sup>3</sup> / <sub>8</sub> in.	1 <sup>1</sup> / <sub>2</sub> in.
10.....	1 <sup>1</sup> / <sub>2</sub> in.	1 <sup>7</sup> / <sub>8</sub> in.
12.....	1 <sup>5</sup> / <sub>8</sub> in.	2 <sup>1</sup> / <sub>4</sub> in.
14.....	1 <sup>3</sup> / <sub>4</sub> in.	2 <sup>1</sup> / <sub>2</sub> in.
16.....	1 <sup>7</sup> / <sub>8</sub> in.	2 <sup>5</sup> / <sub>8</sub> in.
18.....	.....	2 <sup>7</sup> / <sub>8</sub> in.
20.....	.....	3 in.

	Width of Narrow Face	
Shakes, Checks, Splits:	When green	When seasoned
120 lb. Shear Grade.....	1/10	1/5
Wane .....	1/8 width of any face	

**WOLMAN SALTS:—M-119**

Wolman salts shall be either triolith or tanalith as specified or called for on the plans.

Triolith and tanalith shall conform approximately to the following requirements:

(a) Triolith—(To resist decay)	Minimum Percent
Sodium Fluoride.....	50.88
Potassium Dichromate.....	32.37
Dinitrophenol .....	9.25
Insolubles, in hot water.....	0.50
(b) Tanalith—(To resist decay and termites)	Minimum Percent
Sodium Fluoride.....	23.12
Disodium Hydrogen Arsenate.....	23.13
Potassium Dichromate.....	34.68
Dinitrophenol .....	11.57
Insolubles, in hot water.....	0.50

Procedure for Analysis of Wolman Salts:

For Sodium Fluoride: After removal of other ingredients by silver nitrate, followed by sodium chlo-

ride, the filtrate is exactly neutralized to litmus and the fluorine precipitated by calcium chloride, which, after vigorous boiling is filtered through the asbestos mat of a Gooch crucible, dried, and weighed as calcium fluoride.

For Disodium Hydrogen Arsenate: After being treated with sulphuric acid and potassium iodide, followed by continued boiling until all liberated iodine is driven off, the solution is neutralized with sodium bicarbonate, then, with addition of starch solution, titrated to N/10 iodine solution.

For Potassium Dichromate: Precipitate as barium chromate by the addition of barium acetate. After filtering and washing, dissolve with warm hydrochloric acid, add potassium iodide, and titrate against N/10 sodium thiosulphate.

For Dinitrophenol: To the dry salts or to the residue of a solution evaporated nearly to dryness, add a little water and then concentrated sulphuric acid. Place in a separatory funnel and extract the dinitrophenol with ether by drawing it off into a small weighed flask. About four extractions of each sample will suffice. Evaporate with care over water-bath, with very slow final drying in a dessicator. Weigh as dinitrophenol, with the tolerance appropriate for the exact method employed.

#### WROUGHT IRON—M-120

Wrought iron shall conform to the requirements of the Standard Specifications for Rolled Wrought Iron Shapes and Bars A.S.T.M. Designation A-207-39, or Wrought Iron Plates, A.S.T.M. Designation A-42-39, as the case may be, with subsequent amendments and additions thereto adopted by the A.S.T.M.

#### WATER FOR USE WITH CEMENT:—M-121

Water for use with cement in mortar or concrete shall meet the following requirements:

Oil .....	None
Acid .....	None

Alkali—Not over .....	0.1%
Solids (Organic)—Not over.....	0.1%
Solids (Inorganic)—Not over.....	0.4%
Salt (NaCl)—Not over.....	0.5%

Water, when used in standard soundness, time of setting, and 1-3 mortar-strength test as outlined in Standard Method T-26 A.A.S.H.O. with standard sand and cement shall show no unsoundness; nor when compared with similar test of distilled water using the same sand and cement shall it show a marked change in time of setting; shall show at least 95 per cent of the strength at 7 and 28 days of age. No water will be approved for use until a 7-day test has been completed.

**ZINC META-ARSENITE:—M-122**

Zinc meta-arsenite shall be in aqueous solution. The strength, acidity, etc., of the solution shall be such as to insure the required penetration and absorption of the preservative in the quantity required.

The zinc meta-arsenite shall be used in approximately the following proportions:

Arsenious acid ( $As_2O_3$ ) .....	120 parts
Zinc oxide (ZnO) .....	80 parts
Acetic acid.....	Sufficient to keep the zinc meta-arsenite in solution.

**ROLLED BRONZE PLATES:—M-123**

Rolled bronze shall conform to the requirements of the Tentative Specifications for Wrought Phosphor Bronze Bearings and Expansion Plates for Bridges and Structures, A.S.T.M. Designation B 100-35T, Class A.



DIVISION IV

DESIGN OF STRUCTURES

(Printed under separate cover)



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DIVISION V  
MOVABLE BRIDGES  
DESIGN AND CONSTRUCTION  
(Printed under separate cover)

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DIVISION VI  
CONTRACT DOCUMENTARY  
FORMS

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**STATE OF LOUISIANA**  
**DEPARTMENT OF HIGHWAYS**

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**NOTICE TO CONTRACTORS**

Sealed proposals for the construction of the following project will be received by the Department of Highways, \_\_\_\_\_

\_\_\_\_\_, Baton

Rouge, Louisiana until \_\_\_\_\_

\_\_\_\_\_. No proposals will be received after

\_\_\_\_\_. At \_\_\_\_\_ of the same day

and date, they will be publicly opened and publicly read in

\_\_\_\_\_

(Description of Project and other pertinent information to be placed in this space.)

Full information and proposal forms are available at the offices of the Department of Highways at Baton Rouge. Plans and specifications may be inspected at said office or plans will

be furnished upon payment of \_\_\_\_\_, (not to be refunded).

Bids shall be submitted on proposal forms provided by the Department.

The Department of Highways reserves the right to reject any or all proposals.

**DEPARTMENT OF HIGHWAYS**

\_\_\_\_\_, **DIRECTOR**

**STATE OF LOUISIANA  
DEPARTMENT OF HIGHWAYS  
PROPOSAL**

\_\_\_\_\_ PROJECT No. \_\_\_\_\_  
\_\_\_\_\_

Proposals will be received up to \_\_\_\_\_ on

\_\_\_\_\_ by the Department of Highways, \_\_\_\_\_

\_\_\_\_\_ Baton Rouge, Louisiana.

No proposals will be received after \_\_\_\_\_

At \_\_\_\_\_ of the same day and date they will be

publicly opened and publicly read in \_\_\_\_\_  
\_\_\_\_\_

BID OF \_\_\_\_\_

ADDRESS \_\_\_\_\_

DATE \_\_\_\_\_, 19\_\_\_\_

To the Department of Highways,

Baton Rouge, Louisiana.

Gentlemen:

I (We) hereby agree to perform all the work known and described by you as:

\_\_\_\_\_ Project No. \_\_\_\_\_

entitled \_\_\_\_\_

Route \_\_\_\_\_ No. \_\_\_\_\_, Parish \_\_\_\_\_

consisting of \_\_\_\_\_ miles of \_\_\_\_\_

\_\_\_\_\_, located as follows:

(Description of location to be placed in this space)



The specifications, contract and bonds, governing the construction of the work contemplated are those known and designated as Louisiana Standard Specifications for Roads and Bridges, approved by the Department of Highways, July 1, 1947 together with the "Special Provisions," if any, attached to this proposal.

The plans herein referred to are the plans approved by the Chief Engineer and marked with the project number, route and Parish, set out above, together with all standard or special designs that may be designated in such plans.

The undersigned, as bidder, declares that the only persons or parties interested in this proposal as principals are those named herein; that this proposal is made without collusion or combination of any kind or character with any other person, firm, association, or corporation, or any member or officer thereof; that he has (or they have) carefully examined the site of the proposed work, the plans, Standard Specifications and special provisions above mentioned, and the form of contract and contract bond; that he (or they) proposes, and agrees, if this proposal is accepted, to provide all necessary machinery, tools, apparatus, and other means of construction, and will do all the work and furnish all the materials specified in the contract, in the manner and time therein prescribed and in accordance with the requirement of the Chief Engineer as therein set forth; and that he (or they) hereby proposes to accept as full compensation therefor, the amount of the summation of the products of the quantities of work and material actually incorporated in the completed project, as determined by the Chief Engineer, multiplied by the respective unit prices herein bid.

It is understood by the undersigned that the quantities given in the following itemized proposal are a fair approximation of the amount of work to be done, and that the sum of the products of the approximate quantities multiplied by the unit price bid shall constitute gross sum bid, which sum shall be used in the comparison of bids, and the awarding of the contract.

The undersigned further proposes to perform all extra and force account work that may be required on the basis provided in the specifications, to give such work his personal attention and to secure economical performance.

The undersigned further agrees that within ten days after notice of the award of the contract to undersigned, he (or they) will execute the contract and furnish to the Department of Highways a satisfactory surety bond in a sum equal to the contract price as provided in the Standard Specifications.

The undersigned further agrees that work will begin not later than ten calendar days after the date of the Work Order, and shall be diligently prosecuted at such rate and in such manner as, in the opinion of the Chief Engineer, is necessary for the completion of the work within the time specified in the contract, it being understood that time is the essence of the contract.

Accompanying this proposal is a certified check in the amount of \_\_\_\_\_

Dollars (\$ \_\_\_\_\_), payable to the "LOUISIANA DEPARTMENT OF HIGHWAYS." If this proposal shall be accepted and the undersigned shall fail to execute the contract and furnish bond as above provided, then the certified check shall become the property of the State, otherwise, the said check shall be returned to the undersigned. The checks of the two lowest bidders will be retained until after the bidder to whom the award is made has entered into the contract and has given an acceptable bond. All other checks will be returned to the bidders immediately after the amounts of the bids have been determined, compared and the results of such comparisons have been considered by the Department.

Respectfully submitted,

(If a Firm or Individual)

SIGNATURE OF BIDDER \_\_\_\_\_ (Seal)

By: \_\_\_\_\_

ADDRESS OF BIDDER \_\_\_\_\_

Name and Addresses of  
Members of the Firm


(If a Corporation)

SIGNATURE OF BIDDER \_\_\_\_\_ (Seal)

By: \_\_\_\_\_

Names and Business  
Address of Officers

President
Secretary
Treasurer

Legal Domicile \_\_\_\_\_

Return Certified Check to: \_\_\_\_\_

\_\_\_\_\_

**STATE OF LOUISIANA  
DEPARTMENT OF HIGHWAYS**

**CONTRACT**

This Agreement, made and executed in \_\_\_\_\_  
(\_\_\_\_\_) original copies, on this \_\_\_\_\_ day of the month  
of \_\_\_\_\_, in the year of our Lord, one thousand,  
nine hundred and \_\_\_\_\_, by and  
between the Department of Highways, acting by and through  
\_\_\_\_\_, Director of  
Highways, the party of the First Part, and hereinafter desig-  
nated as "Department," and \_\_\_\_\_  
Contractor, domiciled and doing business in \_\_\_\_\_  
\_\_\_\_\_, Party of the Second Part,  
and hereinafter designated as "Contractor."

WITNESSETH, That, in consideration of the covenants and  
agreements herein contained, to be performed by the parties  
hereto and of the payments hereinafter agreed to be made, it  
is mutually agreed as follows:

The Contractor shall and will provide and furnish all ma-  
terials, equipment and labor and perform the work required to  
build, construct and complete in a thorough and workmanlike  
manner, to the satisfaction of the Chief Engineer of the De-

partment of Highways \_\_\_\_\_

Project No. \_\_\_\_\_

entitled \_\_\_\_\_,

Route \_\_\_\_\_ No. \_\_\_\_\_, Parish \_\_\_\_\_

consisting of \_\_\_\_\_ miles of \_\_\_\_\_

\_\_\_\_\_, located as follows:

(Description of location to be placed in this space)

in accordance with the plans, on file in the Office of the Department at Baton Rouge, Louisiana, dated \_\_\_\_\_

\_\_\_\_\_, and with the Standard Specifications for Roads and Bridges approved by the Department of Highways, July 1, 1947, and with the proposal filed with the Department

dated \_\_\_\_\_, and with the Special Provisions accompanying said proposal; copy of said Plans, Specifications and Proposal which are made a part hereof as fully as if set out herein, and hereby become a part of this contract.

It is agreed and understood between the parties hereto that the contractor agrees to accept and the Department agrees to pay for the work at the prices stipulated in said Proposal, such payment to be in lawful money of the United States, and the payment shall be made at the time and in the manner set forth in the Specifications.

Performance will begin within ten calendar days after date of the work order and shall be completed within \_\_\_\_\_ contract days from that date subject to such extensions as may be authorized by the terms of the Specifications.

Total cost of Items Nos. \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

is \_\_\_\_\_

\_\_\_\_\_ Dollars (\$\_\_\_\_\_).

This contract shall become effective immediately upon, and as of the date, all necessary parties hereto have approached and signed the same.

IN WITNESS WHEREOF, The Director of Highways has hereunto subscribed his name, and the same has been duly approved by the Chief Engineer of the Department of Highways,

and \_\_\_\_\_, Contractor,  
has also hereunto subscribed his name on the days and dates  
set forth after their various signatures.

WITNESSES:

\_\_\_\_\_ (Seal)  
Contractor

\_\_\_\_\_  
By: \_\_\_\_\_

\_\_\_\_\_  
on \_\_\_\_\_, 19\_\_\_\_\_

STATE OF LOUISIANA  
DEPT. OF HIGHWAYS

\_\_\_\_\_  
By: \_\_\_\_\_  
Director

on \_\_\_\_\_, 19\_\_\_\_\_

Approved

By: \_\_\_\_\_  
Chief Engineer

on \_\_\_\_\_, 19\_\_\_\_\_

STATE OF LOUISIANA  
DEPARTMENT OF HIGHWAYS

CONTRACT BOND

KNOW ALL MEN BY THIS INSTRUMENT, That we\_\_\_\_\_

\_\_\_\_\_

as principal, and the \_\_\_\_\_,  
a Surety Company authorized to do business in the State of  
Louisiana, as Surety, are held and firmly bound, in solido, unto  
the Department of Highways, and unto all subcontractors,  
workmen, laborers, mechanics, and furnishers of materials and  
equipment, jointly in the full sum of \_\_\_\_\_

\_\_\_\_\_ Dollars

(\$ \_\_\_\_\_), payable in lawful money of the United  
States, and to this bond we obligate our heirs, successors and  
assigns.

Now the consideration of this bond is such, that if the said

\_\_\_\_\_, Contractor,  
shall well and truly perform \_\_\_\_\_ contract, made and  
entered into on this \_\_\_\_\_ day of \_\_\_\_\_,  
19\_\_\_\_, to construct \_\_\_\_\_ Project No. \_\_\_\_\_

\_\_\_\_\_

entitled \_\_\_\_\_,  
Route \_\_\_\_\_ No. \_\_\_\_\_, Parish \_\_\_\_\_,

consisting of \_\_\_\_\_ miles of \_\_\_\_\_,  
according to the stipulations recited in said contract, attached  
hereto and made a part thereof, and shall pay all sums due on  
materials and supplies used and for wages earned by laborers  
and workmen employed upon the work to be done, and if the

above bonded \_\_\_\_\_  
shall in all things stand to and abide by and well and truly  
observe, to keep and perform all and singular the terms, cove-  
nants, conditions, guarantees and agreements in said contract

to be observed, kept, done and performed, and each of them, at the time and in the manner and form therein specified, and shall do and perform all the labor and work and shall furnish all the materials as specified in said contract in strict accordance with all the terms of said contract and the plans and specifications thereto attached and made a part thereof, and shall indemnify and save harmless said Department of Highways against any loss or damage of whatever kind and character arising or occasioned by deeds of negligence of said principal, his agents, servants and employees in the prosecution of the work, or by reason of improper safeguards or incomplete protection to the work and shall pay all bills for materials and labor entered into the construction of said work or used in the course of the performance of the work, then this obligation shall be null and void; otherwise to remain in full force and effect.

In faith whereof, we have subscribed this obligation at Baton Rouge, Louisiana.

WITNESS OUR HANDS AND SEALS, This \_\_\_\_\_

\_\_\_\_\_ day of \_\_\_\_\_, 19\_\_\_\_\_.

WITNESSES

As to Principal:

\_\_\_\_\_  
Principal

\_\_\_\_\_  
By: \_\_\_\_\_

WITNESSES

As to Surety:

\_\_\_\_\_  
Surety

\_\_\_\_\_  
By: \_\_\_\_\_ (Seal)  
Attorney-in-Fact

Countersigned

By: \_\_\_\_\_ (Seal)  
Resident Agent



# TABLES

Standard Weights per cubic foot of various types and gradations of aggregates to be used in all cases in converting quantities of aggregate from weight to volume and from volume to weight.

Type of Material	Dry Rodded Per Cu. Ft.	Weights, Lbs. Per Cu. Yd.	
<i>Aggregates for Concrete</i>			
Gravel Grade A.....	101	2727	
Gravel Grade B.....	103	2781	
Gravel Grade D.....	107	2889	
Gravel or Limestone Grade E, Large Size.....	100	2700	
Gravel or Limestone Grade E, Small Size.....	100	2700	
Sand.....	108	2916	
<i>Aggregates for Surface Treatment</i>			
Crushed Gravel.....	Coarse Aggregate.....	95	2565
Crushed Gravel.....	Fine Aggregate.....	98	2646
Crushed Gravel.....	Seal Coat Aggregate.....	94	2538
Crushed Limestone.....	Coarse Aggregate.....	97	2619
Crushed Limestone.....	Fine Aggregate.....	100	2700
Crushed Limestone.....	Seal Coat Aggregate.....	106	2862
Slag.....	Coarse Aggregate.....	74	1998
Slag.....	Fine Aggregate.....	78	2106
Slag.....	Seal Coat Aggregate.....	82	2214
Uncrushed Gravel.....	Coarse Aggregate.....	98	2646
Uncrushed Gravel.....	Fine Aggregate.....	98	2646
Uncrushed Gravel.....	Seal Coat Aggregate.....	104	2808
<i>Base or Surface Coarse Materials</i>			
Washed Gravel.....		102	2754
Clam Shell.....		65	1755
Reef Shell.....		55	1485
Sand Clay Gravel, All Grades.....		111	2997
Washed Sand Gravel.....		111	2997
Crushed Stone (Winnfield).....		100	2700

## Standard Abridged Volume Correction Table for Petroleum Oils:

The abridged table has been prepared by the U. S. Bureau of Standards and has been approved as American Standard by the American Standards Association.

The groups, coefficients of expansion, gravity (degrees A. P. I.) and gravity ranges for the several subdivisions of the present abridged table follows:

Group Number	Coefficient of Expansion at 60°F	Gravity Degrees A. P. I.	Gravity Range Group (Degrees A. P. I. at 60°F)
0	0.00035	..	Up to 14.9
1	0.00040	22	15.0 to 34.9
2	0.00050	44	35.0 to 50.9
3	0.00060	58	51.0 to 63.9
4	0.00070	72	64.0 to 78.9
5	0.00080	86	79.0 to 88.9
6	0.00085	91	89.0 to 93.9
7	0.00090	97	94.0 to 100.0

### GROUP O

Legend: t=observed temperature in degrees Fahrenheit; M=multiplier for reducing oil volumes to the basis of 60°F.

t	M	t	M	t	M	t	M	t	M
0	1.0211	11	1.0172	22	1.0134	33	1.0095	44	1.0056
1	1.0208	12	1.0168	23	1.0130	34	1.0092	45	1.0052
2	1.0204	13	1.0165	24	1.0126	35	1.0088	46	1.0049
3	1.0201	14	1.0161	25	1.0123	36	1.0084	47	1.0045
4	1.0197	15	1.0158	26	1.0119	37	1.0081	48	1.0042
5	1.0194	16	1.0154	27	1.0116	38	1.0077	49	1.0039
6	1.0190	17	1.0151	28	1.0112	39	1.0074	50	1.0035
7	1.0186	18	1.0147	29	1.0109	40	1.0070	51	1.0032
8	1.0183	19	1.0144	30	1.0106	41	1.0067	52	1.0028
9	1.0178	20	1.0141	31	1.0102	42	1.0063	53	1.0025
10	1.0176	21	1.0137	32	1.0098	43	1.0059	54	1.0021

GROUP O—(Continued)

t	M	t	M	t	M	t	M	t	M
55	1.0017	97	0.9872	139	0.9728	181	0.9586	223	0.9448
56	1.0014	98	0.9869	140	0.9724	182	0.9583	224	0.9445
57	1.0010	99	0.9865	141	0.9721	183	0.9580	225	0.9441
58	1.0007	100	0.9862	142	0.9718	184	0.9576	226	0.9438
59	1.0003	101	0.9858	143	0.9714	185	0.9573	227	0.9435
60	1.0000	102	0.9855	144	0.9711	186	0.9569	228	0.9432
61	0.9997	103	0.9852	145	0.9707	187	0.9566	229	0.9428
62	0.9993	104	0.9848	146	0.9704	188	0.9563	230	0.9425
63	0.9990	105	0.9844	147	0.9701	189	0.9559	231	0.9422
64	0.9986	106	0.9841	148	0.9697	190	0.9556	232	0.9419
65	0.9982	107	0.9837	149	0.9694	191	0.9553	233	0.9415
66	0.9979	108	0.9834	150	0.9691	192	0.9549	234	0.9412
67	0.9976	109	0.9831	151	0.9687	193	0.9546	235	0.9409
68	0.9972	110	0.9827	152	0.9684	194	0.9543	236	0.9406
69	0.9969	111	0.9823	153	0.9680	195	0.9539	237	0.9402
70	0.9965	112	0.9820	154	0.9677	196	0.9536	238	0.9399
71	0.9962	113	0.9816	155	0.9674	197	0.9533	239	0.9396
72	0.9958	114	0.9813	156	0.9670	198	0.9530	240	0.9392
73	0.9955	115	0.9809	157	0.9667	199	0.9527	241	0.9389
74	0.9952	116	0.9806	158	0.9664	200	0.9523	242	0.9386
75	0.9948	117	0.9802	159	0.9660	201	0.9520	243	0.9383
76	0.9944	118	0.9799	160	0.9657	202	0.9517	244	0.9380
77	0.9941	119	0.9795	161	0.9654	203	0.9513	245	0.9376
78	0.9938	120	0.9792	162	0.9650	204	0.9510	246	0.9373
79	0.9934	121	0.9789	163	0.9647	205	0.9507	247	0.9370
80	0.9931	122	0.9785	164	0.9643	206	0.9504	248	0.9367
81	0.9927	123	0.9782	165	0.9640	207	0.9500	249	0.9364
82	0.9924	124	0.9779	166	0.9637	208	0.9497	250	0.9360
83	0.9920	125	0.9775	167	0.9633	209	0.9494	251	0.9357
84	0.9917	126	0.9772	168	0.9630	210	0.9490	252	0.9354
85	0.9914	127	0.9768	169	0.9627	211	0.9487	253	0.9351
86	0.9910	128	0.9765	170	0.9623	212	0.9484	254	0.9347
87	0.9907	129	0.9762	171	0.9620	213	0.9481	255	0.9344
88	0.9903	130	0.9758	172	0.9616	214	0.9477	256	0.9341
89	0.9900	131	0.9755	173	0.9613	215	0.9474	257	0.9338
90	0.9896	132	0.9751	174	0.9610	216	0.9471	258	0.9335
91	0.9892	133	0.9748	175	0.9606	217	0.9468	259	0.9331
92	0.9889	134	0.9745	176	0.9603	218	0.9464	260	0.9328
93	0.9886	135	0.9741	177	0.9600	219	0.9461	261	0.9325
94	0.9882	136	0.9738	178	0.9596	220	0.9458	262	0.9322
95	0.9879	137	0.9736	179	0.9593	221	0.9454	263	0.9319
96	0.9876	138	0.9731	180	0.9590	222	0.9451	264	0.9315

GROUP O—(Continued)

t	M	t	M	t	M	t	M	t	M
265	0.9312	287	0.9242	309	0.9173	331	0.9104	353	0.9036
266	0.9309	288	0.9239	310	0.9169	332	0.9101	354	0.9033
267	0.9306	289	0.9236	311	0.9166	333	0.9098	355	0.9030
268	0.9303	290	0.9233	312	0.9163	334	0.9095	356	0.9027
269	0.9299	291	0.9229	313	0.9160	335	0.9092	357	0.9024
270	0.9296	292	0.9226	314	0.9157	336	0.9088	358	0.9021
271	0.9293	293	0.9223	315	0.9154	337	0.9085	359	0.9017
272	0.9290	294	0.9220	316	0.9151	338	0.9082	360	0.9014
273	0.9287	295	0.9217	317	0.9148	339	0.9079	361	0.9011
274	0.9283	296	0.9214	318	0.9145	340	0.9076	362	0.9008
275	0.9280	297	0.9210	319	0.9141	341	0.9073	363	0.9005
276	0.9277	298	0.9207	320	0.9138	342	0.9070	364	0.9002

GROUP O—(Continued)

t	M	t	M	t	M	t	M	t	M
277	0.9274	299	0.9204	321	0.9135	343	0.9067	365	0.8999
278	0.9271	300	0.9201	322	0.9132	344	0.9064	366	0.8996
279	0.9267	301	0.9198	323	0.9129	345	0.9061	367	0.8993
280	0.9264	302	0.9195	324	0.9126	346	0.9057	368	0.8990
281	0.9261	303	0.9191	325	0.9123	347	0.9054	369	0.8987
282	0.9258	304	0.9188	326	0.9119	348	0.9051	370	0.8984
283	0.9255	305	0.9185	327	0.9116	349	0.9048	371	0.8981
284	0.9252	306	0.9182	328	0.9113	350	0.9045	372	0.8978
285	0.9248	307	0.9179	329	0.9110	351	0.9042	373	0.8975
286	0.9245	308	0.9176	330	0.9107	352	0.9039	374	0.8972

GROUP 1

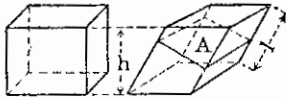
t	M	t	M	t	M	t	M	t	M
0	1.0242	14	1.0185	28	1.0128	42	1.0072	56	1.0016
1	1.0238	15	1.0181	29	1.0124	43	1.0068	57	1.0012
2	1.0234	16	1.0177	30	1.0120	44	1.0064	58	1.0008
3	1.0230	17	1.0173	31	1.0116	45	1.0060	59	1.0004
4	1.0226	18	1.0169	32	1.0112	46	1.0056	60	1.0000
5	1.0222	19	1.0165	33	1.0108	47	1.0052	61	0.9996
6	1.0218	20	1.0161	34	1.0104	48	1.0048	62	0.9992
7	1.0214	21	1.0157	35	1.0100	49	1.0044	63	0.9988
8	1.0210	22	1.0153	36	1.0096	50	1.0040	64	0.9984
9	1.0206	23	1.0148	37	1.0092	51	1.0036	65	0.9980
10	1.0202	24	1.0144	38	1.0088	52	1.0032	66	0.9976
11	1.0198	25	1.0140	39	1.0084	53	1.0028	67	0.9972
12	1.0194	26	1.0136	40	1.0080	54	1.0024	68	0.9968
13	1.0189	27	1.0132	41	1.0076	55	1.0020	69	0.9964

GROUP 1—(Continued)

t	M	t	M	t	M	t	M	t	M
70	0.9960	106	0.9818	142	0.9678	178	0.9540	214	0.9405
71	0.9956	107	0.9814	143	0.9675	179	0.9536	215	0.9401
72	0.9952	108	0.9811	144	0.9671	180	0.9532	216	0.9397
73	0.9948	109	0.9807	145	0.9667	181	0.9528	217	0.9393
74	0.9944	110	0.9803	146	0.9663	182	0.9524	218	0.9390
75	0.9940	111	0.9799	147	0.9659	183	0.9521	219	0.9386
76	0.9936	112	0.9795	148	0.9655	184	0.9517	220	0.9382
77	0.9932	113	0.9791	149	0.9651	185	0.9513	221	0.9378
78	0.9929	114	0.9787	150	0.9647	186	0.9509	222	0.9374
79	0.9925	115	0.9783	151	0.9643	187	0.9505	223	0.9371
80	0.9921	116	0.9779	152	0.9639	188	0.9502	224	0.9367
81	0.9917	117	0.9775	153	0.9636	189	0.9498	225	0.9363
82	0.9913	118	0.9771	154	0.9632	190	0.9494	226	0.9359
83	0.9909	119	0.9767	155	0.9628	191	0.9490	227	0.9356
84	0.9905	120	0.9763	156	0.9624	192	0.9487	228	0.9352
85	0.9901	121	0.9759	157	0.9620	193	0.9483	229	0.9349
86	0.9897	122	0.9755	158	0.9616	194	0.9480	230	0.9345
87	0.9893	123	0.9752	159	0.9612	195	0.9476	231	0.9341
88	0.9889	124	0.9748	160	0.9608	196	0.9472	232	0.9337
89	0.9885	125	0.9744	161	0.9604	197	0.9468	233	0.9334
90	0.9881	126	0.9740	162	0.9601	198	0.9465	234	0.9330
91	0.9877	127	0.9736	163	0.9597	199	0.9461	235	0.9326
92	0.9873	128	0.9732	164	0.9594	200	0.9457	236	0.9322
93	0.9869	129	0.9728	165	0.9590	201	0.9453	237	0.9318
94	0.9865	130	0.9724	166	0.9586	202	0.9449	238	0.9315
95	0.9861	131	0.9720	167	0.9582	203	0.9446	239	0.9311
96	0.9857	132	0.9716	168	0.9578	204	0.9442	240	0.9307
97	0.9853	133	0.9713	169	0.9574	205	0.9438	241	0.9303
98	0.9849	134	0.9709	170	0.9570	206	0.9434	242	0.9300
99	0.9845	135	0.9705	171	0.9566	207	0.9430	243	0.9296
100	0.9841	136	0.9701	172	0.9562	208	0.9427	244	0.9293
101	0.9837	137	0.9697	173	0.9559	209	0.9423	245	0.9289
102	0.9833	138	0.9694	174	0.9555	210	0.9419	246	0.9285
103	0.9830	139	0.9690	175	0.9551	211	0.9415	247	0.9281
104	0.9826	140	0.9686	176	0.9547	212	0.9412	248	0.9278
105	0.9822	141	0.9682	177	0.9543	213	0.9408	249	0.9274

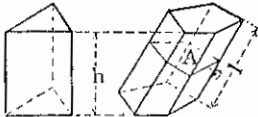
## SURFACE AND VOLUME OF SOLIDS

S=LATERAL OR CONVEX SURFACE. V=VOLUME



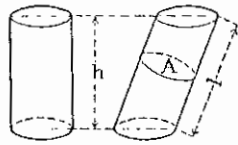
### Parallelepiped

S=perimeter, P, perp. to sides x lat. length, l:  $P l$   
 V=area of base, B x perpendicular height, h:  $B h$   
 V=area of section, A, perp. to sides x lat. length, l:  $A l$



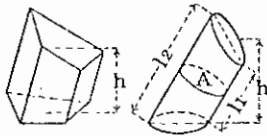
### Prism, Right or Oblique, Regular or Irregular

S=perimeter, P, perp. to sides x lat. length, l:  $P l$   
 V=area of base, B x perpendicular height, h:  $B h$   
 V=area of section, A, perp. to sides x lat. length, l:  $A l$



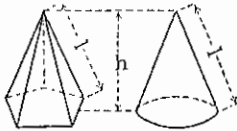
### Cylinder, Right or Oblique, Circular or Elliptic, etc.

S=perimeter of base, P x perp. height, h:  $P h$   
 S=perimeter,  $P_1$ , perp. to sides x lat. length, l:  $P_1 l$   
 V=area of base, B x perpendicular height, h:  $B h$   
 V=area of section, A, perp. to sides x lat. length, l:  $A l$



### Frustum of any Prism or Cylinder

V=area of base, B x perp. distance, h, from base to center of gravity of opposite face:  $B h$   
 For cylinder:  $\frac{1}{2} A (l_1 + l_2)$

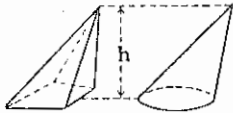


### Pyramid or Cone, Right and Regular

S=perimeter of base, P x  $\frac{1}{2}$  slant height, l:  $\frac{1}{2} P l$   
 V=area of base, B x  $\frac{1}{3}$  perp. height, h:  $\frac{1}{3} B h$

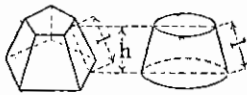
### Pyramid or Cone, Right or Oblique, Regular or Irregular

V=area of base, B x  $\frac{1}{3}$  perp. height, h:  $\frac{1}{3} B h$   
 V= $\frac{1}{3}$  volume of prism or cylinder of same base and perpendicular height  
 V= $\frac{1}{2}$  volume of hemisphere of same base and perpendicular height



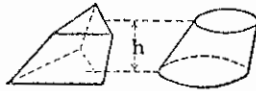
### Frustum of Pyramid or Cone, Right and Regular, Parallel Ends

S=(sum of perimeter of base, P, and top, p) x  $\frac{1}{2}$  slant height, l:  $\frac{1}{2} l (P + p)$   
 V=(sum of areas of base, B, and top, b + square root of their products) x  $\frac{1}{3}$  perp. height, h:  
 $\frac{1}{3} h (B + b + \sqrt{B b})$



### Frustum of any Pyramid or Cone, Parallel Ends

V=(sum of areas of base, B, and top, b + square root of their products) x  $\frac{1}{3}$  perp. height, h:  
 $\frac{1}{3} h (B + b + \sqrt{B b})$

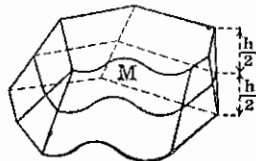


### Wedge, Parallelogram Face

V= $\frac{1}{6}$  (sum of three edges, a b a x perpendicular height, h x perpendicular width, d):  $\frac{1}{6} d h (2a + b)$

### Prismatoid

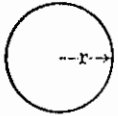
V= $\frac{1}{6}$  perp. height, h (sum of areas of base, B, and top b, + 4 x area of section, M, parallel to bases and midway between them):  $\frac{1}{6} h (B + b + 4 M)$



The Prismatoid formula applies also to any of the foregoing solids with parallel bases, to pyramids, cones, spherical sections, and to many solids with irregular surfaces.

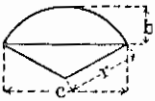
**SURFACE AND VOLUME OF SOLIDS—Concluded**

S=LATERAL OR CONVEX SURFACE. V=VOLUME



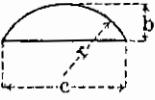
**Sphere**

$S = 4 \pi r^2 = \pi d^2 = 3.14159265 d^2$   
 $V = \frac{4}{3} \pi r^3 = \frac{1}{6} \pi d^3 = 0.52359878 d^3$



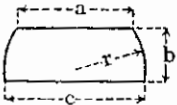
**Spherical Sector**

$S = \frac{1}{2} \pi r (4 b + c)$   
 $V = \frac{2}{3} \pi r^2 b$



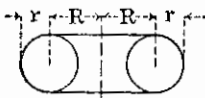
**Spherical Segment**

$S = 2 \pi r b = \frac{1}{4} \pi (4 b^2 + c^2)$   
 $V = \frac{1}{3} \pi b^2 (3 r - b) = \frac{1}{24} \pi b (3 c^2 + 4 b^2)$



**Spherical Zone**

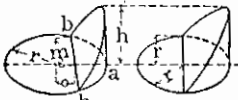
$S = 2 \pi r b$   
 $V = \frac{1}{24} \pi b (3 a^2 + 3 c^2 + 4 b^2)$



**Circular Ring**

$S = 4 \pi^2 R r$   
 $V = 2 \pi^2 R r^2$

**Ungula of Right, Regular Cylinder**



Base=Segment, b a b

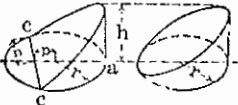
Base=Half Circle

$S = (2 r m - o \times \text{arc, } b a b) \frac{h}{r - o}$

$S = 2 r h$

$V = (\frac{2}{3} m^3 - o \times \text{area, } b a b) \frac{h}{r - o}$

$V = \frac{2}{3} r^2 h$



Base=Segment, c a c

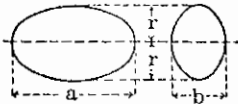
Base=Circle

$S = (2 r n + p \times \text{arc, } c a c) \frac{h}{r + p}$

$S = r \pi h$

$V = (\frac{2}{3} n^3 + p \times \text{area, } c a c) \frac{h}{r + p}$

$V = \frac{1}{2} r^2 \pi h$



**Ellipsoid**

$V = \frac{4}{3} \pi r a b$

**Paraboloid**

$V = \frac{1}{2} \pi r^2 h$

Ratio of corresponding volumes of a Cone, Paraboloid, Sphere, and Cylinder of equal height:  $\frac{1}{6} : \frac{1}{2} : \frac{2}{3} : 1$

**Bodies Generated by Partial or Complete Revolution**

l=length of a curve } rotating about an axis 1-1  
 A=area of a plane } on one side and in plane of axis  
 r=distance of center of gravity of line or plane from axis 1-1 and for any angle of revolution, a°,

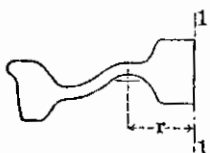
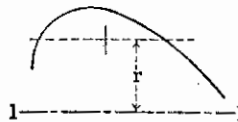
$\frac{2 r \pi a^\circ}{360}$  =length of arc described by center of gravity.

S=length of curve x length of arc about axis

=l  $\frac{2 r \pi a^\circ}{360}$  For complete revolution  $S = 2 r \pi l$

V=area of plane x length of arc about axis

=A  $\frac{2 r \pi a^\circ}{360}$  For complete revolution  $V = 2 r \pi A$





## EQUIVALENTS OF MEASURE

### FORCES OR WEIGHTS PER UNITS OF LENGTH, LINEAR WEIGHTS

1 dyne per centimeter = 0.00101979 g/cm = 0.000183719 poundal/in.  
 1 gram per centimeter = 980.5966 dynes/cm = 0.180154 poundal/in.  
 1 poundal per inch = 5443.11 dynes/cm = 5.55081 g/cm = 0.0310832 pound/in.

Grams per Centimeter g/cm	Grains per Inch, gr./in.	Pounds per Inch, lb./in.	Pounds per Foot, lb./ft.	Pounds per Yard, lb./yd.	Kilograms per Meter, kg/m	Net Tons, 2000 lbs., per Mile	Gross Tons, 2240 lbs., per Mile	Metric Tons, 1000 kg, per Kilometer
1	39.1983	0.075600	0.06720	0.20159	0.10	0.17740	0.15839	0.10
0.02551	1	0.01429	0.01714	0.05143	0.02551	0.04526	0.04041	0.02551
178.579	7000	1	12	36	17.8579	31.6800	28.2857	17.8579
14.8816	583.333	0.08333	1	3	1.48816	2.64000	2.35714	1.48816
4.96054	194.444	0.02778	0.33333	1	0.49605	0.88000	0.78571	0.49605
10	391.983	0.05600	0.67197	2.01591	1	1.77400	1.58393	1
5.63698	220.960	0.03157	0.37879	1.13636	0.56370	1	0.89286	0.56370
6.31342	247.475	0.03535	0.42424	1.27273	0.63134	1.12	1	0.63134
10	391.983	0.05600	0.67197	2.01591	1	1.77400	1.58393	1

### FORCES OR WEIGHTS PER UNITS OF AREA, PRESSURE

1 dyne per sq. centimeter = 0.00101979 g/cm<sup>2</sup> = 0.000466646 pounds/in.<sup>2</sup>.  
 1 gram per sq. centimeter = 980.5966 dynes/cm<sup>2</sup> = 0.457592 pounds/in.<sup>2</sup>.  
 1 poundal per sq. inch = 2142.95 dynes/cm<sup>2</sup> = 2.18536 g/cm<sup>2</sup> = 0.0310832 pound/in.<sup>2</sup>.

Kilograms per Sq. Centimeter, kg/cm <sup>2</sup>	Pounds per Sq. Inch, lb./in. <sup>2</sup>	Pounds per Sq. Foot, lb./ft. <sup>2</sup>	Net Tons, 2000 lbs., per Sq. Foot	Atmospheres, Standard, 760 mm	Columns of Mercury, Hg. 13.59593 Sp. G.		Columns of Water, Max. Density 4° C	
					Millimeters	Inches	Meters	Feet
1	14.2234	2048.17	1.02408	0.96778	735.514	28.9572	10	32.8083
0.07031	1	144	0.07200	0.06804	51.7116	2.03588	0.70307	2.30665
0.04882	0.06944	1	0.00050	0.04725	0.35911	0.01414	0.04882	0.01602
0.97648	13.8889	2000	1	0.94502	718.216	28.2762	9.76482	32.0367
1.03329	14.6969	2116.35	1.05818	1	760	29.9212	10.3329	33.9006
0.01360	0.01934	2.78468	0.01392	0.01316	1	0.03937	0.01360	0.04461
0.03453	0.49119	70.7310	0.03537	0.03342	25.4001	1	0.34534	1.13299
0.10	1.42234	204.817	0.10241	0.09678	73.5514	2.89572	1	3.28083
0.03048	0.43353	62.4283	0.03121	0.02950	22.4185	0.88262	0.30480	1

### FORCES OR WEIGHTS PER UNITS OF VOLUME, DENSITY

1 dyne per cu. centimeter = 0.00101979 gram/cm<sup>3</sup> = 0.00118528 poundals/in.<sup>3</sup>.  
 1 gram per cu. centimeter = 980.5966 dynes/cm<sup>3</sup> = 1.162283 poundals/in.<sup>3</sup>.  
 1 poundal per cu. inch = 843.683 dynes/cm<sup>3</sup> = 0.860378 g/cm<sup>3</sup> = 0.0310832 pound/in.<sup>3</sup>.

Grams per Cu. Centimeter, g/cm <sup>3</sup>	Pounds per Cu. Inch, lb./in. <sup>3</sup>	Pounds per Cu. Foot, lb./ft. <sup>3</sup>	Pounds per Cu. Yard, lb./yd. <sup>3</sup>	Kilograms per Cu. Meter, kg/m <sup>3</sup>	Pounds per Bushel, U. S.	Pounds per Gallon, Dry, U. S.	Pounds per Gallon, Liquid, U. S.	Kilograms per Hectoliter, kg/hl
1	0.03613	62.4283	1685.56	1000	77.6893	9.71116	8.34545	100
27.6797	1	1728	46656	27679.7	2150.42	268.803	231	2767.97
0.01602	0.05787	1	27	16.0184	1.24446	0.15556	0.13368	1.60184
0.05933	0.02143	0.03704	1	0.59327	0.04609	0.05762	0.04951	0.05933
0.001	0.03613	0.06243	1.68556	1	0.07769	0.09711	0.08345	0.10
0.01287	0.04650	0.80356	21.6962	12.8718	1	0.125	0.10742	1.28718
0.10297	0.03720	6.42851	173.570	102.974	8	1	0.85937	10.2974
0.11983	0.04329	7.48052	201.974	119.826	9.30920	1.16365	1	11.9826
0.01	0.03613	0.62428	16.8557	10	0.77689	0.09711	0.08345	1

Notations  $\frac{2}{0}$ ,  $\frac{3}{0}$ ,  $\frac{4}{0}$ , etc., indicate that the  $\frac{2}{0}$ ,  $\frac{3}{0}$ ,  $\frac{4}{0}$ , etc., are to be replaced by 2, 3, 4, etc. ciphers.      EXAMPLE—1 kg/m<sup>3</sup> = 0.03613 = 0.0003613 lb./in.<sup>3</sup>.

## EQUIVALENTS OF MEASURE

### LENGTHS

1 meter, m = 10 decimeters, dm = 100 centimeters, cm = 1000 millimeters, mm.  
 1 meter, m = 0.1 decameter, dkm = 0.01 hectometer, hm = 0.001 kilometer, km.  
 1 meter, m = 39.37 inches, U. S. Standard = 39.370113 inches, British Standard.  
 1 millimeter, mm = 1000 microns,  $\mu$  = 0.03937 inch = 39.37 mils.

Meters, m	Inches, in.	Feet, ft.	Yard, yd.	Rods, r.	Chains, ch.	Miles, U. S.		Kilo- meters, km.
						Statute	Nautical	
1	39.37	3.28083	1.09361	0.19884	0.04971	0. <sup>3</sup> 6214	0. <sup>3</sup> 5396	0.001
0.02540	1	0.08333	0.02778	0. <sup>5</sup> 051	0. <sup>2</sup> 1263	0. <sup>4</sup> 1578	0. <sup>3</sup> 1371	0. <sup>4</sup> 2540
0.30480	12	1	0.33333	0.06061	0.01515	0. <sup>3</sup> 1894	0. <sup>3</sup> 1645	0. <sup>3</sup> 3048
0.91440	36	3	1	0.18182	0.04545	0. <sup>3</sup> 5682	0. <sup>3</sup> 4934	0. <sup>9</sup> 144
5.02921	198	16.5	5.5	1	0.25	0. <sup>2</sup> 3125	0. <sup>2</sup> 2714	0. <sup>2</sup> 5029
20.1168	792	66	22	4	1	0.01250	0.01085	0.02012
1609.35	63360	5280	1760	320	80	1	0.86839	1.60935
1853.25	72962.5	6080.20	2026.73	368.497	92.1243	1.15155	1	1.85325
1000	39370	3280.83	1093.61	198.838	49.7096	0.62137	0.53959	1

1 yard, U. S. = 1.000029 yards British    1 yard British = 0.999971 yard U. S.  
 1 chain, Gunter's = 100 links    1 link = 7.92 inches.  
 1 cable length, U. S. = 120 fathoms = 960 spans = 720 feet = 219.457 meters.  
 1 league, U. S. = 3 statute miles = 24 furlongs.  
 1 international geographical mile =  $\frac{1}{45}^\circ$  at equator = 7422 m  
 = 4.611808 U. S. statute miles.  
 1 international nautical mile =  $\frac{1}{60}^\circ$  at meridian = 1852 m  
 = 0.999326 U. S. nautical miles.  
 1 U. S. nautical mile =  $\frac{1}{60}^\circ$  of circumference of sphere whose surface equals  
 that of the earth = 6080.27 feet = 1.15155 statute miles = 1853.27 meters.  
 1 British nautical mile = 6080.00 feet = 1.15152 statute miles = 1853.19 meters.

### SURFACES AND AREAS

1 sq. meter, m<sup>2</sup> = 100 sq. decimeters, dm<sup>2</sup> = 10000 sq. centimeters, cm<sup>2</sup>.  
 1 sq. meter, m<sup>2</sup> = 0.01 are, a = 0.0001 hectare, ha.  
 1 sq. millimeter, mm<sup>2</sup> = 0.01 cm<sup>2</sup> = 0.00155 sq. inch = 1973.5 circular mils.  
 1 arc, a = 1 sq. decameter, dkm = 0.0247104 acre.

Sq. Meters, m <sup>2</sup>	Sq. Inches, sq. in.	Sq. Feet, sq. ft.	Sq. Yards, sq. yd.	Sq. Rods, sq. r.	Acres, A	Hectares, ha.	Sq. Miles, Statute	Sq. Kilo- meters, km <sup>2</sup>
1	1550.00	10.7639	1.19599	0.03954	0. <sup>3</sup> 2471	0.0001	0. <sup>3</sup> 3861	0. <sup>5</sup>
0. <sup>3</sup> 6452	1	0. <sup>2</sup> 6944	0. <sup>3</sup> 7716	0. <sup>4</sup> 2551	0. <sup>8</sup> 1594	0. <sup>7</sup> 6452	0. <sup>9</sup> 2491	0. <sup>8</sup> 6452
0.09290	144	1	0.11111	0. <sup>2</sup> 3673	0. <sup>4</sup> 2296	0. <sup>5</sup> 9200	0. <sup>7</sup> 3587	0. <sup>7</sup> 9290
0.83613	1296	9	1	0.03306	0. <sup>2</sup> 2066	0. <sup>4</sup> 8361	0. <sup>5</sup> 3228	0. <sup>8</sup> 3361
25.2930	39204	272.25	30.25	1	0.00625	0. <sup>2</sup> 2529	0. <sup>5</sup> 9766	0. <sup>4</sup> 2529
4046.87	6272640	43560	4840	160	1	0.40469	0. <sup>2</sup> 1563	0. <sup>2</sup> 4047
10000	15499969	107639	11959.9	395.366	2.47104	1	0. <sup>2</sup> 3861	0.01
2589999		27878400	3097600	102400	640	259.000	1	2.59000
1000000		10763867	1195985	39536.6	247.104	100	0.38610	1

1 sq. rod, sq. pole, or sq. perch = 625 sq. links =  $\frac{1}{100}$  acre.  
 1 sq. chain, Gunter's = 16 sq. rods =  $\frac{1}{10}$  acre.  
 1 acre = 4 sq. rods = 160 sq. rods.    Square of 1 acre = 208.7103 feet square.

Notations  $\overset{2}{0}$ ,  $\overset{3}{0}$ ,  $\overset{4}{0}$ , etc., indicate that the  $\overset{2}{0}$ ,  $\overset{3}{0}$ ,  $\overset{4}{0}$ , etc., are to be replaced by 2, 3, 4, etc., ciphers.

EXAMPLE—1 sq. rod = 0.<sup>5</sup>9766 = 0.000009766 sq. miles.

## EQUIVALENTS OF MEASURE

### ENERGY, WORK, HEAT

1 dyne-centimeter=1 erg=0.00101979 gram-centimeter=0.<sup>7</sup>737612 foot-pound.

1 gram-centimeter=980.5966 ergs=0.<sup>7</sup>7233 foot-pound.

1 foot-pound=13557300 ergs=13825.5 gram-centimeters.

Kilogram-meters, kg-m	Foot-Pounds, ft.-lbs.	Horsepower-hour		Poncelet-hours, 100 kg-m-h	Kilowatt-hours, kw-h	Joules, 10 <sup>7</sup> ergs, j-s	Thermal Units	
		U. S., H. P.-h	Metric, 75 kg-m-h				B. T. U. b. t. u.	Calorie, kg-cal
1	7.23300	0. <sup>5</sup> 3653	0. <sup>5</sup> 3704	0. <sup>5</sup> 2778	0. <sup>5</sup> 2724	9.80597	0. <sup>2</sup> 9296	0. <sup>2</sup> 2342
0.13826	1	0. <sup>5</sup> 5051	0. <sup>5</sup> 5121	0. <sup>5</sup> 3840	0. <sup>5</sup> 3760	1.35573	0. <sup>2</sup> 1285	0. <sup>3</sup> 3239
273745	1980000	1	1.01387	0.76040	0.74565	2684340	2544.65	641.240
270000	1952910	0.98632	1	0.75	0.73545	2647610	2509.83	632.467
360000	2603880	1.31509	1.33333	1	0.98060	3530147	3346.44	843.289
367123	2655403	1.34111	1.35972	1.01979	1	3600000	3412.66	859.975
0.10198	0.73761	0. <sup>5</sup> 3725	0. <sup>5</sup> 3777	0. <sup>5</sup> 2833	0. <sup>5</sup> 2778	1	0. <sup>3</sup> 9480	0. <sup>3</sup> 2389
107.577	778.104	0. <sup>5</sup> 3930	0. <sup>5</sup> 3984	0. <sup>5</sup> 2988	0. <sup>5</sup> 2930	1054.90	1	0.25200
426.900	3087.77	0. <sup>5</sup> 1559	0. <sup>5</sup> 1581	0. <sup>5</sup> 1186	0. <sup>5</sup> 1163	4186.17	3.96832	1

### POWER, RATE OF ENERGY AND HEAT

1 erg per sec.=1 dyne-cm/sec.=0.00101979 gram-cm/sec.=0.<sup>7</sup>737612 foot-pounds/sec.

1 gram-centimeter per second=980.5966 ergs/sec.=0.<sup>7</sup>7238 foot-pounds/sec.

1 foot-pound per second=13557300 ergs/sec=13825.5 gram-cm/sec.

Kilogram-meters per Second, kg-m/s	Foot-pounds per Second, ft.-lbs./s	Horsepower		Poncelet, 100 kg-m/s	Kilowatt, kw.	Watts, 10 <sup>7</sup> ergs/s	Thermal Units per Sec.	
		U. S., 550 ft.-lbs./s	Metric, 75 kg-m/s				B. T. U. btu/s	Calorie kg-cal/s
1	7.23300	0.01315	0.01333	0.01	0. <sup>2</sup> 9806	9.80597	0. <sup>2</sup> 9296	0. <sup>2</sup> 2342
0.13826	1	0. <sup>2</sup> 1818	0. <sup>2</sup> 1843	0. <sup>2</sup> 1383	0. <sup>2</sup> 1356	1.35573	0. <sup>2</sup> 1285	0. <sup>3</sup> 3237
76.0404	550	1	1.01387	0.76040	0.74565	745.650	0.70685	0.17812
75	542.475	0.98632	1	0.75	0.73545	735.448	0.69718	0.17569
100	723.300	1.31509	1.33333	1	0.98060	980.597	0.92957	0.23425
101.979	737.612	1.34111	1.35972	1.01979	1	1000	0.94796	0.23888
0.10198	0.73761	0. <sup>2</sup> 1341	0. <sup>2</sup> 1360	0. <sup>2</sup> 1020	0.001	1	0. <sup>3</sup> 9480	0. <sup>3</sup> 2389
107.577	778.104	1.41474	1.43436	1.07577	1.05490	1054.90	1	0.25200
426.900	3087.77	5.01412	5.09200	4.26900	4.18617	4186.17	3.96832	1

### VELOCITIES AND ACCELERATIONS

1 kine=1 centimeter per second=0.0328083 foot per second.

1 radian per second=57.2958 degrees per sec.=0.159155 revolutions per sec.

1 gravity=980.5966 centimeters per sec. per sec.=32.1717 feet per sec. per sec.

Meters per Second, m/s	Feet per Second, ft./s	Miles per Hour, M/h	Knots per Hour, U. S.	Kilometers per Hour, km/h	Meter per sec/sec, m/s <sup>2</sup>	Feet per sec/sec, ft./s <sup>2</sup>	Miles per hour/sec, M/h-s	Kilometer per hour/sec, km/h-s
1	3.28083	2.23693	1.94254	3.6				
0.30480	1	0.68182	0.59209	1.09728				
0.44704	1.46667	1	0.86839	1.60935				
0.51479	1.68894	1.15155	1	1.85325				
0.27778	0.91134	0.62137	0.53959	1				
					1	3.28083	2.23693	3.6
					0.30480	1	0.68182	1.09728
					0.44704	1.46667	1	1.60935
					0.27778	0.91134	0.62137	1

Notations  $\frac{2}{0}, \frac{3}{0}, \frac{4}{0}$ , etc., indicate that the  $\frac{2}{0}, \frac{3}{0}, \frac{4}{0}$ , etc., are to be replaced by 2, 3, 4, etc., ciphers. EXAMPLE—1 Calorie=0.<sup>2</sup>1163=0.001163 kilowatt-hours.

## EQUIVALENTS OF MEASURE

### VOLUME AND CAPACITY

1 cu. meter, m<sup>3</sup> = 1000 cu. decimeter, dm<sup>3</sup> = 1000000 cu. centimeters, cm<sup>3</sup>.  
 1 liter, l = 10 deciliters, dl = 100 centiliters, cl = 1000 milliliters, ml  
 = 1000 cu. centimeters, cm<sup>3</sup>. or cc.  
 1 liter, l = 0.1 decaliter, dkl = 0.01 hectoliter, hl = 1 cu. decimeter, dm<sup>3</sup>.

Cubic Decimeter, dm <sup>3</sup> , l	Cubic Inches, cu. in.	Cubic Feet, cu. ft.	Cubic Yards, cu. yd.	U. S. Quarts		U. S. Gallons		U. S. Bushels, bu.
				Liquid, l. qt.	Dry, d. qt.	Liquid, l. gal.	Dry, d. gal.	
1	61.0234	0.03531	0. <sup>2</sup> / <sub>27</sub> 1308	1.05668	0.90808	0.26417	0.22702	0.02838
0.01639	1	0. <sup>3</sup> / <sub>1728</sub> 5787	0. <sup>3</sup> / <sub>27</sub> 2143	0.01732	0.01488	0. <sup>3</sup> / <sub>128</sub> 4329	0. <sup>3</sup> / <sub>128</sub> 3720	0. <sup>3</sup> / <sub>128</sub> 4650
28.3170	1728	1	0.03704	29.9221	25.7140	7.48055	6.42851	0.80356
764.559	46656	27	1	807.896	694.279	201.974	173.570	21.6962
0.94636	57.75	0.03342	0. <sup>2</sup> / <sub>27</sub> 1238	1	0.85937	0.25	0.21484	0.02686
1.10123	67.2006	0.03889	0. <sup>3</sup> / <sub>27</sub> 1440	1.16365	1	0.29091	0.25	0.03125
3.78543	231	0.13368	0. <sup>2</sup> / <sub>27</sub> 4951	4	3.43747	1	0.85937	0.10742
4.40492	268.803	0.15556	0. <sup>2</sup> / <sub>27</sub> 5761	4.65460	4	1.16365	1	0.125
35.2393	2150.42	1.24446	0.04609	37.2368	32	9.30920	8	1

U. S. Dry Measure: 1 bushel = 4 pecks = 8 gallons = 32 quarts = 64 pints.  
 U. S. Liquid Measure: 1 gallon = 4 quarts = 8 pints = 32 gills = 128 fluid ounces.  
 U. S. Apoth. Measure: 1 fl. ounce, f℥ = 8 fl. drams, fʒ = 480 minims, m  
 = 29.574 cu. cm<sup>3</sup>.  
 British Imperial gallon dry and liquid measure = 1.03202 U. S. dry gal.  
 = 1.20091 U. S. liquid gal.  
 British Imperial gallon = 277.410 cu. in. = 4545.9631 cm<sup>3</sup>.  
 Weight of water at maximum density, 4°C, 45° Lat., and sea level.  
 1 cu. ft. = 62.4283 lbs. av. = 28.3170 kg    1 cu. in. = 0.57804 oz. av. = 16.3872 g.  
 1 gal., U. S. liquid = 8.34545 lbs. = 3.78543 kg.  
 1 gal., British Imperial = 10.0221 lbs. = 4.5459631 kg.

### MASSES AND WEIGHTS

1 gram, g = 10 decigrams, dg = 100 centigrams, cg = 1000 milligrams, mg.  
 1 gram, g = 0.1 decagram, dkg = 0.01 hectogram, hg = 0.001 kilogram, kg.  
 1 kilogram, kg = 1 cu. decimeter of water or liter, 4°C, 45° Lat. and sea level  
 = 15432.35639 grains, U. S. and British Standard.

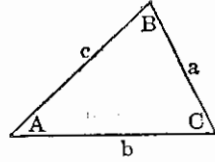
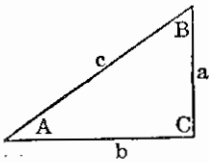
Kilo-grams, kg.	Grains, gr.	Ounces		Pounds		Tons		
		Troy, oz. t.	Avoir, oz. av.	Troy, lb. t.	Avoir, lb. av.	Net, Short, 2000 lbs.	Gross, Long, 2240 lbs.	Metric, 1000 kg.
1	15432.4	32.1507	35.2740	2.67923	2.20462	0. <sup>3</sup> / <sub>2240</sub> 1102	0. <sup>3</sup> / <sub>2240</sub> 9842	0.001
0. <sup>4</sup> / <sub>6480</sub>	1	0. <sup>3</sup> / <sub>1728</sub> 2083	0. <sup>2</sup> / <sub>288</sub> 2286	0. <sup>3</sup> / <sub>1736</sub>	0. <sup>3</sup> / <sub>1429</sub>	0. <sup>7</sup> / <sub>7143</sub>	0. <sup>7</sup> / <sub>6378</sub>	0. <sup>7</sup> / <sub>6480</sub>
0.03110	480	1	1.09714	0.08333	0.06857	0. <sup>4</sup> / <sub>3429</sub>	0. <sup>4</sup> / <sub>3061</sub>	0. <sup>4</sup> / <sub>3110</sub>
0.02835	437.5	0.91146	1	0.07595	0.06250	0. <sup>4</sup> / <sub>3125</sub>	0. <sup>5</sup> / <sub>2790</sub>	0. <sup>4</sup> / <sub>2835</sub>
0.37324	5760	12	13.1657	1	0.82286	0. <sup>3</sup> / <sub>4114</sub>	0. <sup>3</sup> / <sub>3674</sub>	0. <sup>3</sup> / <sub>3732</sub>
0.45359	7000	14.5833	16	1.21528	1	0.00050	0. <sup>3</sup> / <sub>4464</sub>	0. <sup>3</sup> / <sub>4536</sub>
907.185	14000000	29166.7	32000	2430.56	2000	1	0.89286	0.90719
1016.05	15680000	32666.7	35840	2722.22	2240	1.12	1	1.01605
1000	15432356	32150.7	35274.0	2679.23	2204.62	1.10231	0.98421	1

1 ounce avoird. = 16 drams, avoird.    1 ounce troy = 20 pennyweight, dwt.  
 1 ounce apoth., ℥ = 8 drams, ʒ = 24 scruples, ℥ = 480 grains, gr = 31.1035 g.  
 1 hundredweight = 1/20 long ton = 4 quarters = 8 stone = 112 lbs. = 50.8024 kg.

Notations  $\frac{2}{0}$ ,  $\frac{3}{0}$ ,  $\frac{4}{0}$ , etc., indicate that the  $\frac{2}{0}$ ,  $\frac{3}{0}$ ,  $\frac{4}{0}$ , etc., are to be replaced by 2, 3, 4, etc., ciphers.

EXAMPLE—1 grain = 0.<sup>3</sup>/<sub>1728</sub> 2083 = 0.002083 oz. t.    1 grain = 0.<sup>4</sup>/<sub>6480</sub> = 0.0006480 kg.

## TRIGONOMETRIC SOLUTION OF TRIANGLES

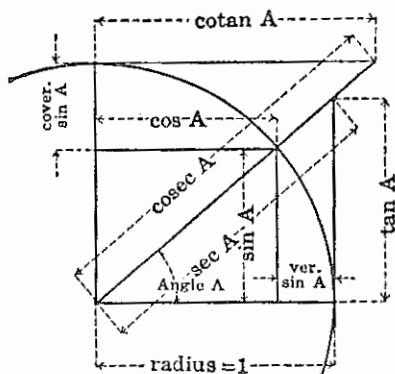


$$s = \frac{a+b+c}{2}$$

Given	Sought	Formulae
<b>RIGHT-ANGLED TRIANGLES</b>		
a, c	A, B, b	$\sin A = \frac{a}{c}, \quad \cos B = \frac{a}{c}, \quad b = \sqrt{c^2 - a^2}$
	Area	$\text{Area} = \frac{a}{2} \sqrt{c^2 - a^2}$
a, b	A, B, c	$\tan A = \frac{a}{b}, \quad \tan B = \frac{b}{a}, \quad c = \sqrt{a^2 + b^2}$
	Area	$\text{Area} = \frac{a b}{2}$
A, a	B, b, c	$B = 90^\circ - A, \quad b = a \cot A, \quad c = \frac{a}{\sin A}$
	Area	$\text{Area} = \frac{a^2 \cot A}{2}$
A, b	B, a, c	$B = 90^\circ - A, \quad a = b \tan A, \quad c = \frac{b}{\cos A}$
	Area	$\text{Area} = \frac{b^2 \tan A}{2}$
A, c	B, a, b	$B = 90^\circ - A, \quad a = c \sin A, \quad b = c \cos A$
	Area	$\text{Area} = \frac{c^2 \sin A \cos A}{2} \text{ or } \frac{c^2 \sin 2A}{4}$
<b>OBLIQUE-ANGLED TRIANGLES</b>		
a, b, c	A	$\sin \frac{1}{2} A = \sqrt{\frac{(s-b)(s-c)}{bc}}, \quad \cos \frac{1}{2} A = \sqrt{\frac{s(s-a)}{bc}}, \quad \tan \frac{1}{2} A = \sqrt{\frac{(s-b)(s-c)}{s(s-a)}}$
	B	$\sin \frac{1}{2} B = \sqrt{\frac{(s-a)(s-c)}{ac}}, \quad \cos \frac{1}{2} B = \sqrt{\frac{s(s-b)}{ac}}, \quad \tan \frac{1}{2} B = \sqrt{\frac{(s-a)(s-c)}{s(s-b)}}$
	C	$\sin \frac{1}{2} C = \sqrt{\frac{(s-a)(s-b)}{ab}}, \quad \cos \frac{1}{2} C = \sqrt{\frac{s(s-c)}{ab}}, \quad \tan \frac{1}{2} C = \sqrt{\frac{(s-a)(s-b)}{s(s-c)}}$
	Area	$\text{Area} = \sqrt{s(s-a)(s-b)(s-c)}$
a, A, B	B, c	$b = \frac{a \sin B}{\sin A}, \quad c = \frac{a \sin C}{\sin A} = \frac{a \sin(A+B)}{\sin A}$
	Area	$\text{Area} = \frac{1}{2} a b \sin C = \frac{a^2 \sin B \sin C}{2 \sin A}$
a, b, A	B	$\sin B = \frac{b \sin A}{a}$
	c	$c = \frac{a \sin C}{\sin A} = \frac{b \sin C}{\sin B} = \sqrt{a^2 + b^2 - 2ab \cos C}$
	Area	$\text{Area} = \frac{1}{2} a b \sin C$
a, b, C	A	$\tan A = \frac{a \sin C}{b - a \cos C}, \quad \tan \frac{1}{2}(A-B) = \frac{a-b}{a+b} \cot \frac{1}{2} C$
	c	$c = \sqrt{a^2 + b^2 - 2ab \cos C} = \frac{a \sin C}{\sin A}$
	Area	$\text{Area} = \frac{1}{2} ab \sin C$

$$a^2 = b^2 + c^2 - 2bc \cos A, \quad b^2 = a^2 + c^2 - 2ac \cos B, \quad c^2 = a^2 + b^2 - 2ab \cos C$$

## TRIGONOMETRIC FORMULAS



$$\text{Radius, } 1 = \sin^2 A + \cos^2 A$$

$$= \sin A \operatorname{cosec} A = \cos A \sec A = \tan A \cot A$$

$$\text{Sine } A = \frac{\cos A}{\cot A} = \frac{1}{\operatorname{cosec} A} = \cos A \tan A = \sqrt{1 - \cos^2 A}$$

$$\text{Cosine } A = \frac{\sin A}{\tan A} = \frac{1}{\sec A} = \sin A \cot A = \sqrt{1 - \sin^2 A}$$

$$\text{Tangent } A = \frac{\sin A}{\cos A} = \frac{1}{\cot A} = \sin A \sec A$$

$$\text{Cotangent } A = \frac{\cos A}{\sin A} = \frac{1}{\tan A} = \cos A \operatorname{cosec} A$$

$$\text{Secant } A = \frac{\tan A}{\sin A} = \frac{1}{\cos A}$$

$$\text{Cosecant } A = \frac{\cot A}{\cos A} = \frac{1}{\sin A}$$

$$\sin(A \pm B) = \sin A \cos B \pm \cos A \sin B$$

$$\cos(A \pm B) = \cos A \cos B \mp \sin A \sin B$$

$$\sin A + \sin B = 2 \sin \frac{1}{2}(A+B) \cos \frac{1}{2}(A-B)$$

$$\sin A - \sin B = 2 \cos \frac{1}{2}(A+B) \sin \frac{1}{2}(A-B)$$

$$\cos A + \cos B = 2 \cos \frac{1}{2}(A+B) \cos \frac{1}{2}(A-B)$$

$$\cos B - \cos A = 2 \sin \frac{1}{2}(A+B) \sin \frac{1}{2}(A-B)$$

$$\sin 2A = 2 \sin A \cos A$$

$$\cos 2A = \cos^2 A - \sin^2 A$$

$$\sin \frac{1}{2} A = \sqrt{\frac{1 - \cos A}{2}} \quad \cos \frac{1}{2} A = \sqrt{\frac{1 + \cos A}{2}}$$

$$\sin^2 A = \frac{1 - \cos 2A}{2} \quad \cos^2 A = \frac{1 + \cos 2A}{2}$$

$$\sin^2 A - \sin^2 B = \sin(A+B) \sin(A-B)$$

$$\frac{\sin A \pm \sin B}{\cos A \pm \cos B} = \tan \frac{1}{2}(A \pm B)$$

$$\tan(A \pm B) = \frac{\tan A \pm \tan B}{1 \mp \tan A \tan B}$$

$$\cot(A \pm B) = \frac{\cot A \cot B \mp 1}{\cot B \pm \cot A}$$

$$\tan A + \tan B = \frac{\sin(A+B)}{\cos A \cos B}$$

$$\tan A - \tan B = \frac{\sin(A-B)}{\cos A \cos B}$$

$$\cot A + \cot B = \frac{\sin(B+A)}{\sin A \sin B}$$

$$\cot A - \cot B = \frac{\sin(B-A)}{\sin A \sin B}$$

$$\tan 2A = \frac{2 \tan A}{1 - \tan^2 A}$$

$$\cot 2A = \frac{\cot^2 A - 1}{2 \cot A}$$

$$\tan \frac{1}{2} A = \frac{\sin A}{1 + \cos A} \quad \cot \frac{1}{2} A = \frac{\sin A}{1 - \cos A}$$

$$\tan^2 A = \frac{1 - \cos 2A}{1 + \cos 2A} \quad \cot^2 A = \frac{1 + \cos 2A}{1 - \cos 2A}$$

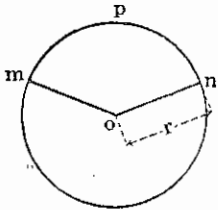
$$\cos^2 A - \sin^2 B = \cos(A+B) \cos(A-B)$$

$$\frac{\sin A \pm \sin B}{\cos B - \cos A} = \cot \frac{1}{2}(A \mp B)$$

Quadrant	Angles				Angle		
	I	II	III	IV	30°	45°	60°
Angles	0° to 90°	90° to 180°	180° to 270°	270° to 360°	30°	45°	60°
Functions	Values vary from				Equivalent values		
sin	+0 to +1	+1 to +0	-0 to -1	-1 to -0	½	½√2	½√3
cos	+1 to +0	-0 to -1	-1 to -0	+0 to +1	½√3	½√2	½
tan	+0 to +∞	-∞ to -0	+0 to +∞	-∞ to -0	½√3	1	√3
cot	+∞ to +0	-0 to -∞	+∞ to +0	-0 to -∞	√3	1	½√3

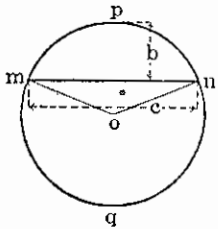
Angle a < 90°				
Angle	sin	cos	tan	cot
φ°	φ°	φ°	φ°	φ°
0° ± a	± sin a	+ cos a	± tan a	± cot a
90° ± a	+ cos a	∓ sin a	∓ cot a	∓ tan a
180° ± a	∓ sin a	- cos a	± tan a	± cot a
270° ± a	- cos a	± sin a	∓ cot a	∓ tan a

## AREA OF CIRCULAR SECTIONS



### Circular Sector, m o n p

$$\begin{aligned} \text{Area} &= \frac{1}{2} (\text{length of arc, } m p n \times \text{radius, } r) \\ &= \text{area of circle} \times \frac{\text{arc } m p n, \text{ in degrees}}{360} \\ &= 0.0087266 \times \text{square of radius, } r^2, \times \text{angle of arc, } m p n, \text{ in degrees.} \end{aligned}$$



### Circular Segment, m p n, less than half circle.

$$\begin{aligned} \text{Area} &= \text{area of sector, } m o n p - \text{area of triangle, } m o n \\ &= \frac{(\text{length of arc, } m p n, \times \text{radius, } r) - (\text{radius, } r, \times \text{rise, } b) \times \text{chord, } c}{2} \end{aligned}$$

### Circular Segment, m q n, greater than half circle.

$$\text{Area} = \text{area of circle} - \text{area of segment, } m n p$$

### Circular Segment, from Table I, page 369.

Given: rise, b, and chord, c.

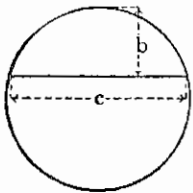
Area = product of rise and chord, b x c, multiplied by the coefficient given opposite the quotient of  $\frac{b}{c}$ :

Intermediate coefficients for values of  $\frac{b}{c}$  not given in tables are obtained by interpolation.

Example - Given: rise = 1.49 and chord = 3.52,

$$\frac{b}{c} = \frac{1.49}{3.52} = 0.4233. \quad \text{Coefficient} = 0.7542.$$

$$\text{Area} = b \times c \times \text{coeff.} = 1.49 \times 3.52 \times 0.7542 = 3.9556.$$



### Circular Segment, from Table II, pages 370 and 371.

Given: rise, b, and diameter, d = 2r.

Area = square of diameter, d<sup>2</sup>, multiplied by the coefficient given opposite the quotient of  $\frac{b}{d}$ .

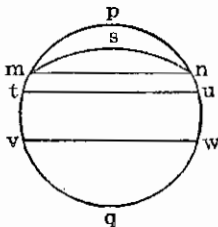
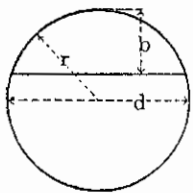
Intermediate coefficients for values of  $\frac{b}{d}$  not given in tables are obtained by interpolation.

Example - Given: rise = 2 $\frac{7}{10}$  and diameter = 5 $\frac{3}{32}$ .

$$\frac{b}{d} = 2\frac{7}{10} \div 5\frac{3}{32} = 0.478528.$$

Coefficient by interpolation = 0.371233.

$$\text{Area} = d^2 \times \text{coeff.} = 25.94629 \times 0.371233 = 9.6321$$



### Circular Zone, t u w v

$$\text{Area} = \text{area of circle} - (\text{area of segment, } t p u + \text{area of segment, } v q w).$$

### Circular Lune, m p n s

$$\text{Area} = \text{segment, } m p n - \text{segment, } m s n.$$

### PROPERTIES OF THE CIRCLE

Circumference of Circle of Dia. 1 =  $\pi = 3.14159265$

Circumference of Circle =  $2 \pi r$

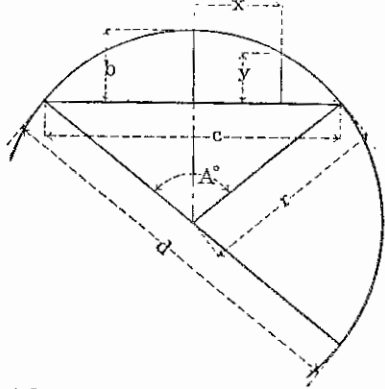
Dia. of Circle = Circumference  $\times 0.31831$

Diameter of Circle of equal periphery as square = side  $\times 1.27324$

Side of Square of equal periphery as circle = diameter  $\times 0.78540$

Diameter of Circle circumscribed about square = side  $\times 1.41421$

Side of Square inscribed in Circle = diameter  $\times 0.70711$



$$\text{Arc, } a = \frac{\pi r A^\circ}{180} = 0.017453 r A^\circ$$

$$\text{Angle, } A = \frac{180^\circ a}{\pi r} = 57.29578 \frac{a}{r}$$

$$\text{Radius, } r = \frac{4b^2 + c^2}{8b} \quad \text{Diameter, } d = \frac{4b^2 + c^2}{4b}$$

$$\text{Chord, } c = 2\sqrt{2br - b^2} = 2r \sin \frac{A^\circ}{2}$$

$$\text{Rise, } b = r - \frac{1}{2}\sqrt{4r^2 - c^2} = \frac{c}{2} \tan \frac{A^\circ}{4} = 2r \sin^2 \frac{A}{4}$$

$$\text{Rise, } b = r + y - \sqrt{r^2 - x^2} \quad y = b - r + \sqrt{r^2 - x^2} \quad x = \sqrt{r^2 - (r + y - b)^2}$$

$$\pi = 3.14159265, \log = 0.4971499$$

$$\frac{1}{\pi} = 0.3183099, \log = \bar{1}.5028501$$

$$\pi^2 = 9.8696044, \log = 0.9942997$$

$$\frac{1}{\pi^2} = 0.1013212, \log = \bar{1}.0057003$$

$$\sqrt{\pi} = 1.7724539, \log = 0.2485749$$

$$\sqrt{\frac{1}{\pi}} = 0.5641896, \log = \bar{1}.7514251$$

$$\frac{\pi}{180} = 0.0174533, \log = \bar{2}.2418774$$

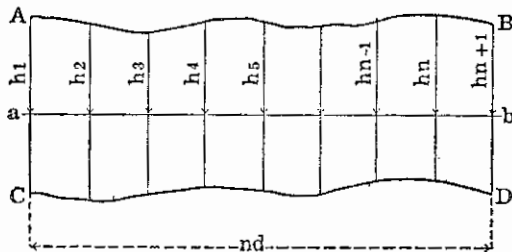
$$\frac{180}{\pi} = 57.2957795, \log = 1.7581226$$



### AREA OF PLANE FIGURES

- Triangle:** Base x  $\frac{1}{2}$  perpendicular height.  
 $\sqrt{s(s-a)(s-b)(s-c)}$ ,  
 $s = \frac{1}{2}$  sum of the three sides a, b and c.
- Trapezium:** Sum of area of the two triangles.
- Trapezoid:**  $\frac{1}{2}$  sum of parallel sides x perpendicular height.
- Parallelogram:** Base x perpendicular height.
- Regular Polygon:**  $\frac{1}{2}$  sum of sides x inside radius.
- Circle:**  $\pi r^2 = 0.78540 \times \text{dia.}^2 = 0.07958 \times \text{circumference}^2$ .
- Sector of Circle:**  $\frac{\pi r^2 A^\circ}{360} = 0.0087266 r^2 A^\circ = \text{arc} \times \frac{1}{2} \text{ radius}$ .
- Segment of Circle:**  $\frac{r^2}{2} \left( \frac{\pi A^\circ}{180} - \sin A^\circ \right)$
- Circle of same area as square:** diameter = side x 1.12838
- Square of same area as circle:** side = diameter x 0.88623
- Ellipse:** Long diameter x short diameter x 0.78540
- Parabola:** Base x  $\frac{2}{3}$  perpendicular height.

#### Irregular plane surface.



Divide any plane surface A, B, C, D, along a line a-b into an even number, n, of parallel and sufficiently small strips, d, whose ordinates are  $h_1, h_2, h_3, h_4, h_5, \dots, h_{n-1}, h_n, h_{n+1}$ , and considering contours between three ordinates as parabolic curves, then for section ABCD,

$$\text{Area} = \frac{d}{3} [h_1 + h_{n+1} + 4(h_2 + h_4 + h_6 \dots + h_n) + 2(h_3 + h_5 + h_7 \dots + h_{n-1})]$$

or, approximately, Area = Sum of ordinates x width, d.

## DECIMAL OF AN INCH AND OF A FOOT

Fractions of Inch or Foot	Inch Equivalents to Foot Fractions	Fractions of Inch or Foot	Inch Equivalents to Foot Fractions	Fractions of Inch or Foot	Inch Equivalents to Foot Fractions	Fractions of Inch or Foot	Inch Equivalents to Foot Fractions
.0052	$\frac{1}{10}$	.2552	$\frac{31}{10}$	.5052	$\frac{61}{10}$	.7552	$\frac{91}{10}$
.0104	$\frac{1}{8}$	.2604	$\frac{31}{8}$	.5104	$\frac{61}{8}$	.7604	$\frac{91}{8}$
$\frac{1}{64}$ .015625	$\frac{9}{10}$	$\frac{17}{64}$ .265625	$\frac{39}{64}$	$\frac{39}{64}$ .515625	$\frac{69}{64}$	$\frac{49}{64}$ .765625	$\frac{99}{64}$
.0208	$\frac{1}{4}$	.2708	$\frac{31}{4}$	.5208	$\frac{61}{4}$	.7708	$\frac{91}{4}$
.0260	$\frac{5}{16}$	.2760	$\frac{35}{16}$	.5260	$\frac{65}{16}$	.7760	$\frac{95}{16}$
$\frac{1}{32}$ .03125	$\frac{3}{8}$	$\frac{9}{32}$ .28125	$\frac{33}{8}$	$\frac{17}{32}$ .53125	$\frac{63}{8}$	$\frac{25}{32}$ .78125	$\frac{93}{8}$
.0365	$\frac{7}{10}$	.2865	$\frac{37}{10}$	.5365	$\frac{67}{10}$	.7865	$\frac{97}{10}$
.0417	$\frac{1}{2}$	.2917	$\frac{31}{2}$	.5417	$\frac{61}{2}$	.7917	$\frac{91}{2}$
$\frac{3}{64}$ .046875	$\frac{9}{16}$	$\frac{19}{64}$ .296875	$\frac{39}{16}$	$\frac{35}{64}$ .546875	$\frac{69}{16}$	$\frac{51}{64}$ .796875	$\frac{91}{16}$
.0521	$\frac{5}{8}$	.3021	$\frac{35}{8}$	.5521	$\frac{65}{8}$	.8021	$\frac{95}{8}$
.0573	$\frac{11}{16}$	.3073	$\frac{311}{16}$	.5573	$\frac{611}{16}$	.8073	$\frac{911}{16}$
$\frac{1}{10}$ .0625	$\frac{3}{4}$	$\frac{5}{10}$ .3125	$\frac{31}{4}$	$\frac{9}{10}$ .5625	$\frac{61}{4}$	$\frac{18}{10}$ .8125	$\frac{91}{4}$
.0677	$\frac{13}{16}$	.3177	$\frac{313}{16}$	.5677	$\frac{613}{16}$	.8177	$\frac{913}{16}$
.0729	$\frac{7}{8}$	.3229	$\frac{37}{8}$	.5729	$\frac{67}{8}$	.8229	$\frac{97}{8}$
$\frac{5}{64}$ .078125	$\frac{15}{16}$	$\frac{21}{64}$ .328125	$\frac{315}{16}$	$\frac{37}{64}$ .578125	$\frac{615}{16}$	$\frac{53}{64}$ .828125	$\frac{915}{16}$
.0833	1	.3333	4	.5833	7	.8333	10
.0885	$\frac{11}{16}$	.3385	$\frac{41}{16}$	.5885	$\frac{71}{16}$	.8385	$\frac{101}{16}$
$\frac{3}{32}$ .09375	$\frac{11}{8}$	$\frac{11}{32}$ .34375	$\frac{41}{8}$	$\frac{19}{32}$ .59375	$\frac{71}{8}$	$\frac{27}{32}$ .84375	$\frac{101}{8}$
.0990	$\frac{13}{10}$	.3490	$\frac{43}{10}$	.5990	$\frac{73}{10}$	.8490	$\frac{103}{10}$
.1042	$\frac{11}{4}$	.3542	$\frac{41}{4}$	.6042	$\frac{71}{4}$	.8542	$\frac{101}{4}$
$\frac{7}{64}$ .109375	$\frac{15}{16}$	$\frac{23}{64}$ .359375	$\frac{45}{16}$	$\frac{39}{64}$ .609375	$\frac{75}{16}$	$\frac{55}{64}$ .859375	$\frac{105}{16}$
.1146	$\frac{13}{8}$	.3646	$\frac{43}{8}$	.6146	$\frac{73}{8}$	.8646	$\frac{103}{8}$
.1198	$\frac{17}{16}$	.3698	$\frac{47}{16}$	.6198	$\frac{77}{16}$	.8698	$\frac{107}{16}$
$\frac{1}{8}$ .1250	$\frac{11}{2}$	$\frac{3}{8}$ .3750	$\frac{41}{2}$	$\frac{5}{8}$ .6250	$\frac{71}{2}$	$\frac{7}{8}$ .8750	$\frac{101}{2}$
.1302	$\frac{19}{10}$	.3802	$\frac{49}{10}$	.6302	$\frac{79}{10}$	.8802	$\frac{109}{10}$
.1354	$\frac{15}{8}$	.3854	$\frac{43}{8}$	.6354	$\frac{73}{8}$	.8854	$\frac{103}{8}$
$\frac{9}{64}$ .140625	$\frac{111}{16}$	$\frac{25}{64}$ .390625	$\frac{411}{16}$	$\frac{41}{64}$ .640625	$\frac{711}{16}$	$\frac{57}{64}$ .890625	$\frac{1011}{16}$
.1458	$\frac{13}{4}$	.3958	$\frac{43}{4}$	.6458	$\frac{73}{4}$	.8958	$\frac{103}{4}$
.1510	$\frac{113}{16}$	.4010	$\frac{413}{16}$	.6510	$\frac{713}{16}$	.9010	$\frac{1013}{16}$
$\frac{5}{32}$ .15625	$\frac{17}{8}$	$\frac{13}{32}$ .40625	$\frac{47}{8}$	$\frac{21}{32}$ .65625	$\frac{77}{8}$	$\frac{29}{32}$ .90625	$\frac{107}{8}$
.1615	$\frac{115}{16}$	.4115	$\frac{415}{16}$	.6615	$\frac{715}{16}$	.9115	$\frac{1015}{16}$
.1667	2	.4167	5	.6667	8	.9167	11
$\frac{11}{64}$ .171875	$\frac{21}{16}$	$\frac{27}{64}$ .421875	$\frac{51}{16}$	$\frac{43}{64}$ .671875	$\frac{81}{16}$	$\frac{59}{64}$ .921875	$\frac{111}{16}$
.1771	$\frac{21}{8}$	.4271	$\frac{51}{8}$	.6771	$\frac{81}{8}$	.9271	$\frac{111}{8}$
.1823	$\frac{23}{16}$	.4323	$\frac{53}{16}$	.6823	$\frac{83}{16}$	.9323	$\frac{113}{16}$
$\frac{3}{10}$ .1875	$\frac{21}{4}$	$\frac{7}{10}$ .4375	$\frac{51}{4}$	$\frac{11}{10}$ .6875	$\frac{81}{4}$	$\frac{15}{10}$ .9375	$\frac{111}{4}$
.1927	$\frac{25}{10}$	.4427	$\frac{55}{10}$	.6927	$\frac{85}{10}$	.9427	$\frac{115}{10}$
.1979	$\frac{23}{8}$	.4479	$\frac{53}{8}$	.6979	$\frac{83}{8}$	.9479	$\frac{113}{8}$
$\frac{13}{64}$ .203125	$\frac{27}{16}$	$\frac{29}{64}$ .453125	$\frac{57}{16}$	$\frac{45}{64}$ .703125	$\frac{87}{16}$	$\frac{61}{64}$ .953125	$\frac{117}{16}$
.2083	$\frac{21}{2}$	.4583	$\frac{51}{2}$	.7083	$\frac{81}{2}$	.9583	$\frac{111}{2}$
.2135	$\frac{29}{16}$	.4635	$\frac{59}{16}$	.7135	$\frac{83}{16}$	.9635	$\frac{113}{16}$
$\frac{7}{32}$ .21875	$\frac{25}{8}$	$\frac{15}{32}$ .46875	$\frac{55}{8}$	$\frac{23}{32}$ .71875	$\frac{85}{8}$	$\frac{31}{32}$ .96875	$\frac{115}{8}$
.2240	$\frac{211}{10}$	.4740	$\frac{511}{10}$	.7240	$\frac{811}{10}$	.9740	$\frac{1111}{10}$
.2292	$\frac{23}{4}$	.4792	$\frac{53}{4}$	.7292	$\frac{83}{4}$	.9792	$\frac{113}{4}$
$\frac{15}{64}$ .234375	$\frac{213}{16}$	$\frac{31}{64}$ .484375	$\frac{513}{16}$	$\frac{47}{64}$ .734375	$\frac{813}{16}$	$\frac{63}{64}$ .984375	$\frac{1113}{16}$
.2396	$\frac{27}{8}$	.4896	$\frac{57}{8}$	.7396	$\frac{87}{8}$	.9896	$\frac{117}{8}$
.2448	$\frac{215}{16}$	.4948	$\frac{515}{16}$	.7448	$\frac{815}{16}$	.9948	$\frac{1115}{16}$
$\frac{1}{4}$ .2500	3	$\frac{1}{2}$ .5000	6	$\frac{3}{4}$ .7500	9	1.0000	12

# UNITED STATES STANDARD GAGE

FOR

## SHEET AND PLATE IRON AND STEEL

Gage Number	Approximate Thickness			Weight per Square Foot, Ounces, Avoirdupois	Weight per Square Foot, Pounds, Avoirdupois	Weight per Square Meter, Kilograms
	Fractional Inches	Decimal Inches	Millimeters			
0000000	1/2	.5	12.7	320	20.00	97.65
000000	15/32	.46875	11.90625	300	18.75	91.55
00000	7/16	.4375	11.1125	280	17.50	85.44
0000	13/32	.40625	10.31875	260	16.25	79.33
000	3/8	.375	9.525	240	15.00	73.24
00	11/32	.34375	8.73125	220	13.75	67.13
0	5/16	.3125	7.9375	200	12.50	61.03
1	9/32	.28125	7.14375	180	11.25	54.93
2	17/64	.265625	6.746875	170	10.625	51.88
3	1/4	.25	6.35	160	10.00	48.82
4	15/64	.234375	5.953125	150	9.375	45.77
5	7/32	.21875	5.55625	140	8.75	42.72
6	13/64	.203125	5.159375	130	8.125	39.67
7	3/16	.1875	4.7625	120	7.50	36.62
8	11/64	.171875	4.365625	110	6.875	33.57
9	5/32	.15625	3.96875	100	6.25	30.52
10	9/64	.140625	3.571875	90	5.625	27.46
11	1/8	.125	3.175	80	5.00	24.41
12	7/64	.109375	2.778125	70	4.375	21.36
13	3/32	.09375	2.38125	60	3.75	18.31
14	5/64	.078125	1.984375	50	3.125	15.26
15	9/128	.0703125	1.7859375	45	2.8125	13.73
16	1/16	.0625	1.5875	40	2.50	12.21
17	7/100	.05625	1.42875	36	2.25	10.99
18	1/20	.05	1.27	32	2.00	9.765
19	7/160	.04375	1.11125	28	1.75	8.544
20	3/80	.0375	.9525	24	1.50	7.324
21	11/420	.034375	.873125	22	1.375	6.713
22	1/32	.03125	.793750	20	1.25	6.103
23	9/320	.028125	.714375	18	1.125	5.493
24	1/40	.025	.635	16	1.00	4.882
25	7/320	.021875	.555625	14	.875	4.272
26	3/180	.01875	.47625	12	.75	3.662
27	11/640	.0171875	.4365625	11	.6875	3.357
28	1/64	.015625	.396875	10	.625	3.052
29	9/640	.0140625	.3571875	9	.5625	2.746
30	1/80	.0125	.3175	8	.50	2.441
31	7/640	.0109375	.2778125	7	.4375	2.136
32	13/1280	.01015625	.25796875	6 1/2	.40625	1.983
33	3/920	.009375	.238125	6	.375	1.831
34	11/1280	.00859375	.21828125	5 1/2	.34375	1.678
35	5/640	.0078125	.1984375	5	.3125	1.526
36	9/1280	.00703125	.17859375	4 1/2	.28125	1.373
37	17/2500	.006640625	.168671875	4 1/4	.265625	1.297
38	1/100	.00625	.15875	4	.25	1.221

The United States Standard Gage is a weight gage based upon the weights per square foot in ounces avoirdupois and approximate thickness based upon 480 pounds per cubic foot.

In the practical use and application of the United States Standard Gage, a weight variation of 2 1/2 per cent either way may be allowed.

**BIRMINGHAM WIRE GAGE**  
**EQUIVALENTS IN INCHES**  
**CORRESPONDING WEIGHTS OF FLAT ROLLED STEEL**

Gage Number	Thickness, Inches	Pounds per Square Foot	Thickness, Inches		Pounds per Square Foot
			Fractional	Decimal	
.....	.....	.....	$\frac{1}{2}$	.5	20.4
0000	.454	18.5232	$\frac{15}{32}$	.46875	19.125
000	.425	17.34	$\frac{7}{16}$	.4375	17.85
.....	.....	.....	$\frac{13}{32}$	.40625	16.575
00	.380	15.504	$\frac{3}{8}$	.375	15.3
0	.340	13.872	$\frac{11}{32}$	.34375	14.025
.....	.....	.....	$\frac{5}{16}$	.3125	12.75
1	.300	12.24	$\frac{19}{64}$	.296875	12.1125
2	.284	11.5872	$\frac{9}{32}$	.28125	11.475
3	.259	10.5672	$\frac{17}{64}$	.265625	10.8375
.....	.....	.....	$\frac{1}{4}$	.25	10.2
4	.238	9.7104	$\frac{15}{64}$	.234375	9.5625
5	.220	8.976	$\frac{7}{32}$	.21875	8.925
6	.203	8.2824	$\frac{13}{64}$	.203125	8.2875
7	.180	7.344	$\frac{3}{16}$	.1875	7.65
8	.165	6.732	$\frac{11}{64}$	.171875	7.0125
9	.148	6.0384	$\frac{5}{32}$	.15625	6.375
10	.134	5.4672	$\frac{9}{64}$	.140625	5.7375
11	.120	4.896	$\frac{3}{8}$	.125	5.1
12	.109	4.4472	$\frac{7}{64}$	.109375	4.4625
13	.095	3.876	$\frac{3}{32}$	.09375	3.825
14	.083	3.3864	$\frac{5}{64}$	.078125	3.1875
15	.072	2.9376	..	.....	.....
16	.065	2.652	$\frac{1}{16}$	.0625	2.55
17	.058	2.3664	..	.....	.....
18	.049	1.992	$\frac{3}{64}$	.046875	1.9125
19	.042	1.7136	..	.....	.....
20	.035	1.428	..	.....	.....
21	.032	1.3056	$\frac{1}{32}$	.03125	1.275
22	.028	1.1424	..	.....	.....
23	.025	1.02	..	.....	.....
24	.022	0.8976	..	.....	.....
25	.020	0.816	..	.....	.....
26	.018	0.7344	..	.....	.....
27	.016	0.6528	$\frac{1}{64}$	.015625	0.6375
28	.014	0.5712	..	.....	.....
29	.013	0.5304	..	.....	.....
30	.012	0.4896	..	.....	.....
31	.010	0.408	..	.....	.....
32	.009	0.3672	..	.....	.....
33	.008	0.3264	$\frac{1}{128}$	.0078125	0.31875
34	.007	0.2856	..	.....	.....
35	.005	0.2040	..	.....	.....
36	.004	0.1632	$\frac{1}{256}$	.00390625	0.159375

TABLE 36.—USEFUL NUMBERS AND FORMULAS

Title	Symbol	Number
Ratio of circumference to diameter . . . . .	$\pi$	3.1415927
Reciprocal of same . . . . .	$\frac{1}{\pi}$	0.3183099
Degrees in arc of length equal to radius . . . . .	$\frac{180^\circ}{\pi}$	57.295780
Minutes in arc of length equal to radius . . . . .	$\frac{10800'}{\pi}$	3437.7468
Seconds in arc of length equal to radius . . . . .	$\frac{648000''}{\pi}$	206264.81
Length of 1° arc, radius unity . . . . .	$\frac{\pi}{180^\circ}$	0.01745329
Length of 1' arc, radius unity . . . . .	$\frac{\pi}{10800}$	0.00029089
Length of 1'' arc, radius unity . . . . .	$\frac{\pi}{648000}$	0.000004848
Radius by which 1 foot of arc = 1 degree . . . . .		57.295780
Radius by which $\frac{1}{60}$ foot of arc = 1 minute . . . . .		343.77468
Radius by which $\frac{1}{600}$ foot of arc = 10 seconds . . . . .		206.26481
Factors for dividing a line into extreme and mean ratio . . . . . {		0.6180340
		0.3819660
Base of hyperbolic logarithms . . . . .	$e$	2.7182818
Modulus of common system of logs = log $e$ . . . . .	$M$	0.4342945
Reciprocal of same = hyp. log. 10 . . . . .	$\frac{1}{M}$	2.3025851
Length of seconds pendulum at New York in inches (at 125 feet above sea level) . . . . .		39.10299
Length of seconds pendulum at New York in feet . . . . .		3.25858
Acceleration due to gravity at New York . . . . .	$g$	32.1609
Square root of same . . . . .	$\sqrt{g}$	5.67106
Yards in 1 meter . . . . .		1.093611
Feet in 1 meter . . . . .		3.280833
Inches in 1 meter . . . . .		39.37
Meters in 1 foot . . . . .		0.304801
Meters in 1 yard . . . . .		0.914418
Meters in 1 mile . . . . .		1609.344
Cubic inches in 1 U. S. gallon . . . . .		231.
Cubic inches in 1 Imperial gallon . . . . .		277.274
Cubic inches in 1 U. S. bushel . . . . .		2150.42

TABLE 36.—USEFUL NUMBERS AND FORMULAS

Title	Symbol	Number
Cubic feet in 1 U. S. gallon.....		0.133681
Cubic feet in 1 Imperial gallon.....		0.160459
Cubic feet in 1 U. S. bushel.....		1.244456
Weight of 1 cubic foot of water, barometer 30 in., thermometer 39°.83 Fahrenheit; pounds...		62.379
thermometer 62° Fahrenheit; pounds.....		62.321
Weight in grains, 1 cubic inch, at 62° Fahrenheit		252.458
Number of grains in 1 pound avoirdupois....		7000.
Number of grains in 1 ounce avoirdupois.....		437.5

LENGTHS OF CIRCULAR ARCS

Let  $r$  = radius of circular arc of length  $l$ , the central angle of which is  $a$  in degrees. Then

$$a^\circ : 360^\circ :: l : 2\pi r$$

or

$$a^\circ = \frac{l}{r} \frac{180^\circ}{\pi}$$

and

$$r = \frac{l}{a^\circ} \frac{180^\circ}{\pi} \quad \text{and} \quad l = \frac{\pi}{180^\circ} a^\circ r = .0174533a^\circ r$$

In place of the table previously given for this last formula the following abridgment may prove of service.

Coefficients for Finding Lengths of Circular Arcs

	Degrees	Minutes	Seconds
1	0.01745329	0.00029089	0.00000484
2	0.03490658	0.00058178	0.00000970
3	0.05235988	0.00087267	0.00001454
4	0.06981317	0.00116355	0.00001939
5	0.08726646	0.00145444	0.00002424
6	0.10471976	0.00174533	0.00002909
7	0.12217305	0.00203622	0.00003394
8	0.13962634	0.00232711	0.00003878
9	0.15707963	0.00261799	0.00004363

**Example.** To find the length of arc for a circle of radius 20 ft. and central angle of 18° 24' 30".

$$\begin{aligned} \text{Coefficient for } 10^\circ &= 0.1745329 \\ 8^\circ &= .1396263 \\ 20' &= .0058178 \\ 4' &= .0011636 \\ 30'' &= .0001454 \\ \hline 0.3212860 \quad \text{times } 20 &= 6.426 \end{aligned}$$

Circumference of circle (radius = $r$ ).....	$2\pi r$
Area of circle.....	$\pi r^2$
Area of sector (length of arc = $l$ ).....	$\frac{1}{2}lr$
Area of sector (angle of arc = $a^\circ$ ).....	$\frac{a}{360} \pi r^2$
Approximate area of segment (chord = $c$ , mid. ord. = $m$ ).....	$\frac{2}{3}cm$

## NATURAL SINES AND COSINES

	0°		1°		2°		
	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	0.000000	1.000000	0.0174524	0.9998477	0.0348995	0.9993908	60
1	.0002909	1.000000	.0177432	.9998426	.0351902	.9993806	59
2	.0005818	.9999998	.0180341	.9998374	.0354809	.9993704	58
3	.0008727	.9999996	.0183249	.9998321	.0357716	.9993600	57
4	.0011636	.9999993	.0186158	.9998267	.0360623	.9993495	56
5	.0014544	.9999989	.0189066	.9998213	.0363530	.9993390	55
6	.0017453	.9999985	.0191974	.9998157	.0366437	.9993284	54
7	.0020362	.9999979	.0194883	.9998101	.0369344	.9993177	53
8	.0023271	.9999973	.0197791	.9998044	.0372251	.9993069	52
9	.0026180	.9999966	.0200699	.9997986	.0375158	.9992960	51
10	0.0029089	0.9999958	0.0203608	0.9997927	0.0378065	0.9992851	50
11	.0031998	.9999949	.0206516	.9997867	.0380971	.9992740	49
12	.0034907	.9999939	.0209424	.9997807	.0383878	.9992629	48
13	.0037815	.9999928	.0212332	.9997745	.0386785	.9992517	47
14	.0040724	.9999917	.0215241	.9997683	.0389692	.9992404	46
15	.0043633	.9999905	.0218149	.9997620	.0392598	.9992290	45
16	.0046542	.9999892	.0221057	.9997556	.0395505	.9992176	44
17	.0049451	.9999878	.0223965	.9997492	.0398411	.9992060	43
18	.0052360	.9999863	.0226873	.9997426	.0401318	.9991944	42
19	.0055268	.9999847	.0229781	.9997360	.0404224	.9991827	41
20	0.0058177	0.9999831	0.0232690	0.9997292	0.0407131	0.9991709	40
21	.0061086	.9999813	.0235598	.9997224	.0410037	.9991590	39
22	.0063995	.9999795	.0238506	.9997155	.0412944	.9991470	38
23	.0066904	.9999776	.0241414	.9997086	.0415850	.9991350	37
24	.0069813	.9999756	.0244322	.9997015	.0418757	.9991228	36
25	.0072722	.9999736	.0247230	.9996943	.0421663	.9991106	35
26	.0075630	.9999714	.0250138	.9996871	.0424569	.9990983	34
27	.0078539	.9999692	.0253046	.9996798	.0427475	.9990859	33
28	.0081448	.9999668	.0255954	.9996724	.0430382	.9990734	32
29	.0084357	.9999644	.0258862	.9996649	.0433288	.9990609	31
30	0.0087265	0.9999619	0.0261769	0.9996573	0.0436194	0.9990482	40
31	.0090174	.9999593	.0264677	.9996497	.0439100	.9990355	29
32	.0093083	.9999567	.0267585	.9996419	.0442006	.9990227	28
33	.0095992	.9999539	.0270493	.9996341	.0444912	.9990098	27
34	.0098900	.9999511	.0273401	.9996262	.0447818	.9989968	26
35	.0101800	.9999482	.0276309	.9996182	.0450724	.9989837	25
36	.0104718	.9999452	.0279216	.9996101	.0453630	.9989706	24
37	.0107627	.9999421	.0282124	.9996020	.0456536	.9989573	23
38	.0110535	.9999389	.0285032	.9995937	.0459442	.9989440	22
39	.0113444	.9999357	.0287940	.9995854	.0462347	.9989306	21
40	0.0116353	0.9999323	0.0290847	0.9995770	0.0465253	0.9989171	20
41	.0119261	.9999289	.0293755	.9995684	.0468159	.9989035	19
42	.0122170	.9999254	.0296662	.9995599	.0471065	.9988899	18
43	.0125079	.9999218	.0299570	.9995512	.0473970	.9988761	17
44	.0127987	.9999181	.0302478	.9995424	.0476876	.9988623	16
45	.0130896	.9999143	.0305385	.9995336	.0479781	.9988484	15
46	.0133805	.9999105	.0308293	.9995247	.0482687	.9988344	14
47	.0136713	.9999065	.0311200	.9995157	.0485592	.9988203	13
48	.0139622	.9999025	.0314108	.9995066	.0488498	.9988061	12
49	.0142530	.9998984	.0317015	.9994974	.0491403	.9987919	11
50	0.0145439	0.9998942	0.0319922	0.9994881	0.0494308	0.9987775	10
51	.0148348	.9998900	.0322830	.9994788	.0497214	.9987631	9
52	.0151256	.9998856	.0325737	.9994693	.0500119	.9987486	8
53	.0154165	.9998812	.0328644	.9994598	.0503024	.9987340	7
54	.0157073	.9998766	.0331552	.9994502	.0505929	.9987194	6
55	.0159982	.9998720	.0334459	.9994405	.0508835	.9987046	5
56	.0162890	.9998673	.0337366	.9994308	.0511740	.9986898	4
57	.0165799	.9998625	.0340274	.9994209	.0514645	.9986748	3
58	.0168707	.9998577	.0343181	.9994110	.0517550	.9986598	2
59	.0171616	.9998527	.0346088	.9994009	.0520455	.9986447	1
60	0.0174524	0.9998477	0.0348995	0.9993908	0.0523360	0.9986295	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	
	89°		88°		87°		

## NATURAL SINES AND COSINES

	3°		4°		5°		
	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	0.0523360	0.9986295	0.0697565	0.9975641	0.0871557	0.9961947	60
1	.0526264	.9986143	.0700467	.9975437	.0874455	.9961693	59
2	.0529169	.9985989	.0703368	.9975233	.0877353	.9961438	58
3	.0532074	.9985835	.0706270	.9975028	.0880251	.9961183	57
4	.0534979	.9985680	.0709171	.9974822	.0883148	.9960926	56
5	.0537883	.9985524	.0712073	.9974615	.0886046	.9960669	55
6	.0540788	.9985367	.0714974	.9974408	.0888943	.9960411	54
7	.0543693	.9985209	.0717876	.9974199	.0891840	.9960152	53
8	.0546597	.9985050	.0720777	.9973990	.0894738	.9959892	52
9	.0549502	.9984891	.0723678	.9973780	.0897635	.9959631	51
10	0.0552406	0.9984731	0.0726580	0.9973569	0.0900532	0.9959370	50
11	.0555311	.9984570	.0729481	.9973357	.0903429	.9959107	49
12	.0558215	.9984408	.0732382	.9973145	.0906326	.9958844	48
13	.0561119	.9984245	.0735283	.9972931	.0909223	.9958580	47
14	.0564024	.9984081	.0738184	.9972717	.0912119	.9958315	46
15	.0566928	.9983917	.0741085	.9972502	.0915016	.9958049	45
16	.0569832	.9983751	.0743986	.9972286	.0917913	.9957783	44
17	.0572736	.9983585	.0746887	.9972069	.0920809	.9957515	43
18	.0575640	.9983418	.0749787	.9971851	.0923706	.9957247	42
19	.0578544	.9983250	.0752688	.9971633	.0926602	.9956978	41
20	0.0581448	0.9983082	0.0755589	0.9971413	0.0929499	0.9956708	40
21	.0584352	.9982912	.0758489	.9971193	.0932395	.9956437	39
22	.0587256	.9982742	.0761390	.9970972	.0935291	.9956165	38
23	.0590160	.9982570	.0764290	.9970750	.0938187	.9955893	37
24	.0593064	.9982398	.0767190	.9970528	.0941083	.9955620	36
25	.0595967	.9982225	.0770091	.9970304	.0943979	.9955345	35
26	.0598871	.9982052	.0772991	.9970080	.0946875	.9955070	34
27	.0601775	.9981877	.0775891	.9969854	.0949771	.9954795	33
28	.0604678	.9981701	.0778791	.9969628	.0952666	.9954518	32
29	.0607582	.9981525	.0781691	.9969401	.0955562	.9954240	31
30	0.0610485	0.9981348	0.0784591	0.9969173	0.0958458	0.9953962	30
31	.0613389	.9981170	.0787491	.9968945	.0961353	.9953683	29
32	.0616292	.9980991	.0790391	.9968715	.0964248	.9953403	28
33	.0619196	.9980811	.0793290	.9968485	.0967144	.9953122	27
34	.0622099	.9980631	.0796190	.9968254	.0970039	.9952840	26
35	.0625002	.9980450	.0799090	.9968022	.0972934	.9952557	25
36	.0627905	.9980267	.0801989	.9967789	.0975829	.9952274	24
37	.0630808	.9980084	.0804889	.9967555	.0978724	.9951990	23
38	.0633711	.9979900	.0807788	.9967321	.0981619	.9951705	22
39	.0636614	.9979716	.0810687	.9967085	.0984514	.9951419	21
40	0.0639517	0.9979530	0.0813587	0.9966849	0.0987408	0.9951132	20
41	.0642420	.9979343	.0816486	.9966612	.0990303	.9950844	19
42	.0645323	.9979156	.0819385	.9966374	.0993197	.9950556	18
43	.0648226	.9978968	.0822284	.9966135	.0996092	.9950266	17
44	.0651129	.9978779	.0825183	.9965895	.0998986	.9949976	16
45	.0654031	.9978589	.0828082	.9965655	.1001881	.9949685	15
46	.0656934	.9978399	.0830981	.9965414	.1004775	.9949393	14
47	.0659836	.9978207	.0833880	.9965172	.1007669	.9949101	13
48	.0662739	.9978015	.0836778	.9964929	.1010563	.9948807	12
49	.0665641	.9977821	.0839677	.9964685	.1013457	.9948513	11
50	0.0668544	0.9977627	0.0842576	0.9964440	0.1016351	0.9948217	10
51	.0671446	.9977433	.0845474	.9964195	.1019245	.9947921	9
52	.0674349	.9977237	.0848373	.9963948	.1022138	.9947625	8
53	.0677251	.9977040	.0851271	.9963701	.1025032	.9947327	7
54	.0680153	.9976843	.0854169	.9963453	.1027925	.9947028	6
55	.0683055	.9976645	.0857067	.9963204	.1030819	.9946729	5
56	.0685957	.9976445	.0859966	.9962954	.1033712	.9946428	4
57	.0688859	.9976245	.0862864	.9962704	.1036605	.9946127	3
58	.0691761	.9976045	.0865762	.9962452	.1039499	.9945825	2
59	.0694663	.9975843	.0868660	.9962200	.1042392	.9945523	1
60	0.0697565	0.9975641	0.0871557	0.9961947	0.1045285	0.9945219	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	
	86°		85°		84°		



## NATURAL SINES AND COSINES

	6°		7°		8°		
	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	0.1045285	0.9945219	0.1218693	0.9925462	0.1391731	0.9902681	60
1	.1048178	.9944914	.1221581	.9925107	.1394612	.9902275	59
2	.1051070	.9944609	.1224468	.9924751	.1397492	.9901869	58
3	.1053963	.9944303	.1227355	.9924394	.1400372	.9901462	57
4	.1056856	.9943996	.1230241	.9924037	.1403252	.9901055	56
5	.1059748	.9943688	.1233128	.9923679	.1406132	.9900646	55
6	.1062641	.9943379	.1236015	.9923319	.1409012	.9900237	54
7	.1065533	.9943070	.1238901	.9922959	.1411892	.9899826	53
8	.1068425	.9942760	.1241788	.9922599	.1414772	.9899415	52
9	.1071318	.9942448	.1244674	.9922237	.1417651	.9899003	51
10	0.1074210	0.9942136	0.1247560	0.9921874	0.1420531	0.9898590	50
11	.1077102	.9941823	.1250446	.9921511	.1423410	.9898177	49
12	.1079994	.9941510	.1253332	.9921147	.1426289	.9897762	48
13	.1082885	.9941195	.1256218	.9920782	.1429168	.9897347	47
14	.1085777	.9940880	.1259104	.9920416	.1432047	.9896931	46
15	.1088669	.9940563	.1261990	.9920049	.1434926	.9896514	45
16	.1091560	.9940246	.1264875	.9919682	.1437805	.9896096	44
17	.1094452	.9939928	.1267761	.9919314	.1440684	.9895677	43
18	.1097343	.9939610	.1270646	.9918944	.1443562	.9895258	42
19	.1100234	.9939290	.1273531	.9918574	.1446440	.9894838	41
20	0.1103126	0.9938969	0.1276416	0.9918204	0.1449319	0.9894416	40
21	.1106017	.9938648	.1279302	.9917832	.1452197	.9893994	39
22	.1108908	.9938326	.1282186	.9917459	.1455075	.9893572	38
23	.1111799	.9938003	.1285071	.9917086	.1457953	.9893148	37
24	.1114689	.9937679	.1287956	.9916712	.1460830	.9892723	36
25	.1117580	.9937355	.1290841	.9916337	.1463708	.9892298	35
26	.1120471	.9937029	.1293725	.9915961	.1466585	.9891872	34
27	.1123361	.9936703	.1296609	.9915584	.1469463	.9891445	33
28	.1126252	.9936375	.1299494	.9915206	.1472340	.9891017	32
29	.1129142	.9936047	.1302378	.9914828	.1475217	.9890588	31
30	0.1132032	0.9935719	0.1305262	0.9914449	0.1478094	0.9890159	30
31	.1134922	.9935389	.1308146	.9914069	.1480971	.9889728	29
32	.1137812	.9935058	.1311030	.9913688	.1483848	.9889297	28
33	.1140702	.9934727	.1313913	.9913306	.1486724	.9888865	27
34	.1143592	.9934395	.1316797	.9912923	.1489601	.9888432	26
35	.1146482	.9934062	.1319681	.9912540	.1492477	.9887998	25
36	.1149372	.9933728	.1322564	.9912155	.1495353	.9887564	24
37	.1152261	.9933393	.1325447	.9911770	.1498230	.9887128	23
38	.1155151	.9933057	.1328330	.9911384	.1501106	.9886692	22
39	.1158040	.9932721	.1331213	.9910997	.1503981	.9886255	21
40	0.1160929	0.9932384	0.1334096	0.9910610	0.1506857	0.9885817	20
41	.1163818	.9932045	.1336979	.9910221	.1509733	.9885378	19
42	.1166707	.9931706	.1339862	.9909832	.1512608	.9884939	18
43	.1169596	.9931367	.1342744	.9909442	.1515484	.9884498	17
44	.1172485	.9931026	.1345627	.9909051	.1518359	.9884057	16
45	.1175374	.9930685	.1348509	.9908659	.1521234	.9883615	15
46	.1178263	.9930342	.1351392	.9908266	.1524109	.9883172	14
47	.1181151	.9929999	.1354274	.9907873	.1526984	.9882728	13
48	.1184040	.9929655	.1357156	.9907478	.1529858	.9882284	12
49	.1186928	.9929310	.1360038	.9907083	.1532733	.9881838	11
50	0.1189816	0.9928965	0.1362919	0.9906687	0.1535607	0.9881392	10
51	.1192704	.9928618	.1365801	.9906290	.1538482	.9880945	9
52	.1195593	.9928271	.1368683	.9905893	.1541356	.9880497	8
53	.1198481	.9927922	.1371564	.9905495	.1544230	.9880048	7
54	.1201368	.9927573	.1374445	.9905095	.1547104	.9879599	6
55	.1204256	.9927224	.1377327	.9904694	.1549978	.9879148	5
56	.1207144	.9926873	.1380208	.9904293	.1552851	.9878697	4
57	.1210031	.9926521	.1383089	.9903891	.1555725	.9878245	3
58	.1212919	.9926169	.1385970	.9903489	.1558598	.9877792	2
59	.1215806	.9925816	.1388850	.9903085	.1561472	.9877338	1
60	0.1218693	0.9925462	0.1391731	0.9902681	0.1564345	0.9876883	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	
	83°		82°		81°		

## NATURAL SINES AND COSINES

	9°		10°		11°		
	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	0.1564345	0.9876883	0.1736482	0.9848078	0.1908090	0.9816272	60
1	.1567218	.9876428	.1739346	.9847572	.1910945	.9815716	59
2	.1570091	.9875972	.1742211	.9847066	.1913801	.9815160	58
3	.1572963	.9875514	.1745075	.9846558	.1916656	.9814603	57
4	.1575836	.9875057	.1747939	.9846050	.1919510	.9814045	56
5	.1578708	.9874598	.1750803	.9845542	.1922365	.9813486	55
6	.1581581	.9874138	.1753667	.9845032	.1925220	.9812927	54
7	.1584453	.9873678	.1756531	.9844521	.1928074	.9812366	53
8	.1587325	.9873216	.1759395	.9844010	.1930928	.9811805	52
9	.1590197	.9872754	.1762258	.9843498	.1933782	.9811243	51
10	0.1593069	0.9872291	0.1765121	0.9842985	0.1936636	0.9810680	50
11	.1595940	.9871827	.1767984	.9842471	.1939490	.9810116	49
12	.1598812	.9871363	.1770847	.9841956	.1942344	.9809552	48
13	.1601683	.9870897	.1773710	.9841441	.1945197	.9808986	47
14	.1604555	.9870431	.1776573	.9840924	.1948050	.9808420	46
15	.1607426	.9869964	.1779435	.9840407	.1950903	.9807853	45
16	.1610297	.9869496	.1782298	.9839889	.1953756	.9807285	44
17	.1613167	.9869027	.1785160	.9839370	.1956609	.9806716	43
18	.1616038	.9868557	.1788022	.9838850	.1959461	.9806147	42
19	.1618909	.9868087	.1790884	.9838330	.1962314	.9805576	41
20	0.1621779	0.9867615	0.1793746	0.9837808	0.1965166	0.9805005	40
21	.1624650	.9867143	.1796607	.9837286	.1968018	.9804433	39
22	.1627520	.9866670	.1799469	.9836763	.1970870	.9803860	38
23	.1630390	.9866196	.1802330	.9836239	.1973722	.9803286	37
24	.1633260	.9865722	.1805191	.9835715	.1976573	.9802712	36
25	.1636129	.9865246	.1808052	.9835189	.1979425	.9802136	35
26	.1638999	.9864770	.1810913	.9834663	.1982276	.9801560	34
27	.1641868	.9864293	.1813774	.9834136	.1985127	.9800983	33
28	.1644738	.9863815	.1816635	.9833608	.1987978	.9800405	32
29	.1647607	.9863336	.1819495	.9833079	.1990829	.9799827	31
30	0.1650476	0.9862856	0.1822355	0.9832549	0.1993679	0.9799247	30
31	.1653345	.9862375	.1825215	.9832019	.1996530	.9798667	29
32	.1656214	.9861894	.1828075	.9831487	.1999380	.9798086	28
33	.1659082	.9861412	.1830935	.9830955	.2002230	.9797504	27
34	.1661951	.9860929	.1833795	.9830422	.2005080	.9796921	26
35	.1664819	.9860445	.1836654	.9829888	.2007930	.9796337	25
36	.1667687	.9859960	.1839514	.9829353	.2010779	.9795752	24
37	.1670556	.9859475	.1842373	.9828818	.2013629	.9795167	23
38	.1673423	.9858988	.1845232	.9828282	.2016478	.9794581	22
39	.1676291	.9858501	.1848091	.9827744	.2019327	.9793994	21
40	0.1679159	0.9858013	0.1850949	0.9827206	0.2022176	0.9793406	20
41	.1682026	.9857524	.1853808	.9826668	.2025024	.9792818	19
42	.1684894	.9857035	.1856666	.9826128	.2027873	.9792228	18
43	.1687761	.9856544	.1859524	.9825587	.2030721	.9791638	17
44	.1690628	.9856053	.1862382	.9825046	.2033569	.9791047	16
45	.1693495	.9855561	.1865240	.9824504	.2036418	.9790455	15
46	.1696362	.9855068	.1868098	.9823961	.2039265	.9789862	14
47	.1699228	.9854574	.1870956	.9823417	.2042113	.9789268	13
48	.1702095	.9854079	.1873813	.9822873	.2044961	.9788674	12
49	.1704961	.9853583	.1876670	.9822327	.2047808	.9788079	11
50	0.1707828	0.9853087	0.1879528	0.9821781	0.2050655	0.9787483	10
51	.1710694	.9852590	.1882385	.9821234	.2053502	.9786886	9
52	.1713560	.9852092	.1885241	.9820686	.2056349	.9786288	8
53	.1716425	.9851593	.1888098	.9820137	.2059195	.9785689	7
54	.1719291	.9851093	.1890954	.9819587	.2062042	.9785090	6
55	.1722156	.9850593	.1893811	.9819037	.2064888	.9784490	5
56	.1725022	.9850091	.1896667	.9818485	.2067734	.9783889	4
57	.1727887	.9849589	.1899523	.9817933	.2070580	.9783287	3
58	.1730752	.9849086	.1902379	.9817380	.2073426	.9782684	2
59	.1733617	.9848582	.1905234	.9816826	.2076272	.9782080	1
60	0.1736482	0.9848078	0.1908090	0.9816272	0.2079117	0.9781476	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	
	80°		79°		78°		

## NATURAL SINES AND COSINES

	12°		13°		14°		
	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	0.2079117	0.9781476	0.2249511	0.9743701	0.2419219	0.9702957	60
1	.2081962	.9780871	.2252345	.9743046	.2422041	.9702253	59
2	.2084807	.9780265	.2255179	.9742390	.2424863	.9701548	58
3	.2087652	.9779658	.2258013	.9741734	.2427685	.9700842	57
4	.2090497	.9779050	.2260846	.9741077	.2430507	.9700136	56
5	.2093341	.9778442	.2263680	.9740419	.2433329	.9699428	55
6	.2096186	.9777832	.2266513	.9739760	.2436150	.9698720	54
7	.2099030	.9777222	.2269346	.9739100	.2438971	.9698011	53
8	.2101874	.9776611	.2272179	.9738439	.2441792	.9697301	52
9	.2104718	.9775999	.2275012	.9737778	.2444613	.9696591	51
10	0.2107561	0.9775387	0.2277844	0.9737116	0.2447433	0.9695879	50
11	.2110405	.9774773	.2280677	.9736453	.2450254	.9695167	49
12	.2113248	.9774159	.2283509	.9735789	.2453074	.9694453	48
13	.2116091	.9773544	.2286341	.9735124	.2455894	.9693740	47
14	.2118934	.9772928	.2289172	.9734459	.2458713	.9693025	46
15	.2121777	.9772311	.2292004	.9733793	.2461533	.9692309	45
16	.2124619	.9771693	.2294835	.9733125	.2464352	.9691593	44
17	.2127462	.9771075	.2297666	.9732458	.2467171	.9690875	43
18	.2130304	.9770456	.2300497	.9731789	.2469990	.9690157	42
19	.2133146	.9769836	.2303328	.9731119	.2472809	.9689438	41
20	0.2135988	0.9769215	0.2306159	0.9730449	0.2475627	0.9688719	40
21	.2138829	.9768593	.2308989	.9729777	.2478445	.9687998	39
22	.2141671	.9767970	.2311819	.9729105	.2481263	.9687277	38
23	.2144512	.9767347	.2314649	.9728432	.2484081	.9686555	37
24	.2147353	.9766723	.2317479	.9727759	.2486899	.9685832	36
25	.2150194	.9766098	.2320309	.9727084	.2489716	.9685108	35
26	.2153035	.9765472	.2323138	.9726409	.2492533	.9684383	34
27	.2155876	.9764845	.2325967	.9725733	.2495350	.9683658	33
28	.2158716	.9764218	.2328796	.9725056	.2498167	.9682931	32
29	.2161556	.9763589	.2331625	.9724378	.2500984	.9682204	31
30	0.2164396	0.9762960	0.2334454	0.9723699	0.2503800	0.9681476	30
31	.2167236	.9762330	.2337282	.9723020	.2506616	.9680748	29
32	.2170076	.9761699	.2340110	.9722339	.2509432	.9680018	28
33	.2172915	.9761068	.2342938	.9721658	.2512248	.9679288	27
34	.2175754	.9760435	.2345766	.9720976	.2515063	.9678557	26
35	.2178593	.9759802	.2348594	.9720294	.2517879	.9677825	25
36	.2181432	.9759168	.2351421	.9719610	.2520694	.9677092	24
37	.2184271	.9758533	.2354248	.9718926	.2523508	.9676358	23
38	.2187110	.9757897	.2357075	.9718240	.2526323	.9675624	22
39	.2189948	.9757260	.2359902	.9717554	.2529137	.9674888	21
40	0.2192786	0.9756623	0.2362729	0.9716867	0.2531952	0.9674152	20
41	.2195624	.9755985	.2365555	.9716180	.2534766	.9673415	19
42	.2198462	.9755345	.2368381	.9715491	.2537579	.9672678	18
43	.2201300	.9754706	.2371207	.9714802	.2540393	.9671939	17
44	.2204137	.9754065	.2374033	.9714112	.2543206	.9671200	16
45	.2206974	.9753423	.2376859	.9713421	.2546019	.9670459	15
46	.2209811	.9752781	.2379684	.9712729	.2548832	.9669718	14
47	.2212648	.9752138	.2382510	.9712036	.2551645	.9668977	13
48	.2215485	.9751494	.2385335	.9711343	.2554458	.9668234	12
49	.2218321	.9750849	.2388159	.9710649	.2557270	.9667490	11
50	0.2221158	0.9750203	0.2390984	0.9709953	0.2560082	0.9666746	10
51	.2223994	.9749556	.2393808	.9709258	.2562894	.9666001	9
52	.2226830	.9748909	.2396633	.9708561	.2565705	.9665255	8
53	.2229666	.9748261	.2399457	.9707863	.2568517	.9664508	7
54	.2232501	.9747612	.2402280	.9707165	.2571328	.9663761	6
55	.2235337	.9746962	.2405104	.9706466	.2574139	.9663012	5
56	.2238172	.9746311	.2407927	.9705766	.2576950	.9662263	4
57	.2241007	.9745660	.2410751	.9705065	.2579760	.9661513	3
58	.2243842	.9745008	.2413574	.9704363	.2582570	.9660762	2
59	.2246676	.9744355	.2416396	.9703661	.2585381	.9660011	1
60	0.2249511	0.9743701	0.2419219	0.9702957	0.2588190	0.9659258	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	
	77°		76°		75°		

## NATURAL SINES AND COSINES

15°		16°		17°			
Sine	Cosine	Sine	Cosine	Sine	Cosine		
0	0.2588190	0.9659258	0.2756374	0.9612617	0.2923717	0.9563048	60
1	.2591000	.9658505	.2759170	.9611815	.2926499	.9562197	59
2	.2593810	.9657751	.2761965	.9611012	.2929280	.9561345	58
3	.2596619	.9656996	.2764761	.9610208	.2932061	.9560492	57
4	.2599428	.9656240	.2767556	.9609403	.2934842	.9559639	56
5	.2602237	.9655484	.2770352	.9608598	.2937623	.9558785	55
6	.2605045	.9654726	.2773147	.9607792	.2940403	.9557930	54
7	.2607853	.9653968	.2775941	.9606984	.2943183	.9557074	53
8	.2610662	.9653209	.2778736	.9606177	.2945963	.9556218	52
9	.2613469	.9652449	.2781530	.9605368	.2948743	.9555361	51
10	0.2616277	0.9651689	0.2784324	0.9604558	0.2951522	0.9554502	50
11	.2619085	.9650927	.2787118	.9603748	.2954302	.9553643	49
12	.2621892	.9650165	.2789911	.9602937	.2957081	.9552784	48
13	.2624699	.9649402	.2792704	.9602125	.2959859	.9551923	47
14	.2627506	.9648638	.2795497	.9601312	.2962638	.9551062	46
15	.2630312	.9647873	.2798290	.9600499	.2965416	.9550199	45
16	.2633118	.9647108	.2801083	.9599684	.2968194	.9549336	44
17	.2635925	.9646341	.2803875	.9598869	.2970971	.9548473	43
18	.2638730	.9645574	.2806667	.9598053	.2973749	.9547608	42
19	.2641536	.9644806	.2809459	.9597236	.2976526	.9546743	41
20	0.2644342	0.9644037	0.2812251	0.9596418	0.2979303	0.9545876	40
21	.2647147	.9643268	.2815042	.9595600	.2982079	.9545009	39
22	.2649952	.9642497	.2817833	.9594781	.2984856	.9544141	38
23	.2652757	.9641726	.2820624	.9593961	.2987632	.9543273	37
24	.2655561	.9640954	.2823415	.9593140	.2990408	.9542403	36
25	.2658366	.9640181	.2826205	.9592318	.2993184	.9541533	35
26	.2661170	.9639407	.2828995	.9591496	.2995959	.9540662	34
27	.2663973	.9638633	.2831785	.9590672	.2998734	.9539790	33
28	.2666777	.9637858	.2834575	.9589848	.3001509	.9538917	32
29	.2669581	.9637081	.2837364	.9589023	.3004284	.9538044	31
30	0.2672384	0.9636305	0.2840153	0.9588197	0.3007058	0.9537170	30
31	.2675187	.9635527	.2842942	.9587371	.3009832	.9536294	29
32	.2677989	.9634748	.2845731	.9586543	.3012606	.9535418	28
33	.2680792	.9633969	.2848520	.9585715	.3015380	.9534542	27
34	.2683594	.9633189	.2851308	.9584886	.3018153	.9533664	26
35	.2686396	.9632408	.2854096	.9584056	.3020926	.9532786	25
36	.2689198	.9631626	.2856884	.9583226	.3023699	.9531907	24
37	.2692000	.9630843	.2859671	.9582394	.3026471	.9531027	23
38	.2694801	.9630060	.2862458	.9581562	.3029244	.9530146	22
39	.2697602	.9629275	.2865246	.9580729	.3032016	.9529264	21
40	0.2700403	0.9628490	0.2868032	0.9579895	0.3034788	0.9528382	20
41	.2703204	.9627704	.2870819	.9579060	.3037559	.9527499	19
42	.2706004	.9626917	.2873605	.9578225	.3040331	.9526615	18
43	.2708805	.9626130	.2876391	.9577389	.3043102	.9525730	17
44	.2711605	.9625342	.2879177	.9576552	.3045872	.9524844	16
45	.2714404	.9624552	.2881963	.9575714	.3048643	.9523958	15
46	.2717204	.9623762	.2884748	.9574875	.3051413	.9523071	14
47	.2720003	.9622972	.2887533	.9574035	.3054183	.9522183	13
48	.2722802	.9622180	.2890318	.9573195	.3056953	.9521294	12
49	.2725601	.9621387	.2893103	.9572354	.3059723	.9520404	11
50	0.2728400	0.9620594	0.2895887	0.9571512	0.3062492	0.9519514	10
51	.2731198	.9619800	.2898671	.9570669	.3065261	.9518623	9
52	.2733997	.9619005	.2901455	.9569825	.3068030	.9517731	8
53	.2736794	.9618210	.2904239	.9568981	.3070798	.9516838	7
54	.2739592	.9617413	.2907022	.9568136	.3073566	.9515944	6
55	.2742390	.9616616	.2909805	.9567290	.3076334	.9515050	5
56	.2745187	.9615818	.2912588	.9566443	.3079102	.9514154	4
57	.2747984	.9615019	.2915371	.9565595	.3081869	.9513258	3
58	.2750781	.9614219	.2918153	.9564747	.3084636	.9512361	2
59	.2753577	.9613418	.2920935	.9563898	.3087403	.9511464	1
60	0.2756374	0.9612617	0.2923717	0.9563048	0.3090170	0.9510565	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	
	74°		73°		72°		

## NATURAL SINES AND COSINES

	18°		19°		20°		
	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	0.3090170	0.9510565	0.3255682	0.9455186	0.3420201	0.9396926	60
1	.3092936	.9509666	.3258432	.9454238	.3422935	.9395931	59
2	.3095702	.9508766	.3261182	.9453290	.3425668	.9394935	58
3	.3098468	.9507865	.3263932	.9452341	.3428400	.9393938	57
4	.3101234	.9506963	.3266681	.9451391	.3431133	.9392940	56
5	.3103999	.9506061	.3269430	.9450441	.3433865	.9391942	55
6	.3106764	.9505157	.3272179	.9449489	.3436597	.9390943	54
7	.3109529	.9504253	.3274928	.9448537	.3439329	.9389942	53
8	.3112294	.9503348	.3277676	.9447584	.3442060	.9388942	52
9	.3115058	.9502443	.3280424	.9446630	.3444791	.9387940	51
10	0.3117822	0.9501536	0.3283172	0.9445675	0.3447521	0.9386938	50
11	.3120586	.9500629	.3285919	.9444720	.3450252	.9385834	49
12	.3123349	.9499721	.3288666	.9443764	.3452982	.9384930	48
13	.3126112	.9498812	.3291413	.9442807	.3455712	.9383925	47
14	.3128875	.9497902	.3294160	.9441849	.3458441	.9382920	46
15	.3131638	.9496991	.3296906	.9440890	.3461171	.9381913	45
16	.3134400	.9496080	.3299653	.9439931	.3463900	.9380906	44
17	.3137163	.9495168	.3302398	.9438971	.3466628	.9379898	43
18	.3139925	.9494255	.3305144	.9438010	.3469357	.9378889	42
19	.3142686	.9493341	.3307889	.9437048	.3472085	.9377880	41
20	0.3145448	0.9492426	0.3310634	0.9436085	0.3474812	0.9376869	40
21	.3148209	.9491511	.3313379	.9435122	.3477540	.9375858	39
22	.3150969	.9490595	.3316123	.9434157	.3480267	.9374846	38
23	.3153730	.9489678	.3318867	.9433192	.3482994	.9373833	37
24	.3156490	.9488760	.3321611	.9432227	.3485720	.9372820	36
25	.3159250	.9487842	.3324355	.9431260	.3488447	.9371806	35
26	.3162010	.9486922	.3327098	.9430293	.3491173	.9370790	34
27	.3164770	.9486002	.3329841	.9429324	.3493898	.9369774	33
28	.3167529	.9485081	.3332584	.9428355	.3496624	.9368758	32
29	.3170288	.9484159	.3335326	.9427386	.3499349	.9367740	31
30	0.3173047	0.9483237	0.3338069	0.9426415	0.3502074	0.9366722	30
31	.3175805	.9482313	.3340810	.9425444	.3504798	.9365703	29
32	.3178563	.9481389	.3343552	.9424471	.3507523	.9364683	28
33	.3181321	.9480464	.3346293	.9423498	.3510246	.9363662	27
34	.3184079	.9479538	.3349034	.9422525	.3512970	.9362641	26
35	.3186836	.9478612	.3351775	.9421550	.3515693	.9361618	25
36	.3189593	.9477684	.3354516	.9420575	.3518416	.9360595	24
37	.3192350	.9476756	.3357256	.9419598	.3521139	.9359571	23
38	.3195106	.9475827	.3359996	.9418621	.3523862	.9358547	22
39	.3197863	.9474897	.3362735	.9417644	.3526584	.9357521	21
40	0.3200619	0.9473966	0.3365475	0.9416665	0.3529306	0.9356495	20
41	.3203374	.9473035	.3368214	.9415686	.3532027	.9355468	19
42	.3206130	.9472103	.3370953	.9414705	.3534748	.9354440	18
43	.3208885	.9471170	.3373691	.9413724	.3537469	.9353412	17
44	.3211640	.9470236	.3376429	.9412743	.3540190	.9352382	16
45	.3214395	.9469301	.3379167	.9411760	.3542910	.9351352	15
46	.3217149	.9468366	.3381905	.9410777	.3545630	.9350321	14
47	.3219903	.9467430	.3384642	.9409793	.3548350	.9349289	13
48	.3222657	.9466493	.3387379	.9408808	.3551070	.9348257	12
49	.3225411	.9465555	.3390116	.9407822	.3553789	.9347223	11
50	0.3228164	0.9464616	0.3392852	0.9406835	0.3556508	0.9346189	10
51	.3230917	.9463677	.3395589	.9405848	.3559226	.9345154	9
52	.3233670	.9462736	.3398325	.9404860	.3561944	.9344119	8
53	.3236422	.9461795	.3401060	.9403871	.3564662	.9343082	7
54	.3239174	.9460854	.3403796	.9402881	.3567380	.9342045	6
55	.3241926	.9459911	.3406531	.9401891	.3570097	.9341007	5
56	.3244678	.9458968	.3409265	.9400899	.3572814	.9339968	4
57	.3247429	.9458023	.3412000	.9399907	.3575531	.9338928	3
58	.3250180	.9457078	.3414734	.9398914	.3578248	.9337888	2
59	.3252931	.9456132	.3417468	.9397921	.3580964	.9336846	1
60	0.3255682	0.9455186	0.3420201	0.9396926	0.3583679	0.9335804	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	
	71°		70°		69°		

## NATURAL SINES AND COSINES

	21°		22°		23°		
	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	0.3583679	0.9335804	0.3746066	0.9271839	0.3907311	0.9205049	60
1	.3586395	.9334761	.3748763	.9270748	.3909989	.9203912	59
2	.3589110	.9333718	.3751459	.9269658	.3912666	.9202774	58
3	.3591825	.9332673	.3754156	.9268566	.3915343	.9201635	57
4	.3594540	.9331628	.3756852	.9267474	.3918019	.9200496	56
5	.3597254	.9330582	.3759547	.9266380	.3920695	.9199356	55
6	.3599968	.9329535	.3762243	.9265286	.3923371	.9198215	54
7	.3602682	.9328488	.3764938	.9264192	.3926047	.9197073	53
8	.3605395	.9327439	.3767632	.9263096	.3928722	.9195931	52
9	.3608108	.9326390	.3770327	.9262000	.3931397	.9194788	51
10	0.3610821	0.9325340	0.3773021	0.9260902	0.3934071	0.9193644	50
11	.3613534	.9324290	.3775714	.9259805	.3936745	.9193499	49
12	.3616246	.9323238	.3778408	.9258706	.3939419	.9191353	48
13	.3618958	.9322186	.3781101	.9257606	.3942093	.9190207	47
14	.3621669	.9321133	.3783794	.9256506	.3944766	.9189060	46
15	.3624380	.9320079	.3786486	.9255404	.3947439	.9187912	45
16	.3627091	.9319024	.3789178	.9254303	.3950111	.9186763	44
17	.3629802	.9317969	.3791870	.9253201	.3952783	.9185614	43
18	.3632512	.9316912	.3794562	.9252097	.3955455	.9184464	42
19	.3635222	.9315855	.3797253	.9250993	.3958127	.9183313	41
20	0.3637932	0.9314797	0.3799944	0.9249888	0.3960798	0.9182161	40
21	.3640641	.9313739	.3802634	.9248782	.3963468	.9181009	39
22	.3643351	.9312679	.3805324	.9247676	.3966139	.9179855	38
23	.3646059	.9311619	.3808014	.9246568	.3968809	.9178701	37
24	.3648768	.9310558	.3810704	.9245460	.3971479	.9177546	36
25	.3651476	.9309496	.3813393	.9244351	.3974148	.9176391	35
26	.3654184	.9308434	.3816082	.9243242	.3976818	.9175234	34
27	.3656891	.9307370	.3818770	.9242131	.3979486	.9174077	33
28	.3659599	.9306306	.3821459	.9241020	.3982155	.9172919	32
29	.3662306	.9305241	.3824147	.9239908	.3984823	.9171760	31
30	0.3665012	0.9304176	0.3826834	0.9238795	0.3987491	0.9170601	30
31	.3667719	.9303109	.3829522	.9237682	.3990158	.9169440	29
32	.3670425	.9302042	.3832209	.9236567	.3992825	.9168279	28
33	.3673130	.9300974	.3834895	.9235452	.3995492	.9167118	27
34	.3675836	.9299905	.3837582	.9234336	.3998158	.9165955	26
35	.3678541	.9298835	.3840268	.9233220	.4000825	.9164791	25
36	.3681246	.9297765	.3842953	.9232102	.4003490	.9163627	24
37	.3683950	.9296694	.3845639	.9230984	.4006156	.9162462	23
38	.3686654	.9295622	.3848324	.9229865	.4008821	.9161297	22
39	.3689358	.9294549	.3851008	.9228745	.4011486	.9160130	21
40	0.3692061	0.9293475	0.3853693	0.9227624	0.4014150	0.9158963	20
41	.3694765	.9292401	.3856377	.9226503	.4016814	.9157795	19
42	.3697468	.9291326	.3859060	.9225381	.4019478	.9156626	18
43	.3700170	.9290250	.3861744	.9224258	.4022141	.9155456	17
44	.3702872	.9289173	.3864427	.9223134	.4024804	.9154286	16
45	.3705574	.9288096	.3867110	.9222010	.4027467	.9153115	15
46	.3708276	.9287017	.3869792	.9220884	.4030129	.9151943	14
47	.3710977	.9285938	.3872474	.9219758	.4032791	.9150770	13
48	.3713678	.9284858	.3875156	.9218632	.4035453	.9149597	12
49	.3716379	.9283778	.3877837	.9217504	.4038114	.9148422	11
50	0.3719079	0.9282696	0.3880518	0.9216375	0.4040775	0.9147247	10
51	.3721780	.9281614	.3883199	.9215246	.4043436	.9146072	9
52	.3724479	.9280531	.3885880	.9214116	.4046096	.9144895	8
53	.3727179	.9279447	.3888560	.9212986	.4048756	.9143718	7
54	.3729878	.9278363	.3891240	.9211854	.4051416	.9142540	6
55	.3732577	.9277277	.3893919	.9210722	.4054075	.9141361	5
56	.3735275	.9276191	.3896598	.9209589	.4056734	.9140181	4
57	.3737973	.9275104	.3899277	.9208455	.4059393	.9139001	3
58	.3740671	.9274016	.3901955	.9207320	.4062051	.9137819	2
59	.3743369	.9272928	.3904633	.9206185	.4064709	.9136637	1
60	0.3746066	0.9271839	0.3907311	0.9205049	0.4067366	0.9135455	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	
	68°		67°		66°		

## NATURAL SINES AND COSINES

	24°		25°		26°		
	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	0.4067366	0.9135455	0.4226183	0.9063078	0.4383711	0.8987940	60
1	.4070024	.9134271	.4228819	.9061848	.4386326	.8986665	59
2	.4072681	.9133087	.4231455	.9060618	.4388940	.8985389	58
3	.4075337	.9131902	.4234090	.9059386	.4391553	.8984112	57
4	.4077993	.9130716	.4236725	.9058154	.4394166	.8982834	56
5	.4080649	.9129529	.4239360	.9056922	.4396779	.8981555	55
6	.4083305	.9128342	.4241994	.9055688	.4399392	.8980276	54
7	.4085960	.9127154	.4244628	.9054454	.4402004	.8978996	53
8	.4088615	.9125965	.4247262	.9053219	.4404615	.8977715	52
9	.4091269	.9124775	.4249895	.9051983	.4407227	.8976433	51
10	0.4093923	0.9123584	0.4252528	0.9050746	0.4409838	0.8975151	50
11	.4096577	.9122393	.4255161	.9049509	.4412448	.8973868	49
12	.4099230	.9121201	.4257793	.9048271	.4415059	.8972584	48
13	.4101883	.9120008	.4260425	.9047032	.4417668	.8971299	47
14	.4104536	.9118815	.4263056	.9045792	.4420278	.8970014	46
15	.4107189	.9117620	.4265687	.9044551	.4422887	.8968727	45
16	.4109841	.9116425	.4268318	.9043310	.4425496	.8967440	44
17	.4112492	.9115229	.4270949	.9042068	.4428104	.8966153	43
18	.4115144	.9114033	.4273579	.9040825	.4430712	.8964864	42
19	.4117795	.9112835	.4276208	.9039582	.4433319	.8963575	41
20	0.4120445	0.9111637	0.4278838	0.9038338	0.4435927	0.8962285	40
21	.4123096	.9110438	.4281467	.9037093	.4438534	.8960994	39
22	.4125745	.9109238	.4284095	.9035847	.4441140	.8959703	38
23	.4128395	.9108038	.4286723	.9034600	.4443746	.8958411	37
24	.4131044	.9106837	.4289351	.9033353	.4446352	.8957118	36
25	.4133693	.9105635	.4291979	.9032105	.4448957	.8955824	35
26	.4136342	.9104432	.4294606	.9030856	.4451562	.8954529	34
27	.4138990	.9103228	.4297233	.9029606	.4454167	.8953234	33
28	.4141638	.9102024	.4299859	.9028356	.4456771	.8951938	32
29	.4144285	.9100819	.4302485	.9027105	.4459375	.8950641	31
30	0.4146932	0.9099613	0.4305111	0.9025853	0.4461978	0.8949344	30
31	.4149579	.9098406	.4307736	.9024600	.4464581	.8948045	29
32	.4152226	.9097199	.4310361	.9023347	.4467184	.8946746	28
33	.4154872	.9095990	.4312986	.9022092	.4469786	.8945446	27
34	.4157517	.9094781	.4315610	.9020838	.4472388	.8944146	26
35	.4160163	.9093572	.4318234	.9019582	.4474990	.8942844	25
36	.4162808	.9092361	.4320857	.9018325	.4477591	.8941542	24
37	.4165453	.9091150	.4323481	.9017068	.4480192	.8940240	23
38	.4168097	.9089938	.4326103	.9015810	.4482792	.8938936	22
39	.4170741	.9088725	.4328726	.9014551	.4485392	.8937632	21
40	0.4173385	0.9087511	0.4331348	0.9013292	0.4487992	0.8936326	20
41	.4176028	.9086297	.4333970	.9012031	.4490591	.8935021	19
42	.4178671	.9085082	.4336591	.9010770	.4493190	.8933714	18
43	.4181313	.9083866	.4339212	.9009508	.4495789	.8932406	17
44	.4183956	.9082649	.4341832	.9008246	.4498387	.8931098	16
45	.4186597	.9081432	.4344453	.9006982	.4500984	.8929789	15
46	.4189239	.9080214	.4347072	.9005718	.4503582	.8928480	14
47	.4191880	.9078995	.4349692	.9004453	.4506179	.8927169	13
48	.4194521	.9077775	.4352311	.9003188	.4508775	.8925858	12
49	.4197161	.9076554	.4354930	.9001921	.4511372	.8924546	11
50	0.4199801	0.9075333	0.4357548	0.9000654	0.4513967	0.8923234	10
51	.4202441	.9074111	.4360166	.8999386	.4516563	.8921920	9
52	.4205080	.9072888	.4362784	.8998117	.4519158	.8920606	8
53	.4207719	.9071665	.4365401	.8996848	.4521753	.8919291	7
54	.4210358	.9070440	.4368018	.8995578	.4524347	.8917975	6
55	.4212996	.9069215	.4370634	.8994307	.4526941	.8916659	5
56	.4215634	.9067989	.4373251	.8993035	.4529535	.8915342	4
57	.4218272	.9066762	.4375866	.8991763	.4532128	.8914024	3
58	.4220909	.9065535	.4378482	.8990489	.4534721	.8912705	2
59	.4223546	.9064307	.4381097	.8989215	.4537313	.8911385	1
60	0.4226183	0.9063078	0.4383711	0.8987940	0.4539905	0.8910065	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	
	65°		64°		63°		

## NATURAL SINES AND COSINES

	27°		28°		29°		
	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	0.4539905	0.8910065	0.4694716	0.8829476	0.4848096	0.8746197	60
1	.4542497	.8908744	.4697284	.8828110	.4850640	.8744786	59
2	.4545088	.8907423	.4699852	.8826743	.4853184	.8743375	58
3	.4547679	.8906100	.4702419	.8825376	.4855727	.8741963	57
4	.4550269	.8904777	.4704986	.8824007	.4858270	.8740550	56
5	.4552859	.8903453	.4707553	.8822638	.4860812	.8739137	55
6	.4555449	.8902128	.4710119	.8821269	.4863354	.8737722	54
7	.4558038	.8900803	.4712685	.8819898	.4865895	.8736307	53
8	.4560627	.8899476	.4715250	.8818527	.4868436	.8734891	52
9	.4563216	.8898149	.4717815	.8817155	.4870977	.8733475	51
10	0.4565804	0.8896822	0.4720380	0.8815782	0.4873517	0.8732058	50
11	.4568392	.8895493	.4722944	.8814409	.4876057	.8730640	49
12	.4570979	.8894164	.4725508	.8813035	.4878597	.8729221	48
13	.4573566	.8892834	.4728071	.8811660	.4881136	.8727801	47
14	.4576153	.8891503	.4730634	.8810284	.4883674	.8726381	46
15	.4578739	.8890171	.4733197	.8808907	.4886212	.8724960	45
16	.4581325	.8888839	.4735759	.8807530	.4888750	.8723538	44
17	.4583910	.8887506	.4738321	.8806152	.4891288	.8722116	43
18	.4586496	.8886172	.4740882	.8804774	.4893825	.8720693	42
19	.4589080	.8884838	.4743443	.8803394	.4896361	.8719269	41
20	0.4591665	0.8883503	0.4746004	0.8802014	0.4898897	0.8717844	40
21	.4594248	.8882166	.4748564	.8800633	.4901433	.8716419	39
22	.4596832	.8880830	.4751124	.8799251	.4903968	.8714993	38
23	.4599415	.8879492	.4753683	.8797869	.4906503	.8713566	37
24	.4601998	.8878154	.4756242	.8796486	.4909038	.8712138	36
25	.4604580	.8876815	.4758801	.8795102	.4911572	.8710710	35
26	.4607162	.8875475	.4761359	.8793717	.4914105	.8709281	34
27	.4609744	.8874134	.4763917	.8792332	.4916638	.8707851	33
28	.4612325	.8872793	.4766474	.8790946	.4919171	.8706420	32
29	.4614906	.8871451	.4769031	.8789559	.4921704	.8704989	31
30	0.4617486	0.8870108	0.4771588	0.8788171	0.4924236	0.8703557	30
31	.4620066	.8868765	.4774144	.8786783	.4926767	.8702124	29
32	.4622646	.8867420	.4776700	.8785394	.4929298	.8700691	28
33	.4625225	.8866075	.4779255	.8784004	.4931829	.8699256	27
34	.4627804	.8864730	.4781810	.8782613	.4934359	.8697821	26
35	.4630382	.8863383	.4784364	.8781222	.4936889	.8696386	25
36	.4632960	.8862036	.4786919	.8779830	.4939419	.8694949	24
37	.4635538	.8860688	.4789472	.8778437	.4941948	.8693512	23
38	.4638115	.8859339	.4792026	.8777043	.4944476	.8692074	22
39	.4640692	.8857989	.4794579	.8775649	.4947005	.8690636	21
40	0.4643269	0.8856639	0.4797131	0.8774254	0.4949532	0.8689196	20
41	.4645845	.8855288	.4799683	.8772858	.4952060	.8687756	19
42	.4648420	.8853936	.4802235	.8771462	.4954587	.8686315	18
43	.4650996	.8852584	.4804786	.8770064	.4957113	.8684874	17
44	.4653571	.8851230	.4807337	.8768666	.4959639	.8683431	16
45	.4656145	.8849876	.4809888	.8767268	.4962165	.8681988	15
46	.4658719	.8848522	.4812438	.8765868	.4964690	.8680544	14
47	.4661293	.8847166	.4814987	.8764468	.4967215	.8679100	13
48	.4663866	.8845810	.4817537	.8763067	.4969740	.8677655	12
49	.4666439	.8844453	.4820086	.8761665	.4972264	.8676209	11
50	0.4669012	0.8843095	0.4822634	0.8760263	0.4974787	0.8674762	10
51	.4671584	.8841736	.4825182	.8758859	.4977310	.8673314	9
52	.4674156	.8840377	.4827730	.8757455	.4979833	.8671866	8
53	.4676727	.8839017	.4830277	.8756051	.4982355	.8670417	7
54	.4679298	.8837656	.4832824	.8754645	.4984877	.8668967	6
55	.4681869	.8836295	.4835370	.8753239	.4987399	.8667517	5
56	.4684439	.8834933	.4837916	.8751832	.4989920	.8666066	4
57	.4687009	.8833569	.4840462	.8750425	.4992441	.8664614	3
58	.4689578	.8832206	.4843007	.8749016	.4994961	.8663161	2
59	.4692147	.8830841	.4845552	.8747607	.4997481	.8661708	1
60	0.4694716	0.8829476	0.4848096	0.8746197	0.5000000	0.8660254	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	
	62°		61°		60°		



## NATURAL SINES AND COSINES

	30°		31°		32°		
	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	0.5000000	0.8660254	0.5150381	0.8571673	0.5299193	0.8480481	60
1	.5002519	.8658799	.5152874	.8570174	.5301659	.8478939	59
2	.5005037	.8657344	.5155367	.8568675	.5304125	.8477397	58
3	.5007556	.8655887	.5157859	.8567175	.5306591	.8475853	57
4	.5010073	.8654430	.5160351	.8565674	.5309057	.8474309	56
5	.5012591	.8652973	.5162842	.8564173	.5311521	.8472765	55
6	.5015107	.8651514	.5165333	.8562671	.5313986	.8471219	54
7	.5017624	.8650055	.5167824	.8561168	.5316450	.8469673	53
8	.5020140	.8648595	.5170314	.8559664	.5318913	.8468126	52
9	.5022655	.8647134	.5172804	.8558160	.5321376	.8466579	51
10	0.5025170	0.8645673	0.5175293	0.8556655	0.5323839	0.8465030	50
11	.5027685	.8644211	.5177782	.8555149	.5326301	.8463481	49
12	.5030199	.8642748	.5180270	.8553643	.5328763	.8461932	48
13	.5032713	.8641284	.5182758	.8552135	.5331224	.8460381	47
14	.5035227	.8639820	.5185246	.8550627	.5333685	.8458830	46
15	.5037740	.8638355	.5187733	.8549119	.5336145	.8457278	45
16	.5040252	.8636889	.5190219	.8547609	.5338605	.8455726	44
17	.5042765	.8635423	.5192705	.8546099	.5341065	.8454172	43
18	.5045276	.8633956	.5195191	.8544588	.5343523	.8452618	42
19	.5047788	.8632488	.5197676	.8543077	.5345982	.8451064	41
20	0.5050298	0.8631019	0.5200161	0.8541564	0.5348440	0.8449508	40
21	.5052809	.8629549	.5202646	.8540051	.5350898	.8447952	39
22	.5055319	.8628079	.5205130	.8538538	.5353355	.8446395	38
23	.5057828	.8626608	.5207613	.8537023	.5355812	.8444838	37
24	.5060338	.8625137	.5210096	.8535508	.5358268	.8443279	36
25	.5062846	.8623664	.5212579	.8533992	.5360724	.8441720	35
26	.5065355	.8622191	.5215061	.8532475	.5363179	.8440161	34
27	.5067863	.8620717	.5217543	.8530958	.5365634	.8438600	33
28	.5070370	.8619243	.5220024	.8529440	.5368089	.8437039	32
29	.5072877	.8617768	.5222505	.8527921	.5370543	.8435477	31
30	0.5075384	0.8616292	0.5224986	0.8526402	0.5372996	0.8433914	30
31	.5077890	.8614815	.5227466	.8524881	.5375449	.8432351	29
32	.5080396	.8613337	.5229945	.8523360	.5377902	.8430787	28
33	.5082901	.8611859	.5232424	.8521839	.5380354	.8429222	27
34	.5085406	.8610380	.5234903	.8520316	.5382806	.8427657	26
35	.5087910	.8608901	.5237381	.8518793	.5385257	.8426091	25
36	.5090414	.8607420	.5239859	.8517269	.5387708	.8424524	24
37	.5092918	.8605939	.5242336	.8515745	.5390158	.8422956	23
38	.5095421	.8604457	.5244813	.8514219	.5392608	.8421388	22
39	.5097924	.8602975	.5247290	.8512693	.5395058	.8419818	21
40	0.5100426	0.8601491	0.5249766	0.8511167	0.5397507	0.8418249	20
41	.5102928	.8600007	.5252241	.8509639	.5399955	.8416679	19
42	.5105429	.8598523	.5254717	.8508111	.5402403	.8415108	18
43	.5107930	.8597037	.5257191	.8506582	.5404851	.8413536	17
44	.5110431	.8595551	.5259665	.8505053	.5407298	.8411963	16
45	.5112931	.8594064	.5262139	.8503522	.5409745	.8410390	15
46	.5115431	.8592576	.5264613	.8501991	.5412191	.8408816	14
47	.5117930	.8591088	.5267085	.8500459	.5414637	.8407241	13
48	.5120429	.8589599	.5269558	.8498927	.5417082	.8405666	12
49	.5122927	.8588109	.5272030	.8497394	.5419527	.8404090	11
50	0.5125425	0.8586619	0.5274502	0.8495860	0.5421971	0.8402513	10
51	.5127923	.8585127	.5276973	.8494325	.5424415	.8400936	9
52	.5130420	.8583635	.5279443	.8492790	.5426859	.8399357	8
53	.5132916	.8582143	.5281914	.8491254	.5429302	.8397778	7
54	.5135413	.8580649	.5284383	.8489717	.5431744	.8396199	6
55	.5137908	.8579155	.5286853	.8488179	.5434187	.8394618	5
56	.5140404	.8577660	.5289322	.8486641	.5436628	.8393037	4
57	.5142899	.8576164	.5291790	.8485102	.5439069	.8391455	3
58	.5145393	.8574668	.5294258	.8483562	.5441510	.8389873	2
59	.5147887	.8573171	.5296726	.8482022	.5443951	.8388290	1
60	0.5150381	0.8571673	0.5299193	0.8480481	0.5446390	0.8386706	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	
	59°		58°		57°		

## NATURAL SINES AND COSINES

	33°		34°		35°		
	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	0.5446390	0.8386706	0.5591929	0.8290376	0.5735764	0.8191520	60
1	.5448830	.8385121	.5594340	.8288749	.5738147	.8189852	59
2	.5451269	.8383536	.5596751	.8287121	.5740529	.8188182	58
3	.5453707	.8381950	.5599162	.8285439	.5742911	.8186512	57
4	.5456145	.8380363	.5601572	.8283864	.5745292	.8184841	56
5	.5458583	.8378775	.5603981	.8282234	.5747672	.8183169	55
6	.5461020	.8377187	.5606390	.8280603	.5750053	.8181497	54
7	.5463456	.8375598	.5608798	.8278972	.5752432	.8179824	53
8	.5465892	.8374009	.5611206	.8277340	.5754811	.8178151	52
9	.5468328	.8372418	.5613614	.8275708	.5757190	.8176476	51
10	0.5470763	0.8370827	0.5616021	0.8274074	0.5759568	0.8174801	50
11	.5473198	.8369236	.5618428	.8272440	.5761946	.8173125	49
12	.5475632	.8367643	.5620834	.8270806	.5764323	.8171449	48
13	.5478066	.8366050	.5623239	.8269170	.5766700	.8169772	47
14	.5480499	.8364456	.5625645	.8267534	.5769076	.8168094	46
15	.5482932	.8362862	.5628049	.8265897	.5771452	.8166416	45
16	.5485365	.8361266	.5630453	.8264260	.5773827	.8164736	44
17	.5487797	.8359670	.5632857	.8262622	.5776202	.8163056	43
18	.5490228	.8358074	.5635260	.8260983	.5778576	.8161376	42
19	.5492659	.8356476	.5637663	.8259343	.5780950	.8159695	41
20	0.5495090	0.8354878	0.5640066	0.8257703	0.5783323	0.8158013	40
21	.5497520	.8353279	.5642467	.8256062	.5785696	.8156330	39
22	.5499950	.8351680	.5644869	.8254420	.5788069	.8154647	38
23	.5502379	.8350080	.5647270	.8252778	.5790440	.8152963	37
24	.5504807	.8348479	.5649670	.8251135	.5792812	.8151278	36
25	.5507236	.8346877	.5652070	.8249491	.5795183	.8149593	35
26	.5509663	.8345275	.5654469	.8247847	.5797553	.8147906	34
27	.5512091	.8343672	.5656868	.8246202	.5799923	.8146220	33
28	.5514518	.8342068	.5659267	.8244556	.5802292	.8144532	32
29	.5516944	.8340463	.5661665	.8242909	.5804661	.8142844	31
30	0.5519370	0.8338858	0.5664062	0.8241262	0.5807030	0.8141155	30
31	.5521795	.8337252	.5666459	.8239614	.5809397	.8139466	29
32	.5524220	.8335646	.5668856	.8237965	.5811765	.8137775	28
33	.5526645	.8334038	.5671252	.8236316	.5814132	.8136084	27
34	.5529069	.8332430	.5673648	.8234666	.5816498	.8134393	26
35	.5531492	.8330822	.5676043	.8233015	.5818864	.8132701	25
36	.5533915	.8329212	.5678437	.8231364	.5821230	.8131008	24
37	.5536338	.8327602	.5680832	.8229712	.5823595	.8129314	23
38	.5538760	.8325991	.5683225	.8228059	.5825959	.8127620	22
39	.5541182	.8324380	.5685619	.8226405	.5828323	.8125925	21
40	0.5543603	0.8322768	0.5688011	0.8224751	0.5830687	0.8124229	20
41	.5546024	.8321155	.5690403	.8223096	.5833050	.8122532	19
42	.5548444	.8319541	.5692795	.8221440	.5835412	.8120835	18
43	.5550864	.8317927	.5695187	.8219784	.5837774	.8119137	17
44	.5553283	.8316312	.5697577	.8218127	.5840136	.8117439	16
45	.5555702	.8314696	.5699968	.8216469	.5842497	.8115740	15
46	.5558121	.8313080	.5702357	.8214811	.5844857	.8114040	14
47	.5560539	.8311463	.5704747	.8213152	.5847217	.8112339	13
48	.5562956	.8309845	.5707136	.8211492	.5849577	.8110638	12
49	.5565373	.8308226	.5709524	.8209832	.5851936	.8108936	11
50	0.5567790	0.8306607	0.5711912	0.8208170	0.5854294	0.8107234	10
51	.5570206	.8304987	.5714299	.8206509	.5856652	.8105530	9
52	.5572621	.8303366	.5716686	.8204846	.5859010	.8103826	8
53	.5575036	.8301745	.5719073	.8203183	.5861367	.8102122	7
54	.5577451	.8300123	.5721459	.8201519	.5863724	.8100416	6
55	.5579865	.8298500	.5723844	.8199854	.5866080	.8098710	5
56	.5582279	.8296877	.5726229	.8198189	.5868435	.8097004	4
57	.5584692	.8295252	.5728614	.8196523	.5870790	.8095296	3
58	.5587105	.8293628	.5730998	.8194856	.5873145	.8093588	2
59	.5589517	.8292002	.5733381	.8193189	.5875499	.8091879	1
60	0.5591929	0.8290376	0.5735764	0.8191520	0.5877853	0.8090170	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	
	56°		55°		54°		

## NATURAL SINES AND COSINES

	36°		37°		38°		
	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	0.5877853	0.8090170	0.6018150	0.7986355	0.6156615	0.7880108	60
1	.5880206	.8088460	.6020473	.7984604	.6158907	.7878316	59
2	.5882558	.8086749	.6022795	.7982853	.6161198	.7876524	58
3	.5884910	.8085037	.6025117	.7981100	.6163489	.7874732	57
4	.5887262	.8083325	.6027439	.7979347	.6165780	.7872939	56
5	.5889613	.8081612	.6029760	.7977594	.6168069	.7871145	55
6	.5891964	.8079899	.6032080	.7975839	.6170359	.7869350	54
7	.5894314	.8078185	.6034400	.7974084	.6172648	.7867555	53
8	.5896663	.8076470	.6036719	.7972329	.6174936	.7865759	52
9	.5899012	.8074754	.6039038	.7970572	.6177224	.7863963	51
10	0.5901361	0.8073038	0.6041356	0.7968815	0.6179511	0.7862165	50
11	.5903709	.8071321	.6043674	.7967058	.6181798	.7860367	49
12	.5906057	.8069603	.6045991	.7965299	.6184084	.7858569	48
13	.5908404	.8067885	.6048308	.7963540	.6186370	.7856770	47
14	.5910750	.8066166	.6050624	.7961780	.6188655	.7854970	46
15	.5913096	.8064446	.6052940	.7960020	.6190939	.7853169	45
16	.5915442	.8062726	.6055255	.7958259	.6193224	.7851368	44
17	.5917787	.8061005	.6057570	.7956497	.6195507	.7849566	43
18	.5920132	.8059283	.6059884	.7954735	.6197790	.7847764	42
19	.5922476	.8057560	.6062198	.7952972	.6200073	.7845961	41
20	0.5924819	0.8055837	0.6064511	0.7951208	0.6202355	0.7844157	40
21	.5927163	.8054113	.6066824	.7949444	.6204636	.7842352	39
22	.5929505	.8052389	.6069136	.7947678	.6206917	.7840547	38
23	.5931847	.8050664	.6071447	.7945913	.6209198	.7838741	37
24	.5934189	.8048938	.6073758	.7944146	.6211478	.7836935	36
25	.5936530	.8047211	.6076069	.7942379	.6213757	.7835127	35
26	.5938871	.8045484	.6078379	.7940611	.6216036	.7833320	34
27	.5941211	.8043756	.6080689	.7938843	.6218314	.7831511	33
28	.5943550	.8042028	.6082998	.7937074	.6220592	.7829702	32
29	.5945889	.8040299	.6085306	.7935304	.6222870	.7827892	31
30	0.5948228	0.8038569	0.6087614	0.7933533	0.6225146	0.7826082	30
31	.5950566	.8036838	.6089922	.7931762	.6227423	.7824270	29
32	.5952904	.8035107	.6092229	.7929990	.6229698	.7822459	28
33	.5955241	.8033375	.6094535	.7928218	.6231974	.7820646	27
34	.5957577	.8031642	.6096841	.7926445	.6234248	.7818833	26
35	.5959913	.8029909	.6099147	.7924671	.6236522	.7817019	25
36	.5962249	.8028175	.6101452	.7922896	.6238796	.7815205	24
37	.5964584	.8026440	.6103756	.7921121	.6241069	.7813390	23
38	.5966918	.8024705	.6106060	.7919345	.6243342	.7811574	22
39	.5969252	.8022969	.6108363	.7917569	.6245614	.7809757	21
40	0.5971586	0.8021232	0.6110666	0.7915792	0.6247885	0.7807940	20
41	.5973919	.8019495	.6112969	.7914014	.6250156	.7806123	19
42	.5976251	.8017756	.6115270	.7912235	.6252427	.7804304	18
43	.5978583	.8016018	.6117572	.7910456	.6254696	.7802485	17
44	.5980915	.8014278	.6119873	.7908676	.6256966	.7800665	16
45	.5983246	.8012538	.6122173	.7906896	.6259235	.7798845	15
46	.5985577	.8010797	.6124473	.7905115	.6261503	.7797024	14
47	.5987906	.8009056	.6126772	.7903333	.6263771	.7795202	13
48	.5990236	.8007314	.6129071	.7901550	.6266038	.7793380	12
49	.5992565	.8005571	.6131369	.7899767	.6268305	.7791557	11
50	0.5994893	0.8003827	0.6133666	0.7897983	0.6270571	0.7789733	10
51	.5997221	.8002083	.6135964	.7896198	.6272837	.7787909	9
52	.5999549	.8000338	.6138260	.7894413	.6275102	.7786084	8
53	.6001876	.7998593	.6140556	.7892627	.6277366	.7784258	7
54	.6004202	.7996847	.6142852	.7890841	.6279631	.7782431	6
55	.6006528	.7995100	.6145147	.7889054	.6281894	.7780604	5
56	.6008854	.7993352	.6147442	.7887266	.6284157	.7778777	4
57	.6011179	.7991604	.6149736	.7885477	.6286420	.7776949	3
58	.6013503	.7989855	.6152029	.7883688	.6288682	.7775120	2
59	.6015827	.7988105	.6154322	.7881898	.6290943	.7773290	1
60	0.6018150	0.7986355	0.6156615	0.7880108	0.6293204	0.7771460	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	
	53°		52°		51°		

NATURAL SINES AND COSINES

	39°		40°		41°		
	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	0.6293204	0.7771460	0.6427876	0.7660444	0.6560590	0.7547096	60
1	.6295464	.7769629	.6430104	.7658574	.6562785	.7545187	59
2	.6297724	.7767797	.6432332	.7656704	.6564980	.7543278	58
3	.6299983	.7765965	.6434559	.7654832	.6567174	.7541368	57
4	.6302242	.7764132	.6436785	.7652960	.6569367	.7539457	56
5	.6304500	.7762298	.6439011	.7651087	.6571560	.7537546	55
6	.6306758	.7760464	.6441236	.7649214	.6573752	.7535634	54
7	.6309015	.7758629	.6443461	.7647340	.6575944	.7533721	53
8	.6311272	.7756794	.6445685	.7645465	.6578135	.7531808	52
9	.6313528	.7754957	.6447909	.7643590	.6580326	.7529894	51
10	0.6315784	0.7753121	0.6450132	0.7641714	0.6582516	0.7527980	50
11	.6318039	.7751283	.6452355	.7639838	.6584706	.7526065	49
12	.6320293	.7749445	.6454577	.7637960	.6586895	.7524149	48
13	.6322547	.7747606	.6456798	.7636082	.6589083	.7522233	47
14	.6324800	.7745767	.6459019	.7634204	.6591271	.7520316	46
15	.6327053	.7743926	.6461240	.7632325	.6593458	.7518398	45
16	.6329306	.7742086	.6463460	.7630445	.6595645	.7516480	44
17	.6331557	.7740244	.6465679	.7628564	.6597831	.7514561	43
18	.6333809	.7738402	.6467898	.7626683	.6600017	.7512641	42
19	.6336059	.7736559	.6470116	.7624802	.6602202	.7510721	41
20	0.6338310	0.7734716	0.6472334	0.7622919	0.6604386	0.7508800	40
21	.6340559	.7732872	.6474551	.7621036	.6606570	.7506879	39
22	.6342808	.7731027	.6476767	.7619152	.6608754	.7504957	38
23	.6345057	.7729182	.6478984	.7617268	.6610936	.7503034	37
24	.6347305	.7727336	.6481199	.7615383	.6613119	.7501111	36
25	.6349553	.7725489	.6483414	.7613497	.6615300	.7499187	35
26	.6351800	.7723642	.6485628	.7611611	.6617482	.7497262	34
27	.6354046	.7721794	.6487842	.7609724	.6619662	.7495337	33
28	.6356292	.7719945	.6490056	.7607837	.6621842	.7493411	32
29	.6358537	.7718096	.6492268	.7605949	.6624022	.7491484	31
30	0.6360782	0.7716246	0.6494480	0.7604060	0.6626200	0.7489557	30
31	.6363026	.7714395	.6496692	.7602170	.6628379	.7487629	29
32	.6365270	.7712544	.6498903	.7600280	.6630557	.7485701	28
33	.6367513	.7710692	.6501114	.7598389	.6632734	.7483772	27
34	.6369756	.7708840	.6503324	.7596498	.6634910	.7481842	26
35	.6371998	.7706986	.6505533	.7594606	.6637087	.7479912	25
36	.6374240	.7705132	.6507742	.7592713	.6639262	.7477981	24
37	.6376481	.7703278	.6509951	.7590820	.6641437	.7476049	23
38	.6378721	.7701423	.6512158	.7588926	.6643612	.7474117	22
39	.6380961	.7699567	.6514366	.7587031	.6645785	.7472184	21
40	0.6383201	0.7697710	0.6516572	0.7585136	0.6647959	0.7470251	20
41	.6385440	.7695853	.6518778	.7583240	.6650131	.7468317	19
42	.6387678	.7693996	.6520984	.7581343	.6652304	.7466382	18
43	.6389916	.7692137	.6523189	.7579446	.6654475	.7464446	17
44	.6392153	.7690278	.6525394	.7577548	.6656646	.7462510	16
45	.6394390	.7688418	.6527598	.7575650	.6658817	.7460574	15
46	.6396626	.7686558	.6529801	.7573751	.6660987	.7458636	14
47	.6398862	.7684697	.6532004	.7571851	.6663156	.7456699	13
48	.6401097	.7682835	.6534206	.7569951	.6665325	.7454760	12
49	.6403332	.7680973	.6536408	.7568050	.6667493	.7452821	11
50	0.6405566	0.7679110	0.6538609	0.7566148	0.6669661	0.7450881	10
51	.6407799	.7677246	.6540810	.7564246	.6671828	.7448941	9
52	.6410032	.7675382	.6543010	.7562343	.6673994	.7446999	8
53	.6412264	.7673517	.6545209	.7560439	.6676160	.7445058	7
54	.6414496	.7671652	.6547408	.7558535	.6678326	.7443115	6
55	.6416728	.7669785	.6549607	.7556630	.6680490	.7441173	5
56	.6418958	.7667918	.6551804	.7554724	.6682655	.7439229	4
57	.6421189	.7666051	.6554002	.7552818	.6684818	.7437285	3
58	.6423418	.7664183	.6556198	.7550911	.6686981	.7435340	2
59	.6425647	.7662314	.6558395	.7549004	.6689144	.7433394	1
60	0.6427876	0.7660444	0.6560590	0.7547096	0.6691306	0.7431448	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	
	50°		49°		48°		

## NATURAL SINES AND COSINES

	42°		43°		44°		
	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	0.6691306	0.7431448	0.6819984	0.7313537	0.6946584	0.7193398	60
1	.6693468	.7429502	.6822111	.7311553	.6948676	.7191377	59
2	.6695628	.7427554	.6824237	.7309568	.6950767	.7189355	58
3	.6697789	.7425606	.6826363	.7307583	.6952858	.7187333	57
4	.6699948	.7423658	.6828489	.7305597	.6954949	.7185310	56
5	.6702108	.7421708	.6830613	.7303610	.6957039	.7183287	55
6	.6704266	.7419758	.6832738	.7301623	.6959128	.7181263	54
7	.6706424	.7417808	.6834861	.7299635	.6961217	.7179238	53
8	.6708582	.7415857	.6836984	.7297646	.6963305	.7177213	52
9	.6710739	.7413905	.6839107	.7295657	.6965392	.7175187	51
10	0.6712895	0.7411953	0.6841229	0.7293668	0.6967479	0.7173161	50
11	.6715051	.7410000	.6843350	.7291677	.6969565	.7171134	49
12	.6717206	.7408046	.6845471	.7289686	.6971651	.7169106	48
13	.6719361	.7406092	.6847591	.7287695	.6973736	.7167078	47
14	.6721515	.7404137	.6849711	.7285703	.6985821	.7165049	46
15	.6723668	.7402181	.6851830	.7283710	.6977905	.7163019	45
16	.6725821	.7400225	.6853948	.7281716	.6979988	.7160989	44
17	.6727973	.7398268	.6856066	.7279722	.6982071	.7158959	43
18	.6730125	.7396311	.6858184	.7277728	.6984153	.7156927	42
19	.6732276	.7394353	.6860300	.7275732	.6986234	.7154895	41
20	0.6734427	0.7392394	0.6862416	0.7273736	0.6988315	0.7152863	40
21	.6736577	.7390435	.6864532	.7271740	.6990396	.7150830	39
22	.6738727	.7388475	.6866647	.7269743	.6992476	.7148796	38
23	.6740876	.7386515	.6868761	.7267745	.6994555	.7146762	37
24	.6743024	.7384553	.6870875	.7265747	.6996633	.7144727	36
25	.6745172	.7382592	.6872988	.7263748	.6998711	.7142691	35
26	.6747319	.7380629	.6875101	.7261748	.7000789	.7140655	34
27	.6749466	.7378666	.6877213	.7259748	.7002866	.7138618	33
28	.6751612	.7376703	.6879325	.7257747	.7004942	.7136581	32
29	.6753757	.7374738	.6881435	.7255746	.7007018	.7134543	31
30	0.6755902	0.7372773	0.6883546	0.7253744	0.7009093	0.7132504	30
31	.6758046	.7370808	.6885655	.7251741	.7011167	.7130465	29
32	.6760190	.7368842	.6887765	.7249738	.7013241	.7128426	28
33	.6762333	.7366875	.6889873	.7247734	.7015314	.7126385	27
34	.6764476	.7364908	.6891981	.7245729	.7017387	.7124344	26
35	.6766618	.7362940	.6894089	.7243724	.7019459	.7122303	25
36	.6768760	.7360971	.6896195	.7241719	.7021531	.7120260	24
37	.6770901	.7359002	.6898302	.7239712	.7023601	.7118218	23
38	.6773041	.7357032	.6900407	.7237705	.7025672	.7116174	22
39	.6775181	.7355061	.6902512	.7235698	.7027741	.7114130	21
40	0.6777320	0.7353090	0.6904617	0.7233690	0.7029811	0.7112086	20
41	.6779459	.7351118	.6906721	.7231681	.7031879	.7110041	19
42	.6781597	.7349146	.6908824	.7229671	.7033947	.7107995	18
43	.6783734	.7347173	.6910927	.7227661	.7036014	.7105948	17
44	.6785871	.7345199	.6913029	.7225651	.7038081	.7103901	16
45	.6788007	.7343225	.6915131	.7223640	.7040147	.7101854	15
46	.6790143	.7341250	.6917232	.7221628	.7042213	.7099806	14
47	.6792278	.7339275	.6919332	.7219615	.7044278	.7097757	13
48	.6794413	.7337299	.6921432	.7217602	.7046342	.7095707	12
49	.6796547	.7335322	.6923531	.7215589	.7048406	.7093657	11
50	0.6798681	0.7333345	0.6925630	0.7213574	0.7050469	0.7091607	10
51	.6800813	.7331367	.6927728	.7211559	.7052532	.7089556	9
52	.6802946	.7329388	.6929825	.7209544	.7054594	.7087504	8
53	.6805078	.7327409	.6931922	.7207528	.7056655	.7085451	7
54	.6807209	.7325429	.6934018	.7205511	.7058716	.7083398	6
55	.6809339	.7323449	.6936114	.7203494	.7060776	.7081345	5
56	.6811469	.7321467	.6938209	.7201476	.7062835	.7079291	4
57	.6813599	.7319486	.6940304	.7199457	.7064894	.7077236	3
58	.6815728	.7317503	.6942398	.7197438	.7066953	.7075180	2
59	.6817856	.7315521	.6944491	.7195418	.7069011	.7073124	1
60	0.6819984	0.7313537	0.6946584	0.7193398	0.7071068	0.7071068	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	
	47°		46°		45°		

AREAS OF WATERWAYS  
BY TALBOT'S FORMULA

Drainage Area		Areas of Waterways in Square Feet						
		Monn- tainous Land	Hilly Land		Rolling Land		Flat Land	
Acres	Square Miles	C=1.00	C=0.80	C=0.60	C=0.50	C=0.40	C=0.30	C=0.20
1	0.0016	1.0	0.8	0.6	0.5	0.4	0.3	0.2
2	.0031	1.7	1.4	1.0	0.8	0.7	0.5	0.3
4	.0062	2.8	2.2	1.7	1.4	1.1	0.8	0.6
6	.0094	3.8	3.0	2.3	1.9	1.5	1.1	0.8
8	.0125	4.8	3.8	2.9	2.4	1.9	1.4	1.0
10	.0160	5.6	4.5	3.4	2.8	2.2	1.7	1.2
15	.023	7.6	6.1	4.6	3.8	3.0	2.3	1.5
20	.031	9.5	7.6	5.7	4.7	3.8	2.8	1.9
30	.047	12.8	10.2	7.7	6.4	5.1	3.8	2.6
40	.062	15.9	12.7	9.5	8.	6.4	4.8	3.2
60	.094	22.	17.6	13.	11.	8.8	6.6	4.4
80	.125	27.	21.6	16.	13.	10.8	8.1	5.4
100	.156	32.	25.6	19.	16.	12.8	9.6	6.4
150	.234	43.	34.4	26.	21.	17.2	12.9	8.6
200	.312	53.	42.4	32.	27.	21.2	15.9	10.6
250	.39	63.	50.	38.	31.	25.	19.	13.
300	.47	72.	58.	43.	36.	29.	22.	14.
400	.62	89.	71.	53.	45.	36.	27.	18.
500	.78	106.	85.	64.	53.	42.	32.	21.
600	.94	121.	97.	73.	61.	48.	36.	24.
800	1.25	150.	120.	90.	75.	60.	45.	30.
1000	1.56	178.	142.	107.	89.	71.	53.	36.
1500	2.34	241.	193.	145.	121.	96.	72.	48.
2000	3.12	299.	239.	179.	149.	120.	90.	60.
2500	3.91	354.	283.	212.	177.	142.	106.	71.
3000	4.7	405.	324.	243.	203.	162.	122.	81.
4000	6.2	503.	402.	302.	252.	202.	151.	101.
5000	7.8	595.	476.	357.	297.	238.	179.	119.
6000	9.4	682.	546.	409.	341.	273.	205.	136.
8000	12.5	846.	677.	508.	423.	338.	254.	169.
10000	15.6	1000.	800.	600.	500.	400.	300.	200.
12000	18.8	1147.	918.	688.	573.	459.	344.	229.
14000	21.9	1287.	1030.	772.	644.	515.	386.	257.
16000	25.0	1423.	1138.	854.	711.	569.	427.	285.
18000	28.1	1554.	1243.	932.	777.	622.	466.	311.
20000	31.2	1682.	1346.	1009.	841.	673.	505.	336.
25000	39.1	1988.	1590.	1193.	994.	795.	596.	398.
30000	47.	2280.	1824.	1368.	1140.	912.	684.	456.
40000	62.	2828.	2262.	1697.	1414.	1131.	848.	566.
50000	78.	3344.	2675.	2006.	1672.	1338.	1003.	669.
80000	125.	4757.	3806.	2854.	2378.	1903.	1427.	951.
100000	156.	5623.	4498.	3374.	2812.	2249.	1687.	1125.
150000	234.	7622.	6098.	4573.	3811.	3049.	2287.	1524.
200000	312.	9457.	7566.	5674.	4728.	3783.	2837.	1891.
300000	469.	12819.	10255.	7691.	6410.	5128.	3845.	2564.
400000	625.	15905.	12724.	9543.	7952.	6362.	4772.	3181.

STANDARD GAGES

COMPARATIVE TABLE

Gage Number	Thickness in Decimals of an Inch					
	Birmingham Wire (B. W. G.) also known as Stubs Iron Wire	American Wire or Browne & Sharpe	American Steel & Wire Co. formerly Washburn & Moon	Trenton Iron Company	British Imperial Standard Wire (S. W. G.)	Standard Birmingham Sheet and Hoop (B. G.)
0000000	.....	.....	.4900	.....	.500	.....
000000	.....	.580000	.4615	.....	.464	.....
00000	.....	.516500	.4305	.450	.432	.....
0000	.454	.460000	.3938	.400	.400	.....
000	.425	.409642	.3625	.360	.372	.5000
00	.380	.364796	.3310	.330	.348	.4452
0	.340	.324861	.3065	.305	.324	.3964
1	.300	.289297	.2830	.285	.300	.3532
2	.284	.257627	.2625	.265	.276	.3147
3	.259	.229423	.2437	.245	.252	.2804
4	.238	.204307	.2253	.225	.232	.2500
5	.220	.181940	.2070	.205	.212	.2225
6	.203	.162023	.1920	.190	.192	.1981
7	.180	.144285	.1770	.175	.176	.1764
8	.165	.128490	.1620	.160	.160	.1570
9	.148	.114423	.1483	.145	.144	.1398
10	.134	.101897	.1350	.130	.128	.1250
11	.120	.090742	.1205	.1175	.116	.1113
12	.109	.080808	.1055	.105	.104	.0991
13	.095	.071962	.0915	.0925	.092	.0882
14	.083	.064084	.0800	.0806	.080	.0785
15	.072	.057068	.0720	.070	.072	.0699
16	.065	.050821	.0625	.061	.064	.0625
17	.058	.045257	.0540	.0525	.056	.0556
18	.049	.040303	.0475	.045	.048	.0495
19	.042	.035890	.0410	.040	.040	.0440
20	.035	.031961	.0348	.035	.036	.0392
21	.032	.028462	.03175	.031	.032	.0349
22	.028	.025346	.0286	.028	.028	.03125
23	.025	.022572	.0258	.025	.024	.02782
24	.022	.020101	.0230	.0225	.022	.02476
25	.020	.017900	.0204	.020	.020	.02204
26	.018	.015941	.0181	.018	.018	.01961
27	.016	.014195	.0173	.017	.0164	.01745
28	.014	.012641	.0162	.016	.0148	.015625
29	.013	.011257	.0150	.015	.0136	.0139
30	.012	.010025	.0140	.014	.0124	.0123
31	.010	.008928	.0132	.013	.0116	.0110
32	.009	.007950	.0128	.012	.0108	.0098
33	.008	.007080	.0118	.011	.0100	.0087
34	.007	.006305	.0104	.010	.0092	.0077
35	.005	.005615	.0095	.0095	.0084	.0069
36	.004	.005000	.0090	.009	.0076	.0061
37	....	.004453	.0085	.0085	.0068	.0054
38	....	.003965	.0080	.008	.0060	.0048
39	....	.003531	.0075	.0075	.0052	.....
40	....	.003144	.0070	.007	.0048	.....

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