Method of Test for
MOISTURE - DENSITY RELATIONSHIPS
DOTD Designation: TR 418-98
ENGLISH VERSION

INTRODUCTION

These methods of test are designed to determine the relationship between the moisture content of the materials listed below and the resulting maximum dry weight density when the material is compacted in the laboratory as specified in this procedure.

These procedures are also applicable to previously stabilized or treated materials and existing materials, including materials containing asphaltic particles or particles of other surfacing, which are to be treated or stabilized.

Record and calculate values in these procedures to the same degree of accuracy shown in the example on the Laboratory Moisture-Density Relationship Worksheet for the applicable procedure.

All materials, except for shell, sand-shell, sand for use in sand-shell, and those containing reclaimed asphaltic concrete or previously stabilized or treated base course, shall be prepared in accordance with DOTD TR 411 and the appropriate method of test. Sand and shell shall be prepared in accordance with DOTD TR 418, Methods C or D. Materials containing reclaimed asphaltic concrete or previously stabilized or treated base course shall be prepared in accordance with DOTD TR 418, Methods H or I. Prior to the determination of maximum dry weight density and optimum moisture content, all materials shall be classified in accordance with DOTD TR 423, except for shell, sand-shell, materials containing reclaimed asphaltic concrete, recycled portland cement concrete, or previously stabilized or treated base course.

TABLE OF METHODS

1. **Method A** - Soils or soil-aggregate mixtures with less than 5% by dry weight of aggregate retained on a No. 4 sieve into which no additives are to be incorporated.
2. **Method B** - Soils or soil-aggregate mixtures with less than 5% by dry weight of aggregate retained on a No. 4 sieve into which cement, lime or other approved dry additives are to be incorporated.
3. **Method C** - Shell or sand-shell into which no additives are to be incorporated.
4. **Method D** - Shell or sand-shell into which cement is to be incorporated.
5. **Method E** - Soil-aggregate mixtures with 5% or more by dry weight of aggregate retained on a No. 4 sieve into which no additives are to be incorporated.
6. **Method F** - Soil-aggregate mixtures, all having 5% or more by dry weight of aggregate retained on a No. 4 sieve into which cement, lime or other approved dry additives are to be incorporated.
7. **Method G** - Designated materials, including stone, slag, or recycled portland cement concrete.
8. **Method H** - Recycled in-place material - specifically designed for existing materials containing asphaltic materials, hydraulic cement, lime, or other stabilizers or surfacings which are to be used as soil or soil-aggregate mixtures.
9. **Method I** - Recycled in-place material to be cement stabilized or treated, or lime treated or conditioned - specifically designed for existing materials containing asphaltic materials, hydraulic cement, lime, or other stabilizers or surfacings which are to be used as soil or soil-aggregate mixtures.

REFERENCE PROCEDURES

1. *DOTD TR 108,* Splitting and Quartering Samples.
2. *DOTD TR 112,* Amount of Material Finer than No. 200 Sieve in Aggregate.
3. *DOTD TR 113,* Sieve Analysis of Fine and Coarse Aggregates.
4. *DOTD TR 403,* Determination of Moisture Content.
5. *DOTD TR 407,* Mechanical Analysis of Soils.
6. *DOTD TR 411,* Dry Preparation of Disturbed Samples for Test.
7. *DOTD TR 415,* Field Moisture - Density Relationships.
8. *DOTD TR 416,* Determination of the Percentage of Lime for Treatment of Soils or Soil-Aggregate Mixtures
9. *DOTD TR 417,* The Mixing Loss of Aggregate Material.
10. *DOTD TR 423,* Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes.
11. *DOTD TR 428,* Determining the Atterberg Limits of Soils.
12. *DOTD TR 432,* Determining the Minimum Cement Content for Soil Cement Stabilization.

DEFINITIONS

For the purposes of this test procedure, the following definitions will apply:

1. **Aggregate** - a naturally occurring or manufactured material, retained on a No. 10 sieve allowed for incorporation into the soil fraction. For testing purposes, previously stabilized or treated materials and existing materials, including materials containing asphaltic particles or particles of other surfacing which are retained on the No. 10 sieve shall be considered as aggregate.
2. **Additive** - an approved cement, lime or other approved additive incorporated dry into the soil, soil-aggregate mixture, shell or sand-shell mixture for stabilization or treatment. When approved liquid additives or slurries are to be incorporated, the testing method shall be determined by the DOTD Materials Engineer Administrator.
3. **Composite** - a blend of two or more samples representing materials with closely similar characteristics.
4. **Gravel** - naturally rounded, siliceous aggregate.
5. **Recycled In-place Materials** - soil or soil-aggregate mixtures which are not naturally occurring, containing asphaltic material, hydraulic cement, lime, or other stabilizers or surfacings excluding portland cement concrete, which exist in-place and are to be reprocessed.
6. **Recycled PCC** - a crushed, graded portland cement concrete prequalified in accordance with DOTD specifications.
7. **Sand** - a material approved for use as sand.
8. **Shell** - approved clam or reef shell.
9. **Siliceous** - a material composed of silica dioxide.
10. **Slag** - a material approved for use as slag.
11. **Stone** - a material approved for use as stone.
12. **Soil** - naturally occurring sand, silt or clay which passes the No. 10 sieve.
13. **Soil-Aggregate** - a mixture of soil and aggregate.

MATERIAL COMPOSITES

When a number of similar samples are submitted from a specific area, instead of developing an individual curve for each sample, a composite may be created and a single curve developed. A composite may consist only of soil or soil-aggregate mixtures which exhibit similar characteristics of geological formation, color, uniformity, weathering, origin, and engineering properties.

To be grouped into a composite, all individual samples must meet all of the following conditions.

1. The aggregate or aggregate-mixture must be the same type(s).
2. The total percentage of material retained on the No. 10 sieve must not vary more than ±5%. The percentage of material retained on the No. 10 and any individual sieve larger than the No. 10 sieve must not vary more than ±5%.
3. The soil types, based on the material passing the No. 10 sieve in accordance with DOTD TR 423, of individual samples to be incorporated into a composite must be identical.
4. The A-Groups, determined in accordance with DOTD TR 423, of individual samples to be incorporated into a composite must be identical.

Materials which meet these criteria may be composited. Composites shall be thoroughly blended. A representative portion will be obtained from the composite for testing purposes.

DOTD Designation: TR 418-98
ENGLISH VERSION

METHOD A

I. Scope

This method of test is designed to determine the optimum moisture content and maximum dry weight density of soils or soil-aggregates with less than 5% aggregate by dry weight retained on a No. 4 sieve, into which no additives are to be incorporated, when the material is compacted in the laboratory in accordance with this procedure. For soils or soil-aggregates with 5% or more aggregate retained on the No. 4 sieve, refer to DOTD TR 418, Method E.

Note A-1: *It is permissible to determine moisture-density relationships of field conditioned material in accordance with the applicable method of DOTD TR 415.*

II. Apparatus

A. **Mold**
1. A cylindrical metal mold, having a capacity of 1/30 ft^3, manufactured with an internal diameter of 4.000±0.016 in. and a height of 4.584±0.005 in., and with a detachable collar approximately 2.5 in. in height, which can be fastened firmly to a base plate.
2. Molds shall be replaced if any diameter is more than 4.024 in. or the height is less than 4.550 in. at any point.

Note A-2: *Different makes of compactive devices may use mold base plates of different designs. The mold base plate must be compatible with the make of compactive device used.*

B. **Compactive device**
1. Automatic Rammer
   a. A metal 5.50±0.05 lb rammer, with a striking face that is a 3.1416 sq in sector face for use with a 4 in. inside diameter mold and arranged to control the height of drop to 12.00±0.06 in.
   b. Alternate - a metal 5.50±0.05 lb rammer, with a striking face that is a 3.1416 sq in sector face for use with a 4 in. inside diameter mold and arranged to control the height of drop to 18.00 ±0.06 in.
2. Manual Rammer - a metal 5.50±0.05 lb rammer with a circular striking face with a diameter of 2.00±0.01 in. and arranged to control the height of drop to 12.00±0.06 in.

C. **Compaction block** - a stable block or pedestal composed of portland cement concrete weighing a minimum of 200 lb.

D. **Straightedge** - steel straightedge, approximately 12 in. long.

E. **Scale** - a scale of 20 lb or more capacity, sensitive to 0.01 lb.

F. **Sieve** - a No. 4 sieve conforming to the requirements of the Standard Specification for Wire Cloth Sieves for Testing Purposes (AASHTO Designation: M 92).

G. **Tools**
1. Mixing pans with appropriate covers.
2. Spoons.
3. Pointed trowel.
4. Spatula or large suitable mechanical device for thoroughly mixing the soil with water.
5. Large screwdriver to remove material from mold.
6. Ruler or Height Gauge - accurate to 0.01 in.

H. **Graduated cylinder** - incremented in mL.

I. **Wax paper.**

J. **Engineer's Curve** - Alvin 1010-21 or equivalent.

K. **Laboratory Moisture-Density Worksheet, Methods A & B** - DOTD Form No. 03-22-4194. (Figure A-1)

L. **Laboratory Compaction Report** - DOTD Form No. 03-22-4165. (Figure A-2)

M. **Soils/Soil-Aggregate Form** - DOTD Form No. 03-22-0723. (Figure A-3)

Note A-3: *It is convenient, but not essential, to have a mechanical device for removing the compacted soil from the mold. Such a device may consist of a closed cylindrical sleeve slightly less than 4.0 in. in diameter or a piston of the same diameter, actuated mechanically, hydraulically or by air pressure.*

III. Test Sample

Obtain a representative portion, weighing a minimum of 10 lb, of the dried prepared material passing the No. 4 sieve from a minimum 30 lb sample (1 full sample sack).

IV. Procedure

A. Record the weight of the representative portion as **D** on the worksheet.

B. Add a quantity of water, measured in mL, sufficient to make the soil slightly damp. Mix thoroughly. Record the quantity of water as **G** for the first point on the worksheet.

Note A-4: *Check the mixture by squeezing it in the palm of the hand. If the mixture is the correct moisture content, it will form a cake which will bear very careful handling without breaking.*

C. Pass the damp representative portion through a No. 4 sieve.

D. Cover the representative portion to which water has been added, protect it so that the moisture content remains constant, then allow it to slake for a minimum of thirty minutes. Remix thoroughly at the end of the slaking period. Recover the representative portion.

E. Compact the test specimen using an approved rammer.

1. If mold requires an attachable base plate, attach base plate. Weigh mold and base plate and record as **I** on the worksheet.
2. When using a mold without an attachable base plate, place wax paper on the compactor base. Weigh the mold and record the weight as **I** on the worksheet. Place the mold over the wax paper and secure the mold to the compactor base.
3. Attach collar to mold.
4. Uncover the representative portion and remix.
5. Place a quantity of the representative portion into the mold in an even layer that will yield slightly more than 1/3 the volume of the mold after compaction. Recover the representative portion.
6. Use a pointed trowel to rearrange particles, filling voids in the loose material without compacting the material, to a uniform lift thickness.
7. Rest the rammer on top of the layer to be compacted. Compact the layer using 25 blows with the 5.50 lb rammer from a 12-in. drop (alternate - 17 blows from an 18-in. drop).
8. Note height of compacted material. If compacted layer is not 1/3 the height of the mold, correct for any deviation by adjusting the quantity of material used for the subsequent layer.
9. Repeat Steps IV.E.4 - 8 for two more layers.
10. After the third layer has been compacted, remove the mold, base plate (if applicable), and compacted specimen from the automatic rammer and place in a pan.
11. Tap the collar with the straightedge to loosen material bond and remove the collar from the mold, without twisting or causing shear stress to the molded specimen.
12. Note the height of the compacted test specimen.
    a. If the compacted material is greater than 0.25 in. above the height of the mold, remove all material from the mold, remix it with the original representative portion and repeat the test.
    b. If the compacted material is below the rim of the mold, remove all material from the mold, remix it with the original representative portion and repeat the test.
13. Keeping the mold, base plate (if applicable), and specimen in the pan, trim the specimen even with the top of the mold, using the straightedge. Fill any depressions with the trimmed material. After the depressions are filled, smooth with the straightedge even with the top of the mold.
14. Brush material from all outside surfaces of mold, and exposed edges of base plate or wax paper.
15. Remove wax paper (if applicable) and brush fines from the wax paper onto top of test specimen. Take care not to lose any fines from test specimen.
16. Weigh mold, base plate (if applicable), and compacted test specimen and record weight as **H** on the worksheet.
17. Remove the base plate, if applicable. Remove material from the mold. Obtain a representative test specimen of approximately 500 g from the center of the compacted material and determine the moisture content in accordance with DOTD TR 403, Method B.
18. Pass the remaining material from the mold through a No. 4 sieve and recombine it with the remaining representative portion.
19. Add water to the recombined representative portion to increase its moisture content by approximately 2% and mix thoroughly. (Refer to Step V.A. to determine the quantity of water to be added.) Record the quantity of water added in mL as **G** on the worksheet.

20. Repeat steps IV.E.1 - 19. Continue repeating the procedure until there is a substantial decrease in the wet weight of the compacted material or the material becomes too wet to compact.

V. Calculations

A. Calculate the incremental quantity of water (G) in mL to equal an approximately 2% increase in the moisture content of the representative portion by using the following formula.

$$G = (D \times 9.072) - (10 \times N)$$

where:

D = dry wt of representative portion, lb
N = the number of moisture content samples removed from the 10 lb representative portion
9.072 = a constant representing a conversion factor from lb to mL for a 2 % increment of water
10 = reduction of incremental water due to 500 g moisture content specimen

example:

D = 10.61 lb
N = 1

$$G = (10.61 \times 9.072) - (10 \times 1)$$

$$= 96.25 - 10$$

$$G = 86$$

Note A-5: 1 g of water = 1 cc of water = 1 mL of water.

B. Calculate wet weight of compacted soil (J) in lb in the mold for each moisture content by using the following formula.

$$J = H - I$$

where:

H = wt of mold, base plate (if applicable) and compacted wet soil, lb
I = wt of mold and base plate (if applicable), lb

example:

H = 13.15 lb
I = 9.25 lb

$$J = 13.15 - 9.25$$

$$J = 3.90$$

C. Calculate wet weight density (WWD) in lb/ft^3 for each moisture content by using the following formula.

$$WWD = J \times 30$$

where:

J = wet wt of compacted soil, lb
30 = a constant representing the reciprocal of the volume of the mold, ft^3

example:

J = 3.90 lb

$$WWD = 3.90 \times 30$$

$$WWD = 117.0$$

D. Calculate the weight of water (WW) in g and the weight of dry material (DW) in g for each moisture content by using the following formulas.

$$WW = K - L \quad \text{and} \quad DW = L - M$$

where:

K = wt of cup and wet material, g
L = wt of cup and dry material, g
M = wt of cup, g

examples:

K = 586.0 g
L = 533.5 g
M = 47.5 g

$$WW = 586.0 - 533.5 \qquad DW = 533.5 - 47.5$$

and

$$WW = 52.5 \qquad DW = 486.0$$

E. For each increment of water added, calculate the moisture content (MC) in % of the material to the nearest 0.1 percent by using the following formula.

$$MC = \left(\frac{WW}{DW}\right) \times 100$$

where:

WW = wt of water, g
DW = wt of dry material, g

example:

WW = 52.5 g
DW = 486.0 g

$$MC = (\frac{52.5}{486.0}) \times 100$$

$$= 0.10802 \times 100$$

$$MC = 10.8$$

F. Calculate the dry weight density (DWD) in lb/ft^3 for each moisture content using the following formula.

$$DWD = \frac{WWD}{100 + MC} \times 100$$

where:

WWD = wet weight density, lb/ft^3
MC = moisture content, %

example:

WWD = 117.0 lb/ft^3
MC = 10.8 %

$$DWD = \frac{117.0}{100 + 10.8} \times 100$$

$$= 1.05595 \times 100$$

$$DWD = 105.6$$

G. Beginning with the lowest moisture content, plot a point on the Laboratory Compaction Report, representing the intersection of a horizontal line projected from the wet weight density and a vertical line projected from the moisture content. Continue for each moisture content until all points for wet weight densities have been plotted. Repeat the process for each moisture content, substituting dry weight densities for wet weight densities.

H. Form a smooth line using the engineer's curve by connecting the plotted points to form two curves, Wet Weight Density vs. Moisture Content and Dry Weight Density vs. Moisture Content. (Refer to the Laboratory Compaction Report.) As close as possible to the intersection, round the peak to form a smooth continuous line.

Note A-6: *If after the results have been plotted, there is not a minimum of three points on the dry side and two points on the wet side of optimum, additional testing must be performed until this minimum is met. If a smooth curve cannot be drawn, additional testing may be required.*

I. Determine the Optimum Moisture Content (%). The Optimum Moisture Content is the moisture content corresponding to the peak of the Dry Weight Density Curve.

J. Determine the Maximum Dry Weight Density. The Maximum Dry Weight Density is the dry weight density of the soil at the optimum moisture content.

VI. Report

A. Report the Maximum Dry Weight Density and Optimum Moisture Content on the Laboratory Compaction Report and on the Soils/Soil-Aggregate Form to the nearest 0.1 lb/ft^3 and 0.1 percent, respectively.

B. From DOTD TR 407 and TR 423, report the following on the Laboratory Compaction Report and on the Soils/Soil-Aggregate Form.
   1. Grain size distribution
   2. Atterberg Limits
   3. Soil group
   4. Group index
   5. Classification

C. Report the DOTD TR 418 method used on the Soils/Soil-Aggregate Form and on the Laboratory Compaction Report.

VII. Normal Test Reporting Time

Normal test reporting time is 3 days.

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

DOTD 03-22-4194
English
Rev. 4/98

LABORATORY MOISTURE - DENSITY RELATIONSHIP
DOTD TR 418 - Methods Ⓐ & B
(English)

PROJECT NO: 999-99-0099 DATE: 12/19/97 LAB NO: 22-999999

*TYPE ADDITIVE: _____ TYPE SOIL: CLAY LOAM SAMPLE NO: S-1

TESTED BY: B.D, T.S. CHECKED BY: JBW

*MAX. DRY DENSITY OF SOIL (__ TR 418-A, __ TR 415-A), lb/ft^3	A		
*REQUIRED % BY VOL. OF ADDITIVE (__ TR 432-A, __ TR 432-B, __ TR 416, __ specified)	B		
*% WT. OF ADDITIVE (____ chart, ____ formula)	C		
DRY WT. OF SOIL (Representative portion), lb	D		10.61
*WT. OF ADDITIVE TO BE ADDED, lb	E	(C x D) ÷ 100	
*TOTAL DRY WT. OF SOIL AND ADDITIVE, lb	F	D + E	

* *FOR USE WITH DOTD TR 418, METHOD B ONLY.*

CURVE POINT NO.	---		1	2	3	4	5	6
MOISTURE CUP NO.	---		27	28	29	30	31	
WATER ADDED, mL	G	See Calculations	520	86	76	66	56	
WT. MOLD, BASE (if appl.) & WET SOIL, lb	H		13.15	13.28	13.45	13.47	13.36	
WT. MOLD & BASE (if applicable), lb	I		9.25	9.25	9.25	9.25	9.25	
WT. WET COMPACTED SOIL, lb	J	H - I	3.90	4.03	4.20	4.22	4.11	
WT. OF CUP & WET SOIL, g	K		586.0	587.8	604.2	601.3	616.9	
WT. OF CUP & DRY SOIL, g	L		533.5	526.5	530.8	521.7	526.8	
WT. OF WATER, g	WW	K - L	52.5	61.3	73.4	79.6	90.1	
WT. OF CUP & DRY SOIL, g	L		533.5	526.5	530.8	521.7	526.8	
WT. OF CUP, g	M		47.5	47.5	47.6	47.6	47.5	
WT. OF DRY SOIL, g	DW	L - M	486.0	479.0	483.2	474.1	479.3	
WET DENSITY, lb/ft^3	WWD	J x 30	117.0	120.9	126.0	126.6	123.3	
MOISTURE CONTENT, %	MC	(WW/DW) x 100	10.8	12.8	15.2	16.8	18.8	
DRY DENSITY, lb/ft^3	DWD	$\frac{WWD}{100 + MC} \times 100$	105.6	107.2	109.4	108.4	103.8	

REMARKS: _____

Laboratory Moisture - Density Relationship Worksheet (03-22-4194)
Figure A-1 - (English)

LAB COMPACTION REPORT - DOTD TR 418 METHOD A

DOTD 03-22-4165
Metric / English
Rev. 3/98

Project No. 999-99-0099 Station S. No. 1 Lab No. 22-999999

COMPACTION REPORT

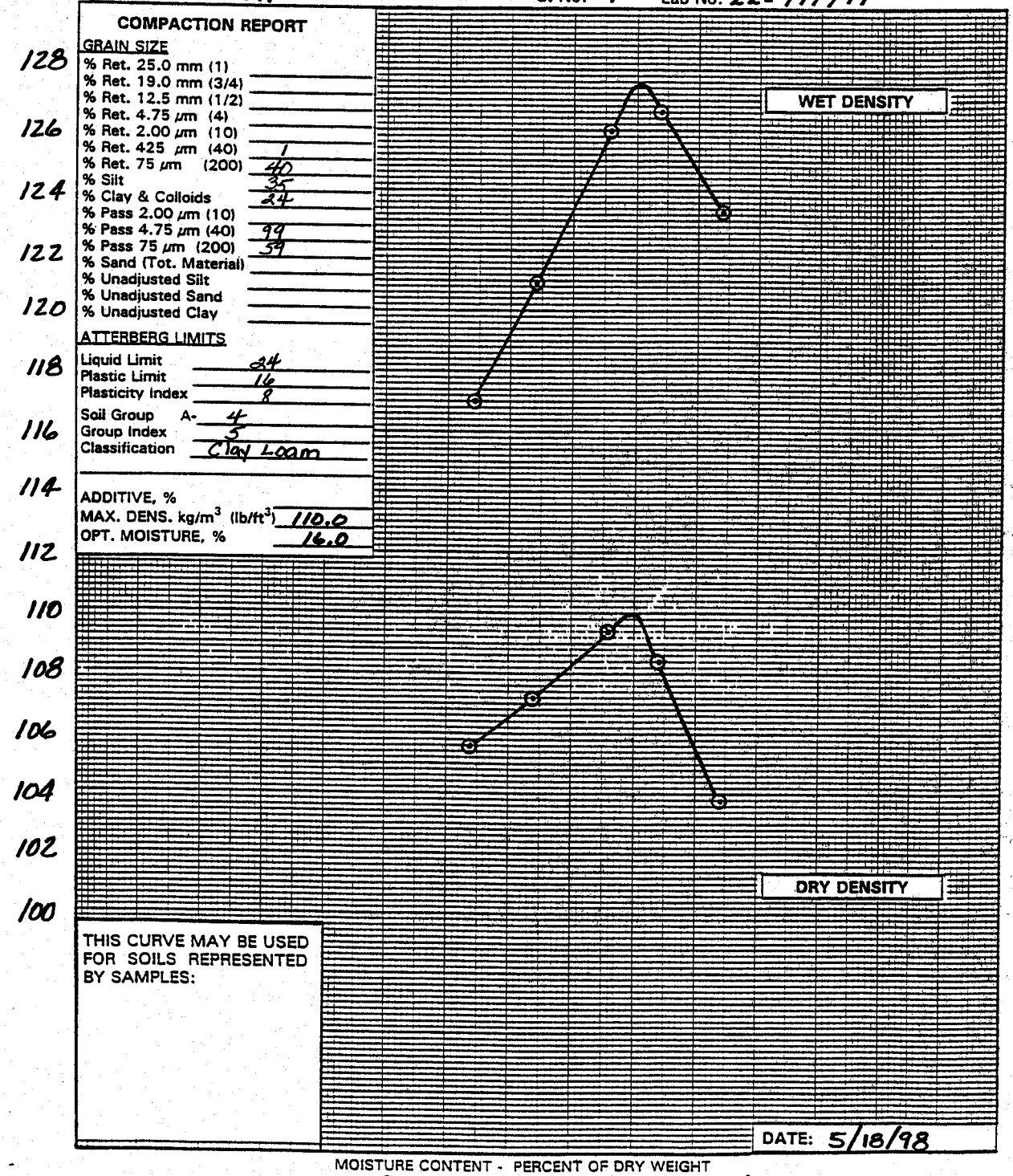
GRAIN SIZE

% Ret. 25.0 mm (1)	
% Ret. 19.0 mm (3/4)	
% Ret. 12.5 mm (1/2)	
% Ret. 4.75 µm (4)	
% Ret. 2.00 µm (10)	
% Ret. 425 µm (40)	1
% Ret. 75 µm (200)	40
% Silt	35
% Clay & Colloids	24
% Pass 2.00 µm (10)	
% Pass 4.75 µm (40)	99
% Pass 75 µm (200)	59
% Sand (Tot. Material)	
% Unadjusted Silt	
% Unadjusted Sand	
% Unadjusted Clay	

ATTERBERG LIMITS

Liquid Limit	24
Plastic Limit	16
Plasticity Index	8
Soil Group A-	4
Group Index	5
Classification	Clay Loam

ADDITIVE, %	
MAX. DENS. kg/m³ (lb/ft³)	110.0
OPT. MOISTURE, %	16.0



THIS CURVE MAY BE USED FOR SOILS REPRESENTED BY SAMPLES:

Laboratory Compaction Report (03-22-4165)
Figure A-2 - (English)

MATT MENU SELECTION - 14

Louisiana Department of Transportation and Development
SOILS/SOIL-AGGREGATE

DOTD 03-22-0723
Rev. 7/98

Metric / English E (M or E - Located on MATT Menu)

Project No. 999999-999999-010199 | Material Code 4011 | Lab. No. 22-9999999999
Date Sampled 10-01-97 | Submitted By 00199 | Quantity
Purp. Code 7 | Pit No. | Spec Code 3
Date Tested 10-19-97 | Ident. 51-11 | Parish No. 117
From Station + | To Station + | Location
Hole No. | Depth, m (ft) | Log Distance, km (mi)
Item No. | Sampled by:
Remarks 1

Hydrometer Analysis (DOTD TR 407)			Graduate No.	Dry Mass of Sample (W), g (1 = 50.0, 2 = 100.0)			
Time	(T) Elapsed Time	Temp°C (0.5° increments)	(h) Hydro Reading (0.5 increments)	(C) Correction (0.5 increments)	Corrected Reading H = h - C	% Finer $P = \frac{H}{W} \times 100$	Effect. Grain Size $D = K\sqrt{\frac{L}{T}}$
	60 Minutes						
	120 Minutes						

RETAINED ON 2.00 µm (10)
Mass Cup + Soil, g
Cup No.
Mass Cup, g
Mass Soil, g

RETAINED ON 425 µm (40)
Mass Cup + Soil, g
Cup No.
Mass Cup, g
Mass Soil, g

RETAINED ON 75 µm (200)
Mass Cup + Soil, g
Cup No
Mass Cup, g
Mass Soil, g

Size	Mass Retained (Wx) Gram	%
Total Mass, g		
25.0 mm (1)		
19.0 mm (3/4)		
12.5 mm (1/2)		
4.75 µm (4)		
2.00 µm (10)		
425 µm (40)		
75 µm (200)		
% Silt		
% Clay & Colloids		
Pass 4.75 µm (#4)		
Pass 2.00 µm (#10)		

(DOTD TR 407)

% Ret. 25.0 mm (1)	
% Ret. 19.0 mm (3/4)	
% Ret. 12.5 mm (1/2)	
% Ret. 4.75 µm (4)	
% Ret. 2.00 µm (10)	
% Ret. 425 µm (40)	1
% Ret. 75 µm (200)	40
% Silt	35
% Clay & Colloids	24
% Pass 2.00 µm (#10)	100
% Pass 4.75 µm (40)	99
% Pass 75 µm (200)	59
% Sand (Tot. Material)	41
% Unadjusted Silt	
% Unadjusted Sand	
% Unadjusted Clay	

LIQUID LIMIT
No. Blows 10
Mass Cup + Wet Soil, g 25.15
Mass Cup + Dry Soil, g 20.14
Mass Water, g 5.1
Factor 0.9733
Cup No. 187
Mass Cup, g 10.0
Mass Dry Soil, g 20.4
% Moisture 25.0

PLASTIC LIMIT
Mass Cup + Wet Soil, g 13.18
Mass Cup + Dry Soil, g 12.12
Mass Water, g 4.6
Cup No. 172
Mass Cup, g 10.0
Mass Dry Soil, g 28.2
% Moisture 16.3

% Organic Matter (TR 413)
Liquid Limit (TR 428) 24
Plasticity Index (TR 428) 8
Natural Moisture Content, % (TR 403)
Optimum Moisture Content, % (TR 418) 16.0
Maximum Density, kg/m³ (lb/ft³) (TR 418) 110.0
Laboratory Compaction Method (TR 418) A
% Cement (TR 432 or Plans)
% Lime (TR 416)
% Fly Ash
% Other (Additive) Material Code Percent
Soil Group (TR 423) A-4(2)
Classification (TR 423) CLAY LOAM
pH (TR 430)
Resistivity, ohm-cm (TR 429)
Classification Prefix (TR 423) (G = Siliceous Aggr. N = Non-Siliceous S = Shell)
(Required only if +2.00 mm (No.10, g) material equals or exceeds 5%)

Remarks 2

Tested By: B.D., I.S. | Checked By: JBW | APPROVED BY:
Date: 10/19/97 | Date: 10/20/97 | DATE:

Soils/Soil-Aggregate Form (03-22-0723)
Figure A-3 (English)

DOTD Designation: TR 418-98
ENGLISH VERSION

METHOD B

I. Scope

This method of test is designed to determine the optimum moisture content and maximum dry weight density of soil cement, lime treated or conditioned soil cement, cement treated or lime treated soils, all containing less than 5% aggregate by dry weight retained on a No. 4 sieve, when the material is compacted in the laboratory in accordance with this procedure. When these materials contain 5% or more aggregate by dry weight retained on a No. 4 sieve, refer to DOTD TR 418, Method F.

Note B-1: *It is permissible to determine moisture-density relationships of field conditioned material in accordance with the applicable method of DOTD TR 415. For field conditioned material which requires the addition of additives, TR 415 Method B can be used in the laboratory to determine moisture-density relationships of the material and additive combination only if the required amount of additive is known; however, for field conditioned material brought into the laboratory for the purpose of determining the required amount of additive, it is not permissible to use Method B of TR 415.*

II. Apparatus

A. **Same as DOTD TR 418, Method A.**
B. **Cement or lime.**

Note B-2: *Cement shall meet DOTD specifications for Type IB. For Type IB cement, a unit weight of 94 lb/ft^3 shall be used.*

When Type II or Type IP cement is used on the project, it shall be used in lieu of Type IB to determine the report values for this method of test. Type II and Type IP cement shall meet DOTD specifications. For Type IP cement, a unit weight of 90 lb/ft^3 shall be used. For Type II cement, a unit weight of 94 lb/ft^3 shall be used.

Lime shall meet DOTD specifications for hydrated lime. A unit weight of 35 lb/ft^3 shall be used.

C. **Personal protective equipment**
1. Respirator.
2. Gloves.
3. Apron.
4. Goggles.

D. **Laboratory Moisture-Density Worksheet, Methods A & B** - DOTD Form No. 03-22-4194. (Figure B-1)
E. **Additive Conversion Chart.** (Figure B-2)
F. **Laboratory Compaction Report** - DOTD Form No. 03-22-4165. (Figure B-3)
G. **Soils/Soil-Aggregate Form** - DOTD Form No. 03-22-0723. (Figure B-4)

III. Test Sample

Obtain a representative sample weighing a minimum of 30 lb (one full sample sack of material).

IV. Health Precautions

Care must be taken not to allow cement or lime to contact skin or to inhale its reaction fumes.

V. Procedure

A. Preparation
1. Determine the maximum dry weight density of the soil using one of the following methods and record as **A** on the worksheet.
   a. DOTD TR 418, Method A.
   b. DOTD TR 415, Method A.
2. Determine the percent by volume of cement in accordance with DOTD TR 432 or the percent of lime in accordance with DOTD TR 416 or use the percent specified. Record as **B** on the worksheet.
3. Convert percent by volume to percent by weight and record as **C** on the worksheet. (Refer to Step VI.A or B for weight - volume conversion calculations.)
4. Prepare a minimum of five 6-pound representative portions from the test sample.

B. Testing
1. Calculate the weight of additive to be added to the representative portion in accordance with Step VI.C and record as **E** on the worksheet.
2. Add the required weight of the additive, determined in Step V.B.1, to each representative portion.
3. Add a sufficient quantity of water, measured

in mL, to make the 6-lb representative portion to be used for the first point slightly damp. Mix thoroughly. Record the quantity of water as **G** for the first point on the worksheet.

Note B-3: *Check the mixture by squeezing it in the palm of the hand. If the mixture is the correct moisture content, it will form a cake which will bear very careful handling without breaking.*

4. Add and thoroughly mix a quantity of water, measured in mL, to each remaining 6 lb representative portion to increase the moisture content of each representative portion by 2% more than the moisture content of the previous portion. (Refer to Step VI.D) Record the quantity of water added to each representative portion as **G** on the worksheet.
5. Cover the representative portions to which water has been added, protect them so that the moisture content remains constant, and allow them to stand for a minimum of 30 min.
6. Remix the individual representative portions, protect them so that the moisture content remains constant, then allow them to slake as follows.
   a. Soil mixed with cement: The combined standing and slaking time plus the compaction time in the laboratory shall approximate the moist mixing time plus the compaction time in the field. This time shall be a minimum of 60 min and a maximum of 90 min.
   b. Soil mixed with lime: The combined standing and slaking time plus compaction time in the laboratory shall approximate the moist mixing time and mellowing time in the field, but shall not be less than 15 hours.
   c. When lime-conditioned soil is to be cement treated or stabilized, mix the soil with the lime and allow it to slake in accordance with Step V.B.6.b. Then add the required weight of cement (determined in accordance with Step V.B.1) to the soil-lime mixture and allow the soil-lime-cement mixture to slake in accordance with Step V.B.6.a.
7. Determine the maximum dry weight density of the soil and additive mixture.
   a. Remix the slaked mixture thoroughly.
   b. Pass the slaked mixture through a No. 4 sieve.
   c. Compact the slaked mixture in accordance with Method A, Steps IV.E. 1-17.
   d. Repeat Steps 7. a - c for each 6-lb representative portion, cleaning the mold between each test specimen. Continue repeating the procedure until there is a substantial decrease in the wet weight of the compacted material or the material becomes too wet to compact.

VI. Calculations

A. Determination of percent of additive by weight by using the Additive Conversion Chart (Figure B-2). This chart may be used for Type IB Portland cement and hydrated lime.
   1. Enter the chart on the left scale. Reading vertically, place a point at the appropriate maximum dry weight density of the soil-aggregate mixture obtained in Step V.A.1.
   2. Reenter the chart on the right scale. Reading vertically, place a point at the design percent by volume of additive.
   3. Draw a straight line across the chart connecting the two points plotted in Steps 1 and 2.
   4. Read the percent by weight directly from the additive scale on the chart at the point where the line drawn in Step 3. intersects the scale for the additive being used.
   5. Record this value as **C** on the worksheet.
   6. Example: Figure B-2
      a. Type IB Cement

         A = 110 lb/ft^3
         B = 8% Type IB cement by volume

         (1) Follow the left scale to the point represented by 110 lb/ft^3.
         (2) Follow the right scale to the point represented by 8% by volume.
         (3) Draw a straight line across the scale, connecting the two points.
         (4) The percent cement by weight, read directly from the middle scale, is 7.3%.

      b. Lime

         A = 107 lb/ft^3
         B = 6% hydrated lime, by volume

         (1) Follow the left scale to the point represented by 107 lb/ft^3.
         (2) Follow the right scale to the point represented by 6% by volume.

(3) Draw a straight line across the scale, connecting the two points.
(4) The percent lime by weight, read directly from the middle scale, is 2.0%.

B. In lieu of the charts or if values are not covered by the charts, determine the percent by weight of additive (C) using the following formula.

$$C = \frac{(UB/100)}{A - (UB/100)} \times 100$$

$$C = \frac{1}{(A/UB) - 0.01}$$

where:

A = max. dry wt density of the soil, lb/ft^3
B = % by volume of additive
U = unit weight of additive, lb/ft^3
100 = constant
0.01 = constant

example: *(Type IP Cement)*

A = 110 lb/ft^3
B = 8 %
U = 90 lb/ft^3

$$C = \frac{1}{[110/(90 \times 8)] - 0.01}$$

$$= \frac{1}{[0.1527] - 0.01}$$

$$= \frac{1}{0.1427}$$

$$C = 7.0$$

Note B-4: *To achieve required accuracy after rounding, carry to four decimal places, as shown.*

C. Calculate the weight of additive (E) in lb to be incorporated into the representative portion of soil using the following formula and record as on the worksheet.

$$E = \frac{C \times D}{100}$$

where:

C = % by wt of additive (from chart or formula)
D = dry wt of representative portion, lb
100 = constant

example:

C = 7.3 %
D = 6.00 lb

$$E = \frac{7.3 \times 6.00}{100}$$

$$= \frac{43.8000}{100}$$

$$E = 0.44$$

D. Calculate the quantity of water to be added to each representative portion (G_n) in mL to yield a moisture content incremented by 2 percent above that of the previous representative portion by using the following formula.

$$G_n = G_{n-1} + (9.072 \times F)$$

where:

G_{n-1} = volume of water added to the previous representative portion, mL
F = total wt of material and additive, lb
9.072 = a constant representing a conversion factor from lb to mL for a 2% increment of moisture

example:

G_{n-1} = 207 mL
F = 6.44 lb

$$G_n = 207 + (9.072 \times 6.44)$$

$$= 207 + 58.42$$

$$G_n = 265$$

Note B-5: *1 g of water = 1 cc of water = 1 mL of water.*

E. Perform all calculation steps for the soil-additive mixture in accordance with Method A, Step V.B - J.

VII. Report

A. Report the Maximum Dry Weight Density and Optimum Moisture Content on the Laboratory Compaction Report and on the Soils/Soil-Aggregate Form to the nearest 0.1 lb/ft^3 and 0.1 percent, respectively.

B. Report the type and percent by volume of additive to the nearest percent on the Laboratory Compaction Report and the Soils/Soil-Aggregate Form.

C. From DOTD TR 407 and TR 423, report the following on the Laboratory Compaction Report and on the Soils/Soil-Aggregate Form.
   1. Grain size distribution
   2. Atterberg Limits
   3. Soil group
   4. Group Index
   5. Classification

VIII. Normal Test Reporting Time

Normal test reporting time is 5 days.

Note B-6: *When percent cement is to be determined by DOTD TR 432, Method B or the percent lime by DOTD TR 416, normal testing and reporting time will be 3 weeks or 2 weeks, respectively.*

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

DOTD 03-22-4194
English
Rev. 4/98

LABORATORY MOISTURE - DENSITY RELATIONSHIP
DOTD TR 418 - Methods A & (B)
(English)

PROJECT NO: 999-99-0099 DATE: 12/29/97 LAB NO: 22-999999

*TYPE ADDITIVE: Type IB Cement TYPE SOIL: Clay Loam SAMPLE NO: S-1

TESTED BY: I.S., N.H. CHECKED BY: G.C.

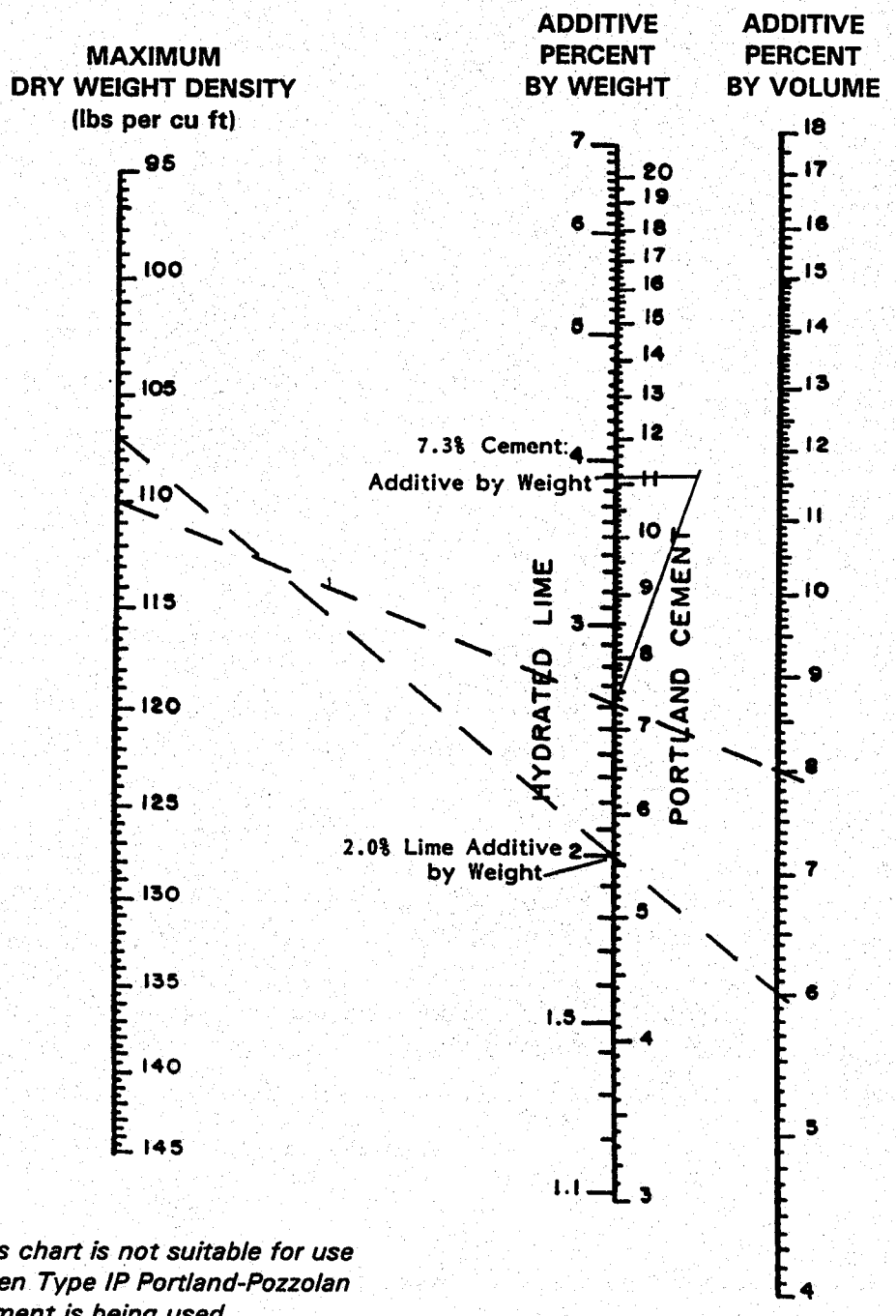
*MAX. DRY DENSITY OF SOIL (__ TR 418-A, __ TR 415-A), lb/ft^3	A		110.0
*REQUIRED % BY VOL. OF ADDITIVE (__ TR 432-A, __ TR 432-B, __ TR 416, __ specified)	B		8
*% WT. OF ADDITIVE (____ chart, ____ formula)	C		7.3
DRY WT. OF SOIL (Representative portion), lb	D		6.00
*WT. OF ADDITIVE TO BE ADDED, lb	E	(C x D) ÷ 100	0.44
*TOTAL DRY WT. OF SOIL AND ADDITIVE, lb	F	D + E	6.44

* *FOR USE WITH DOTD TR 418, METHOD B ONLY.*

CURVE POINT NO.	---		1	2	3	4	5	6
MOISTURE CUP NO.	---		32	33	34	35	36	
WATER ADDED, mL	G	See Calculations	207	265	323	381	439	
WT. MOLD, BASE (if appl.) & WET SOIL, lb	H		13.08	13.21	13.36	13.39	13.27	
WT. MOLD & BASE (if applicable), lb	I		9.25	9.25	9.25	9.25	9.25	
WT. WET COMPACTED SOIL, lb	J	H - I	3.83	3.96	4.11	4.14	4.02	
WT. OF CUP & WET SOIL, g	K		568.0	569.6	584.0	581.4	592.5	
WT. OF CUP & DRY SOIL, g	L		533.5	526.5	530.8	521.7	526.8	
WT. OF WATER, g	WW	K - L	34.5	43.1	53.2	59.7	65.7	
WT. OF CUP & DRY SOIL, g	L		533.5	526.5	530.8	521.7	526.8	
WT. OF CUP, g	M		47.5	47.5	47.6	47.6	47.5	
WT. OF DRY SOIL, g	DW	L - M	486.0	479.0	483.2	474.1	479.3	
WET DENSITY, lb/ft^3	WWD	J x 30	114.9	118.8	123.3	124.2	120.6	
MOISTURE CONTENT, %	MC	(WW/DW) x 100	7.1	9.0	11.0	12.6	13.7	
DRY DENSITY, lb/ft^3	DWD	$\frac{WWD}{100 + MC} \times 100$	107.3	109.0	111.1	110.3	106.1	

REMARKS:

Laboratory Moisture - Density Relationship Worksheet (03-22-4194)
Figure B-1 (English)



Note: This chart is not suitable for use when Type IP Portland-Pozzolan Cement is being used.

ADDITIVE CONVERSION CHART

RELATION IN PERCENT BY WEIGHT OF OVEN-DRY SOIL, SOIL AGGREGATE, OR AGGREGATE TO DESIGN PERCENT BY VOLUME

Additive Conversion Chart
Figure B-2 (English)

LAB COMPACTION REPORT - DOTD TR 418 METHOD B

DOTD 03-22-4165
Metric / English
Rev. 3/98

Project No. 999-99-0099 Station S. No. 1 Lab No. 22-999999

COMPACTION REPORT

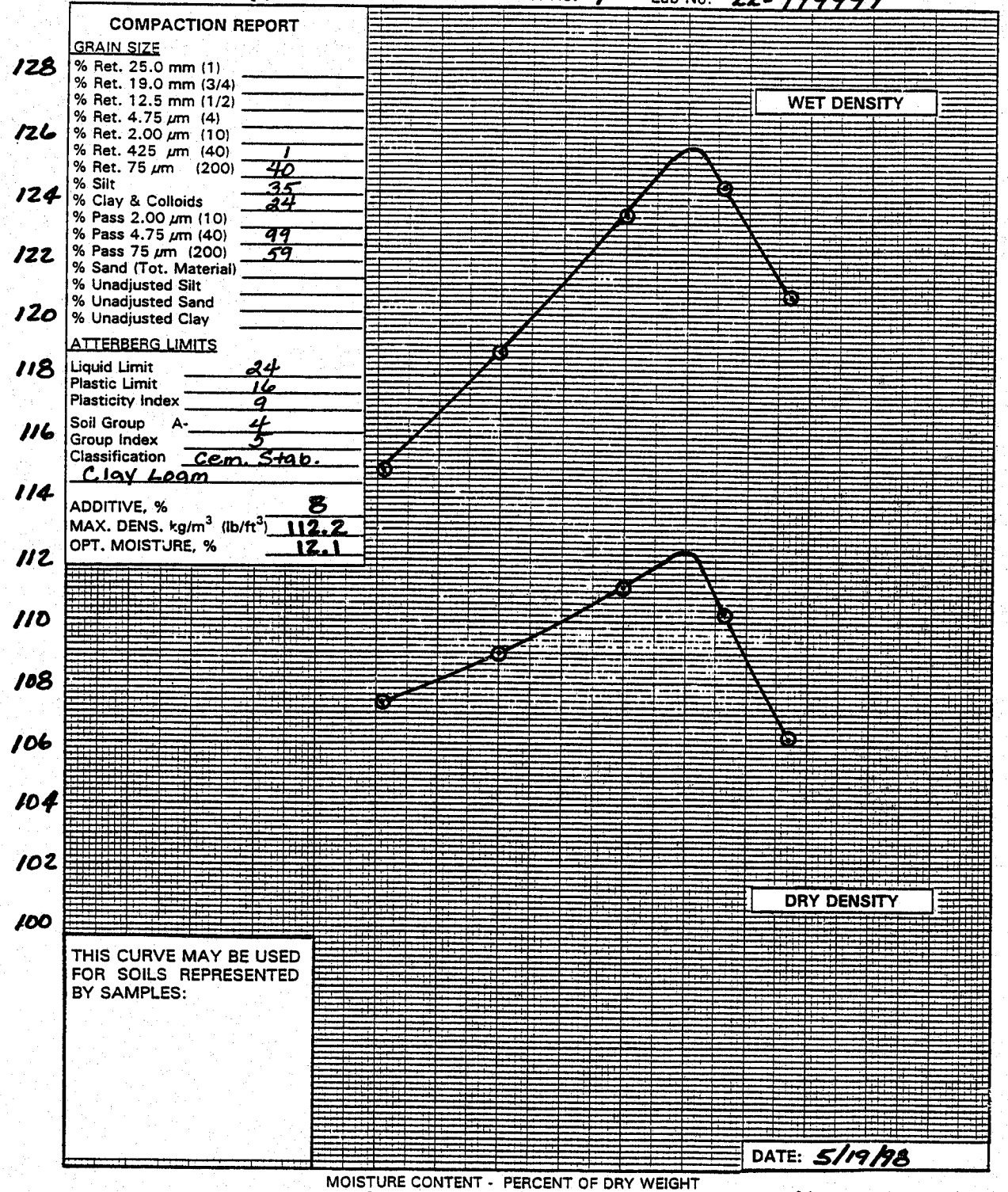
GRAIN SIZE

% Ret. 25.0 mm (1)	
% Ret. 19.0 mm (3/4)	
% Ret. 12.5 mm (1/2)	
% Ret. 4.75 µm (4)	
% Ret. 2.00 µm (10)	
% Ret. 425 µm (40)	1
% Ret. 75 µm (200)	40
% Silt	35
% Clay & Colloids	24
% Pass 2.00 µm (10)	
% Pass 4.75 µm (40)	99
% Pass 75 µm (200)	59
% Sand (Tot. Material)	
% Unadjusted Silt	
% Unadjusted Sand	
% Unadjusted Clay	

ATTERBERG LIMITS

Liquid Limit	24
Plastic Limit	16
Plasticity Index	9
Soil Group A-	4
Group Index	5
Classification	Cem. Stab. Clay Loam

ADDITIVE, %	8
MAX. DENS. kg/m³ (lb/ft³)	112.2
OPT. MOISTURE, %	12.1



THIS CURVE MAY BE USED FOR SOILS REPRESENTED BY SAMPLES:

DATE: 5/19/98

Laboratory Compaction Report (03-22-4165)
Figure B-3 (English)

MATT MENU SELECTION - 14

Louisiana Department of Transportation and Development
SOILS/SOIL-AGGREGATE

DOTD 03-22-0723
Rev. 7/98

Metric / English E *(M or E - Located on MATT Menu)*

Project No. 919191-919191-010919 **Material Code** 4211 **Lab. No.** 2121-919191919191

Date Sampled 1101-1011-1917 **Submitted By** 010919 **Quantity**

Purp. Code 17 **Pit No.** **Spec Code** 5

Date Tested 1101-1891-1917 **Ident.** 51-11 **Parish No.** 117

From Station + **To Station** + **Location**

Hole No. **Depth, m (ft)** **Log Distance, km (mi)**

Item No. **Sampled by:**

Remarks 1

Hydrometer Analysis (DOTD TR 407)			Graduate No.	Dry Mass of Sample (W), g (1 = 50.0, 2 = 100.0)			
Time	(T) Elapsed Time	Temp°C (0.5° increments)	(h) Hydro Reading (0.5 increments)	(C) Correction (0.5 increments)	Corrected Reading H = h - C	% Finer $P = \frac{H}{W} \times 100$	Effect. Grain Size $D = K\sqrt{\frac{L}{T}}$
	60 Minutes						
	120 Minutes						

RETAINED ON 2.00 µm (10)
Mass Cup + Soil, g
Cup No.
Mass Cup, g
Mass Soil, g

RETAINED ON 425 µm (40)
Mass Cup + Soil, g
Cup No.
Mass Cup, g
Mass Soil, g

RETAINED ON 75 µm (200)
Mass Cup + Soil, g
Cup No
Mass Cup, g
Mass Soil, g

Size	Mass Retained (Wx) Gram	%
Total Mass, g		
25.0 mm (1)		
19.0 mm (3/4)		
12.5 mm (1/2)		
4.75 µm (4)		
2.00 µm (10)		
425 µm (40)		
75 µm (200)		
% Silt		
% Clay & Colloids		
Pass 4.75 µm (#4)		
Pass 2.00 µm (#10)		

(DOTD TR 407)

% Ret. 25.0 mm (1)	
% Ret. 19.0 mm (3/4)	
% Ret. 12.5 mm (1/2)	
% Ret. 4.75 µm (4)	
% Ret. 2.00 µm (10)	
% Ret. 425 µm (40)	1
% Ret. 75 µm (200)	40
% Silt	35
% Clay & Colloids	24
% Pass 2.00 µm (#10)	100
% Pass 4.75 µm (40)	99
% Pass 75 µm (200)	59
% Sand (Tot. Material)	41
% Unadjusted Silt	
% Unadjusted Sand	
% Unadjusted Clay	

LIQUID LIMIT
No. Blows
Mass Cup + Wet Soil, g
Mass Cup + Dry Soil, g
Mass Water, g
Factor
Cup No.
Mass Cup, g
Mass Dry Soil, g
% Moisture

PLASTIC LIMIT
Mass Cup + Wet Soil, g
Mass Cup + Dry Soil, g
Mass Water, g
Cup No.
Mass Cup, g
Mass Dry Soil, g
% Moisture

% Organic Matter (TR 413)
Liquid Limit (TR 428) 24
Plasticity Index (TR 428) 8
Natural Moisture Content, % (TR 403)
Optimum Moisture Content, % (TR 418) 12.1
Maximum Density, kg/m³ (lb/ft³) (TR 418) 121.2 (121.24)
Laboratory Compaction Method (TR 418) B
% Cement (TR 432 or Plans) 8.10
% Lime (TR 416)
% Fly Ash
% Other (Additive) Material Code Percent
Soil Group (TR 423) A-4(2)
Classification (TR 423) Cement Stab. Clay Loam
pH (TR 430)
Resistivity, ohm-cm (TR 429)
Classification Prefix (TR 423) (G = Siliceous Aggr. N = Non-Siliceous S = Shell)
(Required only if +2.00 mm (No.10, g) material equals or exceeds 5%)

Remarks 2

Tested By: I.S., N.H. Checked By: G.C. APPROVED BY:
Date: 10/29/97 Date: 11/1/97 DATE:

Soils/Soil-Aggregate Report (03-22-0723)
Figure B-4 (English)

DOTD Designation: TR 418-98
ENGLISH VERSION

METHOD C

I. Scope

This method of test is designed to determine the optimum moisture content and maximum dry weight density of shell or sand-shell when compacted in the laboratory in accordance with this procedure.

II. Apparatus

A. **Mold**
1. A cylindrical metal mold, having a capacity of 1/10 ft^3, manufactured with an internal diameter of 6.000±0.026 in. and a height of 6.100±0.016 in., and with a detachable collar approximately 3.5 in. in height, which can be fastened firmly to a base plate.
2. Molds shall be replaced if any diameter is more than 6.039 in. or the height is less than 6.000 in. at any point.

Note C-1: *Different makes of compactive devices may use mold base plates of different designs. The mold base plate must be compatible with the make of compactive device used.*

B. **Compactive device** - automatic rammer with a 10.0±0.1 lb rammer, with a striking face that is a 3.1416 sq in sector face for use with a 6-in. inside diameter mold and arranged to control the height of drop to 18.0±0.06 in.
C. **Compaction block** - a stable block or pedestal composed of portland cement concrete weighing a minimum of 200 lb.
D. **Straightedge** - steel straightedge, approximately 12 in. long.
E. **Scale** - a scale of 20 lb or more capacity, sensitive to 0.01 lb.
F. **Sieve** - a 3/4 in. sieve, conforming to the requirements of the Standard Specification for Wire Cloth Sieves for Testing Purposes (AASHTO Designation M 92).
G. **Tools**
1. Mixing pans with appropriate covers.
2. Spoons.
3. Pointed trowel.
4. Spatula or large suitable mechanical device for thoroughly mixing material with water.
5. Large screwdriver to remove material from mold.
6. Finishing tool.
7. Height gauge - dial micrometer incremented in 0.001 in., accurate to 0.001 in., mounted on a stand.

H. **Graduated cylinders** - incremented in mL.
I. **Wax paper.**
J. **Engineer's Curve** - Alvin 1010-21, or equivalent.
K. **Power driven wedge crusher.**
L. **Laboratory Moisture - Density Worksheet, Methods C & D** - DOTD Form No. 03-22-4195. (Figure C-1)
M. **Laboratory Compaction Report** - DOTD Form No. 03-22-4165. (Figure C-2)
N. **Aggregate Test Report** - DOTD Form No. 03-22-0745. (Figure C-3)

Note C-2: *It is convenient, but not essential, to have a mechanical device for removing the compacted material from the mold. Such a device may consist of a closed, cylindrical sleeve slightly less than 6.0 in. in diameter or a piston of the same diameter, actuated mechanically, hydraulically or by air pressure.*

III. Test Sample

A. Obtain a representative sample, weighing 120 lb each (4 full sample sacks each) of shell and sand.
B. Dry entire sample of each component in accordance with DOTD TR 411.

IV. Procedure

A. Preparation
1. Set crusher to produce 3/4 in. maximum size material.
2. Crush entire dried shell sample, sieve and recrush, until 95-100 percent of the material passes a 3/4 in. sieve.

Note C-3: *If sand is not to be mixed with the shell, proceed to Step 5.*

3. If the material to be tested is a sand-shell mixture, determine the "unit weight at point of delivery" of each component (sand and crushed shell) in accordance with DOTD TR 417.
4. If the material to be tested is a sand-shell mixture, determine the percent by weight of each component by using the specified percent by volume. Refer to Step V.A.

5. Prepare a minimum of five 15 lb representative portions. If the material is a sand-shell mixture, combine the sand and shell in the proportions by weight determined in Step 4, and mix thoroughly.

B. Testing

1. Add a sufficient quantity of water, measured in mL, to make the 15 lb representative portion to be used for the first point slightly damp. Mix thoroughly. Record the quantity of water added as **G** for the first point on the worksheet.
2. Add and thoroughly mix a quantity of water, measured in mL, to each remaining 15 lb representative portion to increase the moisture content of each portion by 2% more than the moisture content of the previous portion. The 2% increment may be adjusted if necessary. (Refer to Step V.B) Record the quantity of water added as **G** for the remaining points on the Moisture-Density Relationship Worksheet, Methods C and D.
3. Cover the representative portions to which water has been added, protect them so that the moisture content remains constant, then allow them to stand for a minimum of 30 min. Remix and recover the individual representative portions.
4. Compact test specimen.
   a. If mold requires an attachable base plate, attach base plate. Weigh mold and base plate and record as **I** on the worksheet.
   b. When using a mold without an attachable base plate, place wax paper on compactor base. Weigh mold and record as **I** on the worksheet. Place the mold over the wax paper and secure to the compactor base.
   c. Attach collar to mold.
   d. Uncover a representative portion and remix.
   e. Place a quantity of this material into the mold in an even layer that will yield approximately 1/3 the volume of the mold after compaction. Recover the representative portion.
   f. Use a pointed trowel to rearrange particles, filling voids in the loose material without compacting the material, to a uniform lift thickness.
   g. Rest the automatic rammer on top of the layer to be compacted. Compact the layer using 150 blows with the rammer.
   h. Note height of compacted material. If compacted layer is not 1/3 the height of the mold, correct for any deviation by adjusting the quantity of material used for the subsequent layer.
   i. Repeat Steps IV.B.4.d- h for two more layers.
   j. After the third layer has been compacted, remove the mold, base plate, if applicable, and compacted specimen from the automatic rammer and place in a pan.
   k. Tap the collar with the straightedge to loosen material bond and remove the collar from the mold, without twisting or causing shear stress to the molded specimen.
   l. Note the height of the compacted test specimen.
      (1) If the compacted material is less than 5.75 in. in height or is more than 0.50 in. above the height of the mold, remove all material from the mold, remix it with the original representative portion and repeat the test.
      (2) If the compacted material is above the top of the mold, but not more than 0.50 in. above, proceed as follows:
      Keeping the mold, base plate (if applicable), and specimen in the pan, trim the specimen even with the top of the mold, using the steel straightedge. Fill any depressions with the fine, trimmed material, smoothing each area with the straightedge after it is filled. Do not attempt to replace aggregates that have been dislodged.
      (3) If the compacted material is below the top of the mold, but greater than 5.75 in. in height, proceed as follows:
         (a) Place the finishing tool on the compacted surface and rotate it while tapping very lightly to smooth and level the surface. Do not impart additional compactive effort to the specimen.
         (b) Determine the height of the specimen by measuring to the nearest 0.001 in. at three locations spaced equally around the circumference, and averaging.
         (c) Calculate the volume of the specimen in accordance with Step V.C and record as **K** on the worksheet.
   m. Brush material from all outside surfaces of mold and exposed edges of base plate or wax paper.
   n. Remove wax paper (if applicable) and brush

fines from wax paper onto top of test specimen. Take care not to lose any fines from test specimen.

o. Weigh mold, base plate (if applicable), and compacted test specimen and record as **H** on the worksheet.

p. Remove the base plate (if applicable). Remove test specimen from mold and determine moisture content by breaking up and drying the entire test specimen in accordance with DOTD TR 403, Method B.

q. Repeat Steps IV.B.4.a-p for each 15 lb representative portion, cleaning the mold between each test specimen. Continue repeating the procedure until there is a substantial decrease in the wet weight of the compacted material or the material becomes too wet to compact.

V. Calculations

A. If the material tested is a sand-shell mixture, calculate the percent by weight for each component (sand (W_1) and shell (W_2)) using the following formulas, and record on the Moisture-Density Relationship Worksheet, Methods C and D.

$$W_1 = \frac{S_1 \times V_1 \times 100}{(S_1 \times V_1) + (S_2 \times V_2)}$$

$$W_2 = \frac{S_2 \times V_2 \times 100}{(S_1 \times V_1) + (S_2 \times V_2)}$$

where:

S_1 = unit wt of sand at point of delivery (from DOTD TR 417), lb/ft^3
S_2 = unit wt of shell at point of delivery (from DOTD TR 417), lb/ft^3
V_1 = % by volume of sand (as specified)
V_2 = % by volume of shell (as specified)

example:

S_1 = 90.0 lb/ft^3 V_1 = 35 %
S_2 = 60.0 lb/ft^3 V_2 = 65 %

$$W_1 = \frac{90.0 \times 35 \times 100}{(90.0 \times 35) + (60.0 \times 65)}$$

$$= \frac{315000}{(3150) + (3900)}$$

$$= 44.680$$

$$W_1 = 44.7$$

$$W_2 = \frac{60.0 \times 65 \times 100}{(90.0 \times 35) + (60.0 \times 65)}$$

$$= \frac{390000}{(3150) + (3900)}$$

$$= 55.319$$

$$W_2 = 55.3$$

B. Calculate the quantity of water to be added to each representative portion (G_n) to yield a moisture content incremented by 2 percent above that of the previous representative portion by using the following formula.

$$G_n = G_{n-1} + 136$$

where:

G_{n-1} = volume of water added to the previous representative portion, mL
136 = a constant representing the volume of water in mL required for a two percent moisture content for a 15.00 pound representative portion

example:

G_{n-1} = 306 mL

$$G_n = 306 + 136$$

$$G_n = 442$$

***Note C-4:** 1 g of water = 1 cc of water = 1 mL of water*

C. Calculate the volume of the test specimen (K) in ft^3 by using the following formula.

$$K = h \times 0.01636$$

where:

h = average height of test specimen, in.
0.01636 = constant equal to the volume of a 6 in. diameter mold, per in. of height, ft^3

example:

h = 5.903 in.

$$K = 5.903 \times 0.01636$$

$$= 0.09657$$

$$K = 0.097$$

where:

h = average height of test specimen, in.
0.01636 = constant equal to the volume of a 6 in. diameter mold, per in. of height, ft^3

example:

h = 5.903 in.

$K = 5.903 \times 0.01636$

$= 0.09657$

$K = 0.097$

D. Calculate wet weight of compacted material in mold (J) in lb for each representative portion by using the following formula and record on the worksheet.

$$J = H - I$$

where:

H = wt of mold and compacted wet material, lb
I = wt of mold, lb

example:

H = 26.72 lb
I = 14.17 lb

$J = 26.72 - 14.17$

$J = 12.55$

E. Calculate wet weight density (WWD) in lb/ft^3 for each representative portion using the following formula and record on the worksheet.

$$WWD = \frac{J}{K}$$

where:

J = wet wt of compacted material, lb
K = (1/10) a constant representing the volume of the mold or the volume of the specimen (if applicable) as calculated in Step C, ft^3

example:

J = 12.55 lb
K = 0.097 ft^3

$$WWD = \frac{12.55}{0.097}$$

$= 129.381$

$WWD = 129.4$

F. Calculate the weight of dry material (DW) and the weight of water (WW) in lb for each moisture content by using the following formulas.

$DW = L - M$ and $WW = J - DW$

where:

L = wt of pan and dry material, lb
M = wt of pan, lb
J = wet wt of compacted material, lb

examples:

L = 17.14 lb
M = 5.13 lb
J = 12.55 lb

$DW = 17.14 - 5.13$ and $WW = 12.55 - 12.01$

$DW = 12.01$ $WW = 0.54$

G. For each increment of water added, calculate the moisture content (MC) in % of the material to the nearest 0.1 percent by using the following formula.

$$MC = (\frac{WW}{DW}) \times 100$$

where:

WW = wt of water, lb
DW = wt of dry material, lb

example:

WW = 0.54 lb
DW = 12.01 lb

$$MC = (\frac{0.54}{12.01}) \times 100$$

$= 0.04496 \times 100$

$MC = 4.5$

H. Calculate the dry weight density (DWD) for each representative portion in lb/ft^3 using the following formula and record on the worksheet.

$$DWD = \frac{(WWD)}{100 + (MC)} \times 100$$

where:

WWD = wet weight density, lb/ft^3
MC = % moisture content
100 = constant

example:

WWD = 129.4 lb/ft^3
MC = 4.5 %

$$DWD = \frac{129.4}{(100 + 4.5)} \times 100$$

$$= 1.23827 \times 100$$

$$DWD = 123.8$$

I. Beginning with the lowest moisture content, plot a point on the Laboratory Compaction Report, representing the intersection of a horizontal line projected from the wet weight density and a vertical line projected from the moisture content. Continue for each moisture content until all points for wet weight densities have been plotted. Repeat the process for each moisture content, substituting dry weight densities for wet weight densities.

J. Form a smooth line using the engineer's curve by connecting the plotted points to form two curves, Wet Weight Density Vs. Moisture Content and Dry Weight Density Vs. Moisture Content. (Refer to the Laboratory Compaction Report.)

Note C-5: *If after the results have been plotted, there is not a minimum of three points on the dry side and two points on the wet side of optimum, additional testing must be performed until this minimum is met. If a smooth curve cannot be drawn, additional testing may be required.*

K. Determine the Optimum Moisture Content (%) of the total material, which is the moisture content corresponding to the peak of the dry weight density curve.

L. Determine the maximum dry weight density of the total material, which is the weight corresponding to the peak of the Dry Weight Density Curve.

VI. Report

A. Report the Maximum Dry Weight Density and Optimum Moisture Content on the Laboratory Compaction Report and the Aggregate Test Report to the nearest 0.1 lb/ft^3 and 0.1 percent, respectively.

B. Report the material type (shell or sand-shell) on the Laboratory Compaction Report.

C. Report the DOTD TR 418 method used on the Aggregate Test Report and on the Laboratory Compaction Report.

VII. Normal Test Reporting Time

Normal test reporting time is 3 days.

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

DOTD 03-22-4195
English
Rev. 4/98

LABORATORY MOISTURE - DENSITY RELATIONSHIP
DOTD TR 418 - Methods Ⓒ & D
(English)

PROJECT NO: 999-99-0099 DATE: 01/05/97 LAB NO: 22-999999

*TYPE ADDITIVE: _____ TYPE SOIL: Sand/Shell SAMPLE NO: SS-6

TESTED BY: P.B. CHECKED BY: G.C.

	SAND	SHELL	TOTAL
PERCENT BY VOLUME	V_1 = 35	V_2 = 65	$V_1 + V_2$ = 100
UNIT WEIGHT, lb/ft³	S_1 = 90.0	S_2 = 60.0	
THEORETICAL UNIT WEIGHT OF MIX, lb/ft³	S_1V_1 = 31.5	S_2V_2 = 39.0	$S_1V_1 + S_2V_2$ = 70.5
PERCENT BY WEIGHT SAND-SHELL	W_1 = 44.7	W_2 = 55.3	$W_1 + W_2$ = 100.0
MIX WEIGHT OF SAND-SHELL, lb	(W_1 x 15) ÷ 100 = 6.70	(W_2 x 15) ÷ 100 = 8.30	D = 15.00

*MAX. DRY WT. DENSITY OF MATERIAL (From TR 418, Method C), lb/ft³	A		
*REQUIRED % BY VOL. OF ADDITIVE (___ TR 432-B, ___ specified)	B		
*% WT. OF ADDITIVE (___ chart, ___ formula)	C		
DRY WT. OF MATERIAL (Rep. portion) (___ Shell, ___ Sand-Shell), lb	D		15.00
*WT. OF ADDITIVE TO BE ADDED, lb	E	(C x D) ÷ 100	
*TOTAL DRY WT. OF MATERIAL AND ADDITIVE, lb	F	D + E	

* *FOR USE WITH DOTD TR 418, METHOD D ONLY.*

CURVE POINT NO.	***		1	2	3	4	5	6
PAN NO. (if applicable)	***		31	27	61	101	70	
WATER ADDED, mL	G	See Calculations	306	442	578	714	850	
WT. MOLD, BASE (if appl.) & WET MATL, lb	H		26.72	27.18	27.50	27.48	27.23	
WT. MOLD & BASE (if applicable), lb	I		14.17	14.17	14.17	14.17	14.17	
WT. WET COMPACTED MATERIAL, lb	J	H - I	12.55	13.01	13.33	13.31	13.06	
VOLUME OF MOLD (or specimen), ft³	K		0.097					
WT. OF PAN & DRY MATERIAL, lb	L		17.14	17.56	17.63	17.30	16.90	
WT. OF PAN, lb	M		5.13	5.36	5.27	5.16	5.20	
WT. OF DRY MATERIAL, lb	DW	L - M	12.01	12.20	12.36	12.14	11.70	
WT. OF WATER, lb	WW	J - DW	0.54	0.81	0.97	1.17	1.36	
WET DENSITY, lb/ft³	WWD	J/K	129.4	134.1	137.4	137.2	134.6	
MOISTURE CONTENT, %	MC	(WW/DW) x 100	4.5	6.6	7.8	9.6	11.6	
DRY DENSITY, lb/ft³	DWD	$\frac{WWD}{100 + MC} * 100$	123.8	125.8	127.5	125.2	120.6	

REMARKS: _____

Laboratory Moisture - Density Relationship Worksheet (03-22-4195)
Figure C-1 (English)

LAB COMPACTION REPORT - DOTD TR 418 METHOD C

DOTD 03-22-4165
Metric / English
Rev. 3/98

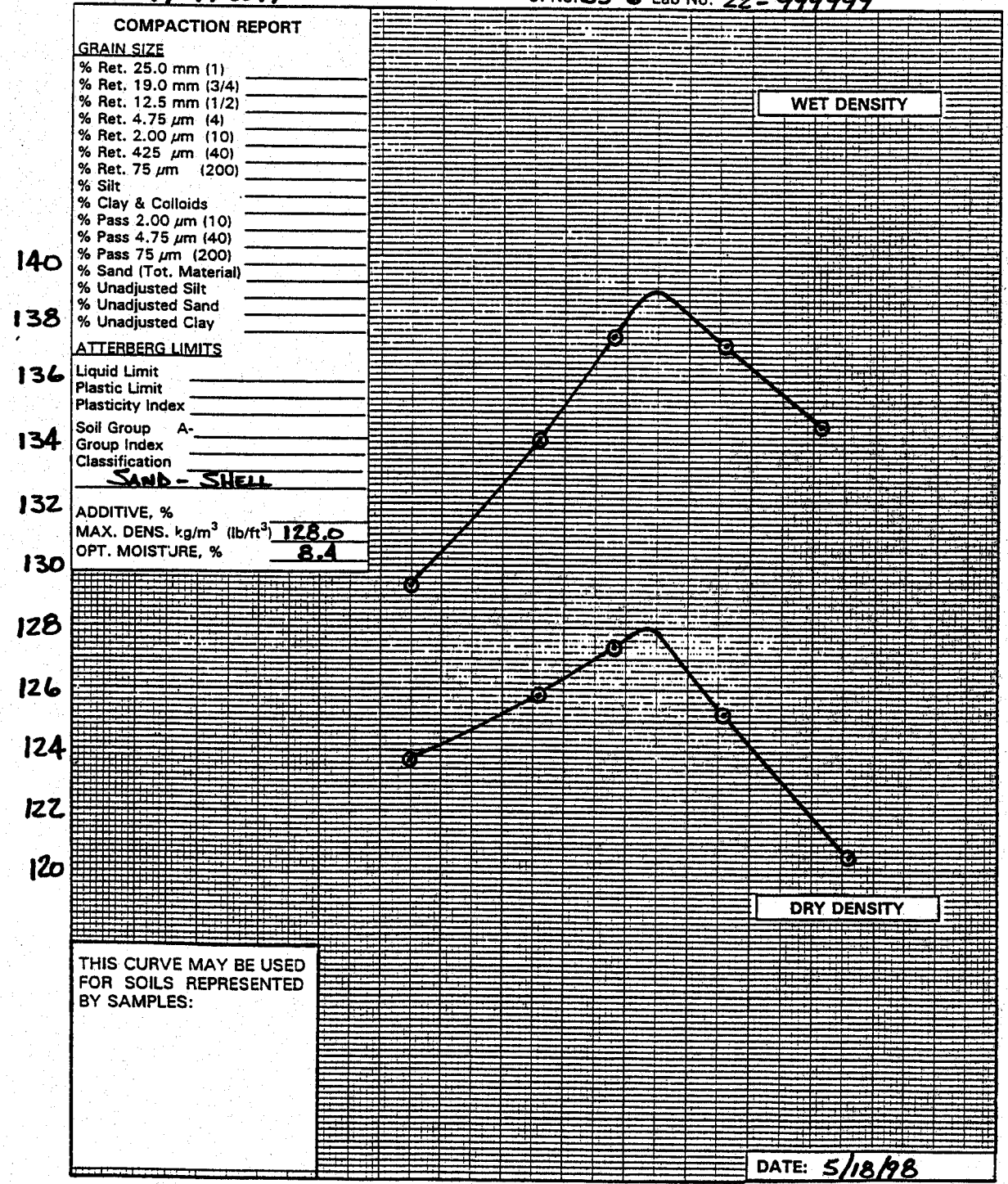
Project No. 999-99-0099 Station S. No. SS-6 Lab No. 22-999999

COMPACTION REPORT

GRAIN SIZE
- % Ret. 25.0 mm (1)
- % Ret. 19.0 mm (3/4)
- % Ret. 12.5 mm (1/2)
- % Ret. 4.75 μm (4)
- % Ret. 2.00 μm (10)
- % Ret. 425 μm (40)
- % Ret. 75 μm (200)
- % Silt
- % Clay & Colloids
- % Pass 2.00 μm (10)
- % Pass 4.75 μm (40)
- % Pass 75 μm (200)
- % Sand (Tot. Material)
- % Unadjusted Silt
- % Unadjusted Sand
- % Unadjusted Clay

ATTERBERG LIMITS
- Liquid Limit
- Plastic Limit
- Plasticity Index
- Soil Group A-
- Group Index
- Classification: SAND - SHELL

ADDITIVE, %
MAX. DENS. kg/m³ (lb/ft³) 128.0
OPT. MOISTURE, % 8.4



THIS CURVE MAY BE USED FOR SOILS REPRESENTED BY SAMPLES:

DATE: 5/18/98

Laboratory Compaction Report (03-22-4165)
Figure C-2 (English)

MATT MENU SELECTION - 2

Louisiana Department of Transportation and Development

AGGREGATE TEST REPORT

DOTD 03-22-0745
Metric / English
Rev. 2/98

Project No. 9191-1919-101919 | Material Code 4216 | Lab No. 21-191919191919
Date Sampled 12-1012-1917 | Submitted By 101919 | Quantity
Purp Code 7 | Source Code AA1919 | Spec Code 3 | P.O. No.
Date Tested - - | Ident 515-16 | Plant Code | Frict.Rating (1-4)
Item No. | Date Rec'd (lab) 12/2/97 | Sampled By: N.D.H.
Remarks 1

Tested By P.B. | Date 12/5/97 | Checked By G.C. | Date 12/20/97

DOTD TR 102, 112, 113 & 309

Unit 1 = grams 2 = pounds

Sieve mm	Sieve In.	Mass Retained	% Retained	% Coarser	% Passing
63	2 1/2				
50	2				
37.5	1 1/2				
31.5	1 1/4				
25.0	1				
19.0	3/4				
16.0	5/8				
12.5	1/2				
9.5	3/8				
4.75	No. 4				
Mass Matl.in Pan					
Acc. Total					
Initial Dry Total Mass			% Diff:		

Unit 1 = grams 2 = pounds

Sieve mm/µm	Sieve No.	Mass Retained	% Retained	% Coarser	% Passing
2.36	8				
2.00	10				
1.18	16				
600	30				
425	40				
300	50				
180	80				
150	100				
75	200				
53	270				
Mass Matl.in Pan					
Decant Loss					
Acc. Total					
Initial Dry Total Mass			% Diff:		
Dry Mass After Wash					

Remarks 2:

DOTD TR 428

Liquid Limit | Plastic Limit
No. of Blows | Mass Cup + Wet Soil,g
Mass Cup + Wet Soil,g | Mass Cup + Dry Soil,g
Mass Cup + Dry Soil,g | Mass Water
Mass Water | Cup No.
Factor | Mass Cup, g
Cup No. | Mass Dry Soil
Mass Cup, g | % Moisture
Mass Dry Soil
% Moisture | Plasticity Index

Absorption (T84 or T85)	
Spec Grav SSD (T84 or T85)	
Spec Grav APP (TR 300)	
Effective Spec Grav (TR 300)	
Opt Moist Content, % (TR 418)	8.4
Maximum Density (TR 418) kg/m³ (lb/ft³)	128.0
Lab Comp Method (TR 418)	C
Cement, % (TR 432 or SPECIFIED)	
Lime, % (TR 416 or SPECIFIED)	
Other (Additive) Code %	
Clay Lumps, % (TR 119)	
Friable Particles, % (TR 119)	
Clay Lumps & Friable Particles % (TR 119)	
Flat or Elongated Part, % (TR 119)	
Coal & Lignite, % (TR 119)	
Glassy Particles, % (TR 119)	
Iron Ore, % (TR 119)	
Wood, % (TR 119)	
Total (Clay Lumps, Fri.Part., Iron Ore, Coal & Lignite, Wood), % (TR 119)	
Foreign Matter, % (TR 109)	
Clam Shell, % (TR 110)	
Soundness, % Loss (T 104)	
Abrasion, % Loss (T 96)	
Colorimetric Test (1 = Pass, 2 = Fail) (T 21)	
Asphalt Content, % (TR 307)	
Retained Asphalt Coating, % (TR 317)	
Percent Crushed (TR 306)	
Retained Marshall Stability (TR 313)	
Resistivity (TR 429)	
pH (TR 430)	
Organic Content, % (TR 413)	
Sand Equivalent (TR 120)	

Approved By: | Date:

Aggregate Test Report (03-22-0745)
Figure C-3 (English)

DOTD Designation: TR 418-98
ENGLISH VERSION

METHOD D

I. Scope

This method of test is designed to determine the optimum moisture content and maximum dry weight density of shell or sand-shell with cement additive when compacted in the laboratory in accordance with this procedure.

II. Apparatus

A. **Same as DOTD TR 418, Method C.**
B. **Cement.**

Note D-1: *Cement shall meet DOTD specifications for Type IB. For Type IB cement, a unit weight of 94 lb/ft^3 shall be used.*

When Type II or Type IP cement is used on the project, it shall be used in lieu of Type IB to determine the report values for this method of test. Type II and Type IP cement shall meet DOTD specifications. For Type IP cement a unit weight of 90 lb/ft^3 shall be used. For Type II cement, a unit weight of 94 lb/ft^3 shall be used.

C. **Personal protective equipment.**
   1. Respirator.
   2. Gloves.
   3. Apron.
   4. Goggles.
D. **Laboratory Moisture-Density Worksheet, Methods C & D** - DOTD Form No. 03-22-4195. (Figure D-1)
E. **Additive Conversion Chart.** (Figure D-2)
F. **Laboratory Compaction Report** - DOTD Form No. 03-22-4165. (Figure D-3)
G. **Aggregate Test Report** - DOTD Form No. 03-22-0745. (Figure D-4)

III. Test Sample

Same as DOTD TR 418, Method C.

IV. Health Precautions

Care must be taken not to allow cement to contact skin or to inhale the dust.

V. Procedure

A. Preparation
   1. Determine the maximum dry weight density of the raw material using DOTD TR 418, Method C, and record as **A** on the worksheet.
   2. Determine the percent by volume of cement in accordance with DOTD TR 432, Method B or use the percent specified. Refer to Step VI.A or B for weight-volume conversion calculations. Record the percent cement by volume as **B** and the percent by weight as **C** on the worksheet.
   3. Prepare a minimum of five 15 pound representative portions from the test sample. If the material is a sand-shell mixture, combine the sand and shell in the proportions by weight determined by DOTD TR 418, Method C.

B. Testing
   1. Calculate the weight of additive to be added to the representative portions in accordance with Step VI.C and record as **E** on the worksheet.
   2. Add the required weight of cement determined in Step V.B.1 to each representative portion.

Note D-2: *Coordinate the initial mixing of cement with the representative portion so that a continuous compaction operation will result without violating the 90 ± 5 minute standing and slaking times in the following steps.*

   3. Add a sufficient quantity of water measured in mL, to make the 15 lb representative portion to be used for the first point slightly damp. Mix thoroughly. Record the quantity of water added as **G** on the worksheet.
   4. Add and thoroughly mix a quantity of water, measured in mL, to each remaining 15 lb representative portion to increase the moisture content of each representative portion by 2% more than the moisture content of the previous portion. The 2% increment may be adjusted if necessary.(Refer to Step VI.D) Record the quantity of water added to each representative portion as **G** on the worksheet.
   5. Cover the representative portions and allow them to stand for approximately 30 minutes, then remix.
   6. Cover the representative portions and protect them so that the moisture content remains

constant, then allow them to slake for 60 ± 5 minutes.

7. Compact test specimen in accordance with Method C, Steps IV.B.4.a-q.

VI. Calculations

A. Calculate percent by weight of cement by Additive Conversion Chart.

1. Enter the chart on the left scale. Reading vertically, place a point at appropriate maximum dry weight density of the shell or sand-shell mixture obtained in Method C.
2. Reenter the chart on the right scale. Reading vertically, place a point at the design percent by volume of cement.
3. Draw a straight line across the chart connecting the two points plotted in Steps 1 and 2.
4. Read the percent cement by weight directly from the chart at the point where the line drawn in Step 3 intersects the middle scale.
5. Record the percent by weight of additive as **C** on the worksheet.
6. Example: Figure D-2

   A = 128 lb/ft^3
   B = 5 % cement by volume
   U = 94 lb/ft^3

   a. Follow the left scale to the point represented by 128 lb/ft^3.
   b. Follow the right scale to the point represented by 5% by volume.
   c. Draw a straight line across the scale, connecting the two points.
   d. The percent cement by weight, read directly from the middle scale, is 3.8%.

B. In lieu of the charts or if values are not covered by the charts, determine the percent by weight of cement (C) by using the following formula.

$$C = \frac{(UB/100)}{A - (UB/100)} \times 100$$

$$C = \frac{1}{(A/UB) - 0.01}$$

where:

A = maximum dry wt density of the shell or sand-shell, lb/ft^3
B = % by volume of cement
U = unit wt of cement, lb/ft^3
100 = constant
0.01 = constant

example:

A = 128 lb/ft^3
B = 5 %
U = 94 lb/ft^3

$$C = \frac{1}{[128/(94 \times 5)] - 0.01}$$

$$= \frac{1}{(0.2723) - 0.01}$$

$$= \frac{1}{0.2623}$$

$$C = 3.8$$

Note D-3: *To achieve required accuracy after rounding, carry to four decimal places, as shown.*

C. Calculate the weight of additive (E) in lb to be incorporated into the representative portion of soil by using the following formula and record on the worksheet.

$$E = \frac{C \times D}{100}$$

where:

C = % by wt of additive (from chart or formula)
D = dry wt of representative portion, lb
100 = constant

example:

C = 3.8 %
D = 15.00 lb

$$E = \frac{3.8 \times 15.00}{100}$$

$$= \frac{57.00}{100}$$

$$E = 0.57$$

D. Calculate the quantity of water to be added to each representative portion (G_n) in mL to yield a moisture content incremented by 2 percent above that of the previous representative portion by using the following formula.

$$G_n = G_{n-1} + (9.072 \times F)$$

where:

G_{n-1} = volume of water added to the previous representative portion, mL
F = total wt of material and cement, lb
9.072 = a constant representing a conversion factor from lb to mL for a 2% increment of moisture

example:

G_{n-1} = 272 mL
F = 15.57 lb

$$G_n = 272 + (9.072 \times 15.57)$$

$$= 272 + 141.25$$

$$G_n = 413$$

Note D-4: *1 g of water = 1 cc of water = 1 mL of water*

E. Perform all calculation steps for the material in accordance with Method C, Step V.C-L.

VII. Report

A. Report the Maximum Dry Weight Density and Optimum Moisture Content on the Laboratory Compaction Report and the Aggregate Test Report to the nearest 0.1 lb/ft^3 and 0.1 percent, respectively.
B. Report the type and percent by volume of cement to the nearest 0.1 percent and the material type (shell or sand-shell) on the Laboratory Compaction Report.

VIII. Normal Test Reporting Time

Normal test reporting time is 5 days.

Note D-5: *When percent cement is to be determined by DOTD TR 432, Method B, normal test reporting time will be 3 weeks.*

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

DOTD 03-22-4195
English
Rev. 4/98

LABORATORY MOISTURE - DENSITY RELATIONSHIP
DOTD TR 418 - Methods C & D
(English)

PROJECT NO: 999-99-0099 DATE: 01/07/97 LAB NO: 22-999999

*TYPE ADDITIVE: Type IB Cement TYPE SOIL: Sand/Shell SAMPLE NO: SS-7

TESTED BY: P.B. CHECKED BY: G.C.

	SAND	SHELL	TOTAL
PERCENT BY VOLUME	V_1 = 35	V_2 = 65	$V_1 + V_2 = 100$
UNIT WEIGHT, lb/ft³	S_1 = 90.0	S_2 = 60.0	
THEORETICAL UNIT WEIGHT OF MIX, lb/ft³	S_1V_1 = 31.5	S_2V_2 = 39.0	$S_1V_1 + S_2V_2$ = 70.5
PERCENT BY WEIGHT SAND-SHELL	W_1 = 44.7	W_2 = 55.3	$W_1 + W_2$ = 100.0
MIX WEIGHT OF SAND-SHELL, lb	(W_1 x 15) ÷ 100 = 6.70	(W_2 x 15) ÷ 100 = 8.30	D = 15.00

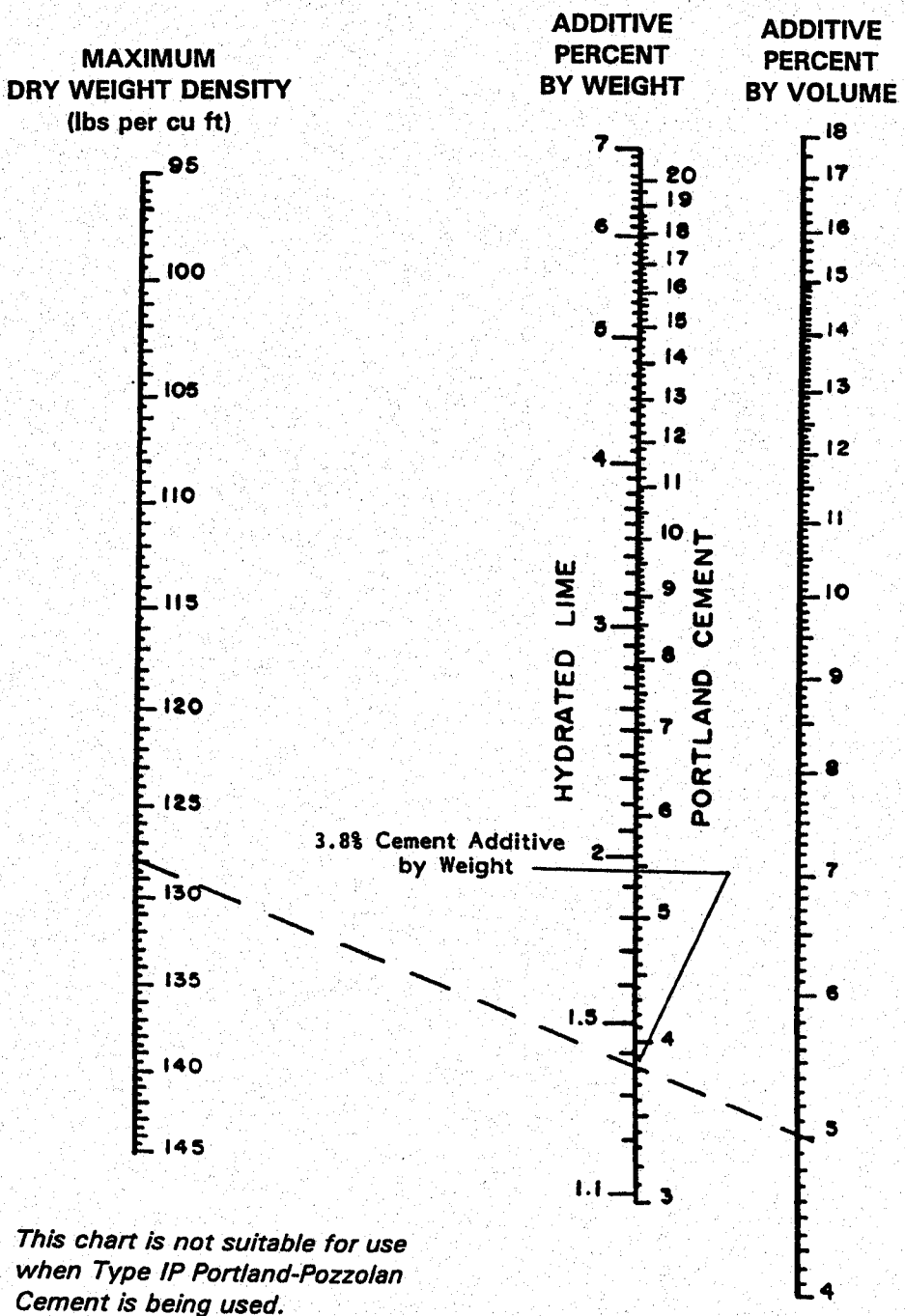
*MAX. DRY WT. DENSITY OF MATERIAL (From TR 418, Method C), lb/ft³	A		128.0
*REQUIRED % BY VOL. OF ADDITIVE (___ TR 432-B, ___ specified)	B		5.0
*% WT. OF ADDITIVE (___ chart, ___ formula)	C		3.8
DRY WT. OF MATERIAL (Rep. portion) (___ Shell, ___ Sand-Shell), lb	D		15.00
*WT. OF ADDITIVE TO BE ADDED, lb	E	(C x D) ÷ 100	0.57
*TOTAL DRY WT. OF MATERIAL AND ADDITIVE, lb	F	D + E	15.57

* *FOR USE WITH DOTD TR 418, METHOD D ONLY.*

CURVE POINT NO.	•••		1	2	3	4	5	6
PAN NO. (if applicable)	•••		31	67	61	101	27	
WATER ADDED, mL	G	See Calculations	272	413	554	695	836	
WT. MOLD, BASE (if appl.) & WET MATL, lb	H		26.60	26.94	27.43	27.45	27.40	
WT. MOLD & BASE (if applicable), lb	I		14.17	14.17	14.17	14.17	14.17	
WT. WET COMPACTED MATERIAL, lb	J	H - I	12.43	12.77	13.26	13.28	13.23	
VOLUME OF MOLD (or specimen), ft³	K		0.097					
WT. OF PAN & DRY MATERIAL, lb	L		17.08	17.42	17.57	17.29	17.07	
WT. OF PAN, lb	M		5.13	5.36	5.27	5.16	5.20	
WT. OF DRY MATERIAL, lb	DW	L - M	11.95	12.06	12.30	12.13	11.87	
WT. OF WATER, lb	WW	J - DW	0.48	0.71	0.96	1.15	1.36	
WET DENSITY, lb/ft³	WWD	J/K	128.1	131.6	136.7	136.9	136.4	
MOISTURE CONTENT, %	MC	(WW/DW) x 100	4.0	5.9	7.8	9.5	11.5	
DRY DENSITY, lb/ft³	DWD	$\frac{WWD}{100 + MC} \times 100$	123.2	124.3	126.8	125.0	122.3	

REMARKS: _____

Laboratory Moisture - Density Relationship Worksheet (03-22-4195)
Figure D-1 (English)



Note: This chart is not suitable for use when Type IP Portland-Pozzolan Cement is being used.

ADDITIVE CONVERSION CHART

RELATION IN PERCENT BY WEIGHT OF OVEN-DRY SOIL, SOIL AGGREGATE, OR AGGREGATE TO DESIGN PERCENT BY VOLUME

Additive Conversion Chart
Figure D-2 (English)

LAB COMPACTION REPORT - DOTD TR 418 METHOD D

DOTD 03-22-4165
Metric / English
Rev. 3/98

Project No. 999-99-0099 Station S. No. SS-7 Lab No. ZZ-999999

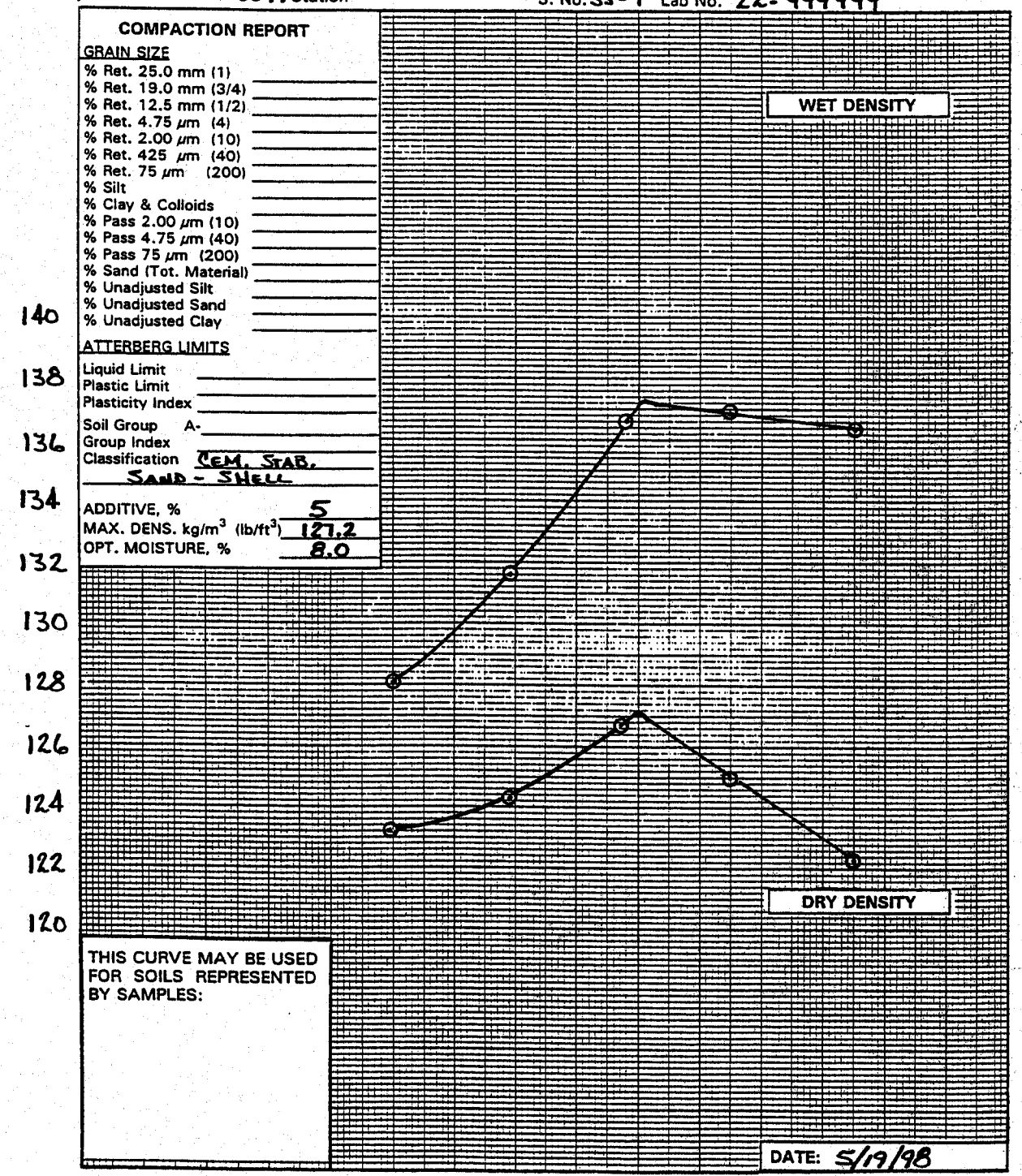
COMPACTION REPORT

GRAIN SIZE

% Ret. 25.0 mm (1)	
% Ret. 19.0 mm (3/4)	
% Ret. 12.5 mm (1/2)	
% Ret. 4.75 µm (4)	
% Ret. 2.00 µm (10)	
% Ret. 425 µm (40)	
% Ret. 75 µm (200)	
% Silt	
% Clay & Colloids	
% Pass 2.00 µm (10)	
% Pass 4.75 µm (40)	
% Pass 75 µm (200)	
% Sand (Tot. Material)	
% Unadjusted Silt	
% Unadjusted Sand	
% Unadjusted Clay	

ATTERBERG LIMITS

Liquid Limit	
Plastic Limit	
Plasticity Index	
Soil Group A-	
Group Index	
Classification	CEM. STAB. SAND - SHELL
ADDITIVE, %	5
MAX. DENS. kg/m³ (lb/ft³)	127.2
OPT. MOISTURE, %	8.0



THIS CURVE MAY BE USED FOR SOILS REPRESENTED BY SAMPLES:

DATE: 5/19/98

MOISTURE CONTENT - PERCENT OF DRY WEIGHT

4 5 6 7 8 9 10 11 12

Laboratory Compaction Report (03-22-4165)
Figure D-3 (English)

MATT MENU SELECTION - 2

Louisiana Department of Transportation and Development

AGGREGATE TEST REPORT

DOTD 03-22-0745
Metric / English
Rev. 2/98

Project No. 999-99-0099 | Material Code 4218 | Lab No. 22-9999999
Date Sampled 01-04-97 | Submitted By 00999 | Quantity
Purp Code 7 | Source Code AA99 | Spec Code 3 | P.O. No.
Date Tested 01-07-97 | Ident SS-7 | Plant Code | Frict.Rating (1-4)
Item No. | Date Rec'd (lab) 1/4/97 | Sampled By: N.D.H.
Remarks 1

Tested By P.B. | Date 1/7/97 | Checked By G.C. | Date 1/20/97

DOTD TR 102, 112, 113 & 309

Unit 1 = grams 2 = pounds

Sieve mm	Sieve In.	Mass Retained	% Retained	% Coarser	% Passing
63	2 1/2				
50	2				
37.5	1 1/2				
31.5	1 1/4				
25.0	1				
19.0	3/4				
16.0	5/8				
12.5	1/2				
9.5	3/8				
4.75	No. 4				
Mass Matl.in Pan					
Acc. Total					
Initial Dry Total Mass			% Diff:		

Unit 1 = grams 2 = pounds

Sieve mm/µm	Sieve No.	Mass Retained	% Retained	% Coarser	% Passing
2.36	8				
2.00	10				
1.18	16				
600	30				
425	40				
300	50				
180	80				
150	100				
75	200				
53	270				
Mass Matl.in Pan					
Decant Loss					
Acc. Total					
Initial Dry Total Mass			% Diff:		
Dry Mass After Wash					

Remarks 2:

DOTD TR 428

Liquid Limit | Plastic Limit

No. of Blows		Mass Cup + Wet Soil,g	
Mass Cup + Wet Soil,g		Mass Cup + Dry Soil,g	
Mass Cup + Dry Soil,g		Mass Water	
Mass Water		Cup No.	
Factor		Mass Cup, g	
Cup No.		Mass Dry Soil	
Mass Cup, g		% Moisture	
Mass Dry Soil			
% Moisture		Plasticity Index	

Absorption (T84 or T85)	
Spec Grav SSD (T84 or T85)	
Spec Grav APP (TR 300)	
Effective Spec Grav (TR 300)	
Opt Moist Content, % (TR 418)	8.0
Maximum Density (TR 418) kg/m³ (lb/ft³)	127.2
Lab Comp Method (TR 418)	D
Cement, % (TR 432 or SPECIFIED)	5.0
Lime, % (TR 416 or SPECIFIED)	
Other (Additive) Code %	
Clay Lumps, % (TR 119)	
Friable Particles, % (TR 119)	
Clay Lumps & Friable Particles % (TR 119)	
Flat or Elongated Part, % (TR 119)	
Coal & Lignite, % (TR 119)	
Glassy Particles, % (TR 119)	
Iron Ore, % (TR 119)	
Wood, % (TR 119)	
Total (Clay Lumps, Fri.Part., Iron Ore, Coal & Lignite, Wood), % (TR 119)	
Foreign Matter, % (TR 109)	
Clam Shell, % (TR 110)	
Soundness, % Loss (T 104)	
Abrasion, % Loss (T 96)	
Colorimetric Test (1 = Pass, 2 = Fail) (T 21)	
Asphalt Content, % (TR 307)	
Retained Asphalt Coating, % (TR 317)	
Percent Crushed (TR 306)	
Retained Marshall Stability (TR 313)	
Resistivity (TR 429)	
pH (TR 430)	
Organic Content, % (TR 413)	
Sand Equivalent (TR 120)	

Approved By: | Date:

Aggregate Test Report (03-22-0745)
Figure D-4 (English)

DOTD Designation: TR 418-98
ENGLISH VERSION

METHOD E

I. Scope

This method of test is designed to determine the optimum moisture content of the total material and maximum dry weight density of raw soil-aggregate mixtures with 5% aggregate or more by dry weight retained on the No. 4 sieve, when compacted in the laboratory in accordance with this procedure.

Note E-1: It is permissible to determine moisture-density relationships of field conditioned material in accordance with the applicable method of DOTD TR 415.

II. Apparatus

A. Mold

1. A cylindrical metal mold, having a capacity of 1/10 ft^3, manufactured with an internal diameter of 6.000±0.026 in. and a height of 6.100±0.016 in., and with a detachable collar approximately 3.5 in. in height, which can be fastened firmly to a base plate.
2. Molds shall be replaced if any diameter is more than 6.039 in. or the height is less than 6.000 in. at any point.

Note E-2: Different makes of compactive devices may use mold base plates of different designs. The mold base plate must be compatible with the make of compactive device used.

B. Compactive Device

1. Automatic Rammer
   a. A 10.0±0.1 lb rammer, with a striking face that is a 3.1416 sq in sector face for use with a 6 inch inside diameter mold and arranged to control the height of drop to 18.00±0.06 in.
   b. A 5.50±0.05 lb rammer, with a striking face that is a 3.1416 sq in sector face for use with a 6 inch inside diameter mold, and arranged to control the height of drop to 12.00±0.06 in.
2. Manual Rammer
   a. A 10.0±0.1 lb rammer, with a circular striking face with a diameter of 2.00 ±0.01 in. and arranged to control the height of drop to 18.00±0.06 in.
   b. A 5.50 ± 0.05 lb rammer, with a circular striking face with a diameter of 2.00±0.01 in. and arranged to control the height of drop to 12.00±0.06 in.

C. **Compaction Block** - a stable block or pedestal composed of portland cement concrete and weighing a minimum of 200 lb.

D. **Straightedge** - steel straightedge, approximately 12 in. in length.

E. **Scale** - a scale of 20 lb or more capacity sensitive to 0.01 lb.

F. **Sieves** - a set of the following sieves conforming to the requirements of the Standard Specification for Wire Cloth Sieves for Testing Purposes (AASHTO Designation: M 92).
   1. 1 inch.
   2. 3/4 inch.
   3. ½ inch.
   4. No. 4.
   5. No. 10.

G. **Tools**
   1. Mixing pans with appropriate covers.
   2. Spoons.
   3. Pointed trowel.
   4. Spatula or large suitable mechanical device for thoroughly mixing material with water.
   5. Large screw driver to remove material from mold.
   6. Finishing tool.
   7. Height gauge - dial micrometer incremented in 0.001 in., accurate to 0.001 in., mounted on a stand.

H. **Graduated cylinders** - incremented in mL.

I. **Wax paper** - for molds without attached base plate.

J. **Engineer's Curve** - Alvin 1010-21 or equivalent.

K. **Laboratory Moisture - Density Worksheet, Methods E & F** - DOTD Form No. 03-22-4196. (Figure E-1).

L. **Laboratory Compaction Report** - DOTD Form No. 03-22-4165. (Figure E-2)

M. **Soils/Soil-Aggregate Form** - DOTD Form No. 03-22-0723. (Figure E-3)

Note E-3: It is convenient, but not essential, to have a mechanical device for removing the compacted material from the mold. Such a device may consist of a closed, cylindrical sleeve slightly less than 6.0 in. in diameter or a piston of the same diameter, actuated mechanically, hydraulically or by air pressure.

III. Test Sample

Obtain a representative sample of material weighing a minimum of 180 lb (6 full sample sacks).

IV. Procedure

A. Preparation

1. Prepare the total sample in accordance with DOTD TR 411, using the 1 inch, 3/4 inch, ½ inch, No. 4, and No. 10 sieves.

Note E-4: *If a gradation has been performed previously on this material, this gradation may be used in lieu of Step IV.A.1.*

2. Retain the separated material in separate containers.
3. Weigh each fraction. Record the weight of material retained on the 1 inch screen as **A** on the worksheet. Record the weight of the fractions retained on the 3/4 inch, ½ inch, No. 4, and No. 10 sieves as $\mathbf{B_n}$, corresponding to the appropriate sieve size. Record the material passing the No. 10 sieve as **D**.
4. Prepare a minimum of five 15 lb composited representative portions, with the same proportions of each size fraction as the original sample, except that for each representative portion remove the material retained on the 1 inch sieve and replace it with an equal weight of material based on the prorated percentages retained on the 3/4 inch, ½ inch, No. 4 and No. 10 sieves. Mix each representative portion thoroughly. (Refer to Step V.A. for example.)

B. Testing

1. Add a quantity of water measured in mL to make the 15 lb representative portion to be used for the first point slightly damp. Mix thoroughly. Record the quantity of water added as **N** for the first point on the worksheet.

Note E-5: *Check the mixture by squeezing the fine portion in the palm of the hand. If the mixture is the correct moisture content, it will form a cake which will bear very careful handling without breaking.*

2. Add and thoroughly mix a quantity of water, measured in mL, to each remaining 15 lb representative portion to increase the moisture content of each portion by 2% more than the moisture content of the previous portion. The 2% increment may be adjusted if necessary for some materials. (Refer to Step V.B.) Record the quantity added to each representative portion as **N** on the worksheet.
3. Cover the representative portions and protect them so that the moisture content remains constant, then allow them to slake for a minimum of 30 min.
4. Compact the test specimens using an approved rammer.
   a. If mold requires an attachable base plate, attach base plate. Weigh mold and base plate and record as **P** on the worksheet.
   b. When using a mold without an attachable base plate, place wax paper on the compactor base. Weigh the mold and record the weight as **P** on the worksheet. Place the mold over the wax paper and secure the mold to the compactor base.
   c. Attach collar to mold.
   d. Uncover a representative portion and remix.
   e. Place a quantity of this material into the mold in an even layer that will yield approximately 1/3 the volume of the mold after compaction. Recover the representative portion.
   f. Use a pointed trowel to rearrange particles, filling voids in the loose material without compacting the material.
   g. Rest the rammer on top of the layer to be compacted. Compact the layer using 28 blows with the 10 lb rammer or 75 blows with the 5.5 lb rammer.
   h. Note height of compacted material. If compacted layer is not 1/3 the height of the mold, correct for any deviation by adjusting the quantity of material used for the subsequent layer.
   i. Repeat Steps IV.B.4.d-h for two more layers.
   j. After the third layer has been compacted, remove the mold, base plate, (if applicable) and compacted specimen from the automatic rammer and place in a pan.
   k. Tap the collar with the straightedge to loosen material bond and remove the collar from the mold, without twisting or causing shear stress to the molded specimen.

l. Note the height of the compacted test specimen.
   (1) If the compacted material is more than 0.50 in. above the height of the mold or more than 0.25 in. below the rim of the mold, remove all material from the mold, remix it with the original representative portion and repeat the test.
   (2) If the compacted material is above the top of the mold, but not more than 0.5 in. above, proceed as follows:
   Keeping the mold, base plate (if applicable), and specimen in the pan, trim the specimen even with the top of the mold, using the steel straightedge. Fill any depressions with the fine, trimmed material, smoothing each area with the straightedge after it is filled. Do not attempt to replace aggregates that have been dislodged.
   (3) If the compacted material is below the top of the rim of the mold, but less than 0.25 in. below, proceed as follows:
      (a) Place the finishing tool on the compacted surface and rotate it while tapping very lightly to smooth and level the surface. Do not impart additional compactive effort to the specimen.
      (b) Determine the height of the specimen by measuring to the nearest 0.001 in. at three locations spaced equally around the circumference, and averaging.
      (c) Calculate the volume of the specimen in accordance with Step V.C. and record as **R** on the worksheet.

m. Brush material from all outside surfaces of mold and exposed edges of base plate or wax paper.

n. Remove wax paper, if applicable, and brush fines from wax paper onto top of test specimen. Take care not to lose any fines from test specimen.

o. Weigh mold, base plate (if applicable), and compacted test specimen and record as **O** on the worksheet.

p. Remove the base plate, (if applicable). Remove test specimen from mold and determine moisture content by breaking up and drying the entire test specimen in accordance with DOTD TR 403, Method B.

q. Repeat Steps IV.B.4.a-p for each 15 lb representative portion, cleaning the mold between each test specimen. Continue repeating the procedure until there is a substantial decrease in the wet weight of the compacted material or the material becomes too wet to compact.

V. Calculations

A. Calculate the plus 1 inch replacement, the prorated weight retained, the percent retained, and the adjusted weight as shown on the worksheet. Calculate the accumulated weight in accordance with DOTD TR 113. Record these values where indicated.

B. Calculate the quantity of water to be added to each representative portion (N_n) in mL to yield a moisture content incremented by 2 percent above that of the previous representative portion by using the following formula.

$$N_n = N_{n-1} + 136$$

where:

N_{n-1} = volume of water added to the previous representative portion, mL
136 = a constant representing the volume of water required for a 2% moisture content for a 15.00 lb representative portion, mL

example:

$N_{n-1} = 401$ mL

$$N_n = 401 + 136$$

$$N_n = 537$$

Note E-6: *1 g of water = 1 cc of water = 1 mL of water*

C. Calculate the volume of the test specimen (R) in ft^3 by using the following formula.

$$R = h \times 0.01636$$

where:

h = avg height of test specimen, in.
0.01636 = constant equal to the volume of a 6 inch diameter mold, per inch of height, ft^3

example:

$h = 6.112$ in.

$$R = 6.112 \times 0.01636$$

$$= 0.09999$$

$$R = 0.100$$

D. Calculate wet weight of compacted material in mold (Q) for each representative portion by using the following formula and record on the worksheet.

$$Q = O - P$$

where:

O = wt of mold, base plate (if used), and compacted wet material, g
P = wt of mold and base plate (if used), g

example:

O = 26.75 g
P = 14.08 g

$$Q = 26.75 - 14.08$$

$$Q = 12.67$$

E. Calculate wet weight density (WWD) in lb/ft^3 for each representative portion using the following formula and record on the worksheet.

$$WWD = \frac{Q}{R}$$

where:

Q = wet wt of compacted material, lb
R = (1/10) a constant representing the volume of the mold or the volume of the specimen (if applicable), as calculated in Step V.C., ft^3

example:

Q = 12.67 lb
R = 0.100 ft^3

$$WWD = \frac{12.67}{0.100}$$

$$WWD = 126.7$$

F. Calculate the weight of water (WW) and the weight of dry material (DW), using the formulas shown on the worksheet and record.

G. Calculate the moisture content (MC) in percent for each representative portion as shown on the worksheet and record.

H. Calculate the dry weight density (DWD) in lb/ft^3 for each representative portion using the following formula.

$$DWD = \frac{(WWD)}{100 + (MC)} \times 100$$

where:

WWD = wet wt density, lb/ft^3
MC = moisture content, %
100 = constant

example:

WWD = 126.7 lb/ft^3
MC = 5.9 %

$$DWD = \frac{126.7}{100 + 5.9} \times 100$$

$$= \frac{126.7}{105.9} \times 100$$

$$= 1.19641 \times 100$$

$$DWD = 119.6$$

I. Beginning with the lowest moisture content, plot a point on the Laboratory Compaction Report, representing the intersection of a horizontal line projected from the wet weight density and a vertical line projected from the moisture content. Continue for each moisture content until all points for wet weight densities have been plotted. Repeat the process for each moisture content, substituting dry weight densities for wet weight densities.

J. Form a smooth line using the engineer's curve by connecting the plotted points to form two curves, Wet Weight Density Vs. Moisture Content and Dry Weight Density Vs. Moisture Content. (Refer to the Laboratory Compaction Report.)

Note E-7: *If after the results have been plotted, there is not a minimum of three points on the dry side and two points on the wet side of optimum, additional testing must be performed until this minimum is met. If a smooth curve cannot be drawn, additional testing may be required.*

K. Determine the Optimum Moisture Content (%) of the total material, which is the moisture content corresponding to the peak of the dry weight density curve.

L. Determine the maximum dry weight density of the total material, which is the weight corresponding to the peak of the Dry Weight Density Curve.

VI. Report

A. Report the Maximum Dry Weight Density and the Optimum Moisture Content on the Laboratory Compaction Report and on the Soils/Soil-Aggregate Form to the nearest 0.1 lb/ft^3 and 0.1 percent, respectively.

B. From DOTD TR 407 and DOTD TR 423, report the following on the Laboratory Compaction Report and on the Soils/Soil-Aggregate Form.
1. Grain size distribution.
2. Atterberg Limits.
3. Soil group.
4. Group index.
5. Classification.

Note E-8: *For sand clay gravel or other materials accepted by gradation determined in accordance with DOTD TR 112 and DOTD TR 113, the report of soil group index and classification will not be required.*

VII. Normal Test Reporting Time

Normal test reporting time is 3 days.

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

DOTD 03-22-4196
English
4/98

LABORATORY MOISTURE - DENSITY RELATIONSHIP
DOTD TR 418 - Methods (E) & F
(English)

PROJECT NO: 999-99-0099 DATE: 12/15/97 LAB NO: 22-999999

*TYPE ADDITIVE: _____ TYPE SOIL: Grav. Clay Loam SAMPLE NO: S-2

TESTED BY: K.B. CHECKED BY: G.C.

SIEVE			Weight Retained, lb	+ 1" Replacement $B_n/(1 - (A/C))$	Prorated Wt. Ret., lb (F)	% Retained (F/E) x 100 (G)	Adjusted Weight, lb (G x 15) ÷ 100	Accumulated Weight lb
1"	A		0.33					
3/4"	B_1		1.01	1.08 →	1.08	4.92	0.74	0.74
1/2"	B_2		0.71	0.76 →	0.76	3.46	0.52	1.26
No. 4	B_3		0.38	0.40 →	0.40	1.82	0.27	1.53
No. 10	B_4		2.85	3.04 →	3.04	13.86	2.08	3.61
Subtotal	C	$A + \Sigma B_{1-n}$	5.28 →		5.28			
- No. 10	D		16.66 →		16.66	75.93	11.39	15.00
Total	E	C + D	21.94 →		21.94	100	K = 15.00	

*MAX. DRY DENSITY OF MATERIAL (__ TR 418-E, __ TR 415-A), lb/ft³	H		
*REQUIRED % BY VOL. OF ADDITIVE (__ TR 432-A, __ TR 432-B, __ TR 416, __ specified)	I		
*% WT. OF ADDITIVE (___ chart, ___ formula)	J		
DRY WT. OF MATERIAL (Representative Portion), lb	K		15.00
*WT. OF ADDITIVE TO BE ADDED, lb	L	(J x K) ÷ 100	
*TOTAL DRY WT. OF MATERIAL AND ADDITIVE, lb	M	K + L	

* ***FOR USE WITH DOTD TR 418, METHOD F ONLY.***

CURVE POINT NO.	•••		1	2	3	4	5	6
WATER ADDED, mL	N	See Calculations	401	537	673	809	945	
WT. MOLD, BASE (if appl.) & WET MATL, lb	O		26.75	27.18	27.71	27.76	27.64	
WT. MOLD & BASE (if applicable), lb	P		14.08	14.08	14.08	14.08	14.08	
WT. WET COMPACTED MATERIAL, lb	Q	O - P	12.67	13.10	13.63	13.68	13.56	
VOLUME OF MOLD (or specimen), ft³	R		0.100					
WT. OF PAN & DRY MATERIAL, lb	S		17.73	17.78	18.27	17.40	17.55	
WT. OF PAN, lb	T		5.77	5.62	5.81	5.10	5.53	
WT. OF DRY MATERIAL, lb	DW	S - T	11.96	12.16	12.46	12.30	12.02	
WT. OF WATER, lb	WW	Q - DW	0.71	0.94	1.17	1.38	1.54	
WET DENSITY, lb/ft³	WWD	Q/R	126.7	131.0	136.3	136.8	135.6	
MOISTURE CONTENT, %	MC	(WW/DW) x 100	5.9	7.7	9.4	11.2	12.8	
DRY DENSITY, lb/ft³	DWD	$\frac{WWD}{100 + MC} \times 100$	119.6	121.6	124.6	123.0	120.2	

REMARKS: _____

Laboratory Moisture - Density Relationship Worksheet (03-22-4196)
Figure E-1 (English)

LAB COMPACTION REPORT - DOTD TR 418 METHOD E

DOTD 03-22-4165
Metric / English
Rev. 3/98

Project No. 999-99-0099 Station S. No. 2 Lab No. 22- 999999

COMPACTION REPORT

GRAIN SIZE

% Ret. 25.0 mm (1)	
% Ret. 19.0 mm (3/4)	
% Ret. 12.5 mm (1/2)	
% Ret. 4.75 µm (4)	5
% Ret. 2.00 µm (10)	13
% Ret. 425 µm (40)	11
% Ret. 75 µm (200)	10
% Silt	31
% Clay & Colloids	24
% Pass 2.00 µm (10)	
% Pass 4.75 µm (40)	65
% Pass 75 µm (200)	55
% Sand (Tot. Material)	
% Unadjusted Silt	
% Unadjusted Sand	
% Unadjusted Clay	

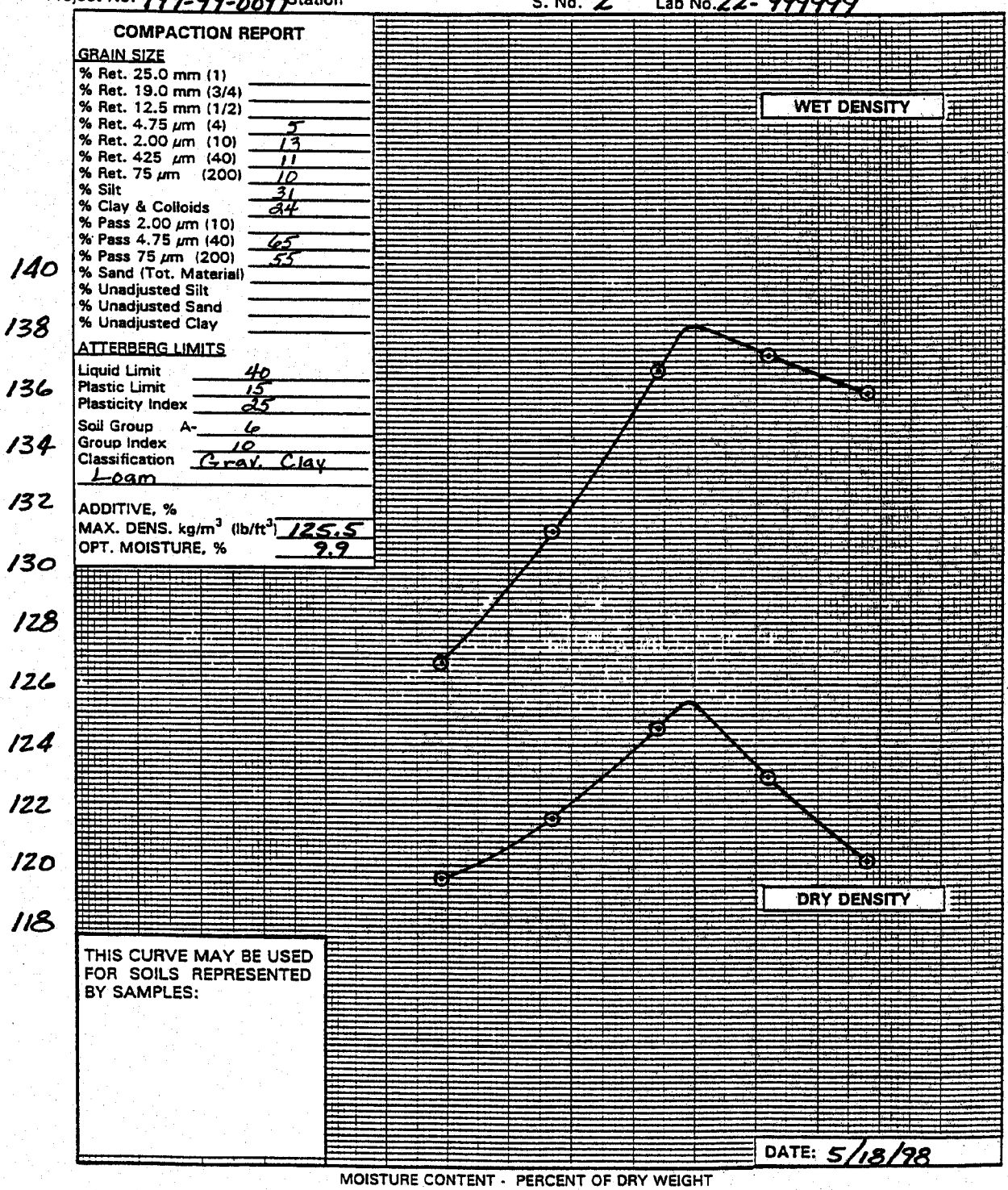
ATTERBERG LIMITS

Liquid Limit	40
Plastic Limit	15
Plasticity Index	25
Soil Group A-	6
Group Index	10
Classification	Grav. Clay Loam

ADDITIVE, %

MAX. DENS. kg/m³ (lb/ft³) 125.5

OPT. MOISTURE, % 9.9



THIS CURVE MAY BE USED FOR SOILS REPRESENTED BY SAMPLES:

Laboratory Compaction Report (03-22-4165)
Figure E-2 (English)

MATT MENU SELECTION - 14

Louisiana Department of Transportation and Development
SOILS/SOIL-AGGREGATE

DOTD 03-22-0723
Rev. 7/98

Metric / English E (M or E - Located on MATT Menu)

Project No. 9999-99-0099 | Material Code 4015 | Lab. No. 22-9999999

Date Sampled 01-05-97 | Submitted By 06619 | Quantity

Purp. Code 1 | Pit No. | Spec Code 3

Date Tested 01-15-97 | Ident. 5-22 | Parish No. 56

From Station + | To Station + | Location

Hole No. | Depth, m (ft) | Log Distance, km (mi)

Item No. | Sampled by:

Remarks 1

Hydrometer Analysis (DOTD TR 407) | Graduate No. | Dry Mass of Sample (W), g (1 = 50.0, 2 = 100.0)

Time	(T) Elapsed Time	Temp°C (0.5° increments)	(h) Hydro Reading (0.5 increments)	(C) Correction (0.5 increments)	Corrected Reading H = h - C	% Finer $P = \frac{H}{W} \times 100$	Effect. Grain Size $D = K\sqrt{\frac{L}{T}}$
	60 Minutes						
	120 Minutes						

RETAINED ON 2.00 µm (10)
Mass Cup + Soil, g
Cup No.
Mass Cup, g
Mass Soil, g

RETAINED ON 425 µm (40)
Mass Cup + Soil, g
Cup No.
Mass Cup, g
Mass Soil, g

RETAINED ON 75 µm (200)
Mass Cup + Soil, g
Cup No
Mass Cup, g
Mass Soil, g

Size	Mass Retained (Wx) Gram	%
Total Mass, g		
25.0 mm (1)		
19.0 mm (3/4)		
12.5 mm (1/2)		
4.75 µm (4)		
2.00 µm (10)		
425 µm (40)		
75 µm (200)		
% Silt		
% Clay & Colloids		
Pass 4.75 µm (#4)		
Pass 2.00 µm (#10)		

(DOTD TR 407)

% Ret. 25.0 mm (1)	
% Ret. 19.0 mm (3/4)	6
% Ret. 12.5 mm (1/2)	
% Ret. 4.75 µm (4)	5
% Ret. 2.00 µm (10)	13
% Ret. 425 µm (40)	11
% Ret. 75 µm (200)	10
% Silt	31
% Clay & Colloids	24
% Pass 2.00 µm (#10)	76
% Pass 4.75 µm (40)	65
% Pass 75 µm (200)	55
% Sand (Tot. Material)	
% Unadjusted Silt	
% Unadjusted Sand	
% Unadjusted Clay	

LIQUID LIMIT
No. Blows
Mass Cup + Wet Soil, g
Mass Cup + Dry Soil, g
Mass Water, g
Factor
Cup No.
Mass Cup, g
Mass Dry Soil, g
% Moisture

PLASTIC LIMIT
Mass Cup + Wet Soil, g
Mass Cup + Dry Soil, g
Mass Water, g
Cup No.
Mass Cup, g
Mass Dry Soil, g
% Moisture

% Organic Matter (TR 413)
Liquid Limit (TR 428) 40
Plasticity Index (TR 428) 25
Natural Moisture Content, % (TR 403)
Optimum Moisture Content, % (TR 418) 9.9
Maximum Density, kg/m³ (lb/ft³) (TR 418) 125.5
Laboratory Compaction Method (TR 418) E
% Cement (TR 432 or Plans)
% Lime (TR 416)
% Fly Ash
% Other (Additive) Material Code Percent
Soil Group (TR 423) A-6(10)
Classification (TR 423) Grav. Clay Loam
pH (TR 430)
Resistivity, ohm-cm (TR 429)
Classification Prefix (TR 423) (G = Siliceous Aggr. N = Non-Siliceous S = Shell)
(Required only if +2.00 mm (No.10, g) material equals or exceeds 5%)

Remarks 2

Tested By: K.B. | Checked By: G.C. | APPROVED BY:
Date: 1/15/97 | Date: 1/20/97 | DATE:

Soils/Soil-Aggregate Worksheet (03-22-0723)
Figure E-3 (English)

DOTD Designation: TR 418-98
ENGLISH VERSION

METHOD F

I. Scope

This method of test is designed to determine the optimum moisture content and maximum dry weight density of soil cement, lime treated or conditioned soil cement, or cement treated or lime treated soil-aggregate mixtures, all containing 5% or more aggregate by dry weight retained on a No. 4 sieve, when the material is compacted in the laboratory in accordance with this procedure. When these materials contain less than 5% aggregate by dry weight retained on the No. 4 sieve, refer to Method B.

Note F-1: *It is permissible to determine moisture-density relationships of field conditioned material in accordance with the applicable method of DOTD TR 415. For field conditioned material which requires the addition of additives, TR 415, Method B can be used in the laboratory to determine moisture-density relationships of the material and additive combination only if the required amount of additive is known; however, for field conditioned material brought into the laboratory for the purpose of determining the required amount of additive, it is not permissible to use Method B of TR 415.*

Note F-2: *It is not permissible to use DOTD TR 415, Method A when the sample contains aggregate other than siliceous gravel.*

II. Apparatus

A. **Same as DOTD TR 418, Method E.**
B. **Cement or lime.**

Note F-3: *Cement shall meet DOTD specifications for Type IB. For Type IB cement, a unit weight of 94 lb/ft^3 shall be used.*

When Type II or Type IP cement is used on the project, it shall be used in lieu of Type IB to determine the report values for this method of test. Type II and Type IP cement shall meet DOTD specifications. For Type IP cement a unit weight of 90 lb/ft^3 shall be used. For Type II cement, a unit weight of 94 lb/ft^3 shall be used.

Lime shall meet DOTD specifications for hydrated lime. A unit weight of 35 lb/ft^3 shall be used.

C. **Personal protective equipment**
   1. Respirator.
   2. Gloves.
   3. Apron.
   4. Goggles.
D. **Laboratory Moisture - Density Worksheet, Methods E & F** - DOTD Form No. 03-22-4196. (Figure F-1)
E. **Additive Conversion Chart.** (Figure F-2)
F. **Laboratory Compaction Report** - DOTD Form No. 03-22-4165. (Figure F-3)
G. **Soils/Soil-Aggregate Form** - DOTD Form No. 03-22-0723. (Figure F-4)

III. Test Sample

Same as DOTD TR 418, Method E.

IV. Health Precautions

Care must be taken not to allow cement or lime to contact skin or to inhale reaction fumes.

V. Procedure

A. Preparation
   1. Determine the maximum dry weight density of the soil aggregate mixture using one of the following methods and record as **H** on the worksheet.
      a. DOTD TR 418, Method E.
      b. DOTD TR 415, Method A, if percent siliceous aggregate is within allowable range of 5-60 percent.
   2. Determine the percent by volume of cement in accordance with DOTD TR 432 or the percent of lime in accordance with DOTD TR 416 or use the percent specified. Record as **I** on the worksheet.
   3. Convert percent by volume to percent by weight and record as **J** on the worksheet. (Refer to Step VI.A or B for weight-volume conversion calculations).
   4. Prepare a minimum of five additional 15 lb composited representative portions, as described in Method E, Step IV.A.1-4.

Note F-4: *If DOTD TR 418, Method E was used to determine the maximum dry weight density of the soil-aggregate mixture, values for accumulated weights determined in DOTD TR 418, Method E are to be used to prepare the five additional representative portions.*

B. Testing

1. Calculate the weight of additive to be added to the representative portions in accordance with Step VI.C. and record as **L** on the worksheet.
2. Add the required weight of the additive determined in Step V.B.1 to each composited representative portion.
3. Add a sufficient quantity of water, measured in mL, to make the 15 lb representative portion to be used for the first point slightly damp. Mix thoroughly. Record the quantity of water added as **N** for the first point on the worksheet.

Note F-5: *Check the mixture by squeezing the fine portion in the palm of the hand. If the mixture is the correct moisture content, it will form a cake which will bear very careful handling without breaking.*

4. Add and thoroughly mix a quantity of water, measured in mL, to each remaining 15 lb representative portion to increase the moisture content of each representative portion by 2% more than the moisture content of the previous portion. The 2% increment may be adjusted if necessary for some materials. (Refer to Step VI.D.) Record the quantity of water added to each representative portion as **N** on the worksheet.
5. Cover the representative portions to which water and additive have been added and allow them to stand for a minimum of 30 minutes, then remix.
6. Cover the representative portions again and protect them so that the moisture content remains constant, then allow them to slake as follows.
   a. Soil-aggregate mixed with cement: The combined standing and slaking time, plus the compaction time in the laboratory shall approximate the moist mixing time, plus the compaction time in the field. This time shall be a minimum of 60 min and a maximum of 90 min.
   b. Soil-aggregate mixed with lime: The combined standing and slaking time plus compaction time in the laboratory shall approximate the moist mixing time and mellowing time in the field, but shall not be less than 15 hours.
   c. When lime conditioned soil is to be cement treated or stabilized, mix the soil with the lime and allow it to slake in accordance with Step V.B.6.b. Then add the required weight of cement (determined in accordance with Step V.B.1) to the soil-aggregate-lime mixture. Then repeat Steps V.B.3-6.a.

Note F-6: *When during a project, the soil-aggregate mixture has been lime treated or conditioned in accordance with Section 304 of the specifications prior to sampling for cement treatment or stabilization, it shall be slaked in accordance with Step V.B.6.a.*

7. Compact the test specimen in accordance with Method E, Step IV.B.4.

VI. Calculations

A. Determine percent of additive by weight by using the Additive Conversion Chart (Figure F-2). This chart may be used for Type IB portland cement and hydrated lime.

1. Enter the chart on the left scale. Reading vertically, place a point at the appropriate maximum dry weight density of the soil-aggregate mixture obtained in Step V.A.1.
2. Reenter the chart on the right scale. Reading vertically, place a point at the design percent by volume of additive.
3. Draw a straight line across the chart connecting the two points plotted in Steps 1 and 2.
4. Read the percent by weight directly from the additive scale on the chart at the point where the line drawn in Step 3 intersects the scale for the additive being used.
5. Record this value as **J** on the worksheet
6. Example: *(Figure F-2)*

   a. Type IB Cement

   H = 126 lb/ft^3
   I = 8% Type IB cement by volume

   (1) Follow the left scale to the point represented by 126 lb/ft^3.
   (2) Follow the right scale to the point represented by 8% by volume.
   (3) Draw a straight line across the scale, connecting the two points.
   (4) The percent cement by wt, read directly from the middle scale is 6.3%.

b. Lime

H = 125 lb/ft^3
I = 6% hydrated lime, by volume

(1) Follow the left scale to the point represented by 125 lb/ft^3.
(2) Follow the right scale to the point represented by 6% by volume.
(3) Draw a straight line across the scale, connecting the two points.
(4) The percent lime by weight, read directly from the middle scale is 1.7%.

B. In lieu of the charts or if values are not covered by the charts, determine the percent by weight of additive (J) using the following formula.

$$J = \frac{(UI/100)}{H - (UI/100)} \times 100$$

$$J = \frac{1}{(H/UI) - 0.01}$$

where:

H = maximum dry wt density of the soil-aggregate, lb/ft^3
I = % by volume of additive
U = unit wt of additive, lb/ft^3
100 = constant
0.01 = constant

example: *(Type IP Cement)*

H = 130 lb/ft^3
I = 8%
U = 90 lb/ft^3

$$J = \frac{1}{[130/(90 \times 8)] - 0.01}$$

$$= \frac{1}{[0.1805] - 0.01}$$

$$= \frac{1}{0.1705}$$

$$J = 5.9$$

Note F-7: *To achieve required accuracy after rounding, carry to four decimal places, as shown.*

C. Calculate the weight of additive (L) in lb to be incorporated into the representative portion of soil using the following formula and record on the worksheet.

$$L = \frac{J \times K}{100}$$

where:

J = % by wt of additive (from chart or formula)
K = dry wt of representative portion, lb
100 = constant

example:

J = 1.7 %
K = 15.00 lb

$$L = \frac{1.7 \times 15.00}{100}$$

$$= \frac{25.5000}{100}$$

$$L = 0.26$$

D. Calculate the quantity of water to be added to each representative portion (N_n) in mL to yield a moisture content incremented by 2 percent above that of the previous representative portion by using the following formula.

$$N_n = N_{n-1} + (9.072 \times M)$$

where:

N_{n-1} = volume of water added to the previous representative portion, mL
M = total wt of material and additive, lb
9.072 = a constant representing a conversion factor from lb to mL for a 2% increment of moisture

example:

N_{n-1} = 286 mL
M = 15.26 lb

$$N_n = 286 + (9.072 \times 15.26)$$

$$= 286 + 138.43$$

$$N_n = 424$$

Note F-8: *1 g of water = 1 cc of water = 1 mL of water.*

E. Perform all calculation steps for the material in accordance with Method E, Step V.C- L.

VII. Report

A. Report the Maximum Dry Weight Density and the Optimum Moisture Content on theLaboratory Compaction Report and on the Soils/Soil-Aggregate Form to the nearest 0.1 lb/ft^3 and 0.1 percent, respectively.

B. For sand clay gravel or other materials accepted by gradation determined in accordance with DOTD TR 112 and DOTD TR 113, the report of soil group index and classification will not be required.

C. From DOTD TR 407 and DOTD TR 423, report on the Laboratory Compaction Report and on the Soils/Soil-Aggregate Form.
   1. Grain size distribution.
   2. Atterberg Limits.
   3. Soil group.
   4. Group index.
   5. Classification.

D. Report the type and percent by volume of additive to the nearest 0.1 percent for cement and to the nearest percent for lime on the Laboratory Compaction Report and on the Soils/Soil-Aggregate Form.

VIII. Normal Test Reporting Time

Normal test reporting time is 6 days.

Note F-9: *When percent cement is to be determined by DOTD TR 432, Method B or the percent lime by DOTD TR 416, normal test reporting time will be 3 weeks or 2 weeks, respectively.*

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

DOTD 03-22-4196
English
4/98

LABORATORY MOISTURE - DENSITY RELATIONSHIP
DOTD TR 418 - Methods E & (F)
(English)

PROJECT NO: 999-99-0099 DATE: 12/20/97 LAB NO: 22-999999

*TYPE ADDITIVE: Hydrated Lime TYPE SOIL: Grav. Clay Loam SAMPLE NO: S-2

TESTED BY: K.B. CHECKED BY: G.C

SIEVE			Weight Retained, lb	+ 1" Replacement $B_n/(1-(A/C))$	Prorated Wt. Ret., lb (F)	% Retained (F/E) x 100 (G)	Adjusted Weight, lb (G x 15) ÷ 100	Accumulated Weight lb
1"	A		0.33					
3/4"	B_1		1.01	1.08 —	1.08	4.92	0.74	0.74
1/2"	B_2		0.71	0.76 —	0.76	3.46	0.52	1.26
No. 4	B_3		0.38	0.40 —	0.40	1.82	0.27	1.53
No. 10	B_4		2.85	3.04 —	3.04	13.86	2.08	3.61
Subtotal	C	$A + \sum B_{1...n}$	5.28 —					
- No. 10	D		16.66 ——		16.66	75.93	11.39	15.00
Total	E	C + D	21.94 ——		21.94	100	K = 15.00	

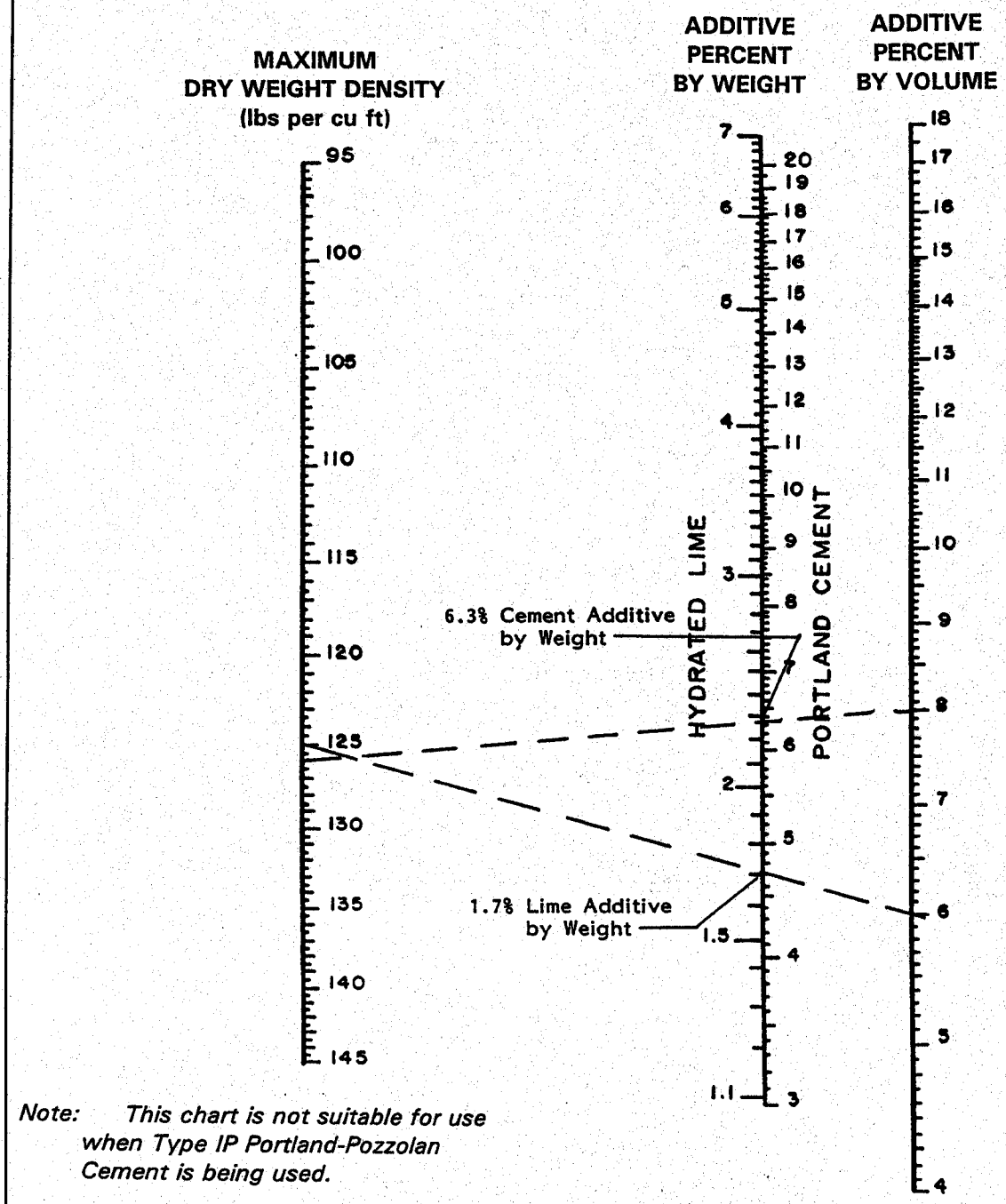
*MAX. DRY DENSITY OF MATERIAL (__ TR 418-E, __ TR 415-A), lb/ft³	H		125.0
*REQUIRED % BY VOL. OF ADDITIVE (__ TR 432-A, __ TR 432-B, __ TR 416, __ specified)	I		6.0
*% WT. OF ADDITIVE (____ chart, ____ formula)	J		1.7
DRY WT. OF MATERIAL (Representative Portion), lb	K		15.00
*WT. OF ADDITIVE TO BE ADDED, lb	L	(J x K) ÷ 100	0.26
*TOTAL DRY WT. OF MATERIAL AND ADDITIVE, lb	M	K + L	15.26

* *FOR USE WITH DOTD TR 418, METHOD F ONLY.*

CURVE POINT NO.	•••		1	2	3	4	5	6
WATER ADDED, mL	N	See Calculations	286	424	562	700	838	
WT. MOLD, BASE (if appl.) & WET MATL, lb	O		26.70	27.04	27.41	27.61	27.58	
WT. MOLD & BASE (if applicable), lb	P		14.08	14.08	14.08	14.08	14.08	
WT. WET COMPACTED MATERIAL, lb	Q	O - P	12.62	12.69	13.33	13.53	13.50	
VOLUME OF MOLD (or specimen), ft³	R		0.100					
WT. OF PAN & DRY MATERIAL, lb	S		17.88	17.87	18.21	17.41	17.67	
WT. OF PAN, lb	T		5.77	5.62	5.81	5.10	5.53	
WT. OF DRY MATERIAL, lb	DW	S - T	12.11	12.25	12.40	12.31	12.14	
WT. OF WATER, lb	WW	Q - DW	0.51	0.71	0.93	1.22	1.36	
WET DENSITY, lb/ft³	WWD	Q/R	126.2	129.6	133.3	135.3	135.0	
MOISTURE CONTENT, %	MC	(WW/DW) x 100	4.2	5.8	7.5	9.9	11.2	
DRY DENSITY, lb/ft³	DWD	$\frac{WWD}{100 + MC} \times 100$	121.1	122.5	124.0	123.1	121.4	

REMARKS: _____

Laboratory Moisture - Density Relationship Worksheet (03-22-4196)
Figure F-1 (English)



Note: This chart is not suitable for use when Type IP Portland-Pozzolan Cement is being used.

ADDITIVE CONVERSION CHART

RELATION IN PERCENT BY WEIGHT OF OVEN-DRY SOIL, SOIL AGGREGATE, OR AGGREGATE TO DESIGN PERCENT BY VOLUME

Additive Conversion Chart
Figure F-2 (English)

LAB COMPACTION REPORT - DOTD TR 418 METHOD F

DOTD 03-22-4165
Metric / English
Rev. 3/98

Project No. 999-99-0099 Station S. No. 2 Lab No. 22-999999

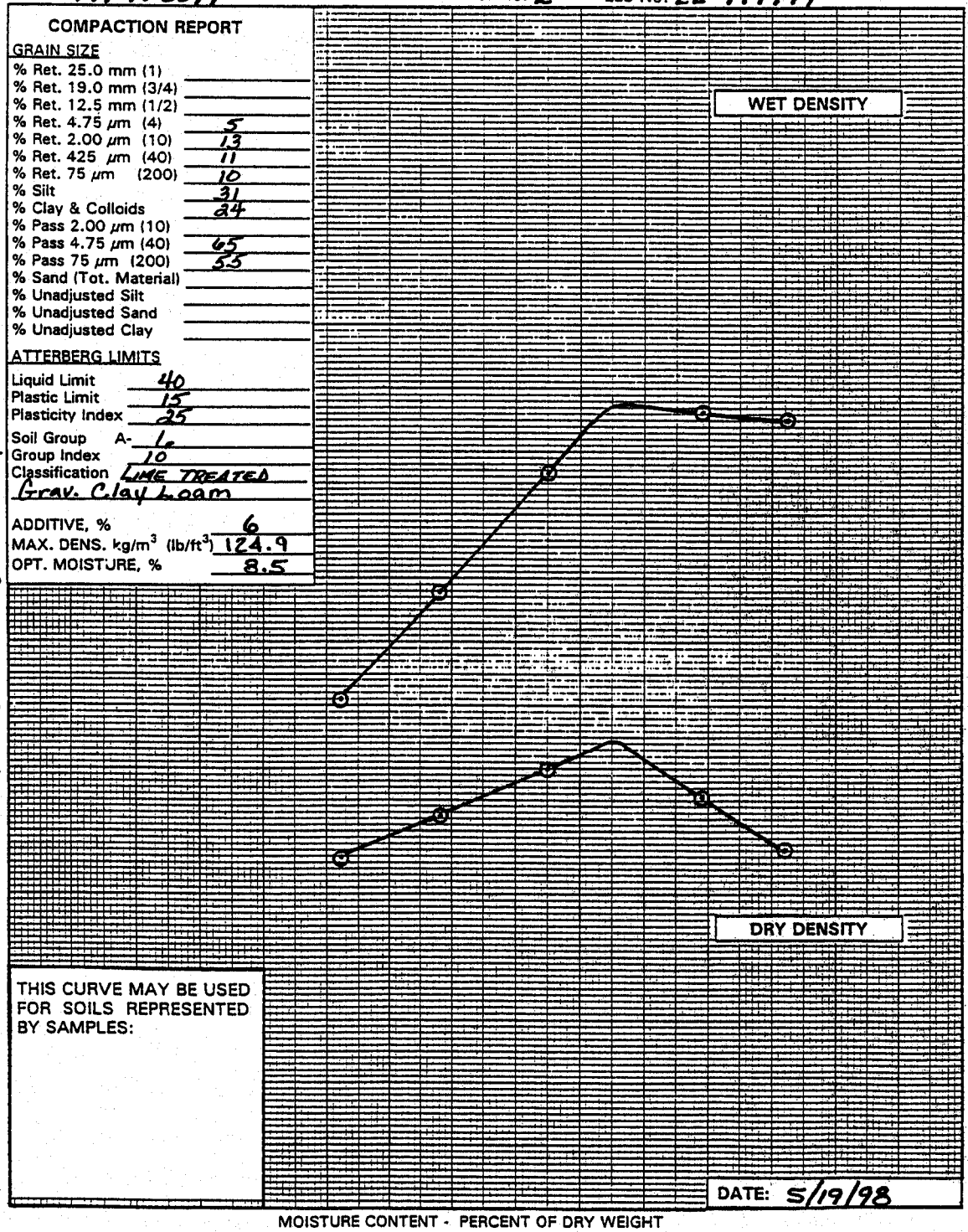
COMPACTION REPORT

GRAIN SIZE

% Ret. 25.0 mm (1)	
% Ret. 19.0 mm (3/4)	
% Ret. 12.5 mm (1/2)	
% Ret. 4.75 µm (4)	5
% Ret. 2.00 µm (10)	13
% Ret. 425 µm (40)	11
% Ret. 75 µm (200)	10
% Silt	31
% Clay & Colloids	24
% Pass 2.00 µm (10)	
% Pass 4.75 µm (40)	65
% Pass 75 µm (200)	55
% Sand (Tot. Material)	
% Unadjusted Silt	
% Unadjusted Sand	
% Unadjusted Clay	

ATTERBERG LIMITS

Liquid Limit	40
Plastic Limit	15
Plasticity Index	25
Soil Group A-	6
Group Index	10
Classification	LIME TREATED Grav. Clay Loam
ADDITIVE, %	6
MAX. DENS. kg/m³ (lb/ft³)	124.9
OPT. MOISTURE, %	8.5



THIS CURVE MAY BE USED FOR SOILS REPRESENTED BY SAMPLES:

DATE: 5/19/98

MOISTURE CONTENT - PERCENT OF DRY WEIGHT

4 5 6 7 8 9 10 11 12

Laboratory Compaction Report (03-22-4165)
Figure F-3 (English)

MATT MENU SELECTION - 14

Louisiana Department of Transportation and Development
SOILS/SOIL-AGGREGATE

DOTD 03-22-0723
Rev. 7/98

Metric / English E *(M or E - Located on MATT Menu)*

Project No. 19191-1919-010919 **Material Code** 4016 **Lab. No.** 23-191919191919

Date Sampled 01/-05-97 **Submitted By** 01616 9 **Quantity**

Purp. Code 11 **Pit No.** **Spec Code** 3

Date Tested 01/-23/0-97 **Ident.** 51-121 **Parish No.** 516

From Station + **To Station** + **Location**

Hole No. **Depth, m (ft)** **Log Distance, km (mi)**

Item No. **Sampled by:**

Remarks 1

Hydrometer Analysis (DOTD TR 407)			Graduate No.	Dry Mass of Sample (W), g (1 = 50.0, 2 = 100.0)			
Time	(T) Elapsed Time	Temp°C (0.5° increments)	(h) Hydro Reading (0.5 increments)	(C) Correction (0.5 increments)	Corrected Reading H = h - C	% Finer $P = \frac{H}{W} \times 100$	Effect. Grain Size $D = K\sqrt{\frac{L}{T}}$
	60 Minutes						
	120 Minutes						

RETAINED ON 2.00 µm (10)
Mass Cup + Soil, g
Cup No.
Mass Cup, g
Mass Soil, g

RETAINED ON 425 µm (40)
Mass Cup + Soil, g
Cup No.
Mass Cup, g
Mass Soil, g

RETAINED ON 75 µm (200)
Mass Cup + Soil, g
Cup No
Mass Cup, g
Mass Soil, g

Size	Mass Retained (Wx) Gram	%
Total Mass, g		
25.0 mm (1)		
19.0 mm (3/4)		
12.5 mm (1/2)		
4.75 µm (4)		
2.00 µm (10)		
425 µm (40)		
75 µm (200)		
% Silt		
% Clay & Colloids		
Pass 4.75 µm (#4)		
Pass 2.00 µm (#10)		

(DOTD TR 407)

% Ret. 25.0 mm (1)	
% Ret. 19.0 mm (3/4)	6
% Ret. 12.5 mm (1/2)	
% Ret. 4.75 µm (4)	5
% Ret. 2.00 µm (10)	13
% Ret. 425 µm (40)	11
% Ret. 75 µm (200)	10
% Silt	31
% Clay & Colloids	24
% Pass 2.00 µm (#10)	76
% Pass 4.75 µm (40)	65
% Pass 75 µm (200)	55
% Sand (Tot. Material)	
% Unadjusted Silt	
% Unadjusted Sand	
% Unadjusted Clay	

LIQUID LIMIT
No. Blows
Mass Cup + Wet Soil, g
Mass Cup + Dry Soil, g
Mass Water, g
Factor
Cup No.
Mass Cup, g
Mass Dry Soil, g
% Moisture

PLASTIC LIMIT
Mass Cup + Wet Soil, g
Mass Cup + Dry Soil, g
Mass Water, g
Cup No.
Mass Cup, g
Mass Dry Soil, g
% Moisture

% Organic Matter (TR 413)
Liquid Limit (TR 428) 40
Plasticity Index (TR 428) 20
Natural Moisture Content, % (TR 403)
Optimum Moisture Content, % (TR 418) 8.3
Maximum Density, kg/m^3 (lb/ft^3) (TR 418) 125.5
Laboratory Compaction Method (TR 418) E
% Cement (TR 432 or Plans)
% Lime (TR 416) 0 6
% Fly Ash
% Other (Additive) Material Code Percent
Soil Group (TR 423) A-6 (10)
Classification (TR 423) Grav. Clay Loam
pH (TR 430)
Resistivity, ohm-cm (TR 429)
Classification Prefix (TR 423) (G = Siliceous Aggr. N = Non-Siliceous S = Shell)
(Required only if +2.00 mm [No.10, g] material equals or exceeds 5%)

Remarks 2

Tested By: K.B. Checked By: G.C. APPROVED BY:
Date: 1/20/97 Date: 1/21/97 DATE:

Soils/Soil-Aggregate Form (03-22-0723)
Figure F-4 (English)

DOTD Designation: TR 418-98
ENGLISH VERSION

METHOD G

I. Scope

This method of test is designed to determine the optimum moisture content and maximum dry weight density of designated materials, including stone, crushed slag or recycled portland cement concrete, when the material is compacted in the laboratory in accordance with this procedure.

II. Apparatus

A. **Mold**
1. A cylindrical metal mold, having a capacity of 0.075 (1/13.33) ft^3, manufactured with an internal diameter of 6.000±0.026 in. and a height of 4.584±0.005 in., and with a detachable collar approximately 2.5 in. in height, which can be fastened firmly to a base plate.
2. Molds shall be replaced if any diameter is more than 6.039 in. or the height is less than 4.550 in. at any point.

Note G-1: *Different makes of compactive devices may use mold base plates of different designs. The mold base plate must be compatible with the make of compactive device used.*

B. **Compactive device**
1. Automatic Rammer - a 10.0±0.1 lb rammer, with a striking face that is a 3.1416 sq in. sector face for use with a 6 in. inside diameter mold and arranged to control the height of drop to 18.00±0.06 in.
2. Manual Rammer - a 10.0±0.1 lb rammer, with a circular striking face with a diameter of 2.00±0.01 in. and arranged to control the height of drop to 18.00±0.06 in.

C. **Compaction Block** - a stable block or pedestal composed of portland cement concrete and weighing a minimum of 200 lb.

D. **Straightedge** - steel straightedge, approximately 12 in. in length.

E. **Scale** - a scale of 20 lb or more capacity sensitive to 0.01 lb.

F. **Sieves** - a set of the following sieves conforming to the requirements of the Standard Specification for Wire Cloth Sieves for Testing Purposes (AASHTO Designation M 92).
1. 1 inch.
2. 3/4 inch.
3. ½ inch.
4. No. 4.

G. **Tools**
1. Mixing pans with appropriate covers.
2. Spoons.
3. Pointed trowel.
4. Spatula or large suitable mechanical device for thoroughly mixing material with water.
5. Large screw driver to remove material from mold.

H. **Graduated cylinder** - incremented in mL.

I. **Engineer's curves** - Alvin 1010-21 or equivalent.

J. **Wax paper**

K. **Laboratory Moisture - Density Worksheet, Method G** - DOTD Form No. 03-22-4197. (Figure G-1)

L. **Laboratory Compaction Report** - DOTD Form No. 03-22-4165. (Figure G-2)

M. **Aggregate Test Report** - DOTD Form No. 03-22-0745. (Figure G-4)

III. Test Sample

A. Obtain a representative sample weighing a minimum of 180 lb (6 full sample sacks).

B. Dry entire sample in accordance with DOTD TR 411.

IV. Procedure

A. Preparation
1. Prepare the total sample in accordance with DOTD TR 411, using the 1 inch, 3/4 inch, ½ inch, and No. 4 sieves.

Note G-2: *If a gradation has been performed previously on this material, this gradation may be used in lieu of Step IV.A.1.*

2. Retain the separated material in separate containers.
3. Weigh each fraction. Record the weight of material retained on the 1 inch sieve as **A** on the worksheet. Record the weight of the fractions retained on the 3/4 inch, ½ inch and No. 4 sieves as $\mathbf{B_n}$, corresponding to the appropriate sieve size. Record the material passing the No. 4 sieve as **D**.
4. Prepare a minimum of five 18 lb composited representative portions, with the same proportions of each size fraction as the original

sample, except that for each representative portion remove the material retained on the 1 inch sieve and replace it with an equal weight of material based on the prorated percentages retained on the 3/4 inch, ½ inch and No. 4 sieves. Mix each representative portion thoroughly. (Refer to Step V.A. for example.)

B. Testing
   1. Add a quantity of water, measured in mL, to make the 18 lb representative portion to be used for the first point with sufficient water slightly damp. Mix thoroughly. Record the quantity added as **H** on the worksheet.
   2. Add and thoroughly mix a quantity of water, measured in mL, to each remaining 18 lb representative portion to increase the moisture content of each portion by 2% more than the moisture content of the previous portion. The 2% increment may be adjusted, if necessary. (Refer to Step V.B.). Record the quantity added to each representative portion as **H** on the worksheet.
   3. Cover the representative portions and protect them so that the moisture content remains constant, then allow them to slake for a minimum of 30 min.
   4. Compact the representative portions using an approved rammer.
      a. If mold requires an attachable base plate, attach base plate. Weigh mold and base plate and record as **J** on the worksheet.
      b. When using a mold without an attachable base plate, place wax paper on base. Place mold over wax paper and attach. Weigh mold and base plate and record as **J** on the worksheet.
      c. Attach collar to mold.
      d. Uncover a representative portion and remix.
      e. Place a quantity of this material into the mold in an even layer that will yield slightly more than 1/5 the volume of the mold after compaction. Recover the representative portion.
      f. Use a pointed trowel to rearrange particles, filling voids in the loose material without compacting the material.
      g. Rest the rammer on top of the layer to be compacted. Compact the layer using 56 blows with the rammer.
      h. Note height of compacted material. If compacted layer is not 1/5 the height of the mold, correct for any deviation by adjusting the quantity of material used for the subsequent layer.
      i. Repeat Steps IV.B.4.d-h for four more layers.
      j. After the fifth layer has been compacted, remove the mold, base plate (if applicable), and compacted specimen from the automatic rammer and place in a pan.
      k. Tap the collar with the straightedge to loosen material bond and remove the collar from the mold, without twisting or causing shear stress to the molded specimen.
      l. Note the height of the compacted test specimen.
         (1) If the compacted material is greater than 0.50 in. above the height of the mold, remove all material from the mold, remix it with the original representative portion and repeat the test.
         (2) If the compacted material is below the rim of the mold, remove all material from the mold, remix it with the original representative portion and repeat the test.
      m. Keeping the mold, base plate, (if applicable), and specimen in the pan, trim the specimen even with the top of the mold, using the steel straightedge. Fill any depressions with the fine, trimmed material, smoothing each area with the straightedge after it is filled. Do not attempt to replace aggregates that have been dislodged.
      n. Brush material from all outside surfaces of mold and exposed edges of base plate or wax paper.
      o. Remove wax paper (if applicable), and brush fines from wax paper onto top of test specimen. Take care not to lose any fines from test specimen.
      p. Weigh mold, base plate (if applicable), and compacted test specimen and record as **I** on the worksheet.
      q. Remove the base plate (if applicable). Remove test specimen from mold and determine moisture content by breaking up and drying the entire test specimen in accordance with DOTD TR 403, Method B.
      r. Repeat Steps IV.B.4.a-q for each 18 lb representative portion, cleaning the mold between each test specimen. Continue repeating the procedure until there is a substantial decrease in the wet weight of the compacted material or the material becomes too wet to compact.

V. Calculations

A. Calculate the plus 1 inch replacement, the prorated weight retained, the percent retained, and the adjusted weight as shown on the worksheet. Calculate the accumulated weight in accordance with DOTD TR 113. Record these values where indicated.

B. Calculate the quantity of water to be added to each representative portion (H_n) in mL to yield a moisture content incremented by 2 percent above that of the previous representative portion by using the following formula.

$$H_n = H_{n-1} + 163$$

where:

H_{n-1} = volume of water, mL, added to the previous representative portion
163 = a constant representing the volume of water in mL required for a two % moisture content for an 18.00 lb representative portion

example:

H_{n-1} = 326 mL

$$H_n = 326 + 163$$

$$H_n = 489$$

Note G-3: *1 g of water = 1 cc of water = 1 mL of water.*

C. Calculate wet weight of compacted material in mold (K) in g for each representative portion in accordance with the following formula and record on the worksheet.

$$K = I - J$$

where:

I = wt of mold, base plate (if used), and compacted wet material, g
J = wt of mold and base plate (if used), g

example:

I = 22.54 g
J = 12.71 g

$$K = 22.54 - 12.71$$

$$K = 9.83$$

D. Calculate wet weight density (WWD) in lb/ft^3 for each representative portion using the following formula and record on the worksheet.

$$WWD = \frac{K}{0.075}$$

where:

K = wet wt of compacted material, lb
0.075 = a constant representing the volume of the mold, ft^3

example:

K = 9.83 lb

$$WWD = \frac{9.83}{0.075}$$

$$= 131.066$$

$$WWD = 131.1$$

E. Calculate the weight of water (WW) in lb and the weight of dry material (DW) in lb, using the formulas shown on the worksheet and record.

F. Calculate the moisture content (MC) in percent for each representative portion as shown on the worksheet and record.

G. Calculate the dry weight density (DWD) in lb/ft^3 for each representative portion using the following formula.

$$DWD = \frac{(WWD)}{100 + (MC)} \times 100$$

where:

WWD = wet wt density, lb/ft^3
MC = moisture content, %

example:

WWD = 131.1 lb/ft^3
MC = 4.0 %

$$DWD = \frac{131.1}{100 + 4.0} \times 100$$

$$= \frac{131.1}{104.0} \times 100$$

$$= 1.26057 \times 100$$

$$DWD = 126.1$$

H. Beginning with the lowest moisture content, plot a point, on the Laboratory Compaction Report, representing the intersection of a horizontal line projected from the wet weight density and a vertical line projected from the moisture content. Continue for each moisture content until all points for wet weight densities and dry weight densities have been plotted. Repeat the process for each moisture content, substituting dry weight densities for wet weight densities.

I. Form a smooth line, using the engineer's curve by connecting the plotted points to form two curves, Wet Weight Density vs. Moisture Content and Dry Weight Density vs. Moisture Content. (Refer to the Laboratory Compaction Report.)

Note G-4: *If after the results have been plotted, there is not a minimum of three points on the dry side and two points on the wet side of optimum, additional testing must be performed until this minimum is met. If a smooth curve cannot be drawn, additional testing may be required.*

J. Determine the Optimum Moisture Content (%) of the total material, which is the moisture content corresponding to the peak of the Dry Weight Density curve.

K. Determine the Maximum Dry Weight Density of the total material, which is the weight corresponding to the peak of the Dry Weight Density curve.

VI. Report

A. Report the Maximum Dry Weight Density and the Optimum Moisture Content on the Laboratory Compaction Report and on the Aggregate Test Report to the nearest 0.1 lb/ft^3 and 0.1 percent, respectively.

B. Report the Gradation from DOTD TR 112 and TR 113 and Atterberg Limits from DOTD TR 428.

VII. Normal Test Reporting Time

Normal test reporting time is 3 days.

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

DOTD 03-22-4197
English
4/98

LABORATORY MOISTURE - DENSITY RELATIONSHIP
DOTD TR 418 - Mehtod G
(English)

PROJECT NO: 999-99-0099 DATE: 12/16/97 LAB NO: 22-999999

TYPE ADDITIVE: _____ TYPE SOIL: Limestone SAMPLE NO: LS-3

TESTED BY: G.C. CHECKED BY: JBW

SIEVE	*		Wt. Retained, lb	+ 1" Replacement $B_n/(1 - (A/C))$	Prorated Wt. Ret., lb (F)	% Retained (F/E) x 100 (G)	Adjusted Wt. lb (G x 18) ÷ 100	Accumulated Wt. lb
1"	A		0.60					
3/4"	B_1		6.40	6.62	6.62	19.91	3.58	3.58
1/2"	B_2		2.32	2.40	2.40	7.22	1.30	4.88
No. 4	B_3		8.91	9.21	9.21	27.70	4.99	9.87
Subtotal	C	$A+B_1+B_2+B_3$	18.23	18.23				
- No. 4	D		15.02	15.02		45.17	8.13	18.00
Total	E	C + D	33.25	33.25		100	K = 18.00	

CURVE POINT NO.	***		1	2	3	4	5	6
WATER ADDED, mL	H	See Calculations	326	489	652	815	978	
WT. MOLD, BASE (if appl.) & WET MATL., lb	I		22.54	22.81	23.23	23.39	23.21	
WT. MOLD & BASE (if applicable), lb	J		12.71	12.71	12.71	12.71	12.71	
WT. WET COMPACTED MATERIAL, lb	K	I - J	9.83	10.10	10.52	10.68	10.50	
WT. OF PAN & DRY MATERIAL, lb	L		15.22	15.19	15.60	14.91	15.06	
WT. OF PAN, lb	M		5.77	5.62	5.81	5.10	5.53	
WT. OF DRY MATERIAL, lb	DW	L - M	9.45	9.57	9.79	9.81	9.53	
WT. OF WATER, lb	WW	K - DW	0.38	0.53	0.73	0.87	0.97	
WET DENSITY, lb/ft³	WWD	K / 0.075	131.1	134.7	140.3	142.4	140.0	
MOISTURE CONTENT, %	MC	(WW/DW) x 100	4.0	5.5	7.5	8.9	10.2	
DRY DENSITY, lb/ft³	DWD	$\frac{WWD}{100 + MC} \times 100$	126.1	127.7	130.5	130.8	127.0	

REMARKS: _____

Laboratory Moisture - Density Relationship Worksheet (03-22-4197)
Figure G-1 (English)

LAB COMPACTION REPORT - DOTD TR 418 METHOD G

DOTD 03-22-4165
Metric / English
Rev. 3/98

Project No. 999-99-0049 Station S. No. LS-3 Lab No. 22-999999

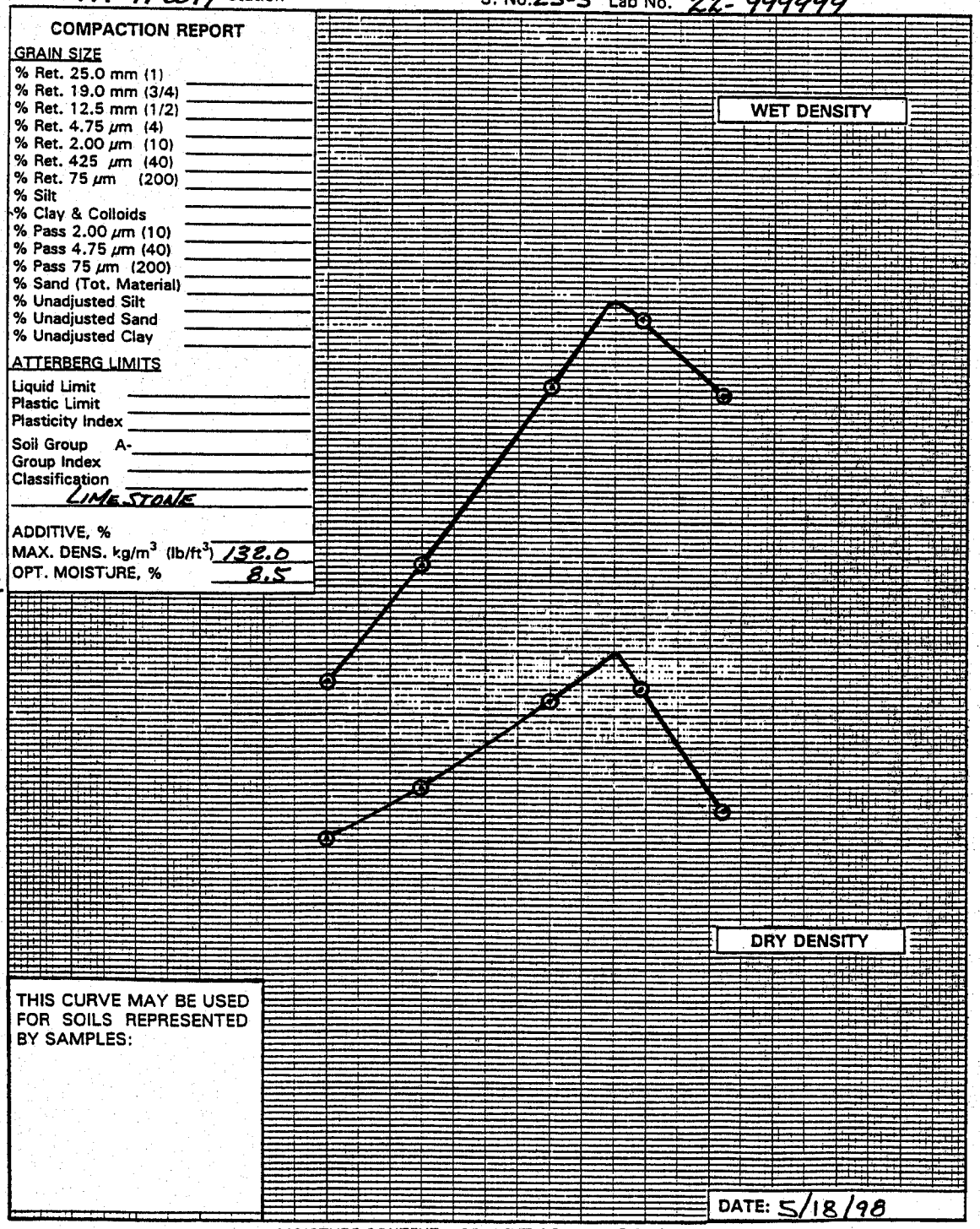
COMPACTION REPORT

GRAIN SIZE
- % Ret. 25.0 mm (1)
- % Ret. 19.0 mm (3/4)
- % Ret. 12.5 mm (1/2)
- % Ret. 4.75 μm (4)
- % Ret. 2.00 μm (10)
- % Ret. 425 μm (40)
- % Ret. 75 μm (200)
- % Silt
- % Clay & Colloids
- % Pass 2.00 μm (10)
- % Pass 4.75 μm (40)
- % Pass 75 μm (200)
- % Sand (Tot. Material)
- % Unadjusted Silt
- % Unadjusted Sand
- % Unadjusted Clay

ATTERBERG LIMITS
- Liquid Limit
- Plastic Limit
- Plasticity Index

Soil Group A-
Group Index
Classification LIME STONE

ADDITIVE, %
MAX. DENS. kg/m³ (lb/ft³) 132.0
OPT. MOISTURE, % 8.5



THIS CURVE MAY BE USED FOR SOILS REPRESENTED BY SAMPLES:

DATE: 5/18/98

MOISTURE CONTENT - PERCENT OF DRY WEIGHT

4 5 6 7 8 9 10 11 12

Laboratory Compaction Report (03-22-4165)
Figure G-2 (English)

MATT MENU SELECTION - 2

Louisiana Department of Transportation and Development

AGGREGATE TEST REPORT

DOTD 03-22-0745
Metric / English
Rev. 2/98

Project No. 999-99-0109 | Material Code 4215 | Lab No. 22-999999
Date Sampled 09-06-97 | Submitted By 0604 | Quantity 9010
Purp Code T | Source Code A056 | Spec Code L | P.O. No.
Date Tested 09-16-97 | Ident LS-3 | Plant Code | Frict.Rating (1-4)
Item No. 301 | Date Rec'd (lab) 9/7/97 | Sampled By: D.B.
Remarks 1

Tested By R.G. | Date 9/16/97 | Checked By T.L.C. | Date 9/18/97

DOTD TR 102, 112, 113 & 309

Unit (1 = grams 2 = pounds)

Sieve mm	Sieve In.	Mass Retained	% Retained	% Coarser	% Passing
63	2 1/2				
50	2				
37.5	1 1/2	0.00	0	0	100
31.5	1 1/4				
25.0	1	0.60	1.80	1.80	98
19.0	3/4	6.40	19.25	21.05	79
16.0	5/8				
12.5	1/2	2.32	6.98	28.03	72
9.5	3/8				
4.75	No. 4	8.91	26.80	54.83	45
Mass Matl.in Pan		1.52	45.17		
Acc. Total		33.25			
Initial Dry Total Mass		33.30		% Diff:	

Unit (1 = grams 2 = pounds)

Sieve mm/µm	Sieve No.	Mass Retained	% Retained	% Coarser	% Passing
2.36	8				
2.00	10				
1.18	16				
600	30				
425	40	99.00	24.98	79.81	20
300	50				
180	80				
150	100				
75	200	48.90	13.34	92.15	8
53	270				
Mass Matl.in Pan		26.88			
Decant Loss		4.24			
Acc. Total		179.02			
Initial Dry Total Mass		179.80		% Diff:	0.10
Dry Mass After Wash		174.96			

Remarks 2:

DOTD TR 428

Liquid Limit | Plastic Limit
No. of Blows | Mass Cup + Wet Soil,g | Mass Cup + Dry Soil,g | Mass Water | Factor | Cup No. | Mass Cup, g | Mass Dry Soil | % Moisture
Plasticity Index NP

Absorption (T84 or T85)	
Spec Grav SSD (T84 or T85)	
Spec Grav APP (TR 300)	
Effective Spec Grav (TR 300)	
Opt Moist Content,% (TR 418)	8.5
Maximum Density (TR 418) kg/m³ (lb/ft³)	132.0
Lab Comp Method (TR 418)	G
Cement, % (TR 432 or SPECIFIED)	
Lime, % (TR 416 or SPECIFIED)	
Other (Additive) Code %	
Clay Lumps, % (TR 119)	
Friable Particles, % (TR 119)	
Clay Lumps & Friable Particles % (TR 119)	
Flat or Elongated Part.,% (TR 119)	
Coal & Lignite, % (TR 119)	
Glassy Particles, % (TR 119)	
Iron Ore, % (TR 119)	
Wood, % (TR 119)	
Total (Clay Lumps, Fri.Part.,Iron Ore, Coal & Lignite, Wood),% (TR 119)	
Foreign Matter, % (TR 109)	
Clam Shell, % (TR 110)	
Soundness, % Loss (T 104)	
Abrasion, % Loss (T 96)	
Colorimetric Test (1 = Pass, 2 = Fail) (T 21)	
Asphalt Content, % (TR 307)	
Retained Asphalt Coating, % (TR 317)	
Percent Crushed (TR 306)	
Retained Marshall Stability (TR 313)	
Resistivity (TR 429)	
pH (TR 430)	
Organic Content, % (TR 413)	
Sand Equivalent (TR 120)	

Approved By: _____ Date: _____

Aggregate Test Report (03-22-0745)
Figure G-3 (English)

DOTD Designation: TR 418-98
ENGLISH VERSION

METHOD H

I. Scope

This method of test is designed to determine the optimum moisture content and the maximum dry weight density of recycled in-place material compacted in the laboratory in accordance with this procedure. This method of test is specifically designed for existing materials containing asphaltic materials, hydraulic cement, lime, or other stabilizers or surfacings which are to be used as soil or soil-aggregate mixtures.

Note H-1: *It is permissible to determine moisture-density relationships of field conditioned material in accordance with the applicable method of DOTD TR 415.*

II. Apparatus

A. **Mold**
1. A cylindrical metal mold, having a capacity of 1/10 ft^3, manufactured with an internal diameter of 6.000±0.026 in. and a height of 6.100±0.016 in., and with a detachable collar approximately 3.5 in. in height, which can be fastened firmly to a base plate.
2. Molds shall be replaced if any diameter is more than 6.039 in. or the height is less than 6.000 in. at any point.

Note H-2: *Different makes of compactive devices may use mold base plates of different designs. The mold base plate must be compatible with the make of compactive device used.*

B. **Compactive Device**
1. Automatic Rammer
   a. A 10.0±0.1 lb rammer, with a striking face that is a 3.1416 sq in. sector face for use with a 6 in. inside diameter mold and arranged to control the height of drop to 18.00±0.06 in.
   b. A 5.50±0.05 lb rammer, with a striking face that is a 3.1416 sq in. sector face for use with a 6 in. inside diameter mold, and arranged to control the height drop to 12.00±0.06 in.
2. Manual Rammer
   a. A 10.0±0.1 lb rammer, with a circular striking face with a diameter of 2.00 ±0.01 in. and arranged to control the height of drop to 18.00±0.06 in.
   b. A 5.50±0.05 lb rammer, with a circular striking face with a diameter of 2.00±0.01 in. and arranged to control the height of drop to 12.00 ± 0.06 in.

C. **Compaction Block** - a stable block or pedestal composed of portland cement concrete and weighing a minimum of 200 lb.

D. **Straightedge** - steel straightedge, approximately 12 in. in length.

E. **Scale** - a scale of 20 lb or more capacity sensitive to 0.01 lb.

F. **Sieves** - a set of the following sieves conforming to the requirements of the Standard Specification for Wire Cloth Sieves for Testing Purposes (AASHTO Designation: M 92).
1. 1 inch
2. 3/4 inch
3. ½ inch
4. No. 4
5. No. 10
6. No. 40
7. No. 200

G. **Tools**
1. Mixing pans with appropriate covers.
2. Spoons.
3. Pointed trowel.
4. Spatula or large suitable mechanical device for thoroughly mixing material with water.
5. Large screw driver to remove material from mold.
6. Finishing tool.
7. Height gauge - dial micrometer incremented in 0.001 in., accurate to 0.001 in., mounted on a stand.
8. Beakers, Dispersing Agent, and Stirring Apparatus, and Dispersion Cup from DOTD TR 407.

H. **Graduated cylinder** - incremented in mL.

I. **Engineer's Curve** - Alvin 1010-21 or equivalent.

J. **Wax paper**

K. **Power driven wedge crusher.**

L. **Laboratory Moisture - Density Worksheet, Methods H & I** - DOTD Form No. 03-22-4198. (Figure H-1)

M. **Laboratory Compaction Report** - DOTD Form No. 03-22-4165. (Figure H-2)

N. **Aggregate Test Report** - DOTD Form No. 03-22-0745. (Figure H-3)

Note H-3: *It is convenient, but not essential, to have a mechanical device for removing the compacted material from the mold. Such a device may consist of a closed, cylindricalsleeve slightly less than 6.0 inches in diameter or a piston of the same diameter, actuated mechanically, hydraulically or by air pressure.*

III. Test Sample

A. Obtain a representative sample weighing a minimum of 180 lb (6 full sample sacks) of material.

B. Dry entire sample in accordance with DOTD TR 411, except for materials containing reclaimed asphaltic concrete (RAP), oils or other hydrocarbons. The maximum drying temperature will be 140°F (60°C).

IV. Procedure

A. Preparation

1. Set the crusher to produce a sample with 95% - 100% passing the 1 inch sieve.
2. Pass the entire dried sample through the crusher.

Note H-4: *When passing the sample through the crusher, do not crush or reduce the size of stone or gravel aggregate or trash such as bottle caps, pavement markers, broken pieces of culvert, steel, etc. Remove these materials prior to the crushing operation. Discard these materials retained on the 1 inch sieve. Do not remove or discard RAP or treated soils prior to crushing.*

3. Obtain a representative portion of material in accordance with DOTD TR 108 (minimum size in accordance with DOTD TR 113). Record as Initial Dry Total Weight on the top portion of the Aggregate Test Report.
4. Determine the Atterberg Limits of the material in accordance with DOTD TR 428.
5. Determine the weight of the material retained on the 1 inch, 3/4 inch, ½ inch, and No. 4 sieves, in accordance with DOTD TR 113 and the weight retained on the No. 10, No. 40, and No. 200 sieves, in accordance with DOTD TR 112 with the following exceptions for the material passing the No. 4 sieve. Record all data on the Aggregate Test Report.
   a. The test specimen will be 100 g.
   b. The test specimen will be soaked in a beaker filled with dispersing agent for a minimum of one hour.
   c. The test specimen will be dispersed withthe mechanical stirrer for three minutes. Prior to dispersion, wash any material remaining in the beaker into the dispersion cup with distilled water and add additional distilled water to the dispersion cup until it is approximately two-thirds full.
   d. Pour the test specimen from the dispersion cup over a nest of sieves, containing the No. 10, No. 40, and No. 200. Wash any remaining particles out of the dispersion cup over the sieve nest.
   e. Place the material retained on each sieve in a separate tared container, place in an oven, dry to a constant weight in accordance with DOTD TR 403 at 110±5°C (230±9°F) (maxi-mum 60°C [140°F], if the material contains RAP, oils or other hydrocarbons). Record each dry weight separately as Weight Retained on the Aggregate Test Report.

Note H-5: *The values for percent retained, percent passing and Atterberg Limits will be used in lieu of classification in accordance with DOTD TR 423 to identify similar materials for moisture-density purposes.*

6. Mix the material prepared in Steps IV.A.1 - 2 and separate into a minimum of five 15 lb representative portions.

B. Testing

1. Add a quantity of water, measured in mL, to make the 15 lb representative portion to be used for the first point slightly damp. Mix thoroughly. Record the quantity added as **G** on the worksheet.

Note H-6: *Check the mixture by squeezing the fine portion in the palm of the hand. If the mixture is the correct moisture content, it will form a cake which will bear very careful handling without breaking.*

2. Add and thoroughly mix a quantity of water, measured in mL, to each remaining 15 lb representative portion to increase the moisture content of each portion by 2% more than the moisture content of the previous portion. The 2% increment may be adjusted, if necessary. (Refer to Step V.B.) Record the quantity added to each representative portion as **G** on the worksheet.

3. Cover the representative portions and protect them so that the moisture content remains constant, then allow them to slake for a minimum of 30 minutes.
4. Remix the individual representative portions, protect them so that the moisture content remains constant, then allow them to slake for minimum of 12 hours.
5. Compact the test specimens using an approved rammer.
   a. If mold requires an attachable base plate, attach base plate. Weigh mold and base plate and record as **I** on the worksheet.
   b. When using a mold without an attachable base plate, place wax paper on base. Place mold over wax paper and attach. Weigh mold and base plate and record as **I** on the worksheet.
   c. Attach collar to mold.
   d. Uncover a representative portion and remix.
   e. Place a quantity of this material into the mold in an even layer that will yield approximately 1/3 the volume of the mold after compaction. Recover the representative portion.
   f. Use a pointed trowel to rearrange particles, filling voids in the loose material without compacting the material.
   g. Rest the rammer on top of the layer to be compacted. Compact the layer using 28 blows with the 10 lb rammer or 75 blows with the 5.5 lb rammer.
   h. Note height of compacted material. If compacted layer is not 1/3 the height of the mold, correct for any deviation by adjusting the quantity of material used for the subsequent layer.
   i. Repeat Steps IV.B.5.d-h for two more layers.
   j. After the third layer has been compacted, remove the mold, base plate (if applicable), and compacted specimen from the rammer and place in a pan.
   k. Tap the collar with the straightedge to loosen material bond and remove the collar from the mold, without twisting or causing shear stress to the molded specimen.
   l. Note the height of the compacted test specimen.
      (1) If the compacted material is more than 0.50 in. above the height of the mold or more than 0.25 in. below the rim of the mold, remove all material from the mold, remix it with the original representative portion and repeat the test.
      (2) If the compacted material is above the top of the mold, but not more than 0.5 in. above, proceed as follows:
         Keeping the mold, base plate (if applicable), and specimen in the pan, trim the specimen even with the top of the mold, using the steel straightedge. Fill any depressions with the fine, trimmed material, smoothing each area with the straightedge after it is filled. Do not attempt to replace aggregates that have been dislodged.
      (3) If the compacted material is below the top of the mold, but less than 0.25 in. below, proceed as follows:
         (a) Place the finishing tool on the compacted surface and rotate it while tapping very lightly to smooth and level the surface. Do not impart additional compactive effort to the specimen.
         (b) Determine the height of the specimen by measuring to the nearest 0.001 in. at three locations spaced equally around the circumference, and averaging.
         (c) Calculate the volume of the specimen in accordance with Step V.C. and record as **K** on the worksheet.
   m. Brush material from all outside surfaces of mold and exposed edges of base plate or wax paper.
   n. Remove wax paper (if applicable), and brush fines from wax paper onto top of test specimen. Take care not to lose any fines from test specimen.
   o. Weigh mold, base plate (if applicable), and compacted test specimen and record as **H** on the worksheet.
   p. Remove the base plate (if applicable). Remove test specimen from mold and determine moisture content by breaking up and drying the entire test specimen in accordance with DOTD TR 403, Method B.
   q. Repeat Steps IV.B.5.a-p for each 15 lb representative portion, cleaning the mold between each test specimen. Continue repeating the procedure until there is a substantial decrease in the wet weight of the compacted material or the material becomes too wet to compact.

V. Calculations

A. Calculate the initial dry total weight of sample, the percent retained on the No. 10 and larger sieves, and the percent passing each of these sieves in accordance with DOTD TR 113. Determine the percent retained and percent passing on the No. 40 and 200 sieves in accordance with the applicable sections of DOTD TR 407. Record in the appropriate location on the worksheet and the Aggregate Test Report.

B. Calculate the quantity of water to be added to each representative portion (G_n) in mL to yield a moisture content incremented by 2% above that of the previous representative portion by using the following formula.

$$G_n = G_{n-1} + 136$$

where:

G_{n-1} = volume of water, mL, added to the previous representative portion
136 = a constant representing the volume of water, mL, required for a two % moisture content for a 15.00 lb representative portion

example:

G_{n-1} = 429 mL

$$G_n = 429 + 136$$

$$G_n = 565$$

Note H-7: *1 g of water = 1 cc of water = 1 mL of water.*

C. Calculate the volume of the test specimen (K) in ft^3 in accordance with the following formula and record on the worksheet.

$$K = h \times 0.01636$$

where:

h = avg. height of test specimen, in.
0.01636 = constant equal to the volume of a 6 in. diameter mold, per in. of height, ft^3

example:

h = 6.112 in.

$$K = 6.112 \times 0.01636$$

$$= 0.09999$$

$$K = 0.100$$

D. Calculate wet weight of compacted material in mold (J) for each point in accordance with the following formula and record on the worksheet.

$$J = H - I$$

where:

H = wt of mold, base plate (if used), and compacted wet material
I = wt of mold and base plate (if used)

example:

H = 25.35
I = 14.08

$$J = 25.35 - 14.08$$

$$J = 11.27$$

E. Calculate wet weight density (WWD) in lb/ft^3 for each representative portion using the following formula and record on the worksheet.

$$WWD = \frac{J}{K}$$

where:

J = wet wt of compacted material, lb
K = (1/10) a constant representing the volume of the mold or the volume of the specimen (if applicable), as calculated in Step C., ft^3

example:

J = 11.27 lb
K = 0.1 ft^3

$$WWD = \frac{11.27}{0.1}$$

$$WWD = 112.7$$

F. Calculate the weight of water (WW) and the weight of dry material (DW), using the formulas shown on the worksheet and record.

G. Calculate the moisture content (MC) in percent for each representative portion as shown on the worksheet and record.

H. Calculate the dry weight density (DWD) in lb/ft^3 for each representative portion using the following formula.

$$DWD = \frac{(WWD)}{100 + (MC)} \times 100$$

where:

WWD = wet wt dens. lb/ft^3
MC = moisture content, %

example:

WWD = 112.7 lb/ft^3
MC = 6.3 %

$$DWD = \frac{112.7}{100 + 6.3} \times 100$$

$$= \frac{112.7}{106.3} \times 100$$

$$= 1.06020 \times 100$$

$$DWD = 106.0$$

I. Beginning with the lowest moisture content, plot a point on the Laboratory Compaction Report, representing the intersection of a horizontal line projected from the wet weight density and a vertical line projected from the moisture content. Continue for each moisture content until all points for wet weight densities have been plotted. Repeat the process for each moisture content, substituting dry weight densities for wet weight densities.

J. Form a smooth line using the engineer's curve by connecting the plotted points to form two curves, Wet Weight Density Vs. Moisture Content and Dry Weight Density Vs. Moisture Content. (Refer to the Laboratory Compaction Report.)

Note H-8: *If after the results have been plotted, there is not a minimum of three points on the dry side and two points on the wet side of optimum, additional testing must be performed until this minimum is met. If a smooth curve cannot be drawn, additional testing may be required.*

K. Determine the Optimum Moisture Content (%), which is the moisture content corresponding to the peak of the dry weight density curve.

L. Determine the maximum dry weight density, which is the weight corresponding to the peak of the Dry Weight Density Curve.

VI. Report

A. Report the Maximum Dry Weight Density and Optimum Moisture Content on the Laboratory Compaction Report and on the Aggregate Test Report to the nearest 0.1 lb/ft^3 and 0.1 percent, respectively.

B. Report the Gradation and Atterberg Limits on the Laboratory Compaction Report and on the Aggregate Test Report.

VII. Normal Test Reporting Time

Normal test reporting time is 3 days.

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

DOTD 03-22-4198
English
4/98

LABORATORY MOISTURE - DENSITY RELATIONSHIP
DOTD TR 418 - Methods (H) & I
(English)

PROJECT NO. 999-99-0099 DATE: 12/6/97 LAB NO: 22-999999

*TYPE ADDITIVE: _____ TYPE SOIL: Sdy. Loam & Asph. SAMPLE NO: S-7

TESTED BY: N.S.H. CHECKED BY: B.J.D.

*MAX. DRY DENSITY OF MATL. (FROM TR 418, METHOD H), lb/ft³	A		
*REQUIRED % BY VOL. OF ADDITIVE (___ TR 432-B, ___ TR 416, ___ specified)	B		
*% WT. OF ADDITIVE (___ chart, ___ formula)	C		
DRY WT. OF MATERIAL (Representative portion), lb	D		15.00
*WT. OF ADDITIVE TO BE ADDED, lb	E	(C x D) ÷ 100	
*TOTAL DRY WT. OF MATERIAL AND ADDITIVE, lb	F	D + E	

* *FOR USE WITH DOTD TR 418, METHOD I ONLY*

CURVE POINT NO.	•••		1	2	3	4	5	6
WATER ADDED, mL	G	See Calculations	429	565	701	837	973	
WT. MOLD, BASE (if appl.) & WET MATL., lb	H		25.35	25.61	26.14	25.87	25.36	
WT. MOLD & BASE (if applicable), lb	I		14.08	14.08	14.08	14.08	14.08	
WT. WET COMPACTED MATERIAL, lb	J	H - I	11.27	11.53	12.06	11.79	11.28	
VOLUME OF MOLD (or specimen), ft³	K		0.100					
WT. OF PAN & DRY MATERIAL, lb	L		16.37	16.34	16.77	15.68	15.55	
WT. OF PAN, lb	M		5.77	5.62	5.81	5.10	5.53	
WT. OF DRY MATERIAL, lb	DW	L - M	10.60	10.72	10.96	10.58	10.02	
WT. OF WATER, lb	WW	J - DW	0.67	0.81	1.10	1.21	1.26	
WET DENSITY, lb/ft³	WWD	J / K	112.7	115.3	120.6	117.9	112.8	
MOISTURE CONTENT, %	MC	(WW/DW) x 100	6.3	7.6	10.0	11.4	12.6	
DRY DENSITY, lb/ft³	DWD	$\frac{WWD}{100 + MC} \times 100$	106.0	107.2	109.6	105.8	100.2	

REMARKS: _____

Laboratory Moisture - Density Relationship Worksheet (03-22-4198)
Figure H-1 (English)

LAB COMPACTION REPORT - DOTD TR 418 METHOD H

DOTD 03-22-4165
Metric / English
Rev. 3/98

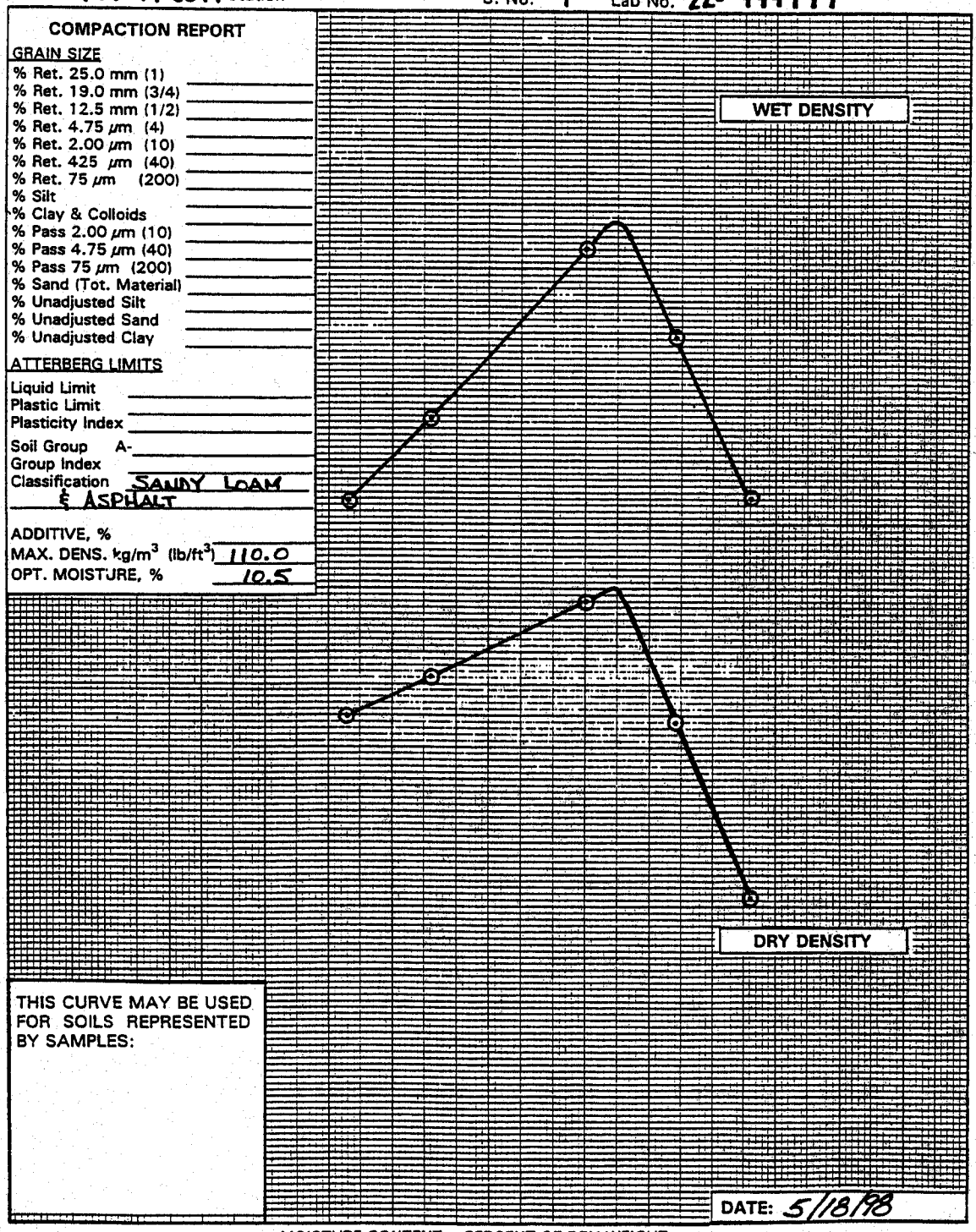
Project No. 999-99-0099 Station S. No. 7 Lab No. 22- 999999

COMPACTION REPORT

GRAIN SIZE
% Ret. 25.0 mm (1)
% Ret. 19.0 mm (3/4)
% Ret. 12.5 mm (1/2)
% Ret. 4.75 μm (4)
% Ret. 2.00 μm (10)
% Ret. 425 μm (40)
% Ret. 75 μm (200)
% Silt
% Clay & Colloids
% Pass 2.00 μm (10)
% Pass 4.75 μm (40)
% Pass 75 μm (200)
% Sand (Tot. Material)
% Unadjusted Silt
% Unadjusted Sand
% Unadjusted Clay

ATTERBERG LIMITS
Liquid Limit
Plastic Limit
Plasticity Index
Soil Group A-
Group Index
Classification SANDY LOAM & ASPHALT

ADDITIVE, %
MAX. DENS. kg/m³ (lb/ft³) 110.0
OPT. MOISTURE, % 10.5



THIS CURVE MAY BE USED FOR SOILS REPRESENTED BY SAMPLES:

DATE: 5/18/98

Laboratory Compaction Report (03-22-4165)
Figure H-2 (English)

MATT MENU SELECTION - 2

Louisiana Department of Transportation and Development

AGGREGATE TEST REPORT

DOTD 03-22-0745
Metric / English
Rev. 2/98

Project No. 9191-9191-010199 | Material Code 410 | Lab No. 212-9191919191
Date Sampled 05-10-11-97 | Submitted By 06104 | Quantity 10101
Purp Code 7 | Source Code A10191 | Spec Code 1 | P.O. No.
Date Tested 05-10-16-97 | Ident 5-7 | Plant Code | Frict.Rating (1-4)
Item No. 3103 | Date Rec'd (lab) 5/8/97 | Sampled By: D.B.
Remarks 1

Tested By N.S.H. | Date 5/6/97 | Checked By P.L.R. | Date 5/7/97

DOTD TR 102, 112, 113 & 309

Unit 1 = grams 2 = pounds

Sieve mm	Sieve In.	Mass Retained	% Retained	% Coarser	% Passing
63	2 1/2				
50	2				
37.5	1 1/2				
31.5	1 1/4				
25.0	1				
19.0	3/4				
16.0	5/8				
12.5	1/2	0.00	0	0	0
9.5	3/8				
4.75	No. 4	379.70	33.0	33.0	67
Mass Matl.in Pan		771.80	67.03		
Acc. Total		1150.50			
Initial Dry Total Mass				% Diff:	

Unit 1 = grams 2 = pounds

Sieve mm/µm	Sieve No.	Mass Retained	% Retained	% Coarser	% Passing
2.36	8				
2.00	10	191.70	13.2	46.2	54
1.18	16				
600	30				
425	40	217.10	18.1	64.3	36
300	50				
180	80				
150	100				
75	200	214.70	16.5	80.8	19
53	270				
Mass Matl.in Pan		228.80			
Decant Loss					
Acc. Total					
Initial Dry Total Mass		1010.40		% Diff: 0.10	
Dry Mass After Wash					

Remarks 2:
GRAV SDV LOAM
ASPHALT A-2-6(0)

DOTD TR 428

Liquid Limit 23 | Plastic Limit 12

No. of Blows	23	Mass Cup + Wet Soil,g	28.3
Mass Cup + Wet Soil,g	40.2	Mass Cup + Dry Soil,g	25.2
Mass Cup + Dry Soil,g	32.6	Mass Water	3.1
Mass Water	7.6	Cup No.	
Factor	0.9899	Mass Cup, g	0.0
Cup No.		Mass Dry Soil	25.2
Mass Cup, g	0.0	% Moisture	12.3
Mass Dry Soil	32.6		
% Moisture	23.3	Plasticity Index	11

Absorption (T84 or T85)	
Spec Grav SSD (T84 or T85)	
Spec Grav APP (TR 300)	
Effective Spec Grav (TR 300)	
Opt Moist Content, % (TR 418)	10.5
Maximum Density (TR 418) kg/m³ (lb/ft³)	110.0
Lab Comp Method (TR 418)	H
Cement, % (TR 432 or SPECIFIED)	
Lime, % (TR 416 or SPECIFIED)	
Other (Additive) Code %	
Clay Lumps, % (TR 119)	
Friable Particles, % (TR 119)	
Clay Lumps & Friable Particles % (TR 119)	
Flat or Elongated Part, % (TR 119)	
Coal & Lignite, % (TR 119)	
Glassy Particles, % (TR 119)	
Iron Ore, % (TR 119)	
Wood, % (TR 119)	
Total (Clay Lumps, Fri.Part., Iron Ore, Coal & Lignite, Wood), % (TR 119)	
Foreign Matter, % (TR 109)	
Clam Shell, % (TR 110)	
Soundness, % Loss (T 104)	
Abrasion, % Loss (T 96)	
Colorimetric Test (1 = Pass, 2 = Fail) (T 21)	
Asphalt Content, % (TR 307)	
Retained Asphalt Coating, % (TR 317)	
Percent Crushed (TR 306)	
Retained Marshall Stability (TR 313)	
Resistivity (TR 429)	
pH (TR 430)	
Organic Content, % (TR 413)	
Sand Equivalent (TR 120)	

Approved By: _____ Date: _____

Aggregate Test Report (03-22-0745)
Figure H-3 (English)

DOTD Designation: TR 418-98
ENGLISH VERSION

METHOD I

I. Scope

This method of test is designed to determine the optimum moisture content and the maximum dry weight density of recycled in-place material to be cement stabilized or treated, or lime treated or conditioned, when compacted in the laboratory in accordance with this procedure. This method of test is specifically designed for existing materials containing asphaltic materials, hydraulic cement, lime, or other stabilizers or surfacings which are to be used as soil or soil-aggregate mixtures.

Note I-1: *It is permissible to determine moisture-density relationships of field conditioned material in accordance with the applicable method of DOTD TR 415. For field conditioned material which requires the addition of additives, TR 415 Method B can be used in the laboratory to determine moisture-density relationships of the material and additive combination only if the required amount of additive is known; however, for field conditioned material brought into the laboratory for the purpose of determining the required amount of additive, it is not permissible to use Method B of TR 415.*

II. Apparatus

A. **Same as DOTD TR 418, Method H.**
B. **Cement or lime.**

Note I-2: *Cement shall meet DOTD specifications for Type IB. For Type IB cement, a unit weight of 94 lb/ft^3 shall be used.*

When Type II or Type IP cement is used on the project, it shall be used in lieu of Type IB to determine the report values for this method of test. Type II and Type IP cement shall meet DOTD specifications. For Type IP cement, a unit weight of 90 lb/ft^3 shall be used. For Type II cement, a unit weight of 94 lb/ft^3 shall be used.

Lime shall meet DOTD specifications for hydrated lime. A unit weight of 35 lb/ft^3 shall be used.

C. **Personal protective equipment**
1. Respirator.
2. Gloves.
3. Apron.
4. Goggles.

D. **Laboratory Moisture - Density Worksheet, Methods H & I** - DOTD From No. 03-22-4198. (Figure I-1)
E. **Additive Conversion Chart.** (Figure I-2)
F. **Laboratory Compaction Report** - DOTD Form No. 03-22-4165. (Figure I-3)
G. **Aggregate Test Report** - DOTD Form No. 03-22-0745. (Figure I-4)

III. Test Sample

Same as DOTD TR 418, Method H.

IV. Health Precautions

Care must be taken not to allow cement or lime to contact skin or to inhale its reaction fumes.

V. Procedure

A. Preparation
1. Determine the maximum dry weight density of the recycled material in accordance with Method H. Record as **A** on the worksheet.
2. Determine the percent by volume of cement in accordance with DOTD TR 432 or the percent of lime in accordance with DOTD TR 416 or use the percent specified. Record as **B** on the worksheet.
3. Convert percent by volume to percent by weight and record as **C** on the worksheet. (Refer to Step VI.A or B for weight-volume conversion calculations).
4. Obtain a minimum of five 15 lb representative portions using the material prepared in accordance with Method H.

B. Testing
1. Add a sufficient quantity of water to make each 15 lb representative portion slightly damp. Mix thoroughly.

Note I-3: *Check the mixture by squeezing the fine portion in the palm of the hand. If the mixture is the correct moisture content, it will form a cake which will bear very careful handling without breaking.*

2. Protect the representative portions so that the moisture content remains constant and allow them to soak for a minimum of 12 hours.

3. Calculate the weight of additive to be added to each representative portion in accordance with Step VI.C. and record as **E** on the worksheet. Add this quantity of additive to each representative portion.
4. Add additional water, measured in mL, to bring the 15 lb representative portion to be used for the first point back to the slightly damp condition described in ***Note I-3***. Mix thoroughly. Record the quantity added as **G** on the worksheet.
5. Add and thoroughly mix a quantity of water, measured in mL, to each remaining 15 lb representative portion to increase the moisture content of each representative portion by 2% more than the moisture content of the previous portion. (Refer to Step VI.D.) The 2% increment may be adjusted, if necessary. Record the quantity of water added to each representative portion as **G** on the worksheet.
6. Cover the representative portions to which water and additive have been added and allow them to stand for a minimum of 30 min.
7. Remix the individual representative portions, cover and protect them so that the moisture content remains constant, then allow them to slake as follows.
   a. Recycled material mixed with cement: The combined standing and slaking time (beginning with Step V.B.6.), plus the compaction time in the laboratory shall approximate the moist mixing time, plus the compaction time in the field, but is not to exceed 90 min.
   b. Recycled material mixed with lime: The combined standing and slaking time (beginning with Step V.B.6.) plus compaction time in the laboratory shall approximate the moist mixing time and mellowing time in the field, but shall not be less than 15 hours.
   c. When recycled material is lime conditioned prior to cement treatment or stabilization, mix the recycled material with the lime and allow it to slake in accordance with Step V.B.7.b. Then, add the required percent cement (determined in accordance with Step VI.A or B) to the lime mixture and allow the lime mixture to slake in accordance with Step V.B.7.a.

Note I-4: *When during a project, the recycled material has been lime treated or conditioned in accordance with Section 304 of the specifications prior to sampling for cement treatment or stabilization, it shall be slaked in accordance with Step V.B.7.a.*

8. Compact the test specimen in accordance with Method H, Step IV.B.5.

VI. Calculations

A. Determine percent of additive by weight by using the Additive Conversion Chart. This chart may be used for Type IB portland cement and lime.
   1. Enter the chart on the left scale. Reading vertically, place a point at the appropriate maximum dry weight density of the soil-aggregate mixture obtained in Step V.A.1.
   2. Reenter the chart on the right scale. Reading vertically, place a point at the design percent by volume of additive.
   3. Draw a straight line across the chart connecting the two points plotted in Steps 1 and 2.
   4. Read the percent by weight directly from the additive scale on the chart at the point where the line drawn in Step 3 intersects the scale for the additive being used.
   5. Record this value as **C** on the worksheet.
   6. Example: *(Figure I-3)*

      a. Type IB Cement

         D = 110 lb/ft^3
         V = 8% Type IB cement by volume

         (1) Follow the left scale to the point represented by 110 lb/ft^3.
         (2) Follow the right scale to the point represented by 8% by volume.
         (3) Draw a straight line across the scale, connecting the two points.
         (4) The percent cement by weight, read directly from the middle scale, is 7.3%.

      b. Lime

         D = 107 lb/ft^3
         V = 6% hydrated lime, by volume

         (1) Follow the left scale to the point represented by 107 lb/ft^3.

(2) Follow the right scale to the point represented by 6% by volume.
(3) Draw a straight line across the scale, connecting the two points.
(4) The percent lime by weight, read directly from the middle scale, is 2.0%.

B. In lieu of the charts or if values are not covered by the charts, determine the percent by weight of additive (C) using the following formula.

$$C = \frac{(UB/100)}{A - (UB/100)} \times 100$$

$$C = \frac{1}{(A/UB) - 0.01}$$

where:

A = maximum dry wt density of the soil-aggregate, lb/ft^3
B = % by volume of additive
U = unit wt of additive, lb/ft^3
100 = constant
0.01 = constant

1. Example: *(Type IP Cement)*

A = 130 lb/ft^3
B = 8%
U = 90 lb/ft^3

$$C = \frac{1}{(130/90 \times 8) - 0.01}$$

$$= \frac{1}{(0.1805) - 0.01}$$

$$= \frac{1}{0.1705}$$

$$C = 5.9$$

Note I-5: *To achieve required accuracy after rounding, carry to four decimal places, as shown.*

2. Example: *(Lime)*

A = 130 lb/ft^3
B = 6%
U = 50 lb/ft^3

$$C = \frac{1}{(130/50 \times 6) - 0.01}$$

$$= \frac{1}{(0.4333) - 0.01}$$

$$= \frac{1}{0.4233}$$

$$C = 2.4$$

C. Calculate the weight of additive (E) in lb to be incorporated into the representative portion of soil using the following formula and record as E on the worksheet.

$$E = \frac{C \times D}{100}$$

where:

C = % by wt of additive (from chart or formula)
D = dry wt. of representative portion, lb
100 = constant

example:

C = 7.3 %
D = 15 lb

$$E = \frac{7.3 \times 15}{100}$$

$$= 1.095$$

$$E = 1.10$$

D. Calculate the quantity of water to be added to each representative portion (G_n), in mL to yield a moisture content incremented by 2 percent above that of the previous representative portion by using the following formula.

$$G_n = G_{n-1} + (9.072 \times F)$$

where:

G_{n-1} = volume of water added to the previous representative portion, mL
F = total wt of material and additive, lb
9.072 = a constant representing a conversion factor from lb to mL for a 2% increment of moisture

example:

G_{n-1} = 551 mL
F = 16.10 lb

$$G_n = 551 + (9.072 \times 16.10)$$

$$= 551 + 146.05$$

$$G_n = 697$$

Note I-6: *1 g of water = 1 cc of water = 1 mL of water.*

E. Perform all calculation steps for the recycled material in accordance with Method H, Step V. C-L.

VII. Report

A. Report the Maximum Dry Weight Density and Optimum Moisture Content on the Laboratory Compaction Report and on the Aggregate Test Report to the nearest 0.1 lb/ft^3 and 0.1 percent, respectively.
B. Report the Gradation and Atterberg Limits on the Laboratory Compaction Report and on the Aggregate Test Report.
C. Report the Type and Percent by Volume of Additive to the nearest percent on the Laboratory Compaction Report and on the Aggregate Test Report.

VIII. Normal Test Reporting Time

Normal test reporting time is 6 days.

Note I-7: *When percent cement must be determined by DOTD TR 432, Method B or the percent lime by DOTD TR 416, normal test reporting time will be 3 weeks or 2 weeks, respectively.*

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

DOTD 03-22-4198
English
4/98

LABORATORY MOISTURE - DENSITY RELATIONSHIP
DOTD TR 418 - Methods H &①
(English)

PROJECT NO. 999-99-0099 DATE: 5/16/97 LAB NO: 22-999999

*TYPE ADDITIVE: Type 1B Cement TYPE SOIL: Sdy. Loam & Asph. SAMPLE NO: S-7

TESTED BY: N.S.H. CHECKED BY: B.J.D.

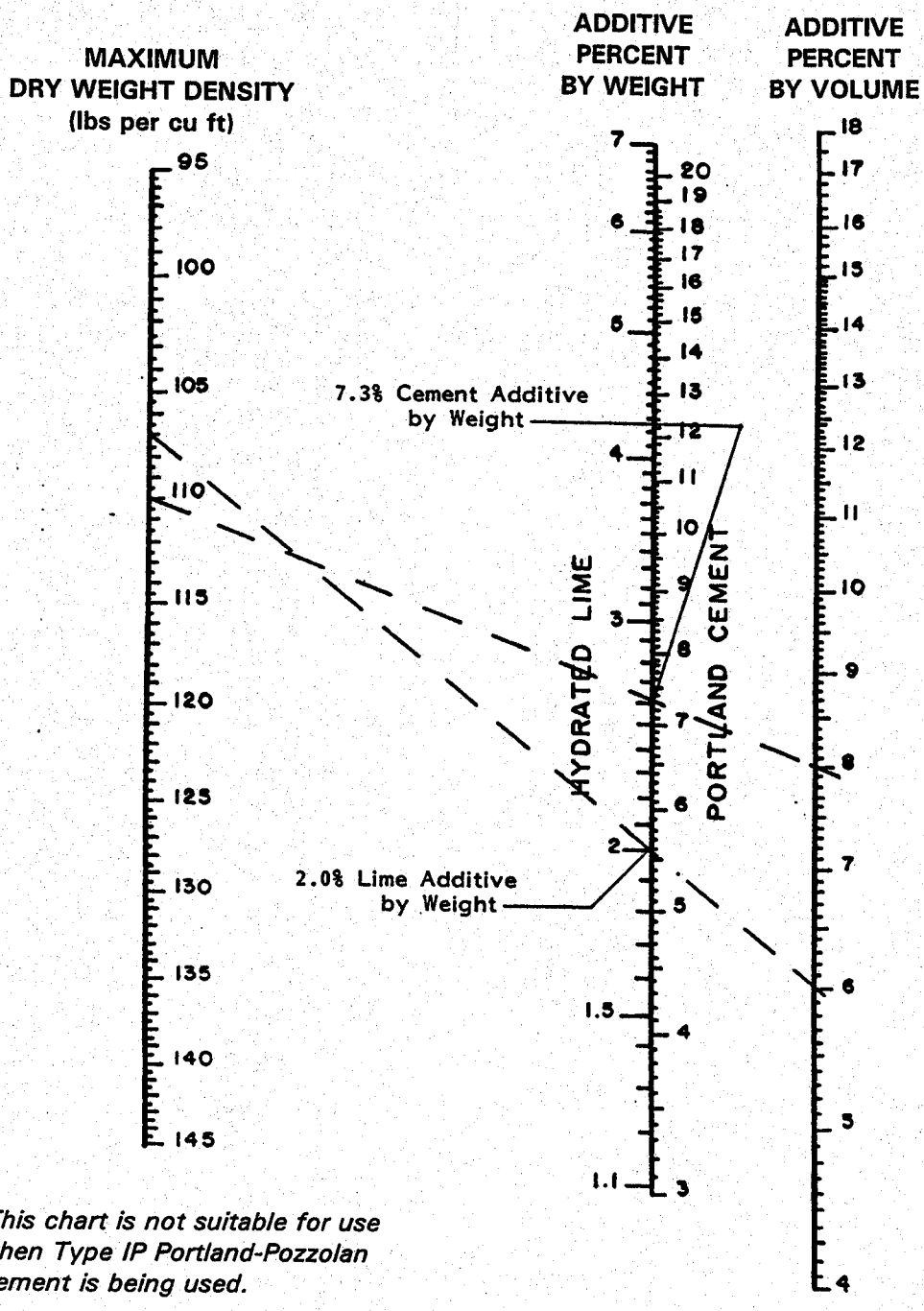
*MAX. DRY DENSITY OF MATL. (FROM TR 418, METHOD H), lb/ft³	A		110.0
*REQUIRED % BY VOL. OF ADDITIVE (___ TR 432-B, ___ TR 416, ___ specified)	B		8
*% WT. OF ADDITIVE (___ chart, ___ formula)	C		7.3
DRY WT. OF MATERIAL (Representative portion), lb	D		15.0
*WT. OF ADDITIVE TO BE ADDED, lb	E	(C x D) ÷ 100	1.10
*TOTAL DRY WT. OF MATERIAL AND ADDITIVE, lb	F	D + E	16.10

* *FOR USE WITH DOTD TR 418, METHOD I ONLY*

CURVE POINT NO.	•••		1	2	3	4	5	6
WATER ADDED, mL	G	See Calculations	551	697	843	989	1135	
WT. MOLD, BASE (if appl.) & WET MATL., lb	H		25.50	26.07	26.45	26.63	26.60	
WT. MOLD & BASE (if applicable), lb	I		14.08	14.08	14.08	14.08	14.08	
WT. WET COMPACTED MATERIAL, lb	J	H - I	11.42	11.99	12.37	12.55	12.52	
VOLUME OF MOLD (or specimen), ft³	K		0.100					
WT. OF PAN & DRY MATERIAL, lb	L		16.33	16.50	16.91	16.14	16.38	
WT. OF PAN, lb	M		5.77	5.62	5.81	5.10	5.53	
WT. OF DRY MATERIAL, lb	DW	L - M	10.56	10.88	11.10	11.04	10.85	
WT. OF WATER, lb	WW	J - DW	0.86	1.11	1.27	1.51	1.67	
WET DENSITY, lb/ft³	WWD	J / K	114.2	119.9	123.7	125.5	125.2	
MOISTURE CONTENT, %	MC	(WW/DW) x 100	8.1	10.2	11.4	13.7	15.4	
DRY DENSITY, lb/ft³	DWD	$\frac{WWD}{100 + MC} \times 100$	105.6	108.8	111.0	110.4	108.5	

REMARKS:

Laboratory Moisture - Density Relationship Worksheet (03-22-4198)
Figure I-1 (English)



Note: This chart is not suitable for use when Type IP Portland-Pozzolan Cement is being used.

ADDITIVE CONVERSION CHART

RELATION IN PERCENT BY WEIGHT OF OVEN-DRY SOIL, SOIL AGGREGATE, OR AGGREGATE TO DESIGN PERCENT BY VOLUME

Additive Conversion Chart
Figure I-2 (English)

LAB COMPACTION REPORT - DOTD TR 418 METHOD I

DOTD 03-22-4165
Metric / English
Rev. 3/98

Project No. 999-99-0099 Station S. No. 7 Lab No. 22-999999

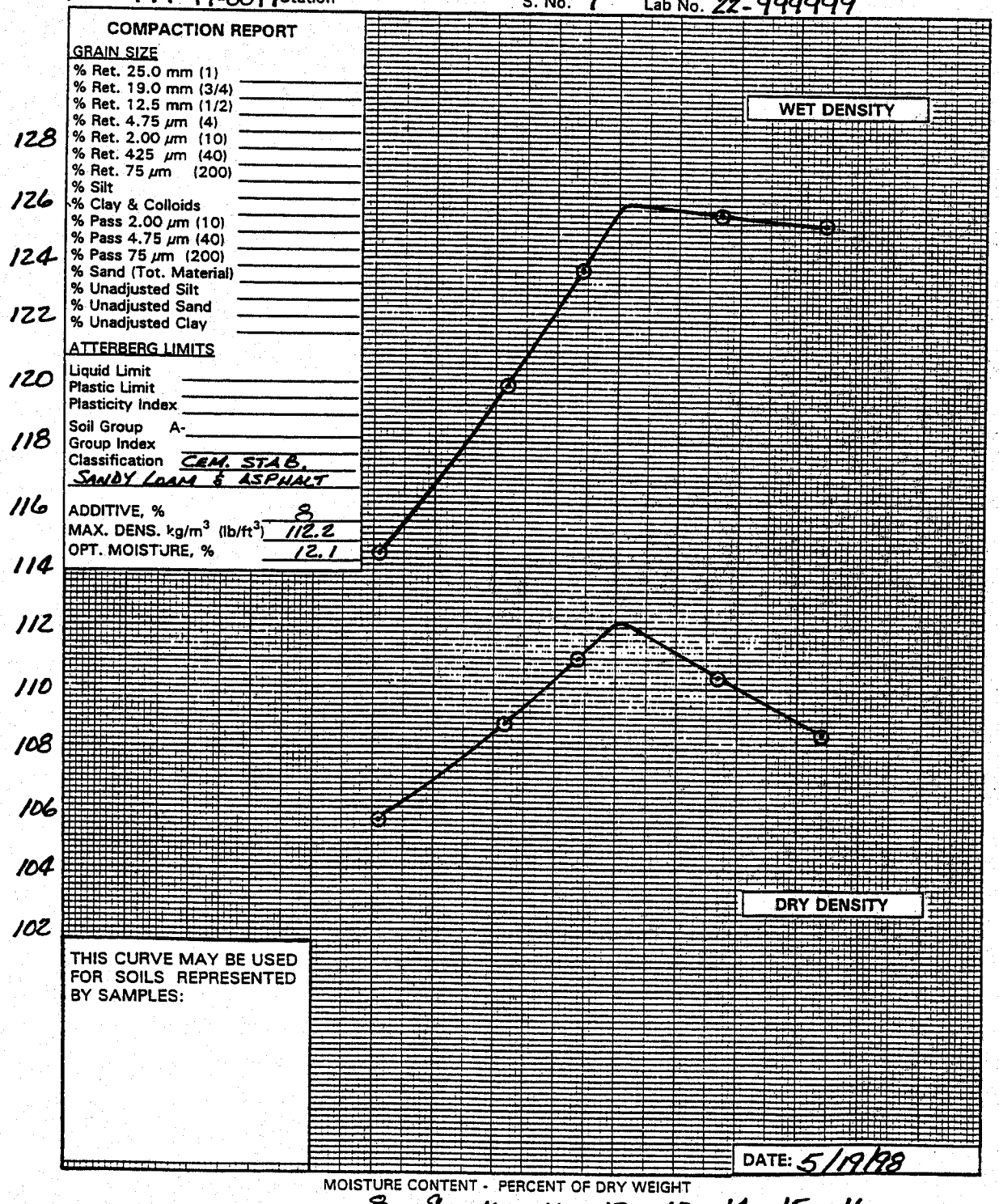
COMPACTION REPORT

GRAIN SIZE

% Ret. 25.0 mm (1)	
% Ret. 19.0 mm (3/4)	
% Ret. 12.5 mm (1/2)	
% Ret. 4.75 µm (4)	
% Ret. 2.00 µm (10)	
% Ret. 425 µm (40)	
% Ret. 75 µm (200)	
% Silt	
% Clay & Colloids	
% Pass 2.00 µm (10)	
% Pass 4.75 µm (40)	
% Pass 75 µm (200)	
% Sand (Tot. Material)	
% Unadjusted Silt	
% Unadjusted Sand	
% Unadjusted Clay	

ATTERBERG LIMITS

Liquid Limit	
Plastic Limit	
Plasticity Index	
Soil Group A-	
Group Index	
Classification	CEM. STAB. SANDY LOAM & ASPHALT
ADDITIVE, %	8
MAX. DENS. kg/m³ (lb/ft³)	112.2
OPT. MOISTURE, %	12.1



THIS CURVE MAY BE USED FOR SOILS REPRESENTED BY SAMPLES:

DATE: 5/19/98

Laboratory Compaction Report (03-22-4165)
Figure I-3 (English)

MATT MENU SELECTION - 2

Louisiana Department of Transportation and Development

AGGREGATE TEST REPORT

DOTD 03-22-0745
Metric / English
Rev. 2/98

Project No. 9999-999-010199 | Material Code 4212 | Lab No. 21-19191919
Date Sampled 05-10-11-97 | Submitted By 01014 | Quantity 10101
Purp Code 7 | Source Code A10199 | Spec Code 1 | P.O. No.
Date Tested 05-10-11-97 | Ident S-7 | Plant Code | Frict.Rating (1-4)
Item No. 303 | Date Rec'd (lab) 5/2/97 | Sampled By: M. L.
Remarks 1

Tested By N. H. | Date 5/16/97 | Checked By P. L. R. | Date 5/17/97

DOTD TR 102, 112, 113 & 309

Unit 2 (1 = grams 2 = pounds)

Sieve mm	Sieve In.	Mass Retained	% Retained	% Coarser	% Passing
63	2 1/2				
50	2				
37.5	1 1/2				
31.5	1 1/4				
25.0	1				
19.0	3/4				
16.0	5/8				
12.5	1/2	0.0	0	0	100
9.5	3/8				
4.75	No. 4	379.70	33.0	33.0	67
Mass Matl.in Pan		770.80	67.03		
Acc. Total		1150.50			
Initial Dry Total Mass				% Diff:	

Unit (1 = grams 2 = pounds)

Sieve mm/µm	Sieve No.	Mass Retained	% Retained	% Coarser	% Passing
2.36	8				
2.00	10	119.70	13.2	46.2	54
1.18	16				
600	30				
425	40	271.10	18.1	64.3	36
300	50				
180	80				
150	100				
75	200	214.70	16.5	80.8	19
53	270				
Mass Matl.in Pan		248.80			
Decant Loss					
Acc. Total		100.30			
Initial Dry Total Mass		1010.40		% Diff:	0.10
Dry Mass After Wash					

Remarks 2:
CEMENT STB. GRAY SDY. LOAM

DOTD TR 428

Liquid Limit 23 | Plastic Limit 12
Plasticity Index 11

No. of Blows		Mass Cup + Wet Soil,g	
Mass Cup + Wet Soil,g		Mass Cup + Dry Soil,g	
Mass Cup + Dry Soil,g		Mass Water	
Mass Water		Cup No.	
Factor		Mass Cup, g	
Cup No.		Mass Dry Soil	
Mass Cup, g		% Moisture	
Mass Dry Soil			
% Moisture			

Absorption (T84 or T85)	
Spec Grav SSD (T84 or T85)	
Spec Grav APP (TR 300)	
Effective Spec Grav (TR 300)	
Opt Moist Content, % (TR 418)	12.1
Maximum Density (TR 418) kg/m³ (lb/ft³)	112.2
Lab Comp Method (TR 418)	E
Cement, % (TR 432 or SPECIFIED)	8.0
Lime, % (TR 416 or SPECIFIED)	
Other (Additive) Code %	
Clay Lumps, % (TR 119)	
Friable Particles, % (TR 119)	
Clay Lumps & Friable Particles % (TR 119)	
Flat or Elongated Part, % (TR 119)	
Coal & Lignite, % (TR 119)	
Glassy Particles, % (TR 119)	
Iron Ore, % (TR 119)	
Wood, % (TR 119)	
Total (Clay Lumps, Fri.Part., Iron Ore, Coal & Lignite, Wood), % (TR 119)	
Foreign Matter, % (TR 109)	
Clam Shell, % (TR 110)	
Soundness, % Loss (T 104)	
Abrasion, % Loss (T 96)	
Colorimetric Test (1 = Pass, 2 = Fail) (T 21)	
Asphalt Content, % (TR 307)	
Retained Asphalt Coating, % (TR 317)	
Percent Crushed (TR 306)	
Retained Marshall Stability (TR 313)	
Resistivity (TR 429)	
pH (TR 430)	
Organic Content, % (TR 413)	
Sand Equivalent (TR 120)	

Approved By: _____ Date: _____

Aggregate Test Report (03-22-0745)
Figure I-4 (English)