

Introduction to Pile Driving Inspection



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Technology Transfer and Training
DOTD Employee Training Manual
ETRN Number C 0820 A
Stock Number 50380

INTRODUCTION TO PILE DRIVING INSPECTION

**Louisiana Department of Transportation and Development
Developed by
Technology Transfer and Training
2011**

Credits

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To The Student

This is a self-study course that allows you to proceed at your own speed. This course is designed to provide you with information, then to test your ability to recall the information by immediately providing questions about the material just presented. This process allows you to read the information, participate actively in the course by answering questions, and learn quickly. This procedure reinforces what you have just read and should enable you to retain what you have studied for a longer period of time than a lecture or a regular textbook.

This course will provide you with the background knowledge and introduction to the process of Pile Driving Inspection. This training manual is part of a series of training modules developed for foundation inspection. Louisiana DOTD employees should have completed the Department's training courses *Mathematics for Construction Personnel Volume I*, *Mathematics for Construction Personnel Volume II*, *Highway Plan Reading I*, *Highway Plan Reading II*, and the *Introduction to the Standard Specifications*. Department and non-DOTD personnel should be familiar with the current *Application of Quality Assurance Specifications for Portland Cement Concrete Pavement and Structures*, *Louisiana Standard Specifications for Roads and Bridges*, *Materials Sampling Manual*, and *Testing Procedures Manual*. These manuals contain all of the information necessary to be a successful certified pile driving inspector.

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CHAPTER 1

INTRODUCTION

1-1 The Louisiana *Standard Specifications for Roads and Bridges* state that quality control and acceptance inspection will be performed on all driven piles used on a DOTD bridge project. Inspection of pile installation ensures that the load bearing capacity anticipated during the design phase of the project is achieved. The goal of this tutorial is to familiarize you with:

- The Pile Driving System, including hammers, cushions, jets, augers, leads, monitoring equipment, etc.
- Types of piles
- The Pile Installation Plan, the evolution from plans to installing pile foundation
- And most importantly, your role as an Inspector ensuring that the pile foundation is installed in accordance with the plans and specifications.

Beneath the ground surface are layers of sands, clays, silts, and bedrock. Naturally, the best material to build on is the bedrock, but here in Louisiana the bedrock is too far below the surface to be built on economically. In these instances, foundation systems are constructed that will enable structures to stand without reaching bedrock.

A foundation is built to transfer the weight of the structure to the natural material below. Foundations come in many different types and sizes, ranging from shallow spread footings to the topic of this tutorial, piles.

Overview

- 1-2 When DOTD begins the design phase of a structure, the foundation selection is based on factors such as the size and weight of the structure being supported, the bearing capacity of the soil, cost of materials, and the environment in which the structure will be built.

Soil borings, other soil investigations, and soil analyses are used to develop the subsurface information for the bridge foundation. This forensic work will take place prior to the design of the structure. This information will be provided on the plans for informational purposes during construction. The contract may require the contractor to do further investigations to verify the design requirements.

Introduction to Piles

- 1-3 Piles are defined as long slender members usually made of timber, steel, or reinforced concrete driven into the ground and used:
- To carry a vertical load
 - To resist a lateral force, as in the case of a batter pile (which is driven at an angle with the vertical)
 - To resist water or earth pressure as in the case of a sheet pile
 - To support a footing foundation or serve as a foundation itself (pile bent)

There are various types of piles used in Louisiana. Some of the typical types are:

- **Precast, Prestressed Concrete Piles** – Precast, prestressed concrete piles are used for both footings and as bent piles. These piles are cast at a manufacturing facility and the steel strands inside the pile are stressed to the

proper tension before casting. These piles are usually shorter in length than other piles, but can be spliced together to achieve longer lengths. This type of pile is very common in Louisiana bridge construction.

- **Steel Pipe Piles** – Pipe piles are normally used in deep foundations to transfer the structure load to stronger soil conditions deep beneath the ground. Pipe piles can be driven either open end or closed end. When driven open end, soil is allowed to enter the bottom of the pipe or tube. If an empty pipe is required, a jet of water or an auger can be used to remove the soil inside following driving. Closed end pipe piles are constructed by covering the bottom of the pile with a steel plate or cast steel shoe. In some cases, pipe piles are filled with concrete to provide additional moment capacity or stiffness.
- **Steel H-Piles** – Piles made of steel H-beams generally used as footings piles. Steel H-piles are used when pile lengths require splicing to achieve adequate resistance. Steel piles are able to absorb high driving forces, so this makes them suitable to drive through dense, hard-to-penetrate strata layers.
- **Timber Piles** – These come in a wide variety of lengths and sizes. They are generally used for temporary bridges, docks, sign trusses, message board supports, pile supported approach slabs, fenders, and have been used in the past as permanent piles.
- **Cylinder Piles** – A reinforced concrete cylindrical pile that is fabricated to required diameters and section lengths. These piles are very heavy due to their large cross section and are typically transported via barge to a project. They have a diameter ranging from 54 inches to 66 inches. They are typically used for major bridge structures.

- **Sheet Piles** – Flat panels of steel, wood, or concrete that may interlock with one another to create a wall structure. Sheet piles are mainly used to resist lateral soil forces. Steel sheet piles are sometimes used as forms for concrete.
- **Cast-in-Place Concrete Piles** – There are several types of cast-in-place concrete piles, including steel shells and steel pipe piles. Steel shells are generally step-tapered and driven with a mandrel. The casing, once driven into place, is then filled with concrete. Shell piles are generally used in soils with low bearing capacities.

Chapter Review

1-4 Answer the following.

1. List three uses of piles.

2. What is the best material to build a structure on? _____
3. Which piles are cast at a manufacturing facility and the steel strands inside the pile are stressed to the proper tension before casting?

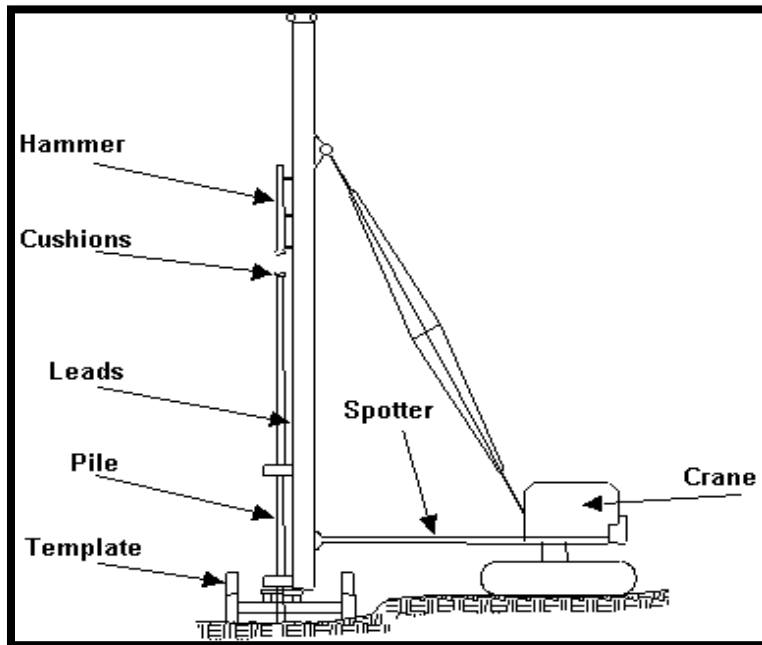
4. **T or F** The cost of materials is a factor when designing a foundation.
5. **T or F** A pile or group of piles can serve as the foundation itself.
6. **T or F** A pile bent is a pile that is damaged.

CHAPTER 2

PILE DRIVING SYSTEM

2-1 All piles have to be driven into the ground. The amount of force required to drive the piles to their proper depth varies based on factors such as soil properties, pile type, driving depth, and installation procedure. We will look at some of the common features of a pile driving system. It is important that you know and recognize the various components; as in many cases, it is part of your responsibility to verify that the proper equipment is on site, operates properly, and is not damaged.

A typical pile driving system is illustrated below. We will discuss the different components and their role in pile driving.



Typical Pile Driving System

Hammers

- 2-2 There are a variety of pile driving hammers for the contractor to choose. Each has its own inherent advantages and disadvantages and the contractor's selection is often dependent upon the project needs and what they have available or can readily get economically.

Hammers advance piles with two different techniques, impact or vibration.

Impact Hammers are hammers that advance the pile through "hitting" it with a ram, hence the name impact.

Vibratory Hammers advance the pile through vibration. Vibratory hammers are not used for permanent structures.

Open End Diesel (Single Acting)

- 2-3 These are perhaps the most commonly used hammers in Louisiana mainly due to their availability and simplicity. The term "open end" comes from the top of the hammer being open; therefore, you can actually observe the ram going up and coming down as it delivers the blow. These are impact hammers and the recording of blow counts and ram height is the general method of inspection.

Fuel is introduced into the cylinder, then the ram drops by gravity, setting off an explosion, which thrusts the ram up. The process is repeated over and over.

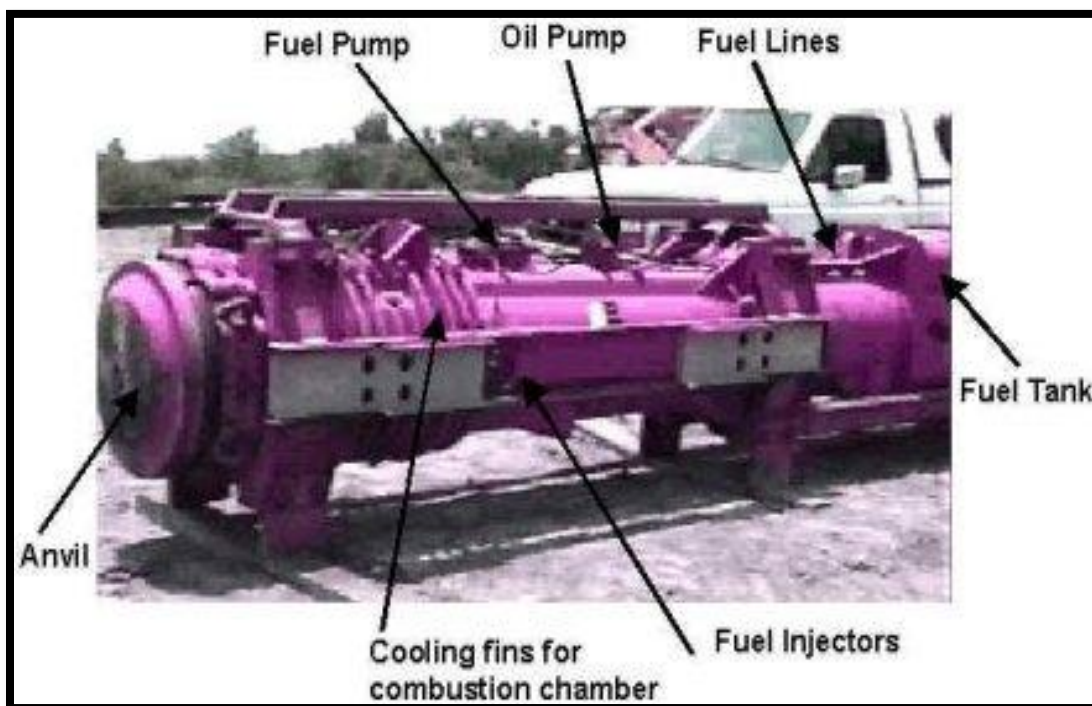
These hammers must be equipped with variable fuel settings that permit ram height adjustment, which in turn, permits adjustment of the hammer energy used during driving.



Advantages

- Very simple; dependable
- No additional support equipment required
- Lightest net weight per foot pound of energy
- Readily available

This picture shows some of the parts of the open end diesel hammer.



Diesel Pile Hammer

Closed End Diesel

2-4 These impact hammers differ from the open ended hammers in that the top is enclosed and the pressure build up in the bounce pressure chamber literally throws the ram back down.

A gauge is attached to the bounce chamber to enable recording of the chamber pressure for inspection purposes, as the ram is not visible for determining stroke height.

These are losing popularity due to their low efficiency rating and the difficulties in spotting operation problems.

Advantages

- No additional equipment required
- Drives piles faster
- Lightweight

Air/Steam Hammers

2-5 Air hammers are the second most common hammers used in Louisiana. Steam hammers have all but disappeared from use. Both are impact hammers and, unlike the diesel hammers, are much cleaner while operating. However, while cleaner than diesel, it requires support equipment, such as a compressor, to produce the air pressure. Air hammers are much heavier than diesel hammers that produce the same energy.

The air hammer is equipped with a slide bar, which provides for adjusting to either of two settings, full stroke or half stroke. Once set, the hammer delivers a constant stroke height on each blow, unlike the open end diesel.

Advantages

- Same stroke height for each impact
- Consistent operation rate
- Low impact velocity
- More efficient than diesel

- Cleaner exhaust than diesel

Hydraulic Hammers

2-6 The hydraulic hammers are probably the third most common used in Louisiana and are impact hammers. The hammer energy on these can be controlled with precise pressure settings. In fact, rather than recording stroke height during driving, the Inspector records the pressure introduced on pressure gauges on the hydraulic pump. The Inspector can also record stroke height by marking increments on the slide bar.

Like the air/steam hammers, these also require support equipment. A big drawback to these hammers is the need for a dedicated person to operate the hydraulic power unit and the need for experts when repairs are required.

Advantages

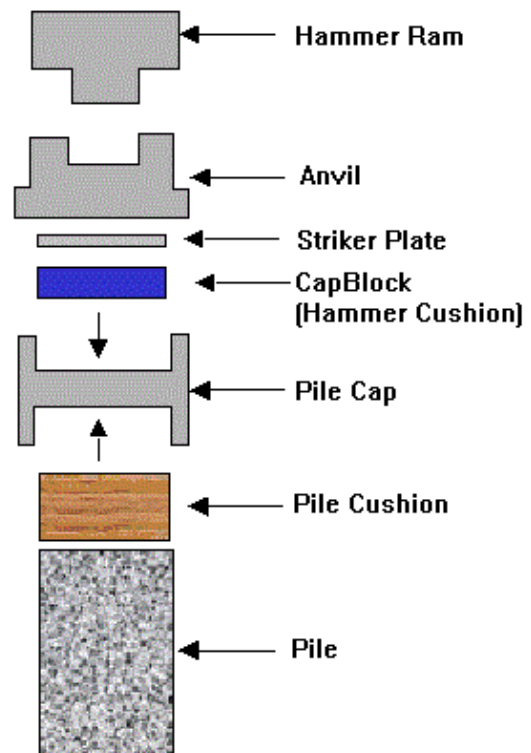
- Controllable variable stroke
- High-efficiency blow
- Low-impact velocity
- Lightweight
- Operates underwater
- Clean running, quieter

Vibratory Hammers

- 2-7 Unlike the other hammers, these operate by vibrating the piling into the ground. There is no requirement in the specifications relating to the inspection of these hammers. However, these hammers are typically used to install sheet piles or remove piles made of steel.

Cushions

- 2-8 Cushions are used to protect both the hammer and the pile. Cushions that protect the hammer are called capblock cushions or hammer cushions. Hammer cushions are located between the point of the ram or anvil and the pile cap. Cushions used to protect the pile are called pile cushions.



Capblock (Hammer Cushions)

- 2-9 Hammer cushions are constructed of man-made materials that are heat resistant, durable, and absorb a certain amount of shock. The thickness of the hammer cushion should be thick enough to prevent damage to the hammer or pile and ensure uniform driving behavior. Common types of materials are aluminum, micarta, and polymer, which are in the form of disks. Aluminum is usually 1/2 inch thick. Micarta is usually 1 inch thick and is used in sandwich form. Polymer

is typically used alone. Another less common hammer cushion material is Hamortex. Wood, wire rope, and asbestos hammer cushions shall not be used. A striker plate recommended by the hammer manufacturer shall be placed on the hammer cushion to ensure uniform compression of the cushion material. The hammer cushions should be inspected at the beginning of driving operations and every 100 hours of use. It should be replaced at any point where it begins to deteriorate or when the thickness is 75 percent of the original thickness.



Various Types of Hammer Cushions

Pile Cushions

- 2-10 Pile cushions are not used on steel piles or timber piles. Pile cushions are made of wood and are usually laminated together. Pile cushions are generally replaced for each pile or as directed by the Engineer. The cushion material and thickness must match what was accepted on the Pile Installation Plan.

Cushions for cylinder piles must provide full cross section load bearing by remaining centered on the pile and in the helmet throughout driving.



Laminated Pile Cushions

Leads

2-11 Pile hammer leads serve to contain the pile hammer and to direct its alignment so that the force of the blows delivered by the ram will be axial to the pile. They also provide a means for confining long, slender piles until they have been driven to sufficient penetration. It is, therefore, essential that leads be well constructed and aligned, and that they provide for free movement of the hammer. There are numerous different lead designs, but box leads have been the most common on DOTD jobs in the past.



Box Lead Supporting Hammer and Pile

Lead systems include three main types:

- Swinging leads
- Semi-fixed leads
- Fixed leads

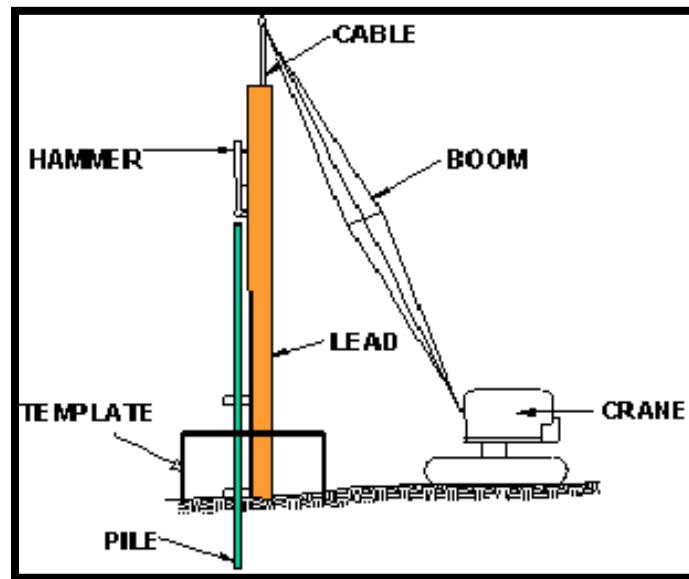
Swinging Leads

2-12 Swinging leads are used in combination with a rigid template for proper pile location and alignment. The leads are suspended from the crane boom by a cable and are not attached to the boom.

Advantages

- Lightest, simplest, and least expensive.

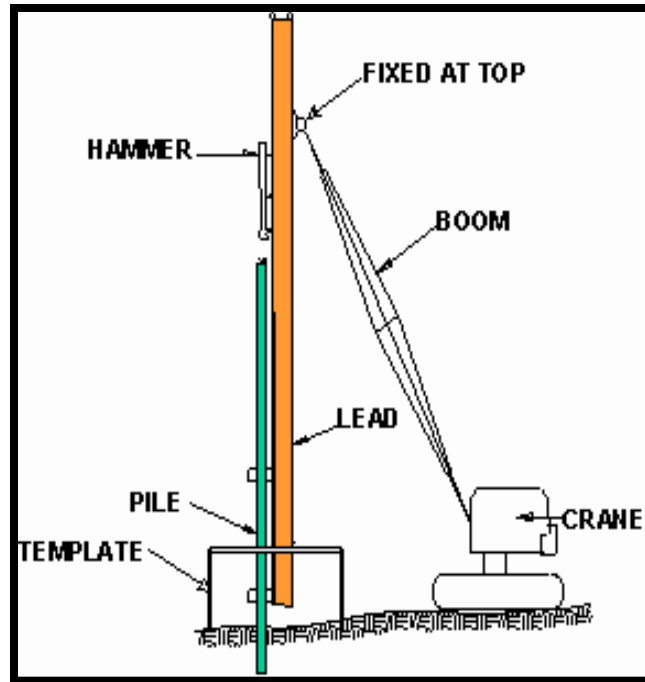
- With stabbing points secured in the ground or to the template, this lead is free to rotate sufficiently to align the hammer with the pile without precise alignment of the crane with the pile.
- Can drive in a hole or ditch or over the edge of an excavation.
- For long lead and boom requirements, the lead weight can be supported on the ground while the pile is lifted into place without excessively increasing the working load.



Swinging Lead System

Semi-fixed Leads

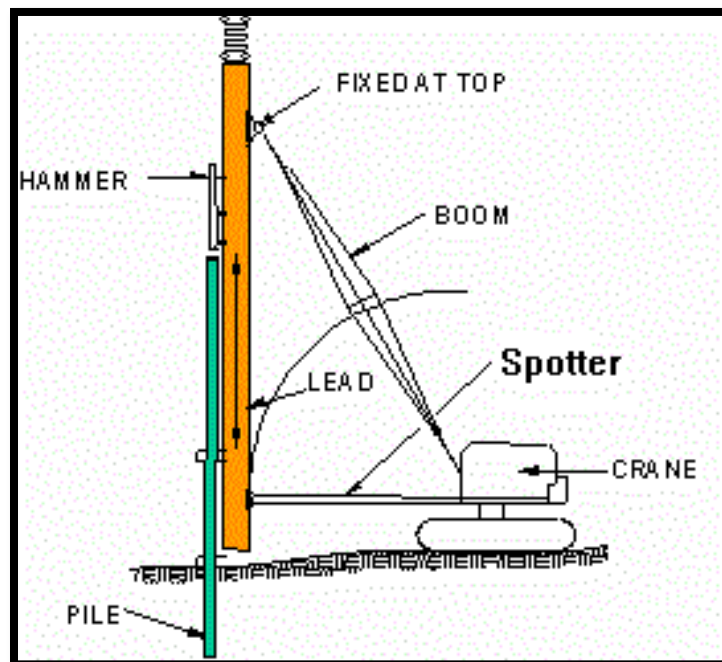
- 2-13 Semi-fixed leads are attached to the crane boom at the top, but not the bottom. Conversely, if the leads are attached at the bottom, they are not attached at the top. A rigid template is also required for this lead system to ensure proper location and alignment of the pile throughout the driving process.



Semi-fixed Leads

Fixed Leads

- 2-14 Fixed leads are attached to the crane at the bottom of the lead and to the boom at the top. A fixed lead system does not require a template for pile alignment and location. Fixed lead systems are easy to move from location to location. Fixed leads are the most expensive and heaviest lead system. Pile alignment and positioning is controlled by the crane. This system is particularly good when driving battered piles.



Fixed Leads

Template

- 2-15 Templates are required when driving piles with swinging leads or with semi-fixed leads. The templates are to be fixed in place and rigid enough to support the pile. When driving battered piles with swinging leads or semi-fixed leads the template design shall be part of the Pile Installation Plan.

For piles on land, the best practice is to locate the template within 5 feet of cutoff to ensure the best location and alignment. For piles in water, the best practice is to locate the template within 5 feet of cutoff. Where practical, place the template so that the pile can be driven to cut-off elevation before removing the template.

The bottom of the swinging leads shall be firmly attached to the template. Template construction shall be designed to allow the pile to freely pass without binding.



Double-Tiered Template



Single-Tiered Template with Piles

Cranes

- 2-16 The crane and leads should be the ones indicated in the Pile Installation Plan submitted by the contractor.

The crane must be large enough to handle the leads, hammer, and the pile not only for the weight involved, but also taking into consideration the reach required to properly locate the pile. Cranes are usually rated based on their lifting capacity. For example, for a small pile driving job, a 50-100 ton crane is commonly used. Larger jobs and over water jobs usually use heavier capacity cranes up to 250 tons or more.

Cranes with fixed leads or semi-fixed leads are specialty cranes that are usually dedicated only to pile driving operations. Swinging leads are not fixed to the crane in anyway, allowing any general crane to be used. Cranes with fixed or semi-fixed leads generally take more time to setup and move between piles. The platform that the crane sits on with fixed or semi-fixed leads must be properly

located and level. Swinging lead cranes have a little more flexibility as far as platform location.



Crane with Fixed-lead

Chapter Review

2-17 Answer the following.

1. _____ are hammers that advance the pile through "hitting" it with a ram.
2. List some of the parts of the Pile Driving System.

3. Cushions that protect the hammer are called _____ or _____.
4. _____ are placed between the pile top and the pile cap on concrete piles.

5. List the three most common types of leads. _____

6. _____ leads are attached to the crane at the bottom of the lead and to the boom at the top.

7. _____ leads are used in combination with a rigid template for proper pile location and alignment.

CHAPTER 3

PILES

3-1 As we discussed in Chapter 1, there are a variety of pile types used in construction. Generally, the designer selects the type of pile to be used for the foundation system based upon several factors:

1. The loads the foundation system must carry
2. The type of structure being built
3. The geologic conditions found on the site (For instance, how long do the piles need to be to reach the material needed to support the structure?)
4. Special design needs, such as resistance to ship impact for bridge piles, splices, or delivery limitations
5. Specifications or standards relating to construction

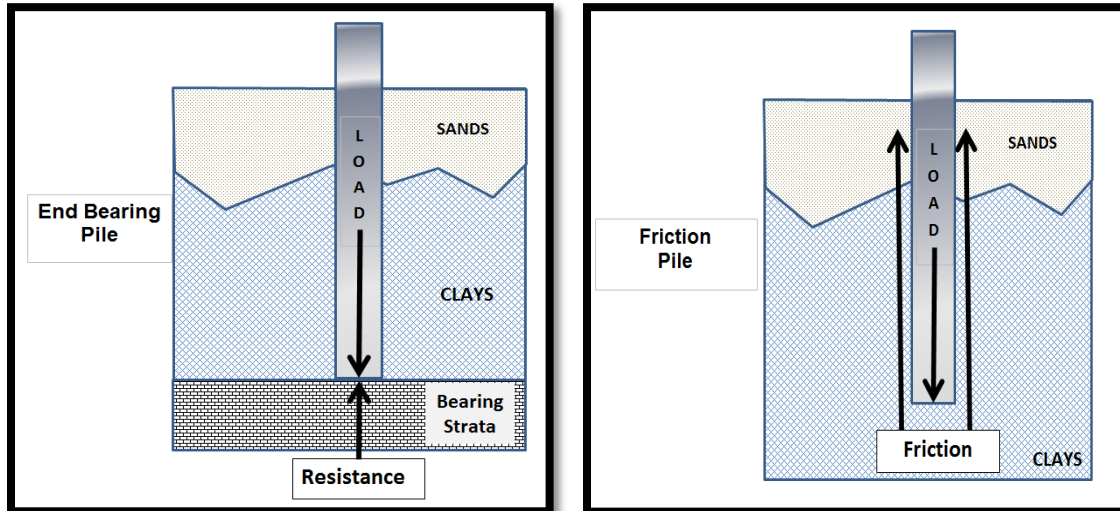
Driven Piles

3-2 Driven piles consist of two basic systems – Displacement piles and Low Displacement (commonly referred to as Non-displacement) piles.

Displacement piles are piles that actually displace the material they are driven into. For instance, if you push your finger down into sand, you actually move aside or displace, virtually all of the sand. Your finger now occupies the area that had been occupied by sand.

Low (Non) Displacement piles are piles that displace very little of the material they are driven into. Insert a knife blade into the sand. It goes in a little easier than your finger because it is not attempting to displace nearly as much material as your finger. Although these piles actually do displace some material, the volume or amount displaced is substantially less than that of displacement piles.

Pile foundations develop their load carrying capacity in two ways. One way is by the pile's tip coming to rest on material hard enough to carry the loads to be imposed, commonly called **end-bearing (tip-resistance)**. Another way is through the ability of the materials to grab onto the sides of the piles and hold them, commonly called **friction**. In many instances, designers rely on a combination of both of these to support the pile.



End Bearing and Friction Pile

Common Pile Types

3-3 This section will go into more depth concerning the various types of piles used in Louisiana. The following are the most common pile types used in structures:

- **Prestressed Square Concrete Piles**

- Prestressed square concrete piles are displacement piles and the most common in Louisiana
- Used in corrosive environments
- Used as friction piles, end bearing piles, and combination of both
- Piles greater than or equal to 24 inches are voided to reduce pile weight
- Solid ends on voided piles provide some protection during driving

- Piles driven as a group can sometimes densify soils in the immediate area. The Specifications dictate the order in which a group of piles are driven.
- Each pile is etched with a unique identification number



Square Prestressed Concrete Pile

- **Steel H-Piles**

- Are non-displacement piles
- Not as common as concrete piles in Louisiana
- Typically used where pile lengths over 125 feet are needed or extremely variable subsurface conditions exist
- Ease of splicing is a big advantage
- Non displacement piles are often used where a large number of piles are needed in a small area



Steel H-piles Driven as a Group

- **Steel Pipe Piles**

- Open end often start as non-displacement piles, but as they plug, become displacement piles
- Closed end are displacement piles
- Typically used where pile lengths over 125 feet are needed or extremely variable subsurface conditions exist or when splicing is required due to height limitations.
- Higher lateral capacity than H-piles

- High tensional load capacity
- Ease of splicing is big advantage
- Non displacement piles are often used where a large number of piles are needed in a small area
- Frequently filled with concrete to a specified elevation



Steel Pipe Pile

- **Cylinder Piles (hollow concrete piles)**

- The least common of the typical piles
- Are hollow precast concrete pipes manufactured to project needs
- Mostly used when project is accessible by barge
- Used in environments that have high impact capacities
- Can be used as both end-bearing and friction piles
- Is considered a displacement pile (following installation, they can be filled with concrete or other materials)
- Are very heavy and require larger barges, cranes, and driving equipment
- Used to handle very large design loads
- Can be prestressed or post tensioned



Segments of Precast Cylinder Piles before Post Tensioning

- **Timber Piles**

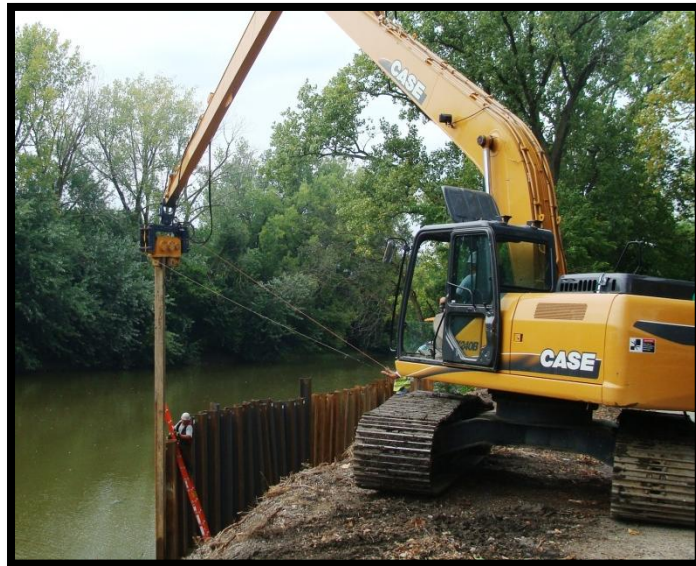
- Typically 8 inch tip and 12 inch butt diameters
- Common lengths 15 feet to 70 feet
- Typically made from pressure treated southern pine or Douglas fir woods
- DOTD project use includes temporary structures, docking and fender systems, sign installation, pile supported approach slabs, and detour bridges



Timber Piles

- **Sheet Piles**

- Generally have interlocking, sand-tight joints
- Made of aluminum, steel, concrete, or timber
- Lengths up to 100 feet
- Used as a retaining wall or barrier
- Can be used as concrete forms

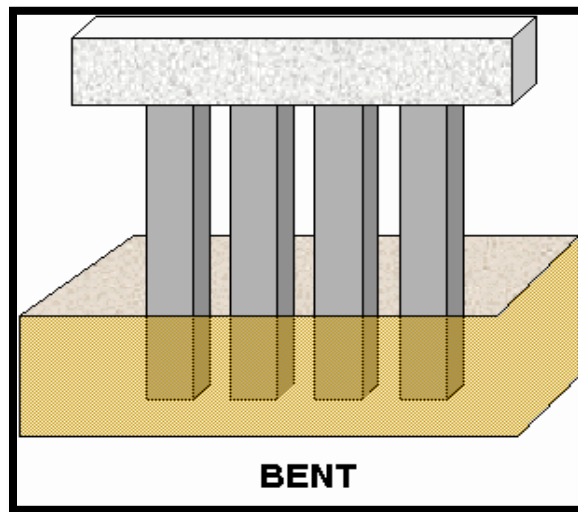


Sheet Piles Installed with a Vibratory Hammer

Pile Bent

- 3-4 Piles are typically driven in groups and finished as either pile bents or as part of a pier foundation.

In a pile bent, the piles rise above the ground surface to a specified elevation. At this elevation, the piles are tied together with a bent cap. The superstructure of the bridge is built on top of the bent cap.

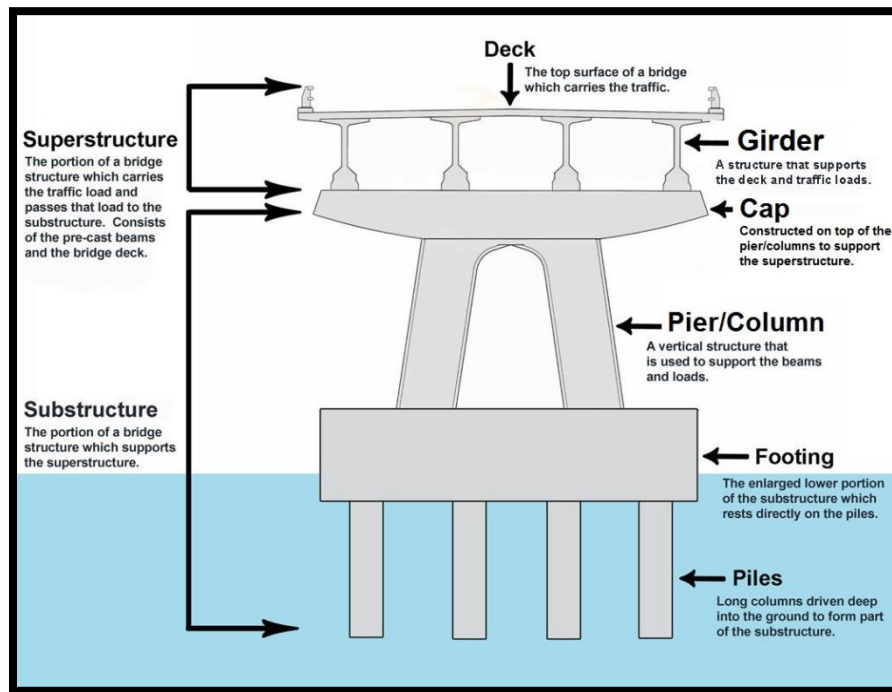


Concrete Pile Bent

Pier/Column Footing

- 3-5 In a **pier/column footing**, the pile tops generally are at or below existing grade. At this elevation, the piles are tied together with a pile cap (footing). Then a column or pier is constructed from the top of the footing up to the bottom of the cap. The superstructure of the bridge is built on top of the cap.

A pier and column serve the same purpose of transferring the structure load to the footing. A pier is generally larger in size and has more load capacity than a column.



Typical Pier/Column Components



Concrete Pile Group for Footing

Chapter Review

3-6 Answer the following

1. _____ piles are piles that actually displace the material they are driven into.
2. List five types of piles. _____, _____,
_____, _____, _____.
3. In a _____, the piles rise above the ground surface to a specified elevation. At this elevation, the piles are tied together with a _____.
4. In a _____, the pile tops generally are at or below existing grade.
5. _____ piles are displacement piles and the most common in Louisiana.

CHAPTER 4

PILE INSTALLATION

- 4-1 Once the project has been designed and the contractor has been awarded the contract, there are several steps to go through before they can actually start driving production piles. The first few steps require a lot of interaction between the department's representatives and the contractor. The whole pile installation process is carefully choreographed and each step is meticulously planned.

Pile Installation Plan

- 4-2 The Pile Installation Plan is the first step in the process. It is a submittal describing in detail the contractor's means and methods of installing piles. The idea behind having the contractor submit this item is to cause him to put thought and planning into the project to provide piles in the right location, undamaged, driven to the proper depth, and that provide the required resistance.

The contractor must provide these documents no less than 30 days prior to beginning pile driving operations to the Project Engineer.

The Pile Installation Plan will contain the contractor's:

- Pile and Driving Equipment Data Form
- List of the proposed driving system
- List of the equipment that will be utilized
- A contractor-provided drivability analyses using the wave equation method (WEAP)
- Detailed drawings of any proposed followers, templates and load test equipment

- Splices, if used. Include detailed information, such as splice type and splice location. Splices not detailed in the Pile Installation Plan must be justified.
- Use and location of shoring, sheet piling, cofferdams, etc.
- Sequence of driving piles for each unique pile layout configuration
- Schedule of driving activities
- Details of the proposed static load test system, equipment, and procedures
- Proposed schedule for test piling and/or indicator pile program
- Methods to install plumb and battered piles
- Proposed schedule for the test pile and/or indicator pile program
- Details of the access system for attaching instrumentation for dynamic monitoring
- Completed Hammer Submittal Form
- Details to protect existing structures in the vicinity
- Any special information required in the plans or by the Engineer

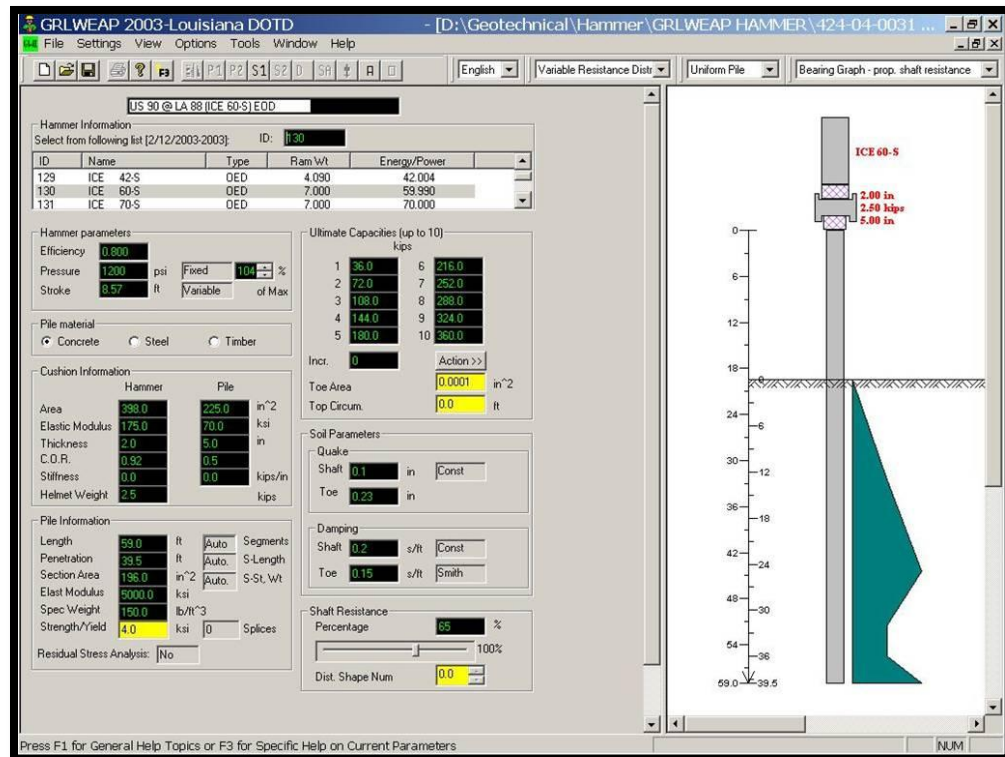
This is the contractor's plan, which must be reviewed and accepted by the Department prior to beginning operations. You, the Inspector, will have certain responsibilities for verifying that certain items, such as the hammer, are as specified in the plan. An example of the Pile Installation Plan is located in the Appendix. **The Inspector must have a copy of this plan during the pile installation.**

Pile Driving Equipment Acceptance

- 4-3 **Wave Equation Hammer Acceptance Method** – Review and acceptance of the contractor's pile driving equipment will be based on the wave equation analysis computer program (FHWA-WEAP87 or newer version). A wave equation analysis

will be performed by the contractor for each pile type and size required in the plans.

Acceptance of the pile driving system does not relinquish the contractor's responsibility from driving the piles to the required pile tip elevation without damage.



WEAP Analysis Software

The criteria the engineer will use to evaluate the pile driving equipment from the wave equation shall be the pile driving resistance. The required number of hammer blows at the required end-of-driving pile capacity shall be from 36 to 146 blows per foot. The pile driving resistance at any depth above the required pile tip elevation shall be achieved with a reasonable driving resistance of less than 240 blows per foot (40 blows per foot for timber piles).

Additional criteria that the engineer will use for the pile driving equipment to be

acceptable are the pile driving stresses that are indicated by the wave equation analysis to be generated during pile driving.

When the wave equation analysis shows that the contractor's proposed equipment or methods will result in either the inability to drive the pile with a reasonable driving resistance to the desired pile bearing capacity or will exceed the maximum allowable pile driving stresses, the contractor shall modify or replace the proposed methods or equipment at his expense until subsequent wave equation analyses indicate that the contractor's proposed pile driving equipment and driving methods meet the required criteria for acceptability.

Test Pile Program

- 4-4 The Test Pile Program may be the second step in the process if included in the plans. It is performed prior to production driving so that actual, on-site field data can be gathered to determine pile driving requirements for the project. The test piles are also driven to determine if the proposed design length of the foundation piles needs to be altered. Most test piles are tested by static load testing. The test piles allow the contractor's proposed equipment and methodologies identified in the Pile Installation Plan to be verified against the design limits.

The purpose of the test pile is to provide in-place geotechnical information to determine the appropriate length of the production piles. The tip elevation of the test pile is shorter than that of the planned production pile of the nearest bent.

Data is gathered to assist in determining:

- The ultimate resistance of the piles
- The nature of the subsurface soils and driving resistance characteristics of the various strata
- The lengths of piles required for the permanent piles

- The driving effort required to obtain the minimum penetration
- The ability of the driving system to do the job

Test piles should be long enough to permit static load testing and dynamic monitoring of the pile. It is the contractor's responsibility to determine the length of the test pile. Typically, a geotechnical engineer is on site monitoring the test pile driving with Pile Driving Analyzer (PDA) equipment.

4-5 Based upon the results of the test pile program, the geotechnical engineer, following PDA data evaluation, will provide the production pile fabrication length and the driving criteria.

The pile length is usually issued as soon as practical after the end of the test pile program to permit the contractor ample time to order the correct pile length. The Department will pay for the lengths that are authorized. If the contractor orders longer lengths, they are not paid for the additional length. If piles must be spliced to achieve the "authorized length," there is no compensation to the contractor.

The driving criteria, issued by the Department, establish the requirements for the driving of the piles. The information obtained during the test pile program is used to develop these criteria. The driving criteria will set the required blow counts based on hammer energy (stroke). It will also set parameters for initial driving, such as using a reduced fuel setting to control stresses in the pile during early driving and practical refusal.

Additionally, the Department should also specify the hammer and cushion materials used for the test pile program and that these materials should continue to be used for the production pile program. Guidelines for replacement of the pile cushion along with replacement of the hammer cushion are generally presented and are available in the Specifications.

Static Load Test

- 4-6 Test piles will be loaded at least 14 calendar days after the initial driving. This period allows for the buildup of skin friction and allows for any soil displaced by the driving procedure to stabilize. All test pile loading results should be reviewed by the engineer to determine ultimate pile capacity. The load shall be applied in increments and loading intervals described in the Specifications.

Gross settlement readings, loads, and any other data shall be recorded by the engineer before and after the application of each load increment. The most useful information is obtained when test piles are loaded until failure.

The Inspector's Role

- 4-7 The Inspector should be present during the installation, loading, and unloading phases of the test pile. The Inspector should verify that the equipment listed on the contractor's Pile Installation Plan is the same equipment being used to drive the test piles. The Inspector should document any equipment identification possible in a project field workbook. The Inspector should verify that the test pile is the same diameter or size as indicated in the plans.

The Inspector should inspect the piles for deficiencies upon delivery of the test pile. The test pile must also be marked in one foot increments from pile tip to cut-off elevation. The best practice is to mark the pile from the tip up. The Inspector is required to measure and record load increments, the settlement values, and rebound values achieved during and after loading. The more details learned during this period will help in identifying potential problems during the installation of permanent piles.

Permanent Piles

- 4-8 Permanent piles are the piles that will actually support the structure. Actual driving operations are essentially the same for both test piles and permanent piles. Permanent piles are driven based on the results of the test pile results. The Driving Criteria letter will have information that must be followed by the contractor, unless directed otherwise by the Engineer.

The equipment used to drive the test piles must match the equipment used to drive the permanent piles. The main difference between the two is that the alignment and positioning control of the permanent piles is more critical.

Permanent piles are to be installed to the planned tip elevation without damage to the pile. The piles may be monitored with the PDA as defined in the installation plan.

Inspector's Role

- 4-9 Two of the most important criteria to observe during pile driving operations are the location of the pile and the number of blows per foot required to drive the pile into the ground. The resistance of the pile is correlated from this blow count, in conjunction with the driving force of the hammer. Verifying that the piles are delivered and stored without being damaged is also an important role of the Inspector. Long concrete piles can crack during delivery or during the lifting of the pile into the leads or cradle.

Alignment

- 4-10 Alignment is just as critical as the pile bearing capacity. If the pile is not in alignment, the structure may not perform as designed. The tolerance for a standard pile is very small when you look at the grand scale of the project. It is important that the pile be located in the proper plan location and be plumb or if

battered, at the correct batter. Though not your ultimate responsibility, you need to verify that tolerances are adhered to. Let's review **tolerances**.



Pile Misalignment

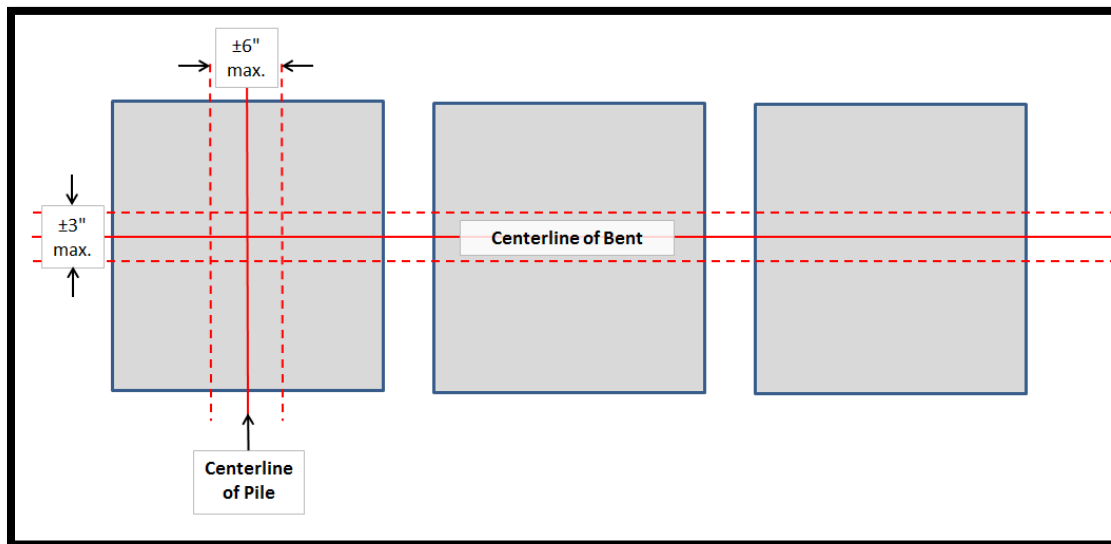
It is critical that the pile be in the correct location. If not, the remainder of the structure may not match up, creating stresses that were not accounted for during design. The plans provide the pile locations, and the specifications provide the degree of accuracy that the contractor must meet.

Location

4-11 How close is the pile to the planned location? The center of the pile is to be within 3 inches of the planned location.

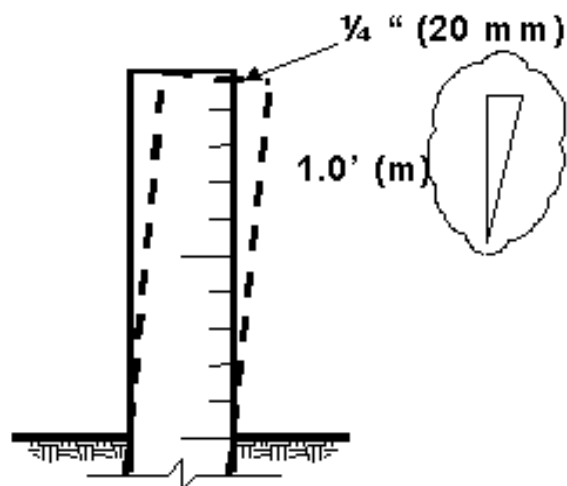
- **Position** - Ensure that the final position of the pile centroid at cut-off elevation is no more than 3 inches perpendicular or 6 inches along the centerline from the plan position indicated in the plans. For footing piles, the centroid of load of any pile at cut-off must be within a 6 inches radius

circle from the planned location. No pile shall be within 3 inches of the edge of a cap or footing. If the pile is to be plumb or battered, it is important that it be within a certain axial alignment as specified.

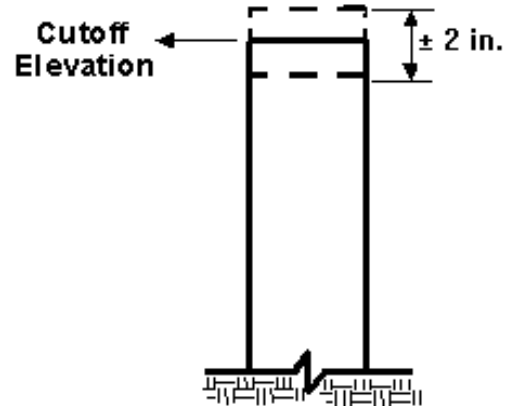


Position Tolerances for Pile Bent

- Axial Alignment** - Ensure that the axial alignment of the driven piles does not deviate by more than 2% ($\frac{1}{4}$ inch per foot) from the vertical or batter line indicated in the plans.



- **Elevation** - The pile cut-off elevation is specified in the plans. The designers want the top of the pile to be at this elevation. In some cases, the contractor may need to build-up the pile or cut it off to achieve the elevation. Ensure that the final elevation is ± 2 inches of the elevation shown in the plans.



Predrilled Holes

- 4-12 The Inspector should monitor the contractor's activities during the construction of predrilled holes. There are situations presented by geologic conditions or other conditions requiring the use of a predrilled hole. All holes are preplanned and should be part of the Pile Installation Plan. There are two main classifications of predrilled holes, **Friction Holes** and **Non-friction Holes**.

Friction holes, which require load transfer, are drilled with a diameter smaller than the pile being driven. The Specifications require friction holes to be at most 80 percent of the smallest dimension of the pile. Sometimes the plans call for predrilled friction holes due to below grade conditions, such as to prevent damage to a pile when driving through densely compacted strata. Any hole predrilled below scour elevation will be a friction hole.

Non-friction holes are predrilled large enough to not carry any load. Non-friction holes are required to be larger than the maximum dimension of the pile being installed. Non-friction holes are required when piles are to be driven through an embankment. The pile must not disturb the embankment material. The depth of

the non-friction hole shall be planned so as to minimize the pile skin friction disturbance and still be sufficient to permit pile installation to the required pile tip elevation. Non-friction holes are drilled through the embankment down to the natural ground elevation before driving operations begin. This is the elevation of the existing grade prior to placement of the embankment fill. Often times this is estimated, if not specifically identified in the plans. The contractor's estimate and the Inspector's estimate of "natural ground" should be fairly close. After the piles have been installed, any void shall be backfilled with an approved granular material and fully saturated with water.

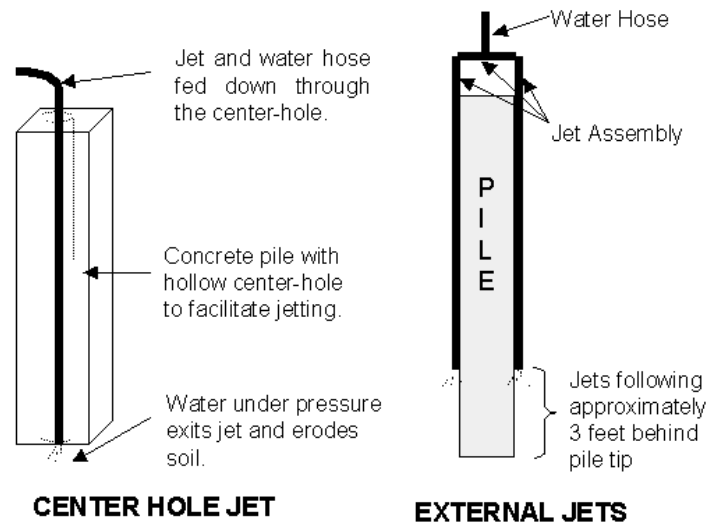


Auger for Predrilling

The depth limits of any predrilled hole shall be developed based on the soil information obtained from soil boring logs or Cone Penetrometer Test soundings. The contractor is responsible for any and all effects due to predrilling. Predrilled holes are not measured for payment and are done at the contractor's expense.

Jetting

- 4-13 When piles must be driven through extremely dense granular materials and it is not possible to drive the pile successfully to tip elevation without possible damage to the pile, it may be necessary to jet the pile. **Jetting** is simply the process of using water under high pressure to erode the soil, thereby allowing for the advancement of the pile. All jetting should be detailed in the Pile Installation Plan. The Engineer **must** accept all jetting. Jetting is typically performed with either a center-hole jet, where a jet is inserted into a hole down the center of the pile or performed by external water jets attached to a template or guide to maintain alignment with the outside of the pile.



Jetting operations can be performed simultaneously with driving operations or jetting may precede the actual driving. If the location is to be prejetted, only one nozzle is to be used. If the jetting operation will be done at the same time as

driving, two nozzles placed on the outside of the pile are used. The two nozzles are placed on exact opposite sides of the pile to prevent the pile from moving out of position laterally.

Care must be taken when jetting piles to be certain that the piles achieve bearing capacity. Only under special circumstances and with authorization from the Project Engineer can jetting operations continue into the last 10 feet above the tip elevation. Jetting will not be allowed in footings, header banks, or where stability of embankments or other structures would be endangered unless accepted in writing by the Engineer.

Changes to the Pile Installation Plan based on field data will be submitted by the contractor to the Engineer for acceptance. When water jets are permitted, the jetting procedures shall be carried out in a manner that will not impair the capacity of the piles already in place or the safety of existing structures or create a crater around the pile causing it to drift.

The contractor shall be responsible for all damage to the site caused by jetting operations. The number and size of jets and the volume and pressure of water at jet nozzles shall be sufficient to erode material adjacent to the pile but not disturb the soil bearing material within 10 feet of the required pile tip elevation.

One jet pipe will be allowed only when the contractor is prejetting a hole prior to placing and driving the pile or when driving is interrupted and the jet is placed inside a steel pipe pile or a voided concrete pile. When jetting and driving is required, the jets shall be above the advancing pile tip approximately 3 feet, or as accepted by the engineer. Jetting operations shall cease when the jet penetration limit is reached, and the pile shall then be driven with the accepted impact hammer to the final pile tip penetration. The pile bearing capacity shall be determined only from the results of driving after the jets have been withdrawn. The contractor shall control, treat if necessary, and dispose of all jet water in a

manner to meet the environmental requirements. Upon completion of jetting a pile, any voids around the pile shall be filled with granular-type material acceptable to the engineer and saturated with water. Jetting disrupts the bearing profile. Adequate time should be allowed before testing for final bearing capacity. DOTD Headquarters' Bridge and Geotechnical Sections should be involved in the evaluation of jetting operations.

Followers

- 4-14 Followers are interposed between a pile hammer and a pile to transmit blows when the pile head is below the reach of the hammer. Followers shall only be used when accepted in writing by the Engineer. It is the responsibility of the Inspector to verify that the contractor is following the specification while using followers. When a follower is permitted, the first pile in each pile group and every tenth pile driven thereafter shall be sufficiently long to permit being driven without a follower, to verify that adequate pile capacity is being attained to develop the desired end-of-driving pile capacity for the pile group. No direct payment will be made for cut-off of these extended piles. The follower and pile shall be held and maintained in equal and proper alignment during driving.

The follower shall be of such material and dimensions to permit the piles to be driven to the planned depth. The follower shall be provided with a socket or hood carefully fitted to the pile head to minimize energy losses and prevent pile damage.

Underwater Hammers

- 4-15 Underwater hammers are adapted to be used under water. The use of a follower is not required when using an underwater hammer. Most underwater hammers are a combination of hydraulic and air powered. Hammers driven by hydraulics alone are not considered environmentally acceptable. The first pile driven and every tenth pile thereafter shall be of sufficient length to verify load capacity is

being achieved. The Pile Installation Plan will include all details pertaining to the use of underwater hammers.

Installation Sequence

4-16 The contractor's pile driving sequence described in the Pile Installation Plan for driving individual piles in a footing shall be used. The pile driving sequence for individual piles in a footing shall be in accordance with one of the following options in order of preference:

- From the center of the pile group outward.
- By rows from the center of the pile group to the side.
- By rows from one side of the pile group to the other side.

Pile Driving Stresses / Limits

4-17 The piles shall be driven in a manner as not to exceed the maximum driving stresses. This is accomplished by following the driving criteria developed by the Geotechnical Engineer. This topic is covered in greater detail in the Advanced Pile Driving Inspection course.

For steel piles, the maximum compressive driving stresses shall not exceed 90 percent of the yield point of the pile material. For timber piles, the compressive driving stress shall not exceed 3600 psi. For precast prestressed concrete piles, the tensile and compressive driving stress in units of psi from the table below shall not be exceeded.

Maximum Allowable Driving Stresses	
Tensile Driving Stress (Normal Environments):	
U.S. Units	Metric Units
$3 \sqrt{f_c} + f_{pe}$	$0.25 \sqrt{f_c} + f_{pe}$
Tensile Driving Stress (Corrosive Environments):	
U.S. Units	Metric Units
f_{pe}	f_{pe}
Compressive Driving Stress (All Environments):	
U.S. Units	Metric Units
$0.85 f_c - f_{pe}$	$0.85 f_c - f_{pe}$
f_c = Concrete Compressive Strength, psi (MPa)	
f_{pe} = Effective Prestress, psi (MPa)	

The plans shall indicate if the allowable tensile driving stress of precast-prestressed concrete piles shall be computed for corrosive environments. Pile driving criteria will be provided by the Geotechnical Engineer to maintain pile driving stresses within the maximum allowable driving stresses.

Penetration Requirements

4-18 Driving shall be continued until the engineer determines satisfactory penetration and pile bearing capacity have been obtained. Acceptance from the engineer shall be required to terminate pile driving above the plan tip elevation. Piles shall be driven to the plan tip elevation in accordance with the Standard Specifications. If the pile penetration requirements and refusal are achieved within 5 feet of the plan pile tip elevation, the engineer may consider the penetration and resistance requirements to be satisfied. If refusal (240 blows/foot or 40 blows/ft. for timber) is achieved more than 10 feet above the plan tip elevation, the DOTD Headquarters Construction Division should be notified. The following requirements shall be used to evaluate satisfactory pile penetration and resistance. In all cases, scour requirements and minimum pile embedment must be met.

- **Energy Delivered to Pile Requirements** - If refusal is encountered above the required plan pile tip elevation, the contractor may be required to obtain a larger hammer capable of achieving the required penetration, or

to use pile installation techniques to facilitate pile driving such as preboring or jetting. Field data from the initial piles will dictate if changes need to be made to the Pile Installation Plan. Refusal conditions shall require that the accepted hammer is operating at the maximum stroke or fuel setting required to achieve the hammer manufacturer's maximum rated energy. The hammer shall be in proper working order. If the hammer performance needs to be evaluated, the engineer may require dynamic monitoring of the pile driving operations. If the hammer performance indicates that the pile driving system's effective efficiency is not satisfactory, the contractor shall be required to adjust the pile driving system until satisfactory performance is observed. The cost of dynamic monitoring and/or delays due to unsatisfactory hammer performance shall be at the contractor's expense.

- **Pile Resistance Requirements** – If pile resistance is less than the required end-of-driving pile capacity as the pile approaches cut-off elevation, the engineer has the option to:
 - Stop driving for a period of time and perform a pile restrike to check for increase in pile resistance due to soil set-up. As you approach final elevation, the contractor should suspend operations 4 to 6 inches above the plan tip elevation to allow room for a restrike. Overdriving to achieve resistance should be upon direction of the DOTD Headquarters' Construction Division.
 - Continue to drive the pile until satisfactory resistance is obtained and build-up, if required. The additional length of pile due to the additional driving shall be furnished in accordance with the construction methods for pile extensions.
 - Load the permanent pile to determine the pile's ultimate capacity.

Excess pore water pressure, usually seen in silts and heavy clays, may give a false bearing capacity until the water has time to move out. If this condition was observed during field testing of test piles, indicator piles, or monitor piles, the pile resistance shall be determined from pile restrikes as directed by the Engineer.

Pile Restrike

- 4-19 Pile restrikes are to be conducted as required for test piles, indicator piles, and production piles, as directed by the Engineer. Pile restrikes shall be conducted at no direct pay. Any production piles to be restruck shall be driven initially to 4 to 6 inches above the required pile tip elevation, or as directed by the Engineer. All pile restrikes shall be performed with a warm hammer that has applied a minimum of 20 blows to another pile or dummy block immediately before being used to restrike the selected pile.

For precast concrete piles, the original pile cushion used during initial driving shall be used. If the original pile cushion used to drive precast concrete piles is no longer in an acceptable condition, another similarly compressed cushion shall be used. A minimum of 2 inches of data or 50 hammer blows are required for restrike evaluation. If the required end-of-driving pile resistance is obtained during the restrike of permanent piles, the pile shall be driven to grade. Restrike blow counts shall be measured as the number of hammer blows per increment of one inch.

Heaved Piles

- 4-20 Whenever piles are driven, soil is displaced. The movements induced on the soil itself may have several undesirable consequences, including the lifting (heave) or lateral displacement of surrounding piles that have already been driven.

Elevations to check on pile heave after driving shall be made at the start of pile driving operations and shall continue until the engineer determines that such

checking is no longer required. Elevations shall be taken immediately after the pile has been driven and again after piles within a radius of 15 feet have been driven. If pile heave is observed, level readings referenced to a fixed datum shall be taken on all piles immediately after installation and periodically thereafter as adjacent piles are driven to determine the pile heave range. All end bearing piles that have been heaved more than 1/4 inch shall be redriven to the required resistance or penetration at no direct pay. Concrete shall not be placed in pile casings until all piles in a footing have been driven, or as directed by the engineer.

Splicing/Extending Piles

4-21 The Specifications use a variety of terms, interchangeably, to describe the conditions of adding on to the top of piles. To keep this simple, remember:

- **Pile Extension-** a build-up of the pile to meet the cutoff elevation requirements. Piles that do not achieve the required driving criteria or are driven below the cut-off elevation need to be extended. All extensions are **not to be driven**. Steel pile extensions are to be welded. Precast concrete piles can be built up a maximum of 5 feet in conformance with CS-216 of the Standard Plans.
- **Splice-** A structural connection between the original pile and another. Spliced piles must be drivable. Splices are pre-planned and are detailed in the Pile Installation Plan. Steel piles are can have up to two field splices per pile. Precast piles require a proprietary splice that meets design requirements.



Steel H-Pile Splice

There are several situations that would necessitate the splicing/extending of piles to achieve additional length, such as:

Splice (Drivable)

- The contractor orders piles at lengths that would require splicing prior to driving. Some projects require pile lengths longer than can be safely transported to the project. All splices are pre-planned and details are located in the Pile Installation Plan. The type and location of the splice is approved by the Bridge Design Section.
- An overhead obstruction requires piles to be spliced to achieve the penetration requirements
- Full length piles are too heavy for transport and must be transported in segments, such as concrete cylinder piles.

Extension (Non-drivable)

- The pile was damaged during installation requiring the end of the pile to be cutoff and an extension installed.
- The expected resistance was not achieved until after the pile is driven below cutoff elevation.

- 4-22 Steel piles or cast-in-place concrete pile shells can be spliced by welding the individual piles together. The Engineer has to accept the pile sections that will be used as splices. Pre-planned splices for concrete piles are integrated into the casting of the pile at the manufacturer's facility. Timber piles cannot be spliced.



Splice Integrated with Steel Reinforcement during Fabrication

Inspector's Role

- 4-23 On occasion certain circumstances require unplanned splices to be necessary. The role of the Inspector is to help ensure that the splices are done adequately. The Inspector must understand the different components that may be utilized to splice or extend a pile based on the pile type.

Concrete Piles

- 4-24 Once the type of splice is determined, the following items should be checked to ensure that the splice is properly performed:

Splices

1. Check to ensure that the pile sections have the LADOTD stamp from the inspector at the casting yard and not damaged during shipment.
2. Verify that the orientation of the splice is in the proper alignment.
3. Check that pins, clips, or other locking devices are attached as per the manufacturer's design.

Spliced prestressed concrete piles are highly susceptible to damage from high tension stresses due to the lack of prestressing in the splice. The Inspector should pay particular attention to the splicing operation and the driving of the spliced pile. Alignment is the most common cause of failure in spliced piles. If any cracking appears, the driving operation should be stopped and the Project Engineer notified.

Extensions

1. Verify the contractor ties the pile to the cap in accordance with CS-216 of the Standard Plans.
2. Verify that the proper epoxy and epoxy ratios are used.
3. Verify that the pile was cutoff clean and level, if applicable.

Steel Piles

- 4-25 For steel piles, a length of pile is welded on as shown in the plans. This is a relatively simple process. As a pile driving inspector, you are responsible for ensuring the following:

Splices

1. Check to ensure that the piece being used for the splice is of the same grade and size steel as the original pile.

2. Steel splices are preplanned and are standardized in the Pile Installation Plan.
 3. The contractor places a beveled edge on the ends of the piles which will be spliced together. The inspector should ensure that the ends are smooth and clean so that a proper weld can be placed.
 4. Steel plates are then placed on either side of the web for a H-pile or sleeves for a pipe pile using tack welds. These are used to hold the piles in proper alignment during welding and provide a backing plate to weld against. The Inspector should check that these are placed as detailed in the plans.
 5. The two sections are then fully butt-welded together. The Inspector should ensure that the two pieces are plumb and the weld is properly placed.
 6. A certified welder is required for the welding procedure being performed.
- Details of the welding plan should be included in the Pile Installation Plan.

Chapter Review

4-26 Answer the following.

1. _____ is a submittal describing in detail the contractor's means and methods of installing piles.
2. Review and acceptance of the contractor's pile driving equipment will be based on the _____.
3. The _____ maybe the second step in the process if included in the plans.
4. Two of the most important criteria to observe during pile driving operations are the _____ of the pile and the _____ required to drive the pile into the ground.

5. Ensure that the final elevation is \pm ____ inches of the elevation shown in the plans.
6. There are two main classifications of predrilled holes, _____ holes and _____ holes.
7. _____ holes, which require load transfer, are drilled with a diameter smaller than the pile being driven.
8. The Specifications require _____ holes to be at most ____ percent of the smallest dimension of the pile.
9. _____ is simply the process of using water under high pressure to erode the soil, thereby allowing for the advancement of the pile.
10. For steel piles, the maximum compressive driving stresses shall not exceed ____ percent of the yield point of the pile material.
11. For timber piles, the compressive driving stress shall not exceed _____ psi.
12. Practical refusal is defined as _____.
13. A _____ is a structural connection between the original pile and another and must be drivable.
14. An _____ is a build-up of the pile to meet the cutoff elevation requirements and is not considered drivable.
15. _____ piles or _____ pile shells can be spliced by welding the individual piles together.

CHAPTER 5

INSPECTION AND CALCULATION

5-1 Well, we have reached the final step of the process, pile driving. This is where you, the Inspector, have significant involvement; although your initial involvement begins in the Test Pile phase. The Inspector's role during the test pile program only differs in that the driving criteria and the pile order lengths have not been issued. In addition, the PDA operator, on-site, with their instrumentation, directs the driving of the test piles as to when to start, stop, etc.

The purpose for a Pile Driving Inspector is to serve as a representative of the state of Louisiana to assure that the procedures are followed resulting in a pile of adequate capacity, proper embedment, and not damaged. However, it is important that the Inspector remembers - **the jobsite belongs to the contractor**. The contractor is ultimately responsible. The Inspector is there to monitor and document the contractor's compliance with the project plans and specifications.

It is the Inspector's responsibility to inform the contractor, in a timely manner, when something is out of compliance. It is the contractor's responsibility to fix it. Your responsibilities are:

1. To know the Specifications and the Project Plans, Special Provisions, Pile Driving Criteria, and the Pile Installation Plan.
2. To record and document activity relative to the Plans and Specifications.
3. Raise a red flag soon enough to make a difference if work is performed outside of those specifications.
4. Call the Project Engineer if judgment is needed to interpret a Specification.

Inspector Attitude - **The Inspector should concern himself with making and documenting accurate, unbiased observations of all-important pile driving events.** These observations are very important should driving proceed other than anticipated. If this is the case, the Inspector should not assume faulty operation on the part of the contractor; the cause may be unanticipated site conditions, errors or omissions on the part of the designer or equipment malfunction.

The pile driving data sheet kept by the Inspector is the only form of tangible data to make an engineering judgment and should be a diary of the day's activities. When questions or problems arise accurate and complete written observations made by the Inspector often can supply the answers.

The screenshot shows the 'AASHTO SiteManager' application window. The 'Daily Work Reports' tab is active. The form includes the following fields and sections:

- DWR Info.** Contract ID: 262-31-0016, Inspector: Harris, David, DWR Date: 08/24/11
- Temperature** High: 99, Low: 78
- Weather Conditions** A.M.: clear, P.M.: clear
- Work Suspended:** Suspended Time: 00:00, Resumed Time: 00:00
- Remarks:** 01-Work Hours, 02-General Remarks, 03-Primary Inspector (selected). The text 'yes' is entered in the remarks field.
- Buttons:** Locked: No, Authorized: Yes, Authorized Date: 08/31/11, No Work Items Installed: [checkbox], No Contractors On Site: [checkbox], No Daily Staff On Site: [checked], Spell Check

The status bar at the bottom shows 'Ready', 'Server', 'PROD', 'Inspt', and 'd6216'.

SiteManager – Daily Work Report

In addition to making data observations, the Inspector documents completion of various phases of construction and makes reports on pay items. The Inspector

should always be aware that prompt performance of these duties is required so that follow-up work can be quickly performed.

Inspector Authority

5-2 You have the responsibility to tell the contractor when the pile meets driving criteria - i.e., blow count, minimum penetration, and practical refusal criteria.

You may also ask the contractor to stop driving operations when you suspect the contractor's equipment or operations are outside of the Specification limits or unsafe. The contractor has two choices - stop or continue. If the contractor chooses to continue driving, they accept full responsibility for this action and you must document their decision by recording time, response and consequence, if any.

You, the Inspector, must immediately advise the contractor whenever you observe:

- unsafe conditions
- out of tolerance
- pile is damaged
- worn cushions
- splice misalignment
- hammer malfunction
- unexpected driving conditions

Make sure to **document** all of the information at hand. In order for the Engineer to make an accurate judgment, you want to present detailed information.

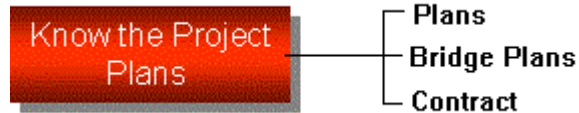
Your Role

- 5-3 The following illustration gives the various phases or steps in which you are involved and play a role. From familiarizing yourself with the project plans to recording information for pay quantities, you have an important role to fulfill.



The following sections have detailed information about each phase.

Know the Project Plans



5-4 The timeline for a project obviously varies by the type and size of the project.

The designers have lived with the project for years and the contractor became very familiar with it during the bidding process.

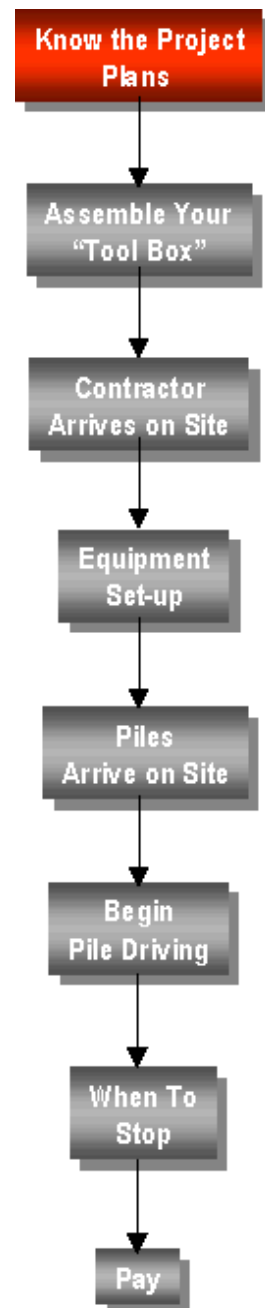
The Inspector is being brought into the project at “the last minute” so it is imperative that you come up to speed on project specifics as quickly as possible.

The various documents you need to become familiar with are Plans, Structure Plans, and Specifications as discussed below.

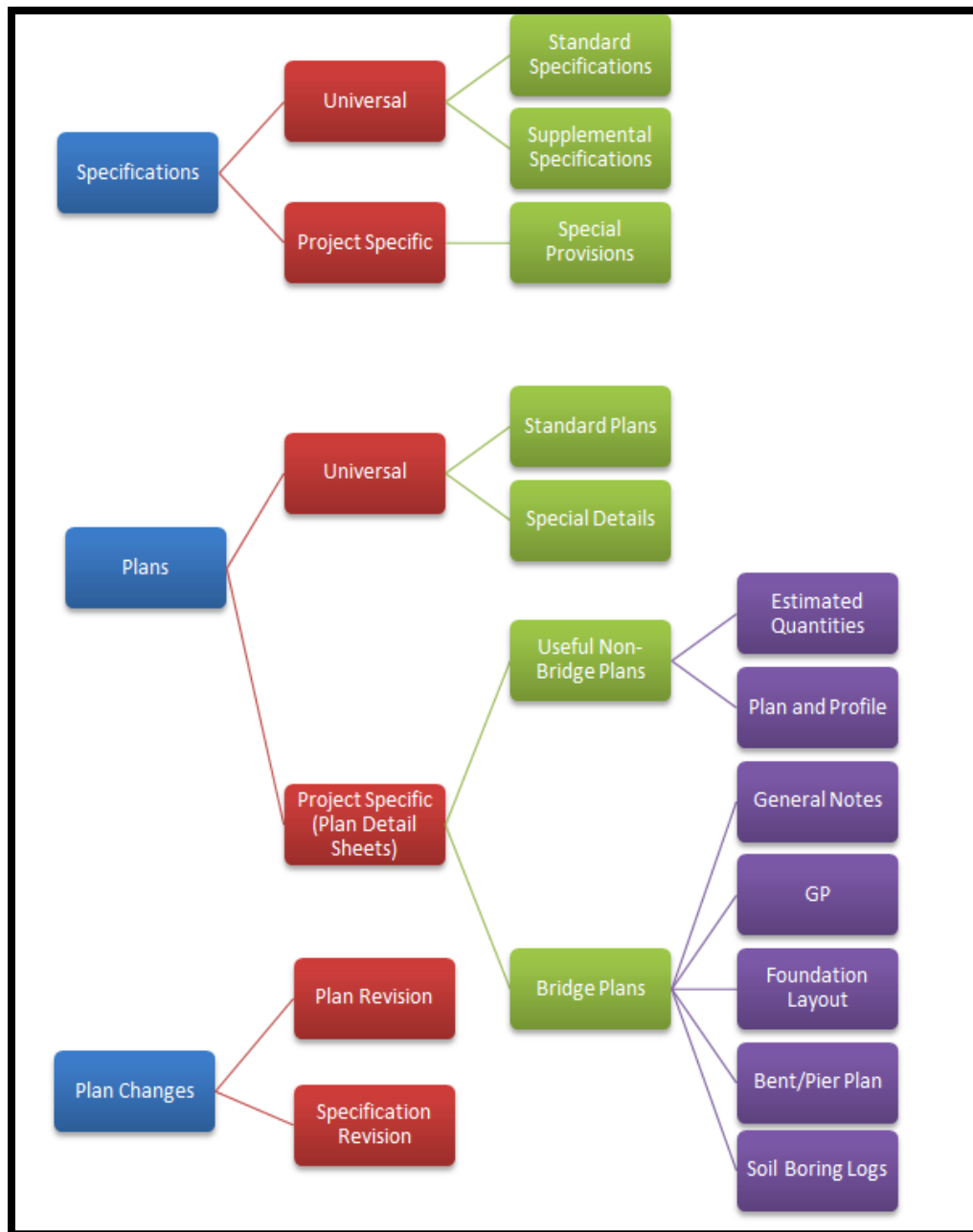
Plans

The project plans and specifications are the instruments by which the contractor will construct the project. The plans and specifications may be divided into two categories:

1. Standard Drawings and Standard Specifications and Supplemental Specifications;
2. Project specific drawings, Specifications, and Non-Standard Items (Special Provisions).



Project specific specifications are usually known as Special Provisions or Non-Standard Items. Special Provisions over-ride the Standard Specifications. Also, the plans may alter some of the Standard Drawings.



Project Details Flowchart

The specific plans and specifications for the project were developed through a design process typically lasting between one to several years. During this time, the designers developed a set of drawings by which the project will be built. Below are outlines of some plans that may typically be reviewed in the process of getting ready for pile driving.

Plan Revisions- Plans are revised often and the revision information is located in the Table of Revisions generally found on the Title Sheet. Always check for revised sheets.

Estimated Quantities- This sheet will contain the quantities estimated for the project and the pay items.

Plan and Profile- These sheets are good for showing the project layout and show some utilities. The Hydraulic Table used to define the scour elevation is normally located here.

These are just some of the plan detail sheets you might review, and depending upon your project, there can be others. **Remember- knowledge is power.**

Bridge Plans

Also part of the Plan Sets for the project are the Bridge Plans. These are sheets that contain the majority of the technical information that you, the Inspector, need.

It's from these sheets you will locate the cutoff elevations, scour elevations, pile data, etc. that you need to perform your role. Review these and become familiar with the information. Specifically for pile driving, the plans will show the locations, capacities, sizes, type of piles, and batter angle. Not all of the plans will pertain to the pile driving operation; however, some of the plans that first do not appear to be specifically needed for the pile driving operation can, nonetheless, be useful.

The purpose for doing this is to get familiar with project specifics, so that when the contractor is ready to drive piles and you start looking for locations and trying to verify pile sizes and lengths, you will already know where to look to find this information. Remember, the contractor will have already studied the project Plans and Specifications for months before you and knows how he intends to perform the job; your lack of knowledge on the project specifics must not hinder the contractor's schedule.

You need to have these with you at all times when on the project. Some Bridge Plan sheets you should review include:

General Notes - You want to review these, as some may be associated with the pile information. There may also be changes to the Specifications.

Standard Plans - These are the Bridge Standard Specification Drawings. Each plan sheet addresses one specific aspect of construction, signed by the Chief Engineer.

Special Details – These are detail sheets that are unique to the project.

General Plan & Profile - These provide the layout and elevation for bridge structures and associated foundations. Generally, the number of bents and piers are shown on here.

Bridge Hydraulic Table - Generally shown on the Plan and Profile Sheet providing the scour elevation which should match the Pile Data Table.

Foundation Layout (on more complex projects) - The specific location of the piles is shown on this sheet along with the Pile Data Table. The batter for battered piles is also shown on this sheet. The contractor's template should conform to the layout. This layout may not apply to all projects. Normally found on plans for more complex bridges.

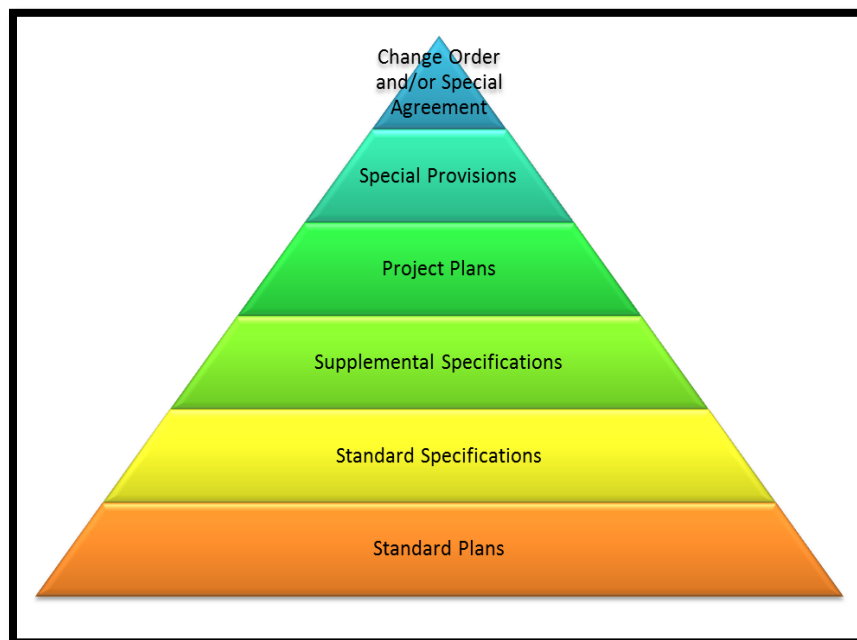
Bent/Pier Plans- The specifics of each bent and pier are shown here and include important elevation data, such as top of pile elevation.

Soil Boring Logs- This provides the subsurface conditions encountered during the geotechnical investigation. This can be useful information as there are some soft or hard layers that will effect driving.

Project Contract

5-5 As a Pile Driving Inspector, you will be dealing with specifications and plans that you need to review and become intimately familiar with.

It is also important for you to understand the governing order of specifications, as certain specifications, such as Special Provisions, over-ride the Standard Specifications. The Title Sheet of the plan set lists which year of Standard Specifications governs the project.



Governing Order of the Contract

Notice that the higher up the order, the smaller the illustrative piece. This reflects reality. Special provisions are very focused while the Standard Specifications and Standard Plans are very broad in nature.

Standard Plans - These are drawings or plans that are generic in nature, and designed for repetitive use. They show details about particular portions of construction. Standard Plans are the same for all projects until the standard is updated and signed by the Chief Engineer.

Standard Specifications – These are the directions, provisions, and requirements contained herein, together with all stipulations contained in the plans or in the contract documents, setting out or relating to the method and manner of performing the work, or to the quantities and qualities of materials and labor to be furnished under the contract.

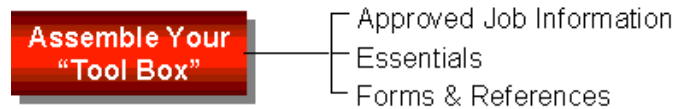
Supplemental Specifications - Approved additions and revisions to the Standard Specifications.

Project Plans (including revisions) – These show the location, character, dimensions and details of the work to be done.

Special Provisions - These are additions or revisions to the Standard and Supplemental Specifications or Plans covering conditions particular to the project. Special Provisions supersede all other specifications.

Change Order and/or Special Agreement - Specific clauses adding to or revising the Contract, setting forth conditions varying from or additional to the Standard Specifications, for a specific project. Change Orders are generally necessary when there are unforeseen circumstances that must be addressed before construction can continue.

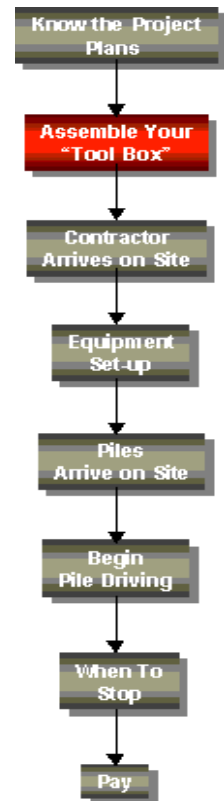
Assemble Your Tool Box



- 5-6 Just as a carpenter does not go to the job without his tools, the same goes for the Pile Driving Inspector. There are certain “tools” that you need to do your job properly. Without some of these, you really can't do your job.

Forms

Daily Work Report (DWR) in SiteManager: The Daily Report of Construction is the standard daily reporting tool used on all projects. SiteManager contains the official DWR. The Inspector will enter all daily activities into SiteManager at the completion of each work day. The Inspector must login with their ID and password. The ID used to login to the SiteManager system is considered an electronic signature. It is important that you do not give someone else your login information.



Pile Driving Record

The Pile Driving Record is unique to pile driving and is recorded in SiteManager. All information about the pile driving activities is included on this report. SiteManager will tabulate the DWR under the contract item for the entire project and allow you to run reports combining data over time.

ITEM NO. 804-01-H PRECAST CONCRETE PILES (36")										S.P.N. 013-05-0044;AMITE RIVER BRIDGE	
BENT	PILE I.D.	STA.	BLOWS LAST 5'	ORDER PILE LENGTH	PAID PILE LENGTH	PLAN CUTOFF ELEV.	ACTUAL CUTOFF ELEV.	FUEL SETTING	REMARKS	DATE AND INSPECTOR	
28W	28W-J	162+56.55	37.41.44. 44.46	75.0	75.0	41.75		LAST 4' SETTING #3		4/4/2008 SP	
28W	28W-K	162+56.56	45.47.40.40.44	75.0	75.0	42.04		#4		4/4/2008 SP	
28W	28W-L	162+56.55	38.39.41.43.44	75.0	75.0	41.46		#3		4/7/2008 SP	
28W	28W-L	162+56.56	65.59.59.58.52	75.0	75.0	42.33		#4		4/7/2008 SP	
27W	27W-J	161+53.37	82.60.50.41.40	75.0	75.0	41.88		#4		4/8/2008 SP	
27W	27W-K	161+53.37	99.85.65.60.50	75.0	75.0	42.17		#4		4/8/2008 SP	
27W	27W-L	161+53.37	89.69.63. 55.45	75.0	75.0	41.59		#4		4/9/2008 SP	
27W	27W-L	161+53.37	81.65.70. 62.45	75.0	75.0	42.46		#4		4/9/2008 SP	
29W	29W-K	163+55.73	116.131.94.69.60	70.0	70.0	42.17		#3		4/14/2008 SP	
29W	29W-J	163+55.73	66.52.47. 40.34	70.0	70.0	41.88		#4		4/15/2008 SP	
29W	29W-L	163+55.73	130.105.86.76.71	70.0	70.0	42.46		#4		4/16/2008 SP	
29W	29W-L	163+55.73	84.80.62. 51.44	70.0	70.0	41.59		#4		4/17/2008 SP	
26W	26W-K	160+58.19	64.66.54. 49.40	75.0	75.0	42.17		#4		4/23/2008 sp	
26W	26W-J	160+58.19	92.77.57. 53.45	75.0	75.0	41.88		#4		4/23/2008 sp	
26W	26W-L	160+58.19	90.86.84. 65.69	75.0	75.0	42.46		#4		4/23/2008 sp	
26W	26W-L	160+58.19	70.69.63. 55.53	75.0	75.0	41.59		#4		4/23/2008 sp	
26E	26E-K	160+73.77	63.66.62. 55.48	75.0	72.0	42.28		#4		4/25/2008 sp	
26E	26E-K	160+73.77	restrike 72.66.60		3.0	42.28		#4		4/25/2008 sp	
26E	26E-J	160+73.77	137.119.89.76.58	75.0	75.0	41.69		#4		4/25/2008 sp	
26E	26E-J	160+73.77	126.117.86.79.64	75.0	75.0	41.99		#4		4/25/2008 sp	
26E	26E-L	160+73.77	71.79.81. 85.79	75.0	75.0	42.28		#4		4/25/2008 sp	
25W	25W-J	159+59.01	105.103.98.87.94	70.0	70.0	41.75		#4		4/29/2008SP	
25W	25W-K	159+59.01	73.68.70. 63.54	70.0	70.0	42.04		#4		4/29/2008SP	
25W	25W-I	159+59.01	85.83.79. 75.70	70.0	70.0	41.46		#4		4/30/2008SP	
25W	25W-L	159+59.01	78.80.72. 69.66	70.0	70.0	42.33		#4		4/30/2008SP	
					1760.0				ESTI #6		

Example of Monthly Pile Driving Report

Information

Project Plans & Specifications- These are the project plans discussed previously and any revisions to the Standard Specifications. (See Know the Project Plans- Specifications)

Special Provisions- This would be any Special Provisions that are part of the project. (See Know the Project Plans- Specifications)

Pile Installation Plan- This is the accepted pile installation process submitted by the contractor to the Department. Splices are identified in this plan. All miscellaneous pile driving details are located in this plan. The contractor cannot vary from this plan unless the plan has been modified and accepted by the Department (See Pile Installation Plan Section). This topic is discussed in further detail in the *Advanced Pile Driving Inspection* course.

Driving Criteria – The parameters set to properly install piles to the correct depth to achieve the required bearing capacity.

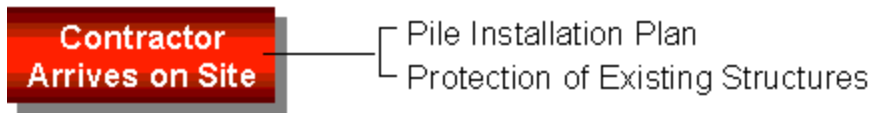
Casting Lengths - this issued by the Project Engineer identifying the length(s) of piles authorized for the project. (See Test Pile Program Section)

Tools

Daily Essentials

- Hard Hat
- Boots
- Eye and Ear Protection
- Scale
- Pen / Pencil / Lumber Crayon / Spray Paint
- Tape Measure (Preferably 20 ft.)
- Pile Driving Data Form
- Life Jacket or reflective jacket
- Watch
- Calculator
- Camera
- Carpenter's Level (4 ft.)
- Spare Batteries

The Contractor Arrives on Site



- 5-7 The contractor has arrived on site. There are a few preliminary items you need to check initially, those being:

Do they have a DOTD accepted Pile Installation Plan?

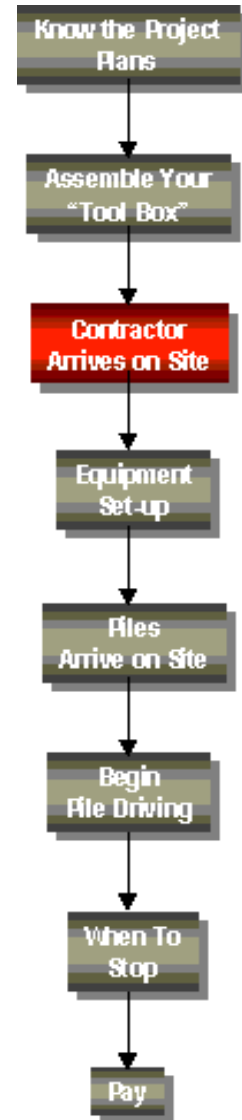
You should already have this and the contractor should also.

Has the contractor met the requirements for Protection of Existing Structures?

On some projects, existing structures are located within close proximity to the pile driving operation. When this condition exists, has the contractor followed the Plans and Specifications? If not covered in the Plans, has the Project Engineer been notified?

Is a cofferdam or sheet piles required?

If a cofferdam or sheet piles are required, the contractor must meet provisions related to its construction.



Equipment Set-Up

- 5-8 The start of pile driving operations is getting close and the equipment has arrived on site. Just as when the contractor arrived on site, the Inspector has a full plate of items he needs to verify and inspect for conformance.

Does the equipment match the accepted Pile Installation Plan?

The Pile Installation Plan was accepted based on the contractor's submitted system. No changes are allowed without the Project Engineer's approval. The Inspector should inspect:

- The pile cushion for proper size and material
- Auger size (if used)
- Jetting equipment (if used)

Does the hammer match the Department Accepted Pile Installation Plan? Has the contractor supplied the required items?

Depending upon the type of hammer, the contractor is to provide certain things, like a Saximeter for open-end diesel hammer driving. The Inspector should verify:

- Hammer model matches
- Hammer cushion is not worn



Saximeter

Does the template provided and constructed match the accepted Pile Installation Plan?

If the contractor is using swinging leads or semi-fixed leads, a template is required. A two-tiered template is required for battered piles.

Piles Arrive on Site

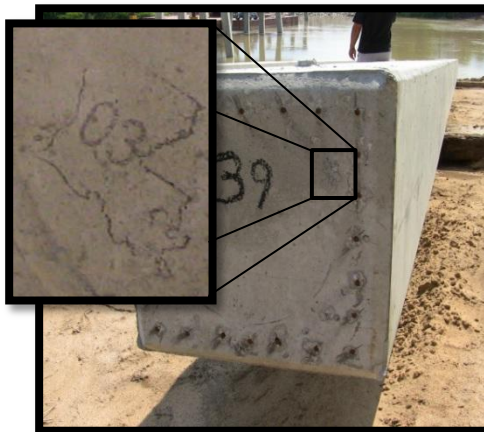


- 5-9 It is the responsibility of the Inspector to examine the delivered piles for evidence of damage prior to installation and, if stored on site, verify they are stored properly. You need to ask these questions and review applicable specifications.

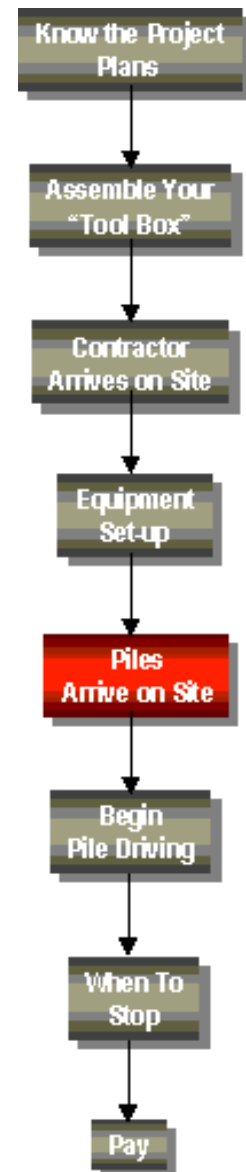
Concrete Piles

Is there a DOTD stamp on the pile?

The stamp indicates the pile was fabricated in conformance with the specifications at the prestress yard. The stamp may be an official DOTD stamp or a stamp accepted and used by a private firm representing the Department. **The stamp does not signify acceptance. Contact the Fabrication Section of DOTD if piles arrive on the project without a stamp.**



Acceptance is considered after the pile is driven in the correct location, to the required depth, reaching the required resistance, and undamaged by driving operations.



Is the length/cross- section/size/prestress configuration correct for your job?

Did you physically measure the pile? The authorized casting length may have been, say 80 feet, but that doesn't mean they are actually 80 feet. They can be off several inches or more. You need to know and document the actual length.

Are the lifting eyes removed and epoxied?

The lifting eyes must be removed to the proper depth and epoxied to prevent future corrosion in accordance with CS 216 of the Standard Plans.

Are there spalling/cracks, micro cracks or other damage visually apparent?

Any damage noted, in particular cracking, should be reported to the Project Engineer for evaluation. The piles should not be used until evaluated. Cracking of piles during transport and storage can be a problem if not lifted or properly supported.



Example of micro cracks

Piles cracked before installation are to be rejected. Piles cracked during the installation period shall be evaluated and repaired before continuing.

For storage on job site, is dunnage placed at correct lifting positions and is placed so that it won't settle?

Dunnage should be located directly under the lifting positions.

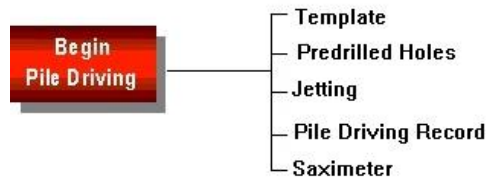


Pile Placed Incorrectly on Dunnage



Piles Placed Properly on Dunnage

Begin Pile Driving

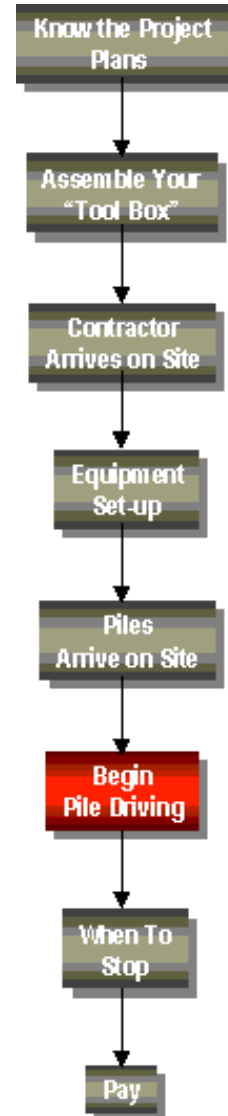


- 5-10 You have verified that the contractor's equipment complies with what was submitted and accepted in the Pile Installation Plan, that they have complied with protection of existing structures requirements and they are now getting ready to place the first pile in position.

The Inspector needs to set-up SiteManager and some information can be entered prior to driving, so let's prepare the **Pile Driving Record**. All record keeping should be prepared as early before driving as possible.

Prior to the contractor commencing pile driving, the Inspector can fill in a vast majority of the Pile Driving Record book for that pile and should make it a habit to do this before driving begins on any pile.

As covered earlier, much of the requested information is already known, either from the plans, the Pile Installation Plan, the Driving Criteria or the Pile Order Lengths. However, following are three helpful items that can be entered prior to driving commencing and will make your job so much easier.



Plan Tip Elevation - This is the elevation specified in the plans or referenced from the Geotechnical Section's findings from the test pile

data. If a minimum tip is specified, this is the elevation the tip of the pile should achieve before driving can be stopped, unless accepted by the Engineer. This is an elevation that you can mark ahead of time. To have to constantly be calculating where the pile tip is in relation to Minimum Tip Elevation can be a hassle. By making a mark ahead of time, the Inspector has one less thing to worry about.

Minimum Tip Elevation – If there is a scour elevation in the plans, pile tip must be 25 feet below that elevation. The Inspector should mark this elevation on the pile.

Stop for Restrike - The “Stop for Restrike” mark is also a mark the Inspector can make ahead of time. The Standard Specifications state we should stop driving, if the pile is within 12 inches of the Tip Elevation and the required bearing capacity has not been achieved, for a 1 day set before restrike. This interruption in driving will allow us to see if the pile gains capacity. By making a mark ahead, the Inspector eliminates one more thing to worry about.

Plan Tip Elevation

5-11 Plan Tip Target is a mark in the Driving Record, prior to driving, which assists the Inspector in easily identifying when the pile tip has reached Plan Tip. So, what is it and how does the Inspector calculate it? Some examples are given next.

For Vertical Pile

MT = Reference
Elev. - Plan Tip
Elev.

EXAMPLE 1:

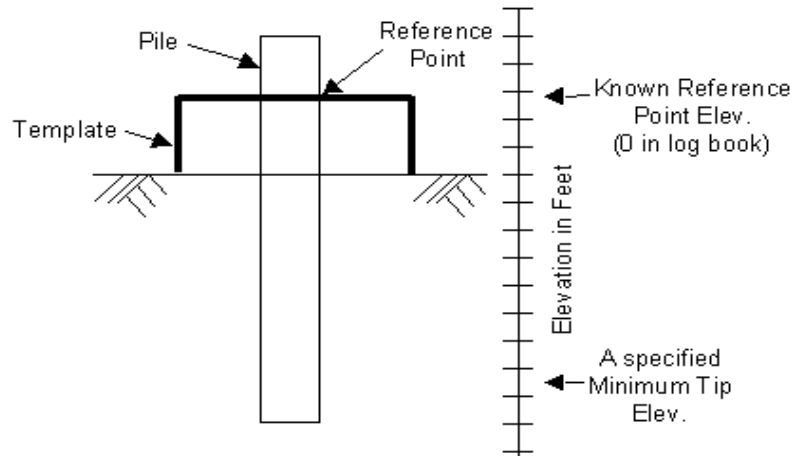
Assume
Reference

Elevation = +10.00 ft.

Assume Specified Plan Tip Elev. = -53.00 ft.

Therefore; $+10.00 - (-53.00)$ (Remember- A plus minus a minus equals a plus
 $+10.00 + 53.00$ (So our equation looks like this now) = **63.00 feet**

Therefore at the 63-foot mark in the record you would make your PT mark and
when the 63 foot mark on the pile reaches the reference point you have reached
Plan Tip Elevation.

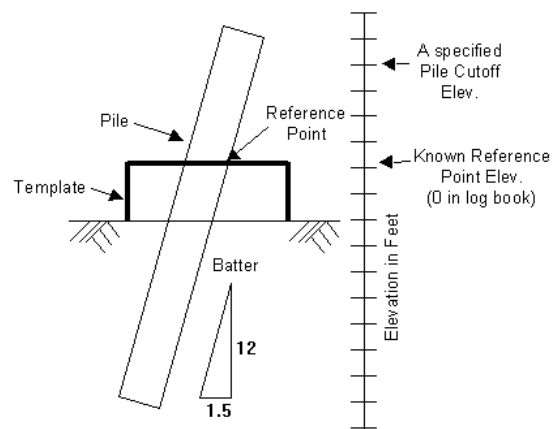


For Battered Pile

MT = (Ref. Elev. - Plan Tip
Elev.)/Correction Factor

Assume Reference Elevation = +80.00
ft.

Assume Specified Min. Tip Elev. =
+20.00 ft.



Assume batter is 1.5:12

First, calculate the correction factor

$$CF = \frac{Rise}{\sqrt{Run^2 + Rise^2}} \rightarrow CF = \frac{12}{\sqrt{1.5^2 + 12^2}} \rightarrow CF = \frac{12}{\sqrt{145}} \rightarrow CF = 0.992$$

Now calculate the corrected Plan Tip Elevation;

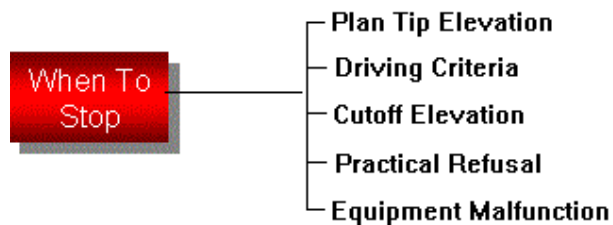
$$(+80.00 - +20.00)/0.992$$

$$60/0.992$$

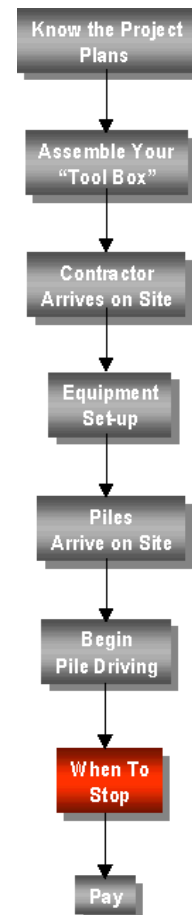
$$= \mathbf{60.48 \text{ feet}}$$

Therefore at the 60.5 -foot mark in the logbook you would make your MT mark.

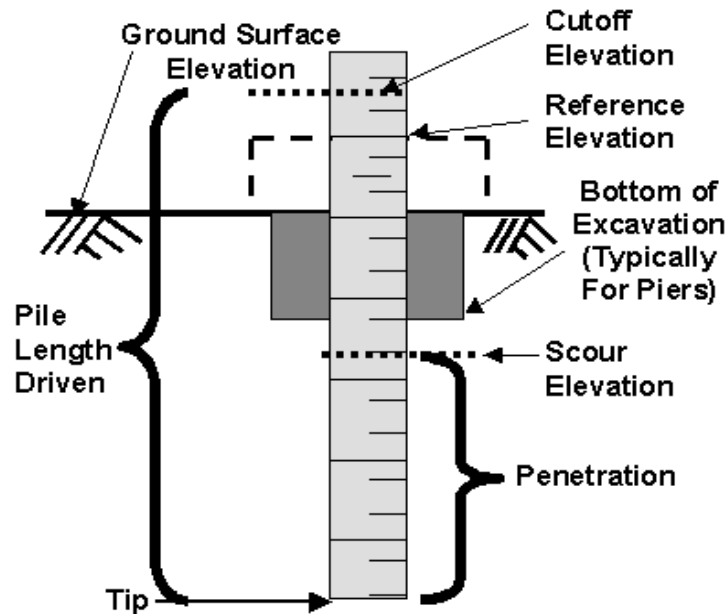
When to Stop



5-12 Knowing when to stop driving is one of the most important responsibilities the Inspector has. Depending upon the situation, this decision has numerous ramifications, such as damage to equipment, damaging the pile, insufficient resistance, not at minimum tip elevation, etc., so it is imperative the Inspector knows and understands the when to stop driving or pile acceptance decision process.



First, let's review some of the terms and definitions the Inspector needs to understand.



Ground Surface Elevation- The elevation of the existing ground surface.

Cutoff Elevation- This is the specified finish elevation for the top of the pile.

Pile Length Driven- The length of pile between the Cutoff Elevation and the Tip Elevation.

Tip (Tip Elevation)- The elevation of the bottom (tip) of the pile.

Penetration- The length of pile below the lowest of three elevations;
Ground Surface; Bottom of Excavation; Scour Elevation.

Scour Elevation- A specified elevation representing the depth of potential scour, which is the action of soil being removed by water movement.

Bottom of Excavation- The elevation of the bottom of an excavation (i.e., footing).

Reference Elevation- This is a fixed point and elevation on the template, string line, or other stationary object, used to observe the increment marks on the pile relative to the reference point (reference elevation).

There are several points, at which the Inspector needs to decide when to stop driving, those being:

- 1. Has the specified Driving Criteria been achieved at the Plan Tip Elevation?
- 2. Has Practical Refusal been reached (maximum blows per foot)?
- 3. Has the resistance not been achieved as you approach Plan Tip Elevation?
- 4. The Inspector may also ask the contractor to stop driving when they suspect the contractor's equipment or operations are outside of the specifications.

The Inspector has the responsibility to tell the contractor when to stop driving due to achieving one of the above conditions. The Inspector must pay close attention to driving operations during the last five feet of driving, especially if the resistance requirements are not close to being met.

Acceptance Determination

5-13 It is desired that all piles are driven to either the required Plan Tip Elevation called for on the plans or based on the Geotechnical Section’s report data gathered from the test piles, and achieve the maximum resistance anticipated. If the pile has achieved practical refusal (40 blows/ft. for timber piles or 240 blows/ft. for other piles) under a properly performing hammer, but has not

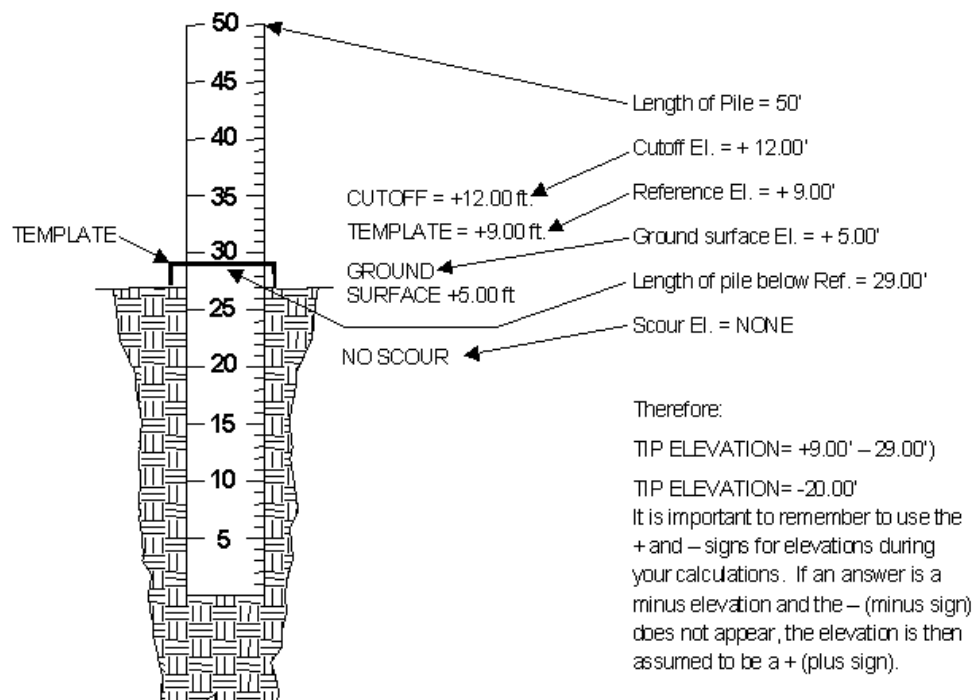
achieved the required tip elevation, an evaluation is required. A determination needs to be made to ensure Minimum Tip and Scour Elevation requirements have been achieved. The following guidelines dictate who will do the evaluation:

1. 0ft. – 5ft. above Plan Tip Elevation the Inspector can make the determination.
2. 5ft. – 10ft. above Plan Tip Elevation the Project Engineer, plus an independent reviewer, must make the determination.
3. > 10ft. above Plan Tip Elevation the Headquarters' Construction Section must make the determination.

Calculation for Determining Tip Elevation

5-14 Tip Elevation = Reference Elev. - Length Below Reference

Using the illustration below, we know the following:



Cutoff = +12.00 ft.

Template = +9.00 ft.

Ground Surface +5.00 ft.

No scour

Length of pile = 50 ft.

Cutoff el. =+12.00 ft.

Reference el. =+9.00 ft.

Ground surface el. =+5.00 ft.

Length of pile below ref. =+29.00 ft.

Scour el. = none

Therefore:

Tip Elevation=+9.00 ft. -29.00 ft.

Tip Elevation=-20.00 ft.

It is important to remember to use the + and - signs for elevations during your calculations. If an answer is a minus elevation and the - (minus sign) does not appear, the elevation is then assumed to be a + (plus sign).

Penetration

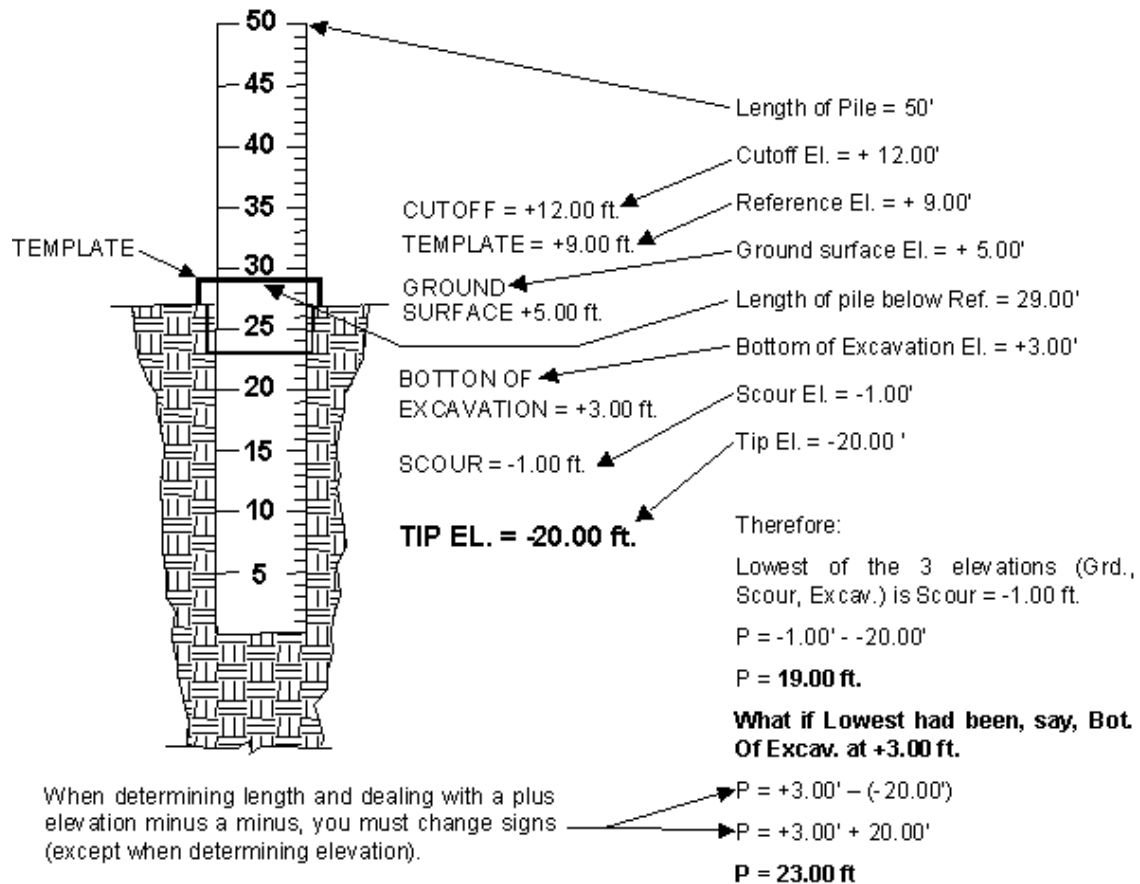
- 5-15 To determine penetration, measure the penetration of piles from the elevation of natural ground, scour elevation shown in the plans, or the bottom of excavation, whichever is lower.

Next we will review how to calculate penetration for plumb and battered piles.

Calculation for Determining Penetration

The following is an example of how to determine penetration for vertical piles.

Penetration (P) = Lowest of 3 elevations. - Tip Elev.



Have You Met the Driving Criteria Specified by the Geotechnical Engineer?

The Driving Criteria (blow count versus energy), set by the Geotechnical Engineer and presented in the Driving Criteria Letter, is what we are hoping to achieve in driving the pile. An example of the Driving Criteria Letter is located in the Appendix.

Remember, in the Test Pile Program section we discussed how the Geotechnical Engineer, based upon the driving of the test pile, developed these blow count criteria.

More specifically, **Blow Count Criteria:** The Geotechnical Engineer will determine the number of blows per foot at a specified energy level required to provide the required bearing according to the methods described herein. Determine the pile resistance by computing the penetration per blow with less than 1/4 inch rebound averaged through 12 inches of penetration.

Have You Reached Practical Refusal?

Practical refusal is the point at which there is a risk of damaging the pile or equipment with continued driving. This is generally caused by the pile encountering dense material and more specifically:

Practical Refusal: Practical refusal is defined as 20 blows per inch for up to three inches with the hammer operating at the highest fuel setting or at a setting defined by the driving criteria and less than 1/4 inch rebound per blow. Stop driving as soon as the Engineer determines that the pile has reached practical refusal. Generally, the Engineer will evaluate the continuation of driving at practical refusal. When the required pile penetration cannot be achieved by driving without exceeding practical refusal and pausing to allow excess pore water pressure to dissipate does not help, other methods may be required.

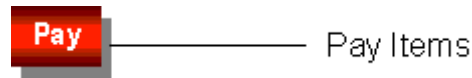
Have you reached Practical refusal? **20 blows per inch (240 blows per foot)**

NOTE: Timber piles reach practical refusal at a much lower rate defined as 40 blows per foot.

Pile Redrive (Restrike):

In the event that the contractor has driven the pile to approximately 12 inches above cut-off without reaching the required resistance, the Engineer may require the contractor to interrupt driving. The Engineer may accept the pile as driven when a restrike shows that the contractor has achieved the minimum required pile resistance and has met all other requirements of this section.

Payment



- 5-16 To the contractor, this is the most important part of the Inspector's paperwork and reporting. They want no mistakes here, and of course, the Inspector represents the State and doesn't want to make any mistakes. It is important the Inspector be knowledgeable of Method of Measurement and Basis of Payment and maintains excellent records and documentation. **The contractor should be paid for those things they are entitled to.**

The Standard Specifications make reference to the payment methods. Unless stated differently in the plans or special provisions, the specification payment information will be followed.

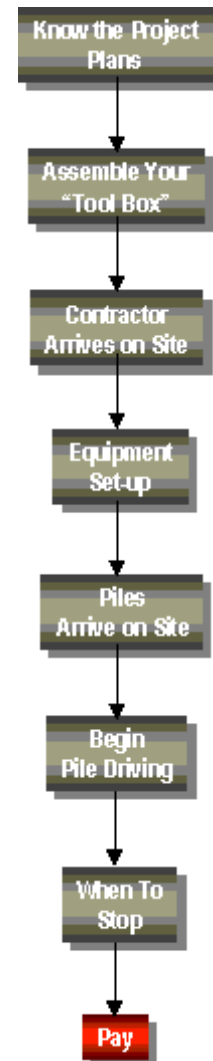
Piling: Payment for piling will be made at the contract unit price per linear foot.

Pile Extensions: Payment for cast-in-place extensions will be made at the adjusted contract unit price per linear foot for the type and size of pile extended.

Cut-Offs: Payment for cut-offs will be made at the contract unit price per linear foot.

Test Piles: Payment for test piles will be made at the contract unit price per each. Redriving of test piles will be paid for under Item 804-11.

Indicator Piles: Payment for indicator piles will be made at the contract unit price per each. Redriving of indicator piles will be paid for under Item 804-11. If it



is determined from the driving records and the dynamic monitoring that the indicator pile should be load tested, each load test will be paid for under Item 804-09.

Loading Test Piles: Payment for loading test piles will be made at the contract unit price per each.

Redriving Test Piles: Payment for redriving test piles or indicator piles will be made at the contract unit price per each.

Reloading Test Piles: The number of reload tests to be paid for will be the number of reload tests ordered and completed.

Loading Permanent Piles: The number of load tests to be paid for will be the number of load tests made as directed.

Dynamic Monitoring: Payment for dynamic monitoring will be made at the unit price per each.

Payment for each individual pay item will be made under:

Item No.	Pay Item	Pay Unit
804-01	Precast Concrete Piles (Size)	Linear Foot (Lin m)
804-02	Treated Timber Piles	Linear Foot (Lin m)
804-03	Steel Piles (Size)	Linear Foot (Lin m)
804-04	Cast-in-Place Concrete Piles (Size)	Linear Foot (Lin m)
804-05	Precast Concrete Test Piles	Each
804-06	Timber Test Piles	Each
804-07	Steel Test Piles	Each
804-08	Cast-in-Place Concrete Test Piles	Each
804-09	Loading Test Piles	Each
804-10	Reloading Test Piles	Each
804-11	Redriving Test Piles	Each
804-12	Loading Permanent Piles	Each
804-13	Precast Concrete Indicator Piles	Each
804-14	Timber Indicator Piles	Each
804-15	Steel Indicator Piles	Each
804-16	Cast-in-Place Concrete Indicator Piles	Each
804-17	Dynamic Monitoring	Each

Chapter Review

5-17 Answer the following.

1. The purpose for a _____ is to serve as a representative of the state of Louisiana to assure that the procedures are followed resulting in a pile of adequate capacity, proper embedment, and not damaged.
2. List five things that the Inspector should be familiar with prior to the beginning of pile driving operations. _____, _____,
_____, _____, _____.
3. **T or F** Plan Change/Change Orders overrule Standard Specifications.
4. **T or F** Supplemental Specifications overrule Standard Plans.
5. **T or F** Standard Plans overrule Standard Specifications.
6. **T or F** The Inspector is not responsible for inspecting the piles upon delivery.
7. **T or F** The inspector must ensure that the pile driving equipment used matches what is listed on the Pile Installation Plan.
8. **T or F** The Inspector is responsible for telling the contractor when to stop driving.
9. List two conditions in which to stop driving. _____,
_____.

Completion

5-18 You have now completed the *Introduction to Pile Driving Inspection* course. The Department hopes that you now have a better grasp of the concepts, materials, and an Inspector's responsibilities involved with pile driving. Now at this point, you will not be able to inspect a DOTD project on your own until you have more field experience, but hopefully you are well on your way. The Department's

publication *Advanced Pile Driving Inspection* goes into greater details about pile driving inspection and the calculations that are involved with pile driving.

Please feel free to send the Technology Transfer and Training Section (Section 33) your comments about this course or any course that you feel needs to be developed or updated. Specifications or techniques are continuously changing, so we need your input to keep the Department's training material valid and as accurate as possible. Please send any comments to:

Cindy Twiner

cindy.twiner@la.gov

or by calling (225) 767-9125

Glossary

AUTHORIZED PILE LENGTHS (Pile Order Length Letter) - Official letter stating Engineer's recommended length of concrete piles to be cast for construction of foundation. Authorized pile lengths are based on, but not limited to, test pile program results, plan lengths, and/or other geotechnical evaluation.

BATTERED PILE - A pile driven on an angle. Usually expressed as a ratio of rise to run (vertical to horizontal). Example 12:1 is a 12-foot rise (vertical) to 1 foot run (horizontal), and is denoted on plans with an arrow to indicate the direction of the batter.

BLOW COUNT - The number of hammer impacts or blows required to move the pile a given unit of measurement - most commonly 1 foot (also could be 1 inch or other increment).

BONNET - See **Helmet**; cast steel housing which fits over the pile top and houses the pile cushion for concrete piles.

BUILD-UPS - Refers to non-driven cast-in-place extensions to concrete piles.

CAP BLOCK - Cast steel insert between the hammer and the helmet that houses the hammer cushion.

CUT-OFF ELEVATION - The finish elevation of the pile top as shown in the Plans

DRIVING CRITERIA LETTER - Official letter stating the Geotechnical Engineer's recommended blow count for piles to provide the required resistance for carrying the design loads shown in the plans. The driving criteria also includes such items as pile and hammer cushion types, thicknesses, hammer stroke or fuel pump settings to be used, jetting or predrilling amounts, restrikes, etc.

ELEVATION - The height above or depth below sea level. Also, may be a "job" elevation where an arbitrary level is set as a reference elevation.

END BEARING - The pile capacity gained from pile tip reacting against the soil. This loading is also known as point bearing capacity (bearing resistance).

ENGINEER - The Chief Engineer, acting directly or through duly authorized representatives, who is responsible for contract administration including engineering supervision of the work. When the term "Chief Engineer" is used, it shall mean the Department's Chief Engineer in person or the Department's duly appointed designee.

FOLLOWERS - An extension, usually steel, used between the top of the pile and the hammer to extend the driving range of the pile (usually below water or below ground).

HELMET - This is the section of the pile driving system that rests between the hammer and the pile. For concrete piles, it contains the striker plate, a hammer cushion, and the pile cushion. For steel piles, it will contain the striker plate and hammer cushion only; no pile cushion is used on steel piles.

INDICATOR PILE - Piles that are driven in advance of the permanent piles for the purpose of determining the length of foundation piles by dynamic load testing. Indicator piles differ from test piles in that static load test is not necessary on an indicator pile.

JETTING - Consists of a pump, supply lines, and one or more jet pipes that use water to displace soil and advance a pile into the ground.

LEADS - Swinging Leads - These leads are attached to the crane at the top by the main cable. They have a gate at the bottom that holds the leads around the pile and will sometimes have spikes on the bottom that are stuck into the ground or template to assist in aligning the hammer. This type of lead is best suited for piles with little or no batter. The advantages of this type of lead include allowing the crane to be used for

other activities; they can be swung into areas with difficult access, and they are relatively easy to set up. A template must be used in conjunction with swinging leads.

Semi-fixed Leads - This type of lead has a pivot or sliding connection to the crane at either the top or bottom of the leads. Normally the connection is at the top of the leads. Semi-fixed leads can accommodate a greater batter than swinging leads; however, they limit what the crane can do and are more difficult to set up. This type of lead also requires the use of a template.

Fixed Leads - This type of lead has connections at both the top or midpoint and the bottom of the leads. The connection at the top is normally a pivot or rotational type connection, at the bottom there is normally a brace which extends from the crane to the leads. This connection normally has a method for adjusting the in or out from the crane and left or right. This allows any type of batter to be used. This system severely limits what the crane can do and in general requires the most set-up time. No template is required for fixed leads.

MINIMUM PENETRATION - Minimum depth below ground surface, scour elevation, or bottom of excavation, to which a pile must be driven.

MONITOR PILES - A permanent production pile that is analyzed with the PDA during driving.

PILE CUSHION - Used to protect pile top and help control pile stresses in concrete piles. Steel and timber piles do not use a pile cushion.

PILE DRIVING ANALYZER (PDA) - Device used to monitor pile stress, integrity, and hammer efficiency during driving operations.

PILE DRIVING LOG - Includes all of the information on the driven pile and serves as an as-built record for future use. It can also help pinpoint the cause of any problems that may occur during driving. Will also be used to document levels of the pile capacity

during production pile driving. The pile driving record may also be used as evidence in contract proceedings.

PILE EXTENSION - A non-drivable addition to the top of a pile. Concrete piles are extended by build-up. Steel piles are extended by welding new sections.

PILE INSTALLATION PLAN - A contractor's submittal to the Engineer for acceptance prior to test pile or production pile driving. Includes a detailed list of the entire contractor's proposed pile driving equipment, details on how the contractor will drive the piles and the sequence of driving.

PILE SPLICE - A splice is a drivable structural connection between two sections of piles. All splices are pre-planned and are defined in the Pile Installation Plan.

PILE TIP ELEVATION - The elevation of the lowest point of a pile at any given time during driving.

PLAN TIP ELEVATION - Optimum elevation to which piles must be driven to assure design requirements are met. Elevation should be shown in the plans.

PLUMB PILE - From the survey term "plumb line," it is a pile driven vertically or true.

PRACTICAL REFUSAL - Practical refusal is defined as 20 blows per inch for up to three inches with the hammer operating at the highest fuel setting or at a setting defined by the driving criteria and less than 1/4 inch rebound per blow.

PREDRILLING - Drilling a hole to place the pile in. There are three reasons for predrilling: (1) a starter hole, (2) holes drilled through embankment fill material to reach natural ground surface, and (3) when rock or strong soil strata will not permit the piles to penetrate to the required depth. Be careful with terminology. Predrilling is not a Pay Item.

PRODUCTION PILE - Term given to all permanent piles. Test piles and indicator piles are usually not production pile. Monitor piles are permanent piles.

RAM - Striking part of the hammer. The weight (pounds) of the Ram is a part of the equation for Hammer Energy.

RESTRIKE - Striking the pile with the hammer after the end of the initial drive, after a specified period of time. A restrike is used to determine the setup of additional frictional resistance on a pile.

SAXIMETER - A battery powered unit used for determining the stroke height of an open-end diesel hammer or blows per minute (operating rate) of any other hammer. The Saximeter is used to average stroke and blows per foot.

SCOUR - Potential for soil to be washed away from channel bottom due to the movement of water.

SPECIFICATIONS - The compilation of provisions and requirements for the performance of prescribed work.

Standard Specifications: A book of specifications for general application and repetitive use.

Supplemental Specifications: Additions and revisions to the Standard Specifications.

Project Specifications: All Standard Specifications, Supplemental Specifications, Special Provisions, and other provisions applicable to a particular project.

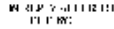
STROKE - This is the term used to describe the height or length of the ram drop. With diesel hammers, stroke is dependent upon fuel and resistance. Air and hydraulic hammers have a set stroke independent of resistance.

TEMPLATE - Used to maintain the pile in the proper location and alignment during driving with swinging or semi-fixed leads. It should be constructed of steel and be rigid

enough to hold the pile in place. Generally the template is placed within 5 feet of the pile cut-off elevation or water or ground surface. A drawing of the proposed template should be submitted with the Pile Installation Plan.

TEST PILE - An exploratory pile used to determine pile lengths and driving criteria for all production piles. Data from the test pile further provides information on the pile, soil, hammer, and method of installation.

Appendix

[illegible]

MEMORANDUM

SUBJECT: Hammer Approval (Wave Equation Analysis)

We analyzed the Pileco D19-42 Open-End-Diesel hammer with the CIRL wave equation analysis program using the soil, pile and hammer properties. According to the contractor's submittal, the Pileco D19-42 would be used for driving all 14 and 16-inch piles. The hammer cushion submitted in the pile and driving equipment data form is 2-inches of Aluminum and Mycorta. The pile cushion submitted is 4 inches of Plywood with an area of 196 square inches. The Pileco D19-42 is capable of driving all 14 and 16-inch piles to the tip elevation with a reasonable blow count. **Caveat** – Due to high compressive stresses throughout driving, we recommend using a **6-inch Plywood pile cushion**. Therefore, we recommend that this hammer be approved for driving the 14 and 16-inch piles with a **6 inch Plywood pile cushion**. The pile driving hammer must be started on fuel setting one to minimize the potential for high tensile stresses.

According to Summary of Estimated Quantities (Sheet 202), Pile Driving Analyzer will be required on the 14-inch test pile. The tensile and compressive pile driving stresses will be verified with the Department's Pile Driving Analyzer.

RECOMMENDED FOR APPROVAL	DATE
RECOMMENDED FOR APPROVAL	DATE
APPROVED	DATE

B-2



Jensen Construction Company

11301 W. 57th Place South / Sand Springs, Oklahoma 74063 / Tel. (918) 245-6691
P.O. BOX 9919 / Tulsa, Oklahoma 74157 / Tel. (918) 245-6691 / Fax: (918) 241-9697

September 24, 2010

Pan American Engineers-Alexandria, Inc.
1717 Jackson Street
PO Box 89
Alexandria, LA 71309-0089

Attention: John Gagnard

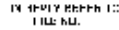
Reference: SP 840-43-0001 – Rapides Parish
Ft. Buhlow Bridge and Approaches
Pile Installation Plan

Dear Mr. Gagnard,

This submittal constitutes our Pile Installation Plan for the 14" and 16" square concrete piles for this project.

1. A Pile & Driving Equipment Data Form for a Pileco D19-42 diesel hammer is attached for your review.
2. The proposed D19-42 is an adjustable energy (42,480 to 21,510 ft-lb) diesel hammer. The hammer will be guided by box leads and a lead spotter system. Information on the leads and spotter are attached.
3. We don't anticipate using any unusual pile driving methods such as preboring or jetting.
4. To determine the hammer energy in the field, the ram stroke height will be observed visually, and it will be monitored with an E-Saximeter. Information on the E-Saximeter is attached.
5. We don't anticipate the use of a follower.
6. Since we are using a lead spotter system to drive the piles, the template required will only be for proper pile location. It will most likely be stringlines or light lumber.
7. We don't anticipate the need for pile splices. Shoring for some footing locations may be necessary. Any required shoring design(s) will be submitted under separate cover.
8. Pile driving sequences for each unique pile layout are attached.
9. The proposed static load system will be submitted under separate cover.
10. We hope to begin driving test piles in early November 2010. Production pile driving is expected to begin in February 2011.

Pile Installation Letter



REFERRED TO:

_____ REFERRED TO ACT 114
 _____ AGREES FOR MY SIGNATURE
 _____ FOR FILE
 _____ FOR YOUR INFORMATION
 _____ FOR SIGNATURE
 _____ RETURN TO ME
 _____ PLEASE RETURN
 _____ PLEASE TELEPHONE ME
 _____ FOR APPROVAL
 _____ PLEASE ADVISE ME

BY _____ DATE _____
BY _____ DATE _____
BY _____ DAY _____

SUBJECT: Pile Driving Criteria for 14 & 16-inch PPC piles (Dents 1-13)

CAPWAP analyses were performed on the initial, next-day restrike, and after-load restrike. The table below provides the corresponding capacities.

Data Set	Type	Size (in.)	Shall Capacity (kips)	Tire Capacity (kips)	Total Capacity (kips)	Blow Count (blows/ft)	Time (Days)
TP 1							
Initial	Dynamic	14"	1.9	133	252	38	11
24 HR RC	Dynamic	14"	115	14	256	40	3
Loading	Static	14"	—	—	273	—	25
ALKE	Dynamic	14"	158	123	281	48	26

DATE _____

DATE

גא

TP 2							
Initial	Dynamic	14"	54	38	92	28	0
24 HR RE	Dynamic	14"	113	56	169	36	1
Loading	Static	14"	---	---	243	---	14
ALRE	Dynamic	14"	172	80	252	58	15

Note: For test pile 1, an inspectors table showing blow count versus stroke height is provided for end-of-initial drive in order to determine if a restrike is necessary. According to the table above, test pile 2 had a considerable increase in capacity for the 2-week loading. Due to the increase of capacity over time, we do not need to achieve the target capacity at the end of initial drive. It is recommended to drive the piles to order list tip elevation, and with time, the necessary resistance will be achieved through setup.

The Objective:

1. Install the piles to the required pile cut-off elevation while staying within the maximum allowable tensile and compressive stresses.
2. Install the piles to the required pile tip elevation with reasonable driving resistance.

Recommendations:

The following pile driving criteria are for driving the 14 & 16-inch production concrete piles for the Fort Buhlow Red River Bridge Bents 1 to 13. *Upon completion of each monitor pile the recommended driving criteria may be altered by the Geotechnical Engineer.*

Pile Driving Criteria: (Bents 1-13)

All pile driving shall begin with the hammer on fuel setting 1. Once blow counts of 35 blows/ft or greater have been observed for 2 consecutive feet, the fuel setting may be advanced to the next highest setting. If the observed blow count drops below 25 blows/ft the fuel setting shall be decreased to the next lowest setting. During the drive, the pile cushion shall be changed if it meets any of the requirements in section 804.06(b)-(3) of the standard specifications.

Termination of pile driving shall be deemed acceptable if the following criteria have been met:

1. The pile has reached the order list pile tip elevation **and** the following minimum blow counts versus stroke criteria have been met. Meaning, this table is for bents 5-6 for the final foot of driving only.

Bents 5-6 (14" Piles) TP1	
Stroke (ft)	Blow Count (bl/ft)
4.5	42
5.0	40
5.5	35
6.0	30
6.5	28
7.0	26
7.5	25
8.0	24
8.5	23

2. For Bent 7, pile driving should achieve at least 15 blows/ft at the end-of-drive based on test pile 2. If fewer blows per foot are attained, please contact the Geotechnical section so that we can determine if a restrike is necessary.
3. The pile has reached practical refusal, defined as a blow count of 240 blows per foot or 20 blows per inch with the hammer operating at a minimum stroke height of 8.0 feet, and the pile tip is within 5 feet of the order list pile tip elevation.

In order to determine the stroke height accurately; we recommend that an approved device, such as a saximeter, be used.

Pile Cushion

- Based on the results from test piles 1 and 2, a minimum of 8-inches of pile cushion shall be used in order to stay below the maximum allowable tensile and compressive stresses.
- We recommend that the pile cushion be replaced after each pile is driven due to the potential of encountering high compression stresses near the end of drive.

If the above criteria have not been met, the pile should be left one foot above the order list tip elevation and the Geotechnical Services section should be contacted to determine if a restrike is necessary to determine capacity.

If any deviations are made from the driving criteria or any equipment is changed during production pile driving, the Geotechnical Services section should be contacted to determine the effects of the changes.

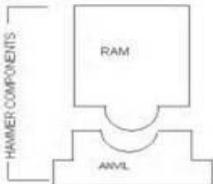


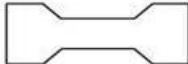


If you have any questions or comments please contact Derek Paille at (225)-379-1371.

DCP/dep

cc: Mr. John Eggers, P.E.
Mr. Chris Nickel, P.E.

PILE & DRIVING EQUIPMENT DATA FORM

Rev. 06/19/2006

S.P. NO. _____		Date _____
Project: _____		Parish _____
Anticipated Date of Driving _____		
Pile driving contractor/subcontractor: _____		
 <p style="font-size: small; transform: rotate(-90deg); position: absolute; left: -40px; top: 50%;">HAMMER COMPONENTS</p>	Manufacturer _____ Model _____ Serial No. _____ Type _____ Rated Energy _____ (kip-ft) at _____ (ft) length of stroke Modifications _____ _____ <p style="font-size: x-small;">Note: Attach any hammer modifications. Manufacturer's hammer specifications may be required if hammer not found in LA DOTD database.</p>	
Striker Plate 	Weight (kips) _____ Diameter (in) _____ Thickness (in) _____	
Hammer Cushion 	Cushion Material _____ Thickness (in) _____ Area (in ²) _____ Weight (kips) _____ Modulus of Elasticity -E (psi) _____ Coefficient of Restitution _____	
Pile Cap 	Helmet _____ Bonnet _____ Anvil Block _____ Drivehead _____ Weight (kips) _____	
Pile Cushion 	Cushion Material _____ Thickness (in) _____ Area (in ²) _____ Modulus of Elasticity -E (PSI) _____ Coefficient of Restitution _____	
PILE 	Pile Type/Size: _____ Pile Area (in ²) _____ Linear Weight (kip/ft) _____ Design Load (tons) _____ Splice Type _____ Pile Length (ft) _____ Splice Location _____ Test Pile Length (ft) _____ Ground Elevation _____ PPC Piles - f'c (psi) _____ PPC Piles - Strand Layout (square/spiral) _____ Note: Attach Pile description for non-uniform cross-section piles.	
LA DOTD Pavement & Geotechnical Design Section Cubical 501 U 1201 Capital Access Rd. Baton Rouge, LA 70804 Tel. No. (225)-379-1016 or (225)-379-1934 Fax No. (225)-379-1705		Note: Submit 30 days prior to pile driving to Project Engineer & LADOTD Geotechnical Design Section Contractor Contact Person: _____ Tel. (_____) _____ Date: _____

Pile and Driving Equipment Form

Termination of pile driving shall be deemed acceptable if either of the following criteria have been met:

1. The pile is within one foot of the order list pile tip elevation **and** the following minimum blow count verses stroke criteria have been met. (As a reminder according to 804.06(b)(3) "Pile bearing capacity shall not be determined using a new pile cushion until after the pile has been driven a minimum of 5 feet or 100 blows")

Stroke (ft)	Blow Count (bl/ft)
6.0	33
6.5	31
7.0	28
7.5	27
8.0	25
8.5	24

2. The pile has reached practical refusal, where practical refusal is defined as blow count of 240 blows per foot with the hammer operating with a minimum average stroke of 8.5 ft, **and** is below the minimum tip elevation of +17.00 ft.

If neither of the criteria above has been met, the pile should be left one foot above the plan tip elevation and the Geotechnical Services section should be contacted to determine if a restrike is necessary to determine capacity.

If any deviations are made from the driving criteria or any equipment is changed during production pile driving the Geotechnical Services section should be contacted to determine the effects of the changes. **The driving criteria above are subject to change after monitoring the first production pile with the Pile Driving Analyzer.**

Driving Criteria – Inspector's Table

Pile Data Table

Answer Key

Chapter 1

1. Any combination of: To carry a vertical load, resist a lateral force, to resist water or earth pressure, to serve as a footing foundation, to serve as a foundation itself **(1-3)**
2. Bedrock **(1-1)**
3. Precast, Prestressed Concrete Piles **(1-3)**
4. True **(1-2)**
5. True **(1-3)**
6. False **(1-3)**

Chapter 2

1. Impact Hammers **(2-2)**
2. Any combination of: Hammers, Leads, Cushions, Pile, Template, Spotter, Crane, or Template **(2-1)**
3. Capblock Cushions or Hammer Cushions **(2-8)**
4. Pile Cushion **(2-10)**
5. Fixed Leads, Semi-Fixed Leads, Swinging Leads **(2-11)**
6. Fixed Leads **(2-14)**
7. Swinging Leads **(2-12)**

Chapter 3

1. Displacement **(3-2)**

2. Any combination of: Timber Pile, Sheet Pile, Steel Pipe Pile, Steel H-Pile, Precast Concrete Pile, Cylinder Pile, or Cast-in-Place Concrete Pile **(3-3)**
3. Pile Bent, Bent Cap **(3-4)**
4. Pier/Column Footing **(3-5)**
5. Prestressed Square Concrete Piles **(3-3)**

Chapter 4

1. Pile Installation Plan **(4-2)**
2. Wave Equation Analysis Computer Program (FHWA-WEAP 87 or Newer) **(4-3)**
3. Test Pile Program **(4-4)**
4. Location, number of blows per foot **(4-9)**
5. 2 **(4-11)**
6. Friction, Non-friction **(4-12)**
7. Friction **(4-12)**
8. Friction, 80 **(4-12)**
9. Jetting **(4-13)**
10. 90 **(4-17)**
11. 3,600 **(4-17)**
12. 240 blows/foot or 40 blows/ft. for timber **(4-18)**
13. Splice **(4-21)**
14. Extension **(4-21)**
15. Steel, Cast-in-Place concrete **(4-22)**

Chapter 5

1. Pile Driving Inspector **(5-1)**

2. Any combination of: Plans, Contract, Special Provisions, Pile Installation Plan, Pile Driving Criteria, Specifications, or Pile Order Length (5-1)
3. True (5-5)
4. True (5-5)
5. False (5-5)
6. False (5-9)
7. True (5-8)
8. True (5-12)
9. Any two of the following: Reached Plan Tip Elevation at the required driving criteria, Reached Practical Refusal, Resistance not achieved as the pile approaches Plan Tip Elevation, or When contractors equipment or operations are out of specifications (5-12)