Lesson 2

THE PILE DRIVING SYSTEM
Learning Outcomes

- Identify Pile Installation Equipment and Tools
- Identify various pile types
- Use Pile Driving Equipment terminology
- Interpret 455 specifications related to the pile driving system
Pile Driving System Components

- Pile Types
  - Hammers & Cushions
  - Cranes & Leads
  - Templates
  - Soil

- Special Installation Tools
  - Jets
  - Drills
  - Punches
  - Followers
Pile Types

- Concrete Piles
- Pipe Piles
- Steel H-Piles
- Composite Piles
- Hollow Core Cylinder Piles
- Steel Sheet Piles
- Timber Piles
Common Florida Pile Types

Square Prestressed Concrete

Steel
- H-Pile Sections
- Pipe Sections

Timber
B. Piling

455-3 Description.
Furnish and install concrete, steel, or wood piling including driving, jetting, preformed pile holes, cutting off, splicing, dynamic load testing, and static load testing of piling.

455-4 Classification.
The Department classifies piling as follows:

(1) Treated timber piling.
(2) Prestressed concrete piling.
(3) Steel piling.
(4) Test piling.
(5) Sheet piling.
   (a) Concrete sheet piling.
   (b) Steel sheet piling.
(6) Polymeric Piles (see Section 471 for requirements).

This course
455-7 Prestressed Concrete Piling

455-7.1 Description: Provide prestressed concrete piles that are manufactured, cured, and driven in accordance with the requirements of the Contract Documents. Provide piles full length without splices when transported by barge or the pile length is less than or equal to 120 feet. When piles are transported by truck and the pile length exceeds 120 feet but is less than the maximum length for a three point pick-up according to Index 20600, and splicing is desired, provide minimal splices. Include the cost of the splices in the cost of the pile.
455-7 Prestressed Concrete Piling

455-7.3.1 Time of Driving Piles: Drive prestressed concrete piles at any time after the concrete has been cured in accordance with Section 450, and the concrete compressive strength is equal to or greater than the specified 28 day compressive strength.

450-16.3 Shipping: Do not ship precast prestressed concrete products to the project site prior to the completion of the 72 hour curing period and attainment of the required 28-day strength.
• Square PSC are displacement piles & the most common

• Typically where limestone or dense stratum is <125’

• Used in corrosive environments

• Used as friction piles, end bearing piles, and combination of both
### Applications of Prestressed Concrete Piles

<table>
<thead>
<tr>
<th>TYPE</th>
<th>SIZE</th>
<th>STRUCTURE TYPE</th>
<th>DESCRIPTION/APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prestressed</td>
<td>Fender, 10&quot;, 14&quot;, 18&quot;, 20&quot;, 24&quot;, 30&quot; square</td>
<td>Bridges, buildings, pipelines, retaining walls, structures</td>
<td>Typically used where geotechnical information suggests limestone stratum or other dense stratum exists no deeper than 175&quot; below ground (pile of thrust). Also used in highly corrosive environments (i.e., saltwater or other). Concrete piles are used as friction piles, end bearing piles and combination of both. Voided piles are made to reduce pile weight for handling. Voided piles should have solid ends to protect the pile from damage during driving. Concrete or other displacement piles driven in a group are sometimes used only to fill soil in the immediate area of the pile group.</td>
</tr>
<tr>
<td>Prestressed w/voided center and solid ends</td>
<td>Typically 11&quot; solid ends</td>
<td>18&quot; dia. voids</td>
<td></td>
</tr>
</tbody>
</table>
Prestressed Concrete Piling

- Voided piles are made to reduce pile weight
- Voided piles have solid ends for protection during driving
- Driven as a group can sometimes densify soils in the immediate area
Cylinder Piles

- Least common of the piles.
- 54” or 60” diameter
- Manufactured for specific project needs.
- Used in corrosive environments.
- Used when project is accessible by large barges and cranes.
- Very heavy, requires larger than typical barges, cranes and driving equipment.
455-8.1 Description: Furnish, splice, drive, and cut off structural steel shapes to form bearing piles. Include in this work the installation of bracing members of structural steel by bolting or welding, construction of splices and the filling of pipe piles with the specified materials.
# Steel Piling

<table>
<thead>
<tr>
<th>TYPE</th>
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<th>STRUCTURE TYPE</th>
<th>DESCRIPTION/APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEEL</td>
<td></td>
<td></td>
<td>H-piles and open end pipe piles are non-displacement types, closed end pipe is another type of displacement pile. Not as common as concrete piles in Florida. Usually used where long piles over 125’ are required (rule-of-thumb) and where geotechnical information shows extremely variable subsurface conditions or very long piles are needed. The benefit to steel piles is the ease of splice. Non displacement piles are also sometimes used in areas where a large number of piles are required in a small area such as under a bascule bridge pier.</td>
</tr>
<tr>
<td>H Pile</td>
<td>Depends upon availability from steel manufacturer. Typical H Pile 14 x 74 (14” depth x 74 lbs./ft. weight)</td>
<td>Bridges, building, pipelines, towers, retaining earth structures, &amp; others</td>
<td></td>
</tr>
<tr>
<td>Pipe open ended</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipe closed ended</td>
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</tbody>
</table>
Steel Piling - Pipe Piles

- Closed Ended are displacement piles; Open Ended not
- Typically used where pile lengths over 125’ are needed
- Higher lateral capacity than H-Piles
- Ease of splicing is big advantage
- Non displacement piles are often used where a large number of piles are needed in a small area, (i.e. under a Bascule bridge pier).
Steel Piling - H Piles

- Are non-displacement piles
- Not as common as concrete
- Typically used where pile lengths over 125' are needed or extremely variable subsurface conditions exist
- Ease of splicing is big advantage
- Non-displacement piles are often used where a large number of piles are needed in a small area, (i.e. under a Bascule bridge pier).
## Composite Piles

<table>
<thead>
<tr>
<th>TYPE</th>
<th>SIZE</th>
<th>STRUCTURE TYPE</th>
<th>DESCRIPTION/APPLICATION</th>
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</thead>
<tbody>
<tr>
<td>COMPOSITE</td>
<td>14&quot;, 18&quot;, 20&quot;, 24&quot;, 30&quot;</td>
<td>Bridges, buildings, pipelines, towers, retaining</td>
<td>Sinker piles are used</td>
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<td></td>
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<td>earth structures, &amp; others</td>
<td>in very hard strata</td>
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<td>to obtain penetration</td>
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<td></td>
<td></td>
<td></td>
<td>of the stinger and</td>
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<td></td>
<td></td>
<td>provide tension and</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>lateral stability.</td>
</tr>
<tr>
<td>Shell or mandrel driven piles</td>
<td>same as above listed pipe sections</td>
<td></td>
<td>Breakage of this pile type can be a problem. The stinger will not help the rest of the pile penetrate deeper. Concrete filled piles increase stiffness of the pile.</td>
</tr>
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</tbody>
</table>

Pipe pile filled with concrete

Composite piles typically include:

- Bridges, buildings, pipelines, towers, retaining earth structures, & others
- Sinker piles are used in very hard strata to obtain penetration of the stinger and provide tension and lateral stability.
Composite Piles

- Used in very hard strata to obtain penetration of the stinger and provide tension and lateral stability
- Breakage can be a problem
- The stinger will not help the rest of the pile penetrate deeper
- Concrete filled pipes increase stiffness of pile
- Shell or mandrel driven piles are backfilled with concrete
455-6.1 Description: Drive timber piles constructed of round timber of the kind and dimensions specified in the plans at the locations and to the elevations shown in the plans, or as directed by the Engineer.
Typically 8” tip and 12” butt diameters

Common lengths 15’ to 50’

Typically made from pressure treated southern pine or Douglas fir woods

FDOT project use includes temporary structures, docking & fender systems, detour bridges & Bailey bridges
- Concrete or Steel

- Utilized for retaining systems, such as cofferdams & bulkheads

- For retaining systems, steel sheet piles are driven in the ground using either impact or vibratory hammers
Square prestressed concrete piles are considered non-displacement piles.

True  False

Timber piles are used for which of the following on which type of projects?

A. Temporary structures
B. Docking & fender systems
C. Light commercial
D. All of the above
Steel H piles are typically used when piles lengths are expected to be over ___ feet.

A. 50  
B. 75  
C. 100  
D. 125  

Concrete piles must be cured ___ days prior to ____ and the concrete has achieved the 28-day compressive strength.

A. 3 driving  
B. 7 driving  
C. 7 shipping  
D. 3 shipping
Pile Driving System Components

- Pile Types
- **Hammers & Cushions**
- Cranes & Leads
- Templates
- Soil
- Special Installation Tools
  - Jets
  - Drills
  - Punches
  - Followers
Pile Driving System Components

- Ram & Anvil
- Striker Plate
- Hammer Cushion (Cap Block)
- Helmet
- Pile cushion
- Pile
Hammers

- Air/Steam
- Diesel
  - Open end
  - Closed end
- Hydraulic
- Vibratory
455-5.2 Pile Hammers

455-5.2 Pile Hammers: All equipment is subject to satisfactory field performance. Use a variable energy hammer to drive concrete piles. Hammers will be rated based on the theoretical energy of the ram at impact.

Supply driving equipment which provides the required resistance at a blow count ranging from 3 blows per inch (36 blows per foot) to 10 blows per inch (120 blows per foot) at the end of initial drive, unless approved otherwise by the Engineer after satisfactory field trial.
455-5.2 Pile Hammers: (Continued)

.... When the Engineer determines the stroke height or bounce chamber pressure readings do not adequately determine the energy of the hammer, provide and maintain a device to measure the velocity of the ram at impact. Determine the actual hammer energy in the field so that it is consistent with the hammer energy used for each bearing capacity determination. When requested, furnish to the Engineer all technical specifications and operating instructions related to hammer equipment.
In this slide we see an air/steam single acting hammer. This hammer has the following advantages:
• Same stroke each impact
• Consistent operation rate
• Low impact velocity
• More efficient than diesel
• Cleaner exhaust than diesel

This hammer has the following disadvantages:
• Additional support equipment required
• Heaviest hammer
• Not as dependable as diesel
• Thick hammer cushion stack required

Single acting air/steam hammers are essentially gravity, or drop hammers, for which the hoist line has been replaced by a pressurized medium, being either steam or air. While originally developed for steam power, most of these hammers today operate on compressed air. To lift the ram weight with motive pressure, a simple one-cylinder steam engine principle is used. During the upstroke cycle, the ram is raised by externally produced air or steam pressure acting against a piston housed in the hammer cylinder. The piston, in turn, is connected to the ram by a rod. During the downstroke cycle, the ram falls by gravity (less friction) to impact the striker plate and hammer cushion. Just before impact, the pressure valve is activated and pressure again enters the cylinder. These hammers must be equipped with at least two strokes, one full stroke and another of lesser height called short stroke.
The stroke is controlled by the use of a device called slide bar shown in this picture. The slide bar has cams that trip the valves at fixed locations. The maximum stroke of single acting air/steam hammers generally ranges from 2 to 5 feet. Single acting air/steam hammers have the advantages of moderate cost and relatively simple operation and maintenance. They are versatile for many pile types, particularly large concrete and steel pipe piles.
455-5.2.1 Air/steam: Variable energy air/steam hammers shall be capable of providing at least two ram stroke lengths. The short ram stroke length shall be approximately half of the full stroke for hammers with strokes up to 4 feet and no more than 2 feet for hammers with maximum strokes lengths over 4 feet. Operate and maintain air/steam hammers within the manufacturer’s specified ranges. Use a plant and equipment for steam and air hammers with sufficient capacity to maintain, under working conditions, the hammer, volume and pressure specified by the manufacturer.
455-5.2.1 Air/steam: (Continued)

.... Equip the plant and equipment with accurate pressure gauges which are easily accessible to the Engineer. The Engineer will not accept final bearing on piles the Contractor drives with air/steam hammers unless the Contractor operates the hammers within 10% of the manufacturer's rated speed in blows per minute, unless otherwise authorized by the Engineer.
### Open-End Diesel Hammer

<table>
<thead>
<tr>
<th>Advantages</th>
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<tbody>
<tr>
<td>• Very Simple; dependable</td>
</tr>
<tr>
<td>• No additional support equipment required</td>
</tr>
<tr>
<td>• Lightest net weight per ft.-lb. of energy</td>
</tr>
<tr>
<td>• Readily available</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Delivered energy variable</td>
</tr>
<tr>
<td>• Less efficient energy transfer</td>
</tr>
<tr>
<td>• Produces higher pile stresses</td>
</tr>
<tr>
<td>• Dirty exhaust spray</td>
</tr>
<tr>
<td>• Difficult to spot operation problems</td>
</tr>
</tbody>
</table>

- **Advantages**
  - Very Simple; dependable
  - No additional support equipment required
  - Lightest net weight per ft.-lb. of energy
  - Readily available

- **Disadvantages**
  - Delivered energy variable
  - Less efficient energy transfer
  - Produces higher pile stresses
  - Dirty exhaust spray
  - Difficult to spot operation problems
**455-5.2.2 Diesel**

| 455-5.2.2 Diesel: Variable energy diesel hammers shall have at least three fuel settings that will produce reduced strokes. Operate and maintain diesel hammers within the manufacturer’s specified ranges. Determine the rated energy of diesel hammers using measured ram stroke length multiplied by the weight of the ram for open end hammers and by methods recommended by the manufacturer for closed end hammers. |
455-5.2.2 Diesel: (Continued)

..... Provide the Engineer with a chart from the hammer manufacturer equating stroke and blows per minute for the open-end diesel hammer to be used. Also provide and maintain in working order for the Engineer’s use an approved device to automatically determine and display ram stroke for open-end diesel hammers.
### Closed-End Diesel (Double Acting)

**Advantages**
- No additional support equipment required
- Drives piles faster
- Lightweight

**Disadvantages**
- Lowest efficiency
- Most difficult to spot operation problems
455-5.2.2 Diesel: (Continued)

….. Equip closed-end (double acting) diesel hammers with a bounce chamber pressure gauge, in good working order, mounted near ground level so the Engineer can easily read. Also, provide the Engineer with a chart, calibrated to actual hammer performance within 30 days prior to initial use, equating bounce chamber pressure to either equivalent energy or stroke for the closed-end diesel hammer to be used.
Bounce Chamber Pressure Gauge

LINK-BELT SPEEDER
MODEL 520 DIESEL PILE HAMMER
BOUNCE CHAMBER PRESSURE vs. EQUIVALENT WH ENERGY
SEA LEVEL TO 2000' ELEVATION

EQUIVALENT WH ENERGY - FT. - LBS
16,000 18,000 20,000 22,000 24,000 26,000
Up to 50 ft. Hose
Up to 80 ft. Hose
Up to 110 ft. Hose
### Hydraulic Hammer

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Controllable variable stroke</td>
<td>- Need hydraulic power pack and hoses</td>
</tr>
<tr>
<td>- High efficiency blow</td>
<td>- Need dedicated person for hydraulic controls</td>
</tr>
<tr>
<td>- Low impact velocity</td>
<td>- Repairability / high tech</td>
</tr>
<tr>
<td>- Light weight</td>
<td>- Expertise in hammer operation needed</td>
</tr>
<tr>
<td>- Clean running, quiet</td>
<td></td>
</tr>
</tbody>
</table>

- Need hydraulic power pack and hoses
- Need dedicated person for hydraulic controls
- Repairability / high tech
- Expertise in hammer operation needed
### 455-5.2.3 Hydraulic

**455-5.2.3 Hydraulic:** Variable energy hydraulic hammers shall have at least three hydraulic control settings that provide for predictable energy or equivalent ram stroke. The shortest stroke shall be a maximum of 2 feet for the driving of concrete piles. The remaining strokes shall include full stroke and approximately halfway between minimum and maximum stroke.

Supply hammer instrumentation with electronic read out, and control unit that allows the operator to read and adjust the hammer energy or equivalent ram stroke. When pressure measuring equipment is required to determine hammer energy, calibrate the pressure measuring equipment before use.
Vibratory Hammer

- Generally used for driving and extracting sheet piles and non-displacement H-piles and pipe piles.
- Not impact hammers.
Vibratory: Vibratory hammers of sufficient capacity (force and amplitude) may be used to drive steel sheet piles and, with approval of the Engineer, to drive steel bearing piles a sufficient distance to get the impact hammer on the pile (to stick the pile). The Engineer will determine the allowable depth of driving using the vibratory hammer based on site conditions. However, in all cases, use a power impact hammer for the last 15 feet or more of the final driving of steel bearing piles for bearing determinations after all piles in the bent/pier have been driven with a vibratory hammer. Do not use vibrating hammers to install concrete piles, or to install support or reaction piles for a load test.
<table>
<thead>
<tr>
<th>Learning Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which of the following hammers is NOT to be used to drive concrete piles?</td>
</tr>
</tbody>
</table>
| A. Vibratory  
| B. Diesel  
| C. Hydraulic  
| D. Air/Steam  |

A bounce chamber pressure gauge is to be provided for which of the following hammers?

A. Air/Steam  
B. Open end diesel  
C. Closed end diesel  
D. Hydraulic
A “scale” or “jumpstick” is to be provided for which hammer?

A. Closed end diesel  
B. Open end diesel  
C. Hydraulic  
D. Not required on any hammer

A diesel hammer is to have a least ___ fuel settings that produce reduced strokes.

A. 2  
B. 3  
C. 4  
D. None required
Hammer and Helmet Assembly

- Hammer
- Ram & Anvil
- Striker Plate
- Hammer Cushion (Cap Block)
- Helmet
Hammer Cushions

• Used on all impact hammers except gravity (drop) hammers.

• Must be made of durable manufactured (man-made) materials.

• Wood, & asbestos not allowed.

• Striker plate must be used.
Cushions Not Allowed

Wood
Asbestos
455-5.3.1 Capblock: Provide a capblock (also called the hammer cushion) as recommended by the hammer manufacturer. Use commercially manufactured capblocks constructed of durable manmade materials with uniform known properties. Do not use wood chips, wood blocks, rope, or other material which permit excessive loss of hammer energy. Do not use capblocks constructed of asbestos materials. Obtain the Engineer’s approval for all proposed capblock materials and proposed thickness for use.
455-5.3.1 Capblock: (Continued)

... Maintain capblocks in good condition, and change them when charred, melted, or otherwise significantly deteriorated. The Engineer will inspect the capblock before driving begins and weekly or at appropriate intervals determined by the Engineer based on field trial. Replace or repair any hammer cushion which loses more than 25% of its original thickness, in accordance with the manufacturer's instructions, before permitting further driving.
Pile Cushion

- Hammer
- Ram & Anvil
- Striker Plate
- Hammer Cushion (Cap Block)
- Helmet
- Pile Cushion
- Pile
Pile Cushion

- Used with concrete piles.
- Made of pine plywood or oak lumber
- Replaced if compressed to more than one-half original thickness.
- Replaced if charred, starts to burn, splintered, or per the Engineers instruction.
455-5.3  **Cushions & Pile Helmet**

**455-5.3.2 Pile Cushion:** Provide a pile cushion that is adequate to protect the pile from being overstressed in compression and tension during driving. Use a pile cushion sized so that it will fully fill the lateral dimensions of the pile helmet minus one inch but does not cover any void or hole extending through the top of the pile. Determine the thickness based upon the hammer-pile-soil system. For driving concrete piles, use a pile cushion made from pine plywood or oak lumber. Alternative materials may be used with the approval of the Engineer. Obtain the Engineer’s approval for all pile cushions....
455-5.3 Cushions & Pile Helmet

455-5.3.2 Pile Cushion: (Continued)

.... Do not use materials previously soaked, saturated or treated with oil. Maintain pile cushions in good condition and change when charred, splintered, excessively compressed, or otherwise deteriorated to the point it will not protect the pile against overstressing in tension and/or compression. Protect cushions from the weather, and keep them dry. Do not soak the cushions in any liquid. Replace the pile cushion if, during the driving of any pile, the cushion is either compressed more than one-half the original thickness or begins to burn....
455-5.3.2 Pile Cushion: (Continued)

... Provide a new cushion for each pile unless approved otherwise by the Engineer after satisfactory field trial.

Reuse pile cushions in good condition to perform all set-checks and redrives. Use the same cushion to perform the set-check or redrive as was used during the initial driving, unless this cushion is unacceptable due to deterioration, in which case use a similar cushion.
455-5.3.3 Pile Helmet: Provide a pile helmet suitable for the type and size of piling being driven. Use a pile helmet deep enough to adequately contain the required thickness of pile cushion and to assist in maintaining pilehammer alignment. Use a pile helmet that fits loosely over the pile head and is at least 1 inch larger than the pile dimensions. Use a pile helmet designed so that it will not restrain the pile from rotating.
Pile Driving System Components

- Pile Types
- Hammers & Cushions
- **Cranes & Leads**
- Templates
- Soil
- Special Installation Tools
  - Jets
  - Drills
  - Punches
  - Followers
Cranes

- JIB GANTRY
- JIB LINES
- BOOM LINE (PENNENTS)
- BOOM SToppers
- TOPPING LIFT
- BOOM GANTRY
- YOKE
- CAB
- MERGE TABLE
- OUTRIGGER PADS
- COUNTER WEIGHT
- MAIN LOAD BLOCK
- HEADACHE BALL
- MAIN LINE
- WHIP LINE
- RADIUS
Semi-fixed Lead

- HAMMER
- BOOM
- LEAD
- CRANE
- FIXED AT TOP
- MUST HAVE TEMPLATE

PILE
Fixed Lead

- Hammer
- Boom
- Brace
- Lead
- Crane
- Pile

Fixed at top

Template not required
Fixed Lead
455-5.4 Leads: Provide pile leads constructed in a manner which offers freedom of movement to the hammer and that have the strength and rigidity to hold the hammer and pile in the correct position and alignment during driving.

When using followers, use leads that are long enough and suitable to maintain position and alignment of the hammer, follower, and pile throughout driving.
Pile Driving System Components

- Pile Types
- Hammers & Cushions
- Cranes & Leads
- Templates
- Soil
- Special Installation Tools
  - Jets
  - Drills
  - Punches
  - Followers
Templates

Required for all pile driving systems except where fixed leads are utilized.
Templates
Pile Cut-off Elev.

Template Elev. is 5 ft. above Pile Cut-off Elev.

As-built C Plan

15”

C Plan

Pile in incorrect position

Pile in correct position
455-5.6 Templates: Provide a fixed template, adequate to maintain the pile in proper position and alignment during driving with swinging leads or with semi-fixed leads. Where practical, place the template so that the pile can be driven to cut-off elevation before removing the template. Ensure that templates do not restrict the vertical movement of the pile....
455-5.6 Templates: (Continued)

…Supply a stable reference close to the pile, which is satisfactory in the opinion of the Engineer, for determination of the pile penetration. At the time of driving piles, furnish the Engineer with elevations of the original ground and template at each pile or pile group location. Note the highest and lowest elevation at each required location and the ground elevation at all piles.
Acceptable Template?
Pile Driving System Components

- Pile Types
- Hammers & Cushions
- Cranes & Leads
- Templates

• **Soil**

- Special Installation Tools
  - Jets
  - Drills
  - Punches
  - Followers
Standard Penetration Test (SPT)

- Automatic Hammer
- Increased safety
- Most Efficient SPT Hammer
- Most Consistent blow
Standard penetration Test- SPT.
This is a pictorial illustration of the SPT Test. The Standard Penetration Test is a field test performed during the advancement of a soil boring to obtain an approximate measure of the dynamic soil resistance, as well as a disturbed drive sample (split barrel type). The test is the most common In situ test worldwide, and you will see this information presented in your Report of Core Boring plans. In lesson 3 we will show you a typical Report of Core Boring plan.

The SPT is conducted at the bottom of a borehole that has been prepared using either flight augers or rotary wash drilling methods. At regular depth intervals, the drilling process is interrupted to perform the SPT. Generally, tests are taken every 2.5 feet at depths shallower than 10 feet and at intervals of 5.0 feet thereafter. However, for FDOT bridge projects is required to test every 2.5 to 3.0 ft maximum interval.

The SPT involves the driving of a hollow thick-walled tube into the ground and measuring the number of blows to advance the split-barrel sampler a vertical distance of 1 foot. A drop weight system is used for the pounding where a 140-lb hammer repeatedly falls from 30 inches to achieve three successive increments of 6-inches each. The first increment is recorded as a “seating”, while the number of blows to advance the second and third increments are summed to give the N-value ("blow count") or SPT-resistance (reported in blows per foot). If the sampler cannot be driven 18 inches, the number of blows per each 6 inch increment and per each partial increment is recorded on the boring log together with the penetration, reported to the nearest inch. For partial increments, the depth of penetration is recorded in addition to the number of blows. Occasionally, a longer split-spoon is used and a fourth 6 inch increment is driven. This is to merely obtain additional soil sample and is not considered in the “N” value.
Pile Driving System Components

- Pile Types
- Hammers & Cushions
- Cranes & Leads
- Templates
- Soil
- Special Installation Tools
  - Jets
  - Drills
  - Punches
  - Followers
Jetting
455-5.7 Water Jets

455-5.7 Water Jets: Use jet pumps, supply lines, and jet pipes that provide adequate pressure and volume of water to freely erode the soil. **Do not perform jetting without prior approval by the Engineer or unless allowed by the plans.**

Do not perform jetting in the embankment or for end bents. Where conditions warrant, with approval by the Engineer, perform jetting on the holes first, place the pile therein, then drive the pile to secure the last few feet of penetration. Only use one jet for prejetting or jetting through piles constructed with a center jet-hole....
455-5.7 Water Jets: (Continued)

Use two jets when using external jets. When jetting and driving, position the jets slightly behind the advancing pile tip (approximately 3 feet or as approved by the Engineer). When using water jets in the driving, determine the pile bearing only from the results of driving after withdrawing the jets, except where using jets to continuously eliminate soil resistance through the scour zone, ensure that they remain in place as directed by the Engineer and operating during pile bearing determination.
455-5.7 Water Jets: (Continued)

.... Where practical, perform jetting on all piles in a pile group before driving begins. When large pile groups or pile spacing and batter make this impractical, or when the plans specify a jet-drive sequence, set check a sufficient number of previously driven piles in a pile group to confirm their capacity after completing all jetting.
Punches

Punch

Combination Jet/Punch
Soil augers or drills is one of the tools frequently used to install piles. Predrilling is used to perform the following:

- Install piles by preforming holes or predrilling through soils with obstructions, such as old timbers, boulders, and riprap.
- Install piles through soil embankments.
- Drill a starter hole.
- To assist in the advancement of the piles through very dense materials that prevent the piles to reach a minimum penetration.
- To reduce pile heave when displacement piles are driven at close spacings.
- To predrill holes in order to minimize vibrations
- Where jetting or punching are not allowed by the Contract documents.
Followers

- Generally used for water projects.
- Only when authorized in writing by Engineer or in contract documents.
**Followers**

**455-5.5 Followers:** Use followers only for underwater driving. Obtain the Engineer’s approval for the type of follower, when used, and the method of connection to the leads and pile. Use followers constructed of steel with an adequate cross-section to withstand driving stresses. When driving concrete piles, ensure that the cross-sectional area of the follower is at least 18% of the cross-sectional area of the pile. When driving steel piles, ensure that the cross-sectional area of the follower is greater than or equal to the cross-sectional area of the pile. Provide a pile helmet at the lower end of the follower sized according to the requirements of 455-5.3.3.
Followers

**455-5.5 Followers: (continued)** Use followers constructed that maintain the alignment of the pile, follower, and hammer and still allow the pile to be driven within the allowable tolerances. Use followers designed with guides adapted to the leads that maintain the hammer, follower, and the piles in alignment.

Use information from driving full length piles described in 455-5.1.2 compared to driving piles with the follower and/or dynamic load tests described in 455-5.13 to evaluate the adequacy of the follower and to establish the blow count criteria when using the follower.
For piles on land, the template should be located:

A. Within 2 feet of cutoff elev.
B. Within 5 feet of cutoff elev. or ground surface elev.
C. Within 10 feet of cutoff elev. or ground surface elev.
D. No specific requirement

Learning Outcome

Which of the following leads does not require the use of a template?

A. Swinging
B. Semi-fixed
C. Fixed
D. None require the use of a template
When jetting & driving, the jets should be positioned approx. ___ ft. behind the pile tip.

A. 2  
B. 3  
C. 4  
D. 5

Jetting in the embankment is permitted when ____.

A. Not permitted  
B. Anytime  
C. Embankment heights are less than 10 feet  
D. Embankment heights less than 20 feet
Learning Outcomes

• Identify Pile Installation Equipment and Tools
• Identify various pile types
• Use Pile Driving Equipment terminology
• Interpret 455 specifications related to the pile driving system
End of Lesson 1

ANY
QUESTIONS?