Section 7

Driven Piles

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View ODOT Video, Part 7/12

Pile Foundations

What is a Driven Pile?

A Driven Pile is a deep foundation that is constructed by driving a concrete, steel or timber pile to support the anticipated loads in competent subsurface material.
End Bearing and Friction Piles

**END BEARING LOAD**

- Sands
- Soft Clays
- Rock

**FRICITION LOAD**

- Sands
- Clays
- Sand

\[
\Delta z_1 \quad R_{S1} \quad \text{Layer 1}
\]
\[
\Delta z_2 \quad R_{S2} \quad \text{Layer 2}
\]
\[
\Delta z_3 \quad R_{S3} \quad \text{Layer 3}
\]
\[
\Delta z_4 \quad R_{S4} \quad \text{Layer 4}
\]

\[
Q_u = R_{SN} + R_T
\]
Displacement piles are piles that actually displace the material they are driven into.

Low (Non) Displacement piles are piles that displace very little of the material they are driven into.

“Rebound”

- The upward movement of a pile during driving
- High displacement piles increase potential for rebound
- Highly plastic and expansive clayey soils present increased potential for rebound
Pile Strength Vs. Time

Strength Gain (pile setup or “freeze”)

Piles can gain strength over time after they are driven in certain cohesive soils like stiff clays and clayey silts. This is due to the slow dissipation of excess pore water pressure that is created during pile driving.

Strength Lose

Piles can lose strength after driving in certain soils like very dense sands and gravels due to “relaxation” of the soil. Relaxation has to do with a change in soil structure after driving. The Geotechnical Engineer will determine if this effect applies at a given site.

Pile Driving Equipment

- Crane
- Hammer
- Cushions
- Leads
- Template
- Special Tools
Crane

Hammers

**Drop** (Gravity Hammers)  
- Air/Steam
  - Single Acting
  - Double Acting
- Diesel
  - Single Acting
  - Double Acting
- Hydraulic
  - Single Acting
  - Double Acting
Driven Piles

Open End Diesel Hammers
Single-Acting

- Advantages
  - Very simple
  - No additional support equipment required
  - Lightest net weight per ft.-lb. of energy
  - Readily available (common)

- Disadvantages
  - Delivered energy variable
  - Less efficient energy transfer
  - Produces higher pile stresses
  - Dirty exhaust spray and smoke
  - Difficult to spot operation problems

Vibratory Hammer

Generally used for driving and extracting sheet piles, low-displacement H-piles, and pipe piles.

Not impact hammers.
Hammer Cushions

- Used on all impact hammers except gravity (drop) hammers
- Must be made of durable manufactured (man-made) materials
- Wood, wire rope and asbestos not allowed
- Striker plate must be used

Hammer Cushions (Cont’d)

- Inspected when beginning driving
- Inspected every 100 hours of driving
- Replaced when there is a reduction of thickness exceeding 25% of original thickness
Hammer Cushions (Cont’d)

Helmet

- Guided by leads, not free-swinging
- Must maintain proper alignment of hammer and pile
- Minimum 1 inch larger than pile
Helmet (Cont’d)

- Used with concrete piles
- Minimum original thickness not less than 4 inches
- Replaced if compressed to more than one-half original thickness
- Replaced if starts to burn

Pile Cushion

- Used with concrete piles
- Minimum original thickness not less than 4 inches
- Replaced if compressed to more than one-half original thickness
- Replaced if starts to burn
Driven Piles Section 7.1

Pile Cushion (Cont’d)

Pile Driving System Components – Leads

- Crane
- Hammer
- Cushions
- Leads
- Template
- Special Tools
**Fixed Lead System**

- Fixed at both top & bottom
- Maximum control of pile alignment
- Higher Cost

**Semi-fixed Lead System**

- **Low Cost**
- **Simple, mobile**
- **Some control of pile alignment**

Fixed either at top or bottom but allowing vertical movement
Swinging Lead System

- **Low Cost**
- **Simple, mobile**
- **Less control of pile alignment**
- **Must be approved by The Engineer**

Not fixed at top or bottom

Templates

Required for offshore leads.

Maintains the pile and hammer in the correct location and position.
Driven Piles

Section 7.1

Templates (Cont’d)

As-built

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

Pile in incorrect position

Pile in correct position

Special Tools

- Jets
- Drills (Preboring)
- Punches
- Followers
Jets

- Permitted when in the plans or approved by the Engineer in writing.
- Jetting plant must provide pressure equal to 100 psi at two ¾ inch jet nozzles.
- Jets must be removed for the final 5 feet of pile penetration.

Preboring

Used only when specified or with approval of the Engineer
**Punches**

Aids for advancing pre-drilled holes through hard materials

- Combination Jet/Punch

**Followers**

- Generally used for water projects.
- Only when authorized in writing by Engineer or in contract documents.
- The first pile in each bent and every tenth pile thereafter must be driven without a follower.
Driven Piles

Section 7.1

Pile Types

• Steel Pipe Piles
• Steel H-Piles
• Concrete Piles
• Timber Piles
• Cylinder Concrete Piles
• Composite Piles
• Steel Sheet Piles

Steel Pipe Piles

• Most commonly used in ODOT
• Driven either open or closed end
• Can be filled with concrete
Steel H-Piles
- End Bearing Piles
- Low-Displacement
- High Bearing

Timber Piles
- Low Bearing Piles
- High-Displacement
- Used typically for temporary structures
Sheet Piles

- Utilized mostly for temporary retaining systems, such as shoring, cofferdams and bulkheads
- Driven using either impact or vibratory hammers

Pile Tip Attachments – Steel H-Pile

See Section 02520.10 (e) Reinforced Pile Tips
Pile Tip Attachments
– Steel Pipe Pile

See Section 02520.10 (e) Reinforced Pile Tips

Typical Pipe Pile End Plate

Fillet Weld

Flat End Plate
Subsurface Information

Subsurface Information Available to the Contractor:

- Foundation Reports
- Foundation Data Sheets
- Drill Logs
- Groundwater Conditions
- Soil & Rock Unit Descriptions
- Material Engineering Properties

General Materials Classification

- “Course Grained” Materials
  - Granular Soils
    - (sand, gravel, cobbles and boulders)

- “Fine Grained” Materials
  - Clay (plastic or nonplastic)
  - Silt; may be plastic (clayey silt) or non-plastic (sandy silt)

- Intermediate Geomaterials:
  - weathered rock
  - glacial till
  - cemented soils

- Rock
## DRILL LOG

**OREGON DEPARTMENT OF TRANSPORTATION**

**Project:** Willamette River Bridge (MP192.75)

**Highway:** Pacific Hwy 001

**Equipment:** CME 75

**Purpose:** Willamette River Bridge Fnd. Inv.

**Driller:** Ernie Phillips

**Project Geologist:** Bernie Kleutsch

**End Date:** March 28, 2003

**Recorder:** John Rehm

**Hole No.:** DH-2-03

**No.:** PE000724-010

**County:** Lane

**Easting:** 1,295,707.11

**Start Date:** March 28, 2003

**Total Depth:** 10.95m

**Ground Elev.:** 131.67m

**Bridge No.:** 19620

**Key No.:** 13110

### Test Type

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Soil Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;A&quot; - Agger Core</td>
<td></td>
</tr>
<tr>
<td>&quot;X&quot; - Agger</td>
<td></td>
</tr>
<tr>
<td>&quot;C&quot; - Core, Barrel Type</td>
<td></td>
</tr>
<tr>
<td>&quot;N&quot; - Standard Penetration</td>
<td></td>
</tr>
<tr>
<td>&quot;U&quot; - Undisturbed Sample</td>
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</tr>
<tr>
<td>&quot;T&quot; - Test Pit</td>
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</tbody>
</table>

### Rock Abbreviations

- **Discontinuity:**
  - J - Joint
  - F - Fault
  - B - Bedding
  - Fo - Foliation
  - S - Shear

- **Shape:**
  - Pl - Planar
  - C - Curved
  - U - Undulating
  - S - Smooth
  - Ir - Irregular

- **Surface Roughness:**
  - P - Polished
  - S - Slickensided
  - R - Rough
  - VR - Very Rough

### Typical Drilling Abbreviations

- **Drilling Method:**
  - WL - Wire Line
  - HS - Hollow Stem Auger
  - DP - Drill Fluid
  - SA - Solid Fligh Auger
  - CA - Casing Advance
  - HA - Hand Auger

- **Drilling Remarks:**
  - LW - Lost Water
  - WR - Water Return
  - WC - Water Color
  - D - Down Pressure
  - DR - Drill Rate
  - DA - Drill Action

### Material Description

**SOIL:**
- Soil Name, USC, Color, Plasticity, Moisture, Consistency/Relative Density, Texture, Cementation, Structure, Origin.

**ROCK:**
- Rock Name, Color, Weathering, Hardness, Discontinuity, Spacing, Joint Filling, Core Recovery, RQD, Formation Name.

### Unit Description

- **Depth (meters):**

<table>
<thead>
<tr>
<th>Depth</th>
<th>Test Type</th>
<th>Soil</th>
<th>Rock</th>
<th>Percent Recovery</th>
<th>Percent RQD</th>
<th>Material Description</th>
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<td>0</td>
<td>C1</td>
<td></td>
<td></td>
<td>48.0</td>
<td>98%</td>
<td>C-1 (0.00 - 1.83) GRAVEL and COBBLES up to 3.5 inch size; GW; Gray; Nonplastic; fines washed away; (Alluvium)</td>
</tr>
<tr>
<td>2</td>
<td>C2</td>
<td></td>
<td></td>
<td>39.0</td>
<td>74%</td>
<td>C-4 (4.87 - 6.39) BASALT; Gray to 6.06m then Light Brown; Fresh then Moderately Weathered; Soft (R2); RQD = 74%; wide jointed with spacing up to 2 feet; calcite in healed joints; yellow silt in joints below 6.06m; unconfined compression = 40.274 kPa; Intrusive Basalt</td>
</tr>
<tr>
<td>5</td>
<td>C3</td>
<td></td>
<td></td>
<td>100.0</td>
<td>70%</td>
<td>C-6 (6.39 - 7.91) Tuffaceous SANDSTONE; SILTSTONE/LAPILLI TUFF; 7.5m then LAPILLI TUFF; Light Brown grading to Light Gray; grades from Predominately Decomposed to Fresh; Extremely Soft (R0) to Medium Hard (R3); RQD = 70%; close to moderately close jointed with spacing up to 2 feet; sandstone and siltstone dipping at 45 degrees; discoloration along joints to 7.3m; calcite cementation in lapilli tuff; Eugene Fm</td>
</tr>
<tr>
<td>6</td>
<td>C4</td>
<td></td>
<td></td>
<td>100.0</td>
<td>93%</td>
<td>C-7 (9.43 - 10.95) LAPILLI TUFF; Green Gray; Fresh; Soft (R2); RQD = 100%; wide jointed; calcite cemented; unconfined compression = 39.329 kPa; Eugene Fm</td>
</tr>
<tr>
<td>10</td>
<td>C5</td>
<td></td>
<td></td>
<td>100.0</td>
<td>100%</td>
<td>C-9 (11.15 - 12.28) LAPILLI TUFF; Green Gray; Fresh; Very Close to Moderately Close Jointed (Eugene Fm)</td>
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<tr>
<td>11</td>
<td>C6</td>
<td></td>
<td></td>
<td>93%</td>
<td>100%</td>
<td>7.3 - 10.65 LAPILLI TUFF; green gray; fresh; (R2) to (R3); well jointed; calcite cemented clasts (Eugene Fm);</td>
</tr>
<tr>
<td>12</td>
<td>C7</td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
<td>10.95 End of Hole</td>
</tr>
</tbody>
</table>

### Test Type Iconography

**Graphic Log:**
- HQTBE coring

**Unit Description Iconography:**
- Drilling Methods, Site Remarks, Water Level/Date, Backfill/Instrumentation
PILE AND DRIVING EQUIPMENT DATA

HIGHWAY MILEPOST

CONTRACT NO STRUCTURE NAME AND NO.

PROJECT NAME (SECTION)

PROJECT MANAGER CONTRACTOR

COUNTY PILE DRIVING SUBCONTRACTOR (Piles Driven By):

TYPE OF LEADS:  □ Fixed  □ Semi-Fixed  □ Swinging
OTHER (Provide Description):

LEAD DIMENSIONS Depth ________ Width ________

MANUFACTURER MODEL TYPE

SERIAL NO. OWNER:

RATED ENERGY (@ LENGTH OF STROKE) RAM WT.
(KN-m) (m) (KN)

MODIFICATIONS

MATERIALS

TOTAL THICKNESS AREA
(mm.) (mm²)

MODULUS OF ELASTICITY (E): COEFFICIENT OF RESTITUTION (e)

(MPa)

CUSHION MATERIALS

NO OF LAYERS THICKNESS (EACH) TOTAL THICKNESS
(mm.) (mm.) (mm.)

MODULUS OF ELASTICITY (E): COEFFICIENT OF RESTITUTION (e)

(MPa)

PILE TYPE & SIZE

LENGTH IN LEADS (KN/m)

WALL THICKNESS TAPER (m) (mm)

NOMINAL PILE RESISTANCE ACCEPTANCE BY WAVE EQUATION (KN) □ Yes □ No

DESCRIPTION OF SPLICE

TIP TREATMENT DESCRIPTION (TYPE, MANUFACTURER, MODEL NO., ETC.)

NOTE: If mandrel is used to drive the pile, attach separate manufacturer’s detail sheet(s) including weight and dimensions.

SUBMITTED BY: DATE

734-2608 (8-2009)
Driven Piles

Section 7.1

Pile Hammer Acceptance Process

Contractor prepares Pile Driving and Equipment Data Form and submits to Engineer for Approval, no later than 2 weeks prior to driving first pile. (00520.20 (d))

Changes to Contractor

Contractor resubmits to Engineer

Review

Changes

Engineer accepts Pile Driving & Equip. Data Sheet and issues Hammer Approval Letter with final pile driving criteria.

Acceptance

Changes

No changes may be made without the Engineers approval

Hammer Approval Letter

After reviewing the Contractors hammer submittal, the Geotechnical Engineer will provide a letter to the Project Manager summarizing the following:

- Hammer Approval (or reasons why the hammer is not approved)
- Driving Criteria (stroke vs. required blow count and Inspectors Graph)
- Any pile driving issues such as:
  - Pile Freeze (set-up criteria)
  - Hard driving conditions (high pile stress conditions)
  - Details on Preboring requirements
November 18, 2004

TO: Bill Edmundson  
    Project Manager

FROM: Jan Six, P.E.  
      Geotechnical Engineer

SUBJECT: Sylvan O'Xing Sunset Hwy, Bridge No. 18674  
          Camelot Intchg. – Sylvan Intchg. (Phase 2) Section  
          Contract 12465           CON 01747  
          Multnomah & Washington Counties

The Pile and Driving Equipment Data Sheet submitted for use on this bridge has been reviewed and is conditionally approved for use in driving the permanent piles. The hammer is fully suitable and approved for use in driving the PP24x0.500 piles for the bridge. However, the hammer is somewhat oversized for use in driving the smaller PP12.75x0.375 piles for the wingwalls and is conditionally approved pending field hammer performance. For the wingwall piles the hammer stroke must be strictly controlled in the low range to provide the minimum acceptable blow count of 3.0, allowed in the Special Provisions and to minimize overstressing the piles.

The data sheet submitted is for a Berminghammer B5505 diesel hammer. The serial number was “to-be-determined”. Please obtain the serial number off the hammer for our records. All piles should be Grade 3 steel, (45ksi).

The end-of-driving (EOD) pile criteria are listed in the tables below. This criterion is based on a wave equation analysis for the PP610x12.7 piles and on the ODOT Gates Equation for the PP12.75x0.375 piles. Inspector’s graphs are also attached showing the required driving resistance (blows/inch) versus hammer stroke.

For the PP12.75x0.375 wingwall piles, the maximum allowable hammer is only 7.0 feet for the minimum allowable blow count of 3.0. Stroke higher than 7 feet will result in blow counts below this minimum acceptable value. The fuel setting for the Berminghammer must be reduced such that the stroke does not exceed 7 feet.

For Bents 1 & 2 the hammer should be operating near its maximum fuel setting and stroke at the end of driving in order to satisfy the required criteria. Pile stresses should not be a problem during driving the PP24x0.500 piles.
Sylvan O'Xing Sunset Hwy.
Bents 1 & 2
PP 24 x 0.500, driven open end
Ultimate Capacity, $R_{ult} = 1075$ kips

<table>
<thead>
<tr>
<th>STROKE (ft)</th>
<th>BLOWS/INCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>10.5</td>
<td>13</td>
</tr>
<tr>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>11.5</td>
<td>10</td>
</tr>
</tbody>
</table>

Note: Strokes are rounded to the nearest 0.50ft. for convenience in field recording. If more precise strokes can be determined in the field then use linear interpolation between the corresponding blow counts required.

Wingwall Locations
PP 12.75 x 0.375, driven open end
Ultimate Capacity, $R_{ult} = 490$ kips

<table>
<thead>
<tr>
<th>STROKE (ft)</th>
<th>BLOWS/INCH</th>
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</thead>
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<tr>
<td>7.0 (max)</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>5.2</td>
<td>5</td>
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</tbody>
</table>

All the piles at both bents may come up to bearing very quickly in the basalt bedrock or rubble. This could quickly lead to a high driving stress condition for the wingwall piles. The inspector should be aware of this condition and immediately stop driving at any signs of pile damage.

A saximeter is available for measuring the field hammer stroke and will be sent to your office on request. Please contact me at 986-3377 if you have any questions.

Attachments:
Inspector's Graphs (PP24x0.500 & PP12.75x0.375)
Construction Documents

General Notes

Steel piling conforming to ASTM 252, grade 3.
All piling shall be PP12 3/4 x 0.25 driven closed ended to an ultimate capacity of 270 kips per pile.
Pile tip elevation for minimum pile penetration for each bent shall be elevation 210.
All piling shall be driven to the ultimate capacity using driving criteria developed from a wave equation analysis.
Steel piling conforming to ASTM 252, grade 3.
All piling shall be PP12³⁄₄ x 0.25 driven closed ended to an ultimate capacity of 270 kips per pile.
Pile tip elevation for minimum pile penetration for each bent shall be elevation 210.
All piling shall be driven to the ultimate capacity using driving criteria developed from a wave equation analysis.
Foundation Data Sheet
Record Keeping

- Pile Record Book
- General Daily Progress Report
- Personal Field Diary
# Pile Record Book

<table>
<thead>
<tr>
<th>BRIDGE OR PROJECT NAME</th>
</tr>
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<tbody>
<tr>
<td>HAMMER DESCRIPTION (MAKE, TYPE, SIZE)</td>
</tr>
<tr>
<td>LOCATION</td>
</tr>
<tr>
<td>CUT-OFF ELEV.</td>
</tr>
</tbody>
</table>

| BRIDGE NO. | CONTRACT NO. | INSPECTOR(S) |
| KIND OF PILING | | | |
| Cutoff | Tip | Set | Date | REMARKS AND SKETCHES |
# Pile Record Book

(Record Pile)

- A continuous record for every foot of penetration

- One Record Pile should be recorded for each bent and at least one in every 10 piles.
<table>
<thead>
<tr>
<th>LOCATION</th>
<th>ONYX ORDER LEN.</th>
<th>REV. ORDER LEN.</th>
<th>DEL. LEN.</th>
<th>FRESH HEAD</th>
<th>LEN. IN LEADS</th>
<th>PAY</th>
<th>NO PAY</th>
<th>SALV.</th>
<th>SCRAP</th>
<th>CUT OFF</th>
<th>DRIVEN LEN.</th>
<th>LENGTH</th>
<th>RADIUS</th>
<th>AREA</th>
<th>ELEV.</th>
<th>TIP ELEV.</th>
<th>SET</th>
<th>DATE</th>
<th>BEARING</th>
<th>INSPECTOR</th>
<th>REMARKS AND SKETCHES</th>
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<tbody>
<tr>
<td>Bent 1</td>
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<td>81</td>
<td>9</td>
<td>614</td>
<td>1198</td>
<td>6.7</td>
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<td></td>
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<td>1248</td>
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<td>PP Open End</td>
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<td></td>
<td>1281/02</td>
<td>1281/02</td>
<td>PP Open End</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Minimum Tip 1250 ft
Driven PP Length Rounded to Nearest M = 9' + 9' + 11' + 12' + 12' + 11' = 67 M
Pay B24 #400

1-8-08

David
# Pile Driving Checklist

Confirm all checklist items have been addressed. This list does not replace contract documents and is only an inspection tool.

## Pre-Construction

<table>
<thead>
<tr>
<th>No</th>
<th>Yes</th>
<th>NA</th>
<th>1. Has the Contractor submitted the pile and driving equipment data form? 00520.20(d)</th>
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<tbody>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>2. Do you have a copy of the Hammer Approval Letter / End of Driving Criteria, issued by the Geotechnical Engineer?</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>3. If followers are to be used, were they approved by the Engineer or specified in the contract documents? 00520.20(c)(4)</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>4. Has the embankment and excavation work been completed according to Section 00520.40(a) and (b)?</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>5. If a cofferdam is required, has the Contractor submitted a design in accordance with Section 00510?</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>6. If preboring is required, have the equipment and methods been approved? 00520.41(d)</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>7. If jetting is required, are the jets and supporting equipment approved? 00520.42(e)</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>8. Do you have a reference elevation to determine the pile cut-off and a minimum penetration depth?</td>
</tr>
</tbody>
</table>

## Piles and Equipment Arrive On Site

<table>
<thead>
<tr>
<th>No</th>
<th>Yes</th>
<th>NA</th>
<th>9. Are the leads fixed? If not, did the Professional of Record approve the lead system? 00520.20(c)(5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>10. Are there any visual defects on the pile? (If yes, please explain in the Notes / Comments section below.)</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>11. Does the pile diameter, length, type and grade match the contract documents?</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>12. Are the pile tips the right type and size and welded on properly (reinforced tips or closed end plates)? 00520.43</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>13. Did the Contractor supply the mill certification reports?</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>14. Do piles on site match the mill certification reports?</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>15. Has the minimum penetration depth (minimum tip) mark been placed on the pile?</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>16. Are the piles marked at intervals to determine depth while diving?</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>17. Is all shop pile splicing performed per Section 00520.43(f)? Do you have inspection reports from Structure Services?</td>
</tr>
</tbody>
</table>

## Prestressed Concrete Piles (00520.44)

<table>
<thead>
<tr>
<th>No</th>
<th>Yes</th>
<th>NA</th>
<th>18. During delivery, are the piles being lifted by the correct number of pick points and at the correct locations?</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>19. Do the piles have the required information on the pile (stamp, casting date, pile #, length, prestressed yard #)?</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>20. Is the casting date older than 21 days for normal installation and 30 days for exposure to seawater and sulfate soils?</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>21. Does the length/cross-section/size/prestress configuration match the contract documents?</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>22. Did you physically measure the piles?</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>23. Are the lifting eyes removed and coated with epoxy?</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>24. Are there spalling/cracks or other damage visually apparent? Any damage should be reported to your supervisor for evaluation. (If so, please explain in the Notes / Comments section below.)</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>25. Are prestress strands cut off below the surface of concrete?</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>26. For storage on job site, is dunnage placed at correct lifting positions and is it placed so that it won't settle?</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>NA</td>
<td>27. Other special details that are in the specifications, such as vents, centerhole jet pipes, voids, etc., should be explained in the Notes / Comments section below.</td>
</tr>
</tbody>
</table>
### Begin Pile Driving

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>28. Is the Contractor using the approved hammer system provided in the Pile &amp; Driving Equipment Data Sheet?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29. Has the set period elevation been determined and marked on pile, if required by the contract documents?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30. Have the horizontal and vertical pile positions been verified at the start of driving?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31. If a set period is specified, has the hammer been warmed up prior to redriving?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32. If PDA Testing is included, has the end of driving criteria been issued by the Geotechnical Engineer?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33. Has all available pre-driving data been entered into the Pile Record Book?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34. Is the saximeter being used to record stroke?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35. If using jetting to advance pile, has the Contractor removed the jets a minimum of 5 ft. above the specified tip elevation and used an impact hammer to drive to the required bearing capacity?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36. If concrete piles require field splicing, is it in accordance with 00520.44?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37. If steel piles require splicing, is it in accordance with 00520.43(f) and (g)?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>38. If included in the contract documents, is the proper number of test piles being recorded?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>39. If using a pile cushion for concrete pile, does it need to be replaced? 00520.20(c)(1)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### When to Stop

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>40. Is there a minimum penetration depth (minimum tip) specified?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41. If &quot;Yes&quot; to #40, has the pile reached the minimum penetration depth?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>42. Has the pile met the end of Driving Criteria specified by the Geotechnical Engineer (i.e., PDA testing or min. blows per inch)?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>43. Has the pile achieved the specified bearing resistance (i.e., PDA testing or min. blows per inch)? 00520.42</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>44. Is the top of pile within 2 feet of cut-off elevation.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45. Has the pile reached “refusal” driving (Practical Refusal)? 00520.42</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>46. Are the piles within allowable horizontal and vertical tolerances? 00520.41(f)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>47. Have any of the piles heaved? 00520.41(g)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>48. Have the piles been capped per the contract documents? 00520.43(i)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>49. Is each row/column of the ODOT Pile Record Book filled out?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Sample Pile Acceptance Decision Chart

![Sample Pile Acceptance Decision Chart](chart.png)
Piling Set Check

- Within 2 ft of estimated pile length.
- Wait for 24 hours to see if freeze will occur and bearing can be reached.
- Conserves piling and maximizes the friction ability of the soil.
Pre-Production Program (test piles)

- Determine Pile Lengths Required for Production – concrete and timber pile order lengths
- Check Drivability of Proposed Hammer System
- Check Performance of Contractor’s proposed Driving System
- Determine Required Driving Resistance
Check the Driving System

- Manufacturer
- Model
- Type
- Serial Number
- Energy Rating
- Ram Weight
- Ram Stroke

Check the Driving System

Are the leads the proper type and configuration for the job?
Does the helmet and hammer cushion meet the requirements of the Driving Criteria Letter?

**Pile Drive Head (Helmet):**
- Axially aligned with the hammer and pile
- Guided by the leads
- Not free-swinging
- Cut squarely for steel and timber
- Plane and perpendicular to longitudinal axis for concrete piles

**Hammer Cushion:**
- Required for all impact hammers except gravity (drop)
- Made of manufactured materials
- Wood, wire rope and asbestos not allowed

**Steel Piles**

Check the Pile Certifications. Do the heat numbers on the piles match the Certificate of Analysis for the piles?

Bearing Pile

Depth & Width

Weight per foot of pile, in pounds

Steel Piles
Steel Pipe Piles

Compare diameter, length and wall thickness to plan details.

Steel Pipe Piles

Verify Open End or Closed End.

**Closed End**
Verify the bottom plate is the correct diameter and thickness and welded per the plans.
Steel H Piles

Measure the Pile Depth and Flange Width for comparison to plan details.

Pile Depth

10 in.

Flange Width

10 in.

Steel H Piles
Pile Splices

The Project Plans and Specifications detail the splicing requirements for piles. For Steel Pipe Pile a full penetration butt weld is required with a backing ring.

Pile Splice Measurement

00520.80 (f)(1)

- None if within length listed in Special Provision
- One splice if splice is 5 ft or more when estimated pile length is 60 ft or less
- One splice if splice is 10 ft or more when estimated pile length is over 60 ft
- Only one splice per pile
Marking Piles

Monitoring Driven Pile Lengths

Cutoff Elevation = +5.00'
Reference Elevation= +2.00'
Ground Surface Elevation= +0.00'
Tip Elev. = -27.00'

Length Driven is the length of pile below the cutoff elevation!
Pile Marker @ 29' penetration
Saximeter

Method to determine hammer stroke in the field

Calculating Stroke Heights

(Air-Steam Hammer)  
**Blows per minute**

\[
\text{height} = \frac{14,400}{[\text{bpm}^2]} - 0.3
\]

**Example:** bpm = 36  
\[14,400/1296 = 11.11\]  
\[11.11 - 0.3 = 10.81 \text{ ft}\]

(Open-End Diesel Hammers)  
**Seconds per blow**

\[
h = 0.0402 (T^2) - 0.3
\]

**h = Stroke Height in Feet**  
\[T = \text{Time in Seconds for 10 blows}\]

**EXAMPLE**  
Took 16 seconds for 10 blows, therefore:

\[
h = 0.0402 \times 256 - 0.3
\]

\[h = 9.99 \text{ or } 10 \text{ ft.}\]
Marking Pile To Check For Bearing

Pile Bearing
00520.42 (a)

- Maintain required blows/inch (bpi) for 3 consecutive inches unless refusal is first obtained.
- Refusal is defined as 20 bpi
PDA Testing

• Tends to result in shorter pile lengths.

Horizontal Tolerance for Driving 00520.41 (f)

Within 6” of plan location

At least 4” from edge of cap
Common Problems
– Open End Diesel

<table>
<thead>
<tr>
<th>Common Problems</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water in fuel</td>
<td>Hollow sound, white smoke</td>
</tr>
<tr>
<td>Fuel lines clogged</td>
<td>No smoke or little gray smoke</td>
</tr>
<tr>
<td>Fuel pump malfunctioning</td>
<td>Inconsistent ram strokes, little gray or black</td>
</tr>
<tr>
<td>Fuel injectors malfunctioning</td>
<td>Inconsistent ram strokes, little gray or black</td>
</tr>
<tr>
<td>Oil low</td>
<td>Blows per minute rate is lower than specified</td>
</tr>
<tr>
<td>Oil pump malfunctioning</td>
<td>Blows per minute rate is lower than specified</td>
</tr>
<tr>
<td>Water in combustion chamber</td>
<td>Hollow sound, white smoke</td>
</tr>
<tr>
<td>Piston rings worn</td>
<td>Low strokes</td>
</tr>
<tr>
<td>Tripping device broken</td>
<td>Pawl does not engage piston</td>
</tr>
<tr>
<td></td>
<td>Pawl engages but doesn't lift piston</td>
</tr>
<tr>
<td>Over heating</td>
<td>Paint and oil on cooling fins start to burn/sound changes</td>
</tr>
</tbody>
</table>

Steel Piles
# Steel Piles

<table>
<thead>
<tr>
<th>Typical causes of damage</th>
<th>Possible indicators during driving</th>
<th>Types of damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Transporting and Lifting</td>
<td>• Pile moving out of position during driving</td>
<td>• Bending</td>
</tr>
<tr>
<td>• Low Steel Strength</td>
<td>• Abrupt blow count change</td>
<td>• Buckling</td>
</tr>
<tr>
<td>• Hard Driving (Compression)</td>
<td>• Observed pile damage near the pile head</td>
<td>• Accordion</td>
</tr>
<tr>
<td>• Welding</td>
<td></td>
<td>• Splitting</td>
</tr>
<tr>
<td>• Splices</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

# Timber Piles

Timber Piles are banded to prevent "brooming".
### Timber Piles

<table>
<thead>
<tr>
<th>Typical causes of damage</th>
<th>Possible indicators during driving</th>
<th>Types of damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Transporting</td>
<td>• Pile moving out of position during driving</td>
<td>• Splintering</td>
</tr>
<tr>
<td>• Knots and natural defects</td>
<td>• Abrupt blow count change</td>
<td>• Cracking</td>
</tr>
<tr>
<td>• Handling</td>
<td>• Appearance</td>
<td>• Shearing</td>
</tr>
<tr>
<td>• Driving</td>
<td></td>
<td>• Brooming (head &amp; tip)</td>
</tr>
</tbody>
</table>

### Safety

- **DANGER**
  - Construction Area
- **DANGER**
  - Hard Hat Area

Where is that Pile Data Table?
Pile Exercise

• Are obstructions anticipated? _____
  See SP00520.41(d)
• If so, what is the course of action? _______
• Why is stroke limited to 8.5 ft? __________
  See Approval Letter
• What is the required blows/inch for a stroke of 7.5 ft? _____
SECTION 00520 - DRIVEN PILES

Comply with Section 00520 of the Standard Specifications supplemented and/or modified as follows:

00520.00 Scope - Add the following:

Furnish and install PP 324x9.5 steel pipe piles.

00520.10 General - For steel pipe piling, provide inside, fit, open ended cutting shoes meeting the requirements of 02520.10(b).

00520.11 Engineer's Estimated Length List - The Engineer’s estimated lengths of steel piling are:

<table>
<thead>
<tr>
<th>Location</th>
<th>No.</th>
<th>Length (m)</th>
<th>Kind</th>
</tr>
</thead>
<tbody>
<tr>
<td>#19184 Lake Creek Bridge</td>
<td>16</td>
<td>6.61</td>
<td>PP 324 x 9.5 (Grade 3)</td>
</tr>
</tbody>
</table>

00520.41(d) Preboring - Use auguring, wet-rotary drilling or other approved methods of preboring as directed.

If a pile cannot be driven to the specified pile tip elevation for minimum penetration, the pile shall be removed and preboring for that pile shall be performed to the pile tip elevation for minimum penetration. Have preboring equipment available on site during pile driving. This equipment shall be capable of preboring to a depth of 4.5 meters below the pile cap.

If preboring is necessary, permanent casing will be installed in the preboring to the tip elevation required for minimum pile penetration. The casing will have a minimum diameter of 24 inches. After the preboring has been completed and a pile has been driven in the preboring to the required end-of-driving criteria, the annulus between the casing and the pile shall be filled with Controlled Low Strength Material (CLSM) as described in Section 00442 with the following exception: the CLSM shall attain a minimum compressive strength of 1.7 MPa, not a compressive strength of 1.0 – 1.7 MPa as stated in 00442.13.

00520.42(d) Set Period and Redriving - Piles may be redriven after being allowed to set.

00520.43(c) End Treatment - Add the following:

Drive steel pipe piles open-ended with tip treatment as shown.

00520.80 Furnish Equipment for Driving Piles - Add the following:

There will be no measurement for furnishing preboring equipment.
March 10, 2005

TO: Shane Ottosen
   Project Manager

FROM: Bruce Novakovitch
       Geotechnical Design Engineer

SUBJECT: US20: Lake Creek Bridge Section
         Lake Creek Bridge (Br. #19184)
         ICE 42-S Pile Driving Hammer
         Contract 13088
         Santiam Highway
         Jefferson County

The Pile and Driving Equipment Data Sheet submitted for Lake Creek Bridge has been reviewed. The data sheet submitted shows an ICE model 42-S is proposed for driving the permanent piles at the bridge. The serial number and owner of this pile driver was not included on the Pile and Driving Equipment Data Sheet. We request the contractor supply us with this information to complete the sheet.

The ICE 42-S pile driving hammer would need to be able to operate in a fairly restricted range to adequately install the permanent piles at the Lake Creek Bridge (Bridge No. 19184). The ODOT Gates equation indicates this hammer will need to operate at a stroke of at least 2.1 meters (6.9 feet) to install the piles to the design ultimate capacity in the blow count range required in the ODOT Standard Provisions (3-15 blows per 25mm). A WAVE equation analysis indicates high driving pile stresses may occur if the stroke exceeds 2.6 m (8.5 feet). The ICE 42-S hammer will have to be capable of operating in this limited range at the end of pile driving to successfully drive the piles to the design ultimate capacity without overstressing them. Therefore, the ICE 42-S pile driving hammer is conditionally approved, the condition being it must be able to operate at a stroke between 2.1 and 2.6 meters at the corresponding blow count necessary to achieve the design ultimate capacity. However, if the mill certification for the Lake Creek Bridge piles shows yield strengths of 389 MPa (56.4 ksi) or greater, the upper limit on the stroke can be ignored.

The end of driving pile criteria are listed in the table 1 on page 2 below. The criteria are based on the ODOT Gates Equation, as called for in the plans, with the piles driven to the ultimate capacity indicated.
Lake Creek Bridge, Bridge 19184
PP 324 x 9.5, driven open ended with Interior plug 3 meters above tip
ICE 42-S
Ultimate Capacity, Rult, =2135 kN

<table>
<thead>
<tr>
<th>Stroke (m)</th>
<th>Stroke (ft)</th>
<th>BLOWS/IN OR 25 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.59</td>
<td>8.5</td>
<td>9</td>
</tr>
<tr>
<td>2.44</td>
<td>8.0</td>
<td>11</td>
</tr>
<tr>
<td>2.29</td>
<td>7.5</td>
<td>13</td>
</tr>
<tr>
<td>2.13</td>
<td>7.0</td>
<td>15</td>
</tr>
</tbody>
</table>

Table 1

An inspector's graph is presented on page 3. The stroke is plotted in both English and Metric units on the graph.

If any problems are encountered during pile driving I can be contacted at 503-986-3378.

c: Matt Halverson
Pile Driving Example

• BPI measured at 15 for 3” with required BPI of 13. Pile tip is at minimum tip elevation. What do you do? ___________

Stop & Accept Pile
Pile Driving Exercise 1

• BPI measured at 10 with required BPI of 13. Pile tip is at minimum tip elevation and is within 2' of estimated pile length. What do you do? ___________

Sample Pile Acceptance Decision Chart
Pile Driving Exercise 2

- BPI measured at 20 with required BPI of 13. Pile tip is 2 ft above minimum tip elevation. What do you do? ___________

Sample Pile Acceptance Decision Chart

- Is there a minimum tip elevation specified in the plans?
  - Yes
    - Have you reached the required minimum tip elevation?
      - Yes
      - Have you met the driving criteria specified by the geotechnical engineer?
        - Yes
        - Stop accept pile
        - Stop for set check
        - Contact project manager
        - Yes
      - Stop - contact project manager
      - No
      - Keep driving
      - No
      - Is the pile within 2 ft of the estimated pile length?
        - Yes
        - Stop accept pile
        - Stop for set check
        - Contact project manager
        - Yes
      - Stop - contact project manager
      - No
      - Keep driving
      - No
      - Have you reached the minimum penetration requirements?
        - Yes
        - Have you reached practical refusal?
          - Yes
          - Stop accept pile
          - Stop for set check
          - Contact project manager
          - Yes
        - Stop - contact project manager
        - No
        - Keep driving
        - No
      - No
    - No
  - No
<table>
<thead>
<tr>
<th>Project Name/Section</th>
<th>Project NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHANE OTJESEN</td>
<td>2005-006</td>
</tr>
<tr>
<td>JEFFERSON</td>
<td>SANITAM</td>
</tr>
<tr>
<td>CONTRACT NO.</td>
<td>13368</td>
</tr>
<tr>
<td>V520: LAKE CREEK</td>
<td></td>
</tr>
</tbody>
</table>

**Pile Record Book**

19184
**US20: LAKE CREEK BRIDGE**

**BENT 2**

**BENT 1**

**PP 324 x 9.5 ASTM Z52, Grade 3**
- BENT 1 Min. Tip = ELV. 1042.5
- BENT 2 Min. Tip = ELV. 1044.5
- Qult = 2135 KN per pile
- Ultimate capacity

**Driven open ended with interior plug 2 meters above tip**
<table>
<thead>
<tr>
<th>LOCATION</th>
<th>ORIG. ORDER LEN.</th>
<th>REV. ORDER LEN.</th>
<th>DEL. LEN.</th>
<th>FRESH HEAD</th>
<th>LEN. IN LEADS</th>
<th>SPLUGED</th>
<th>CUT OFF</th>
<th>DRIVEN LEN.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1</td>
<td>6.61m</td>
<td>25'</td>
<td>25'</td>
<td>1.38'</td>
<td>7.16'</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-2</td>
<td>25'</td>
<td>25'</td>
<td>2.13'</td>
<td>5.5m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-3</td>
<td>25'</td>
<td>25'</td>
<td>1.62'</td>
<td>5.99'</td>
<td></td>
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<td>25'</td>
<td>2.17'</td>
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<tr>
<td>1-6</td>
<td>7.62'</td>
<td>2.0m</td>
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<td>28'</td>
<td>9.62m</td>
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<tr>
<td>1-7</td>
<td>25'</td>
<td>.1'</td>
<td>7.0'</td>
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<tr>
<td>1-8</td>
<td>25'</td>
<td>2.46'</td>
<td>5.16'</td>
<td>1046.97</td>
<td>1041.81'</td>
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</table>

**Remarks and Sketches**
- Heat # 45225
- Spliced 2.29m to 7.62
- Dr 25'
**US 20: LAKE CR. BRIDGE**

**HARNESS DESCRIPTION (MAKE, TYPE, SIZE):**
ICE MODEL 425 DIESEL

**SERIAL #:** 257

**LOCATION**

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>ORIG. ORDER LEN.</th>
<th>REV. ORDER LEN.</th>
<th>DEL. LEN.</th>
<th>FRESH HEAD</th>
<th>LEADS</th>
<th>SPLUGES</th>
<th>CUT OFF</th>
<th>DRIVEN LEN.</th>
<th>CUT-OFF ELEV.</th>
<th>TIP ELEV.</th>
<th>SET</th>
<th>DATE</th>
<th>BEARING</th>
<th>INSPECTOR</th>
<th>REMARKS AND SKETCHES</th>
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<tr>
<td>2-1</td>
<td>6.6'</td>
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<td>5.33'</td>
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<td>17</td>
<td>7B PI</td>
<td>12-05</td>
<td>HEAT # 44652</td>
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<td>25'</td>
<td>25'</td>
<td>6.18'</td>
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<td>7B PI</td>
<td>12-05</td>
<td>HEAT # 45225</td>
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<tr>
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<td>7B SPIKE</td>
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<td>12-05</td>
<td>HEAT # 44652</td>
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<td>25'</td>
<td>4.72'</td>
<td>1048.63</td>
<td>15</td>
<td>7B SPIKE</td>
<td>12-05</td>
<td>HEAT # 44652</td>
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<td>Sketches, etc</td>
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<tr>
<td>Each pile was cored to minimum tip elevation A 24&quot;</td>
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<tr>
<td>Steel casing was then set into hole and then the pile was set inside casing</td>
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<tr>
<td>And begin driving until we achieve NUN, TIP, Contractor later placed clush between pile and casing</td>
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</table>
No record done on file.
Each pile were cored to
minimum tip elev. 13'4" casing
was installed then pile
was driven until we acheved
minimum tip elev.
Contractor then placed cslm
between pile and casing.