

## **Section 7**

# **Driven Piles**

<b>7.1 ODOT Video, Part 7/12: Pile Foundations</b>	<b>1</b>
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<b>Pile Exercise</b>	<b>38</b>

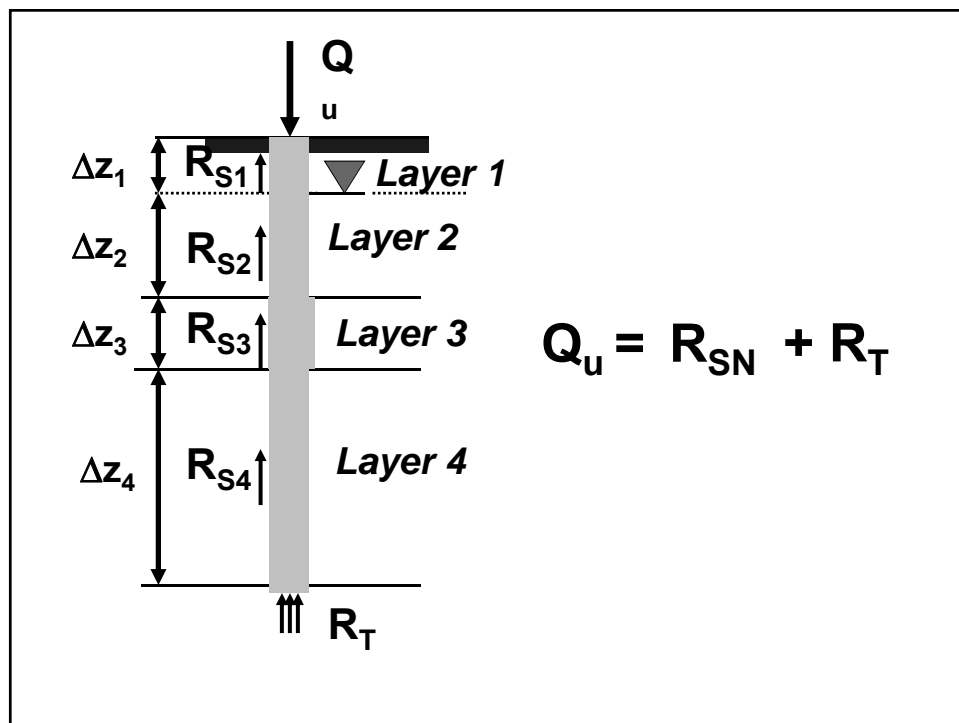
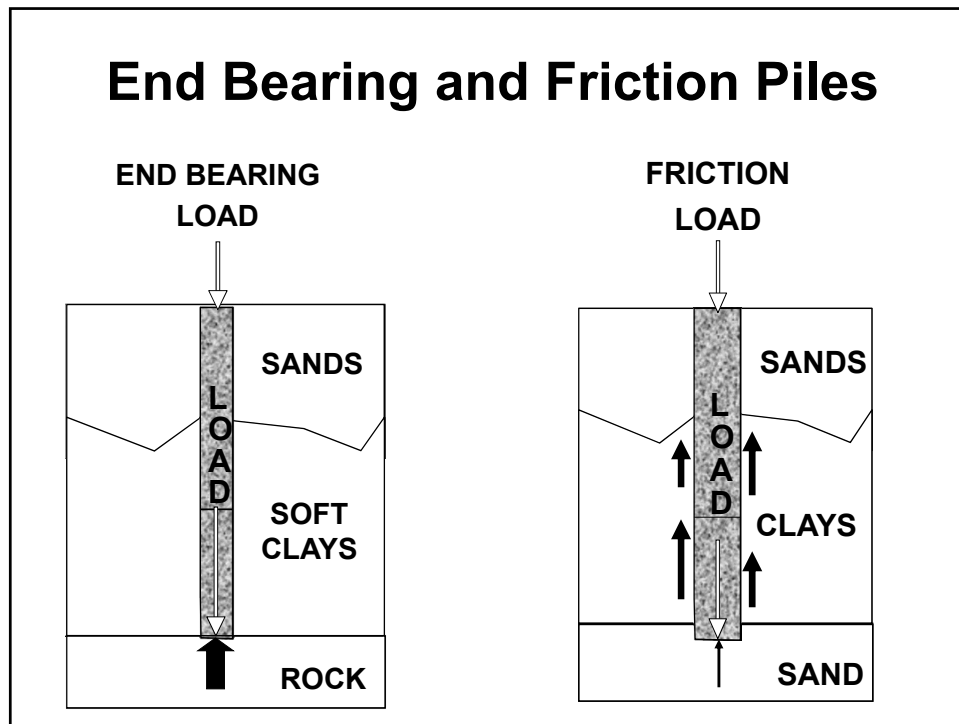
## **View ODOT Video, Part 7/12**

### **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.



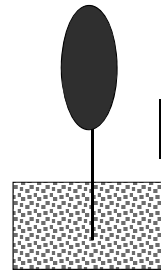


## Displacement or Low-Displacement?



*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.

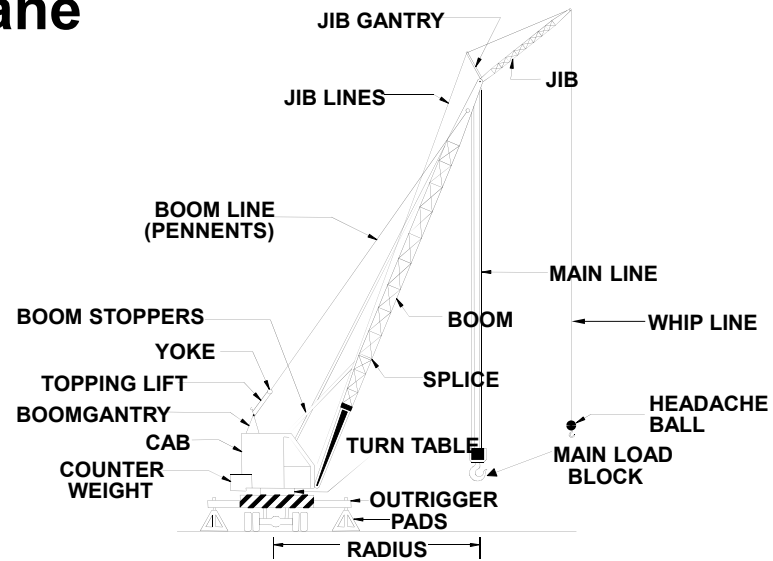
### **Strength Lose**

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.

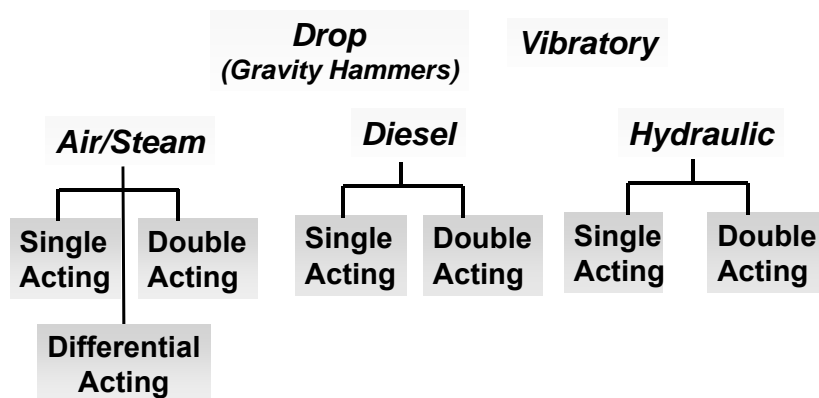
## **Pile Driving Equipment**

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

## Crane



## Hammers

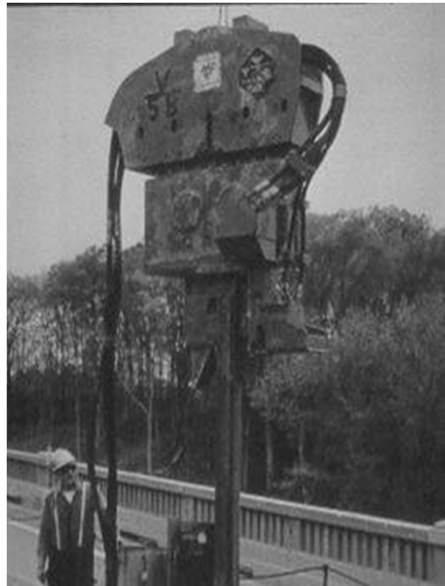


## Open End Diesel Hammers Single-Acting



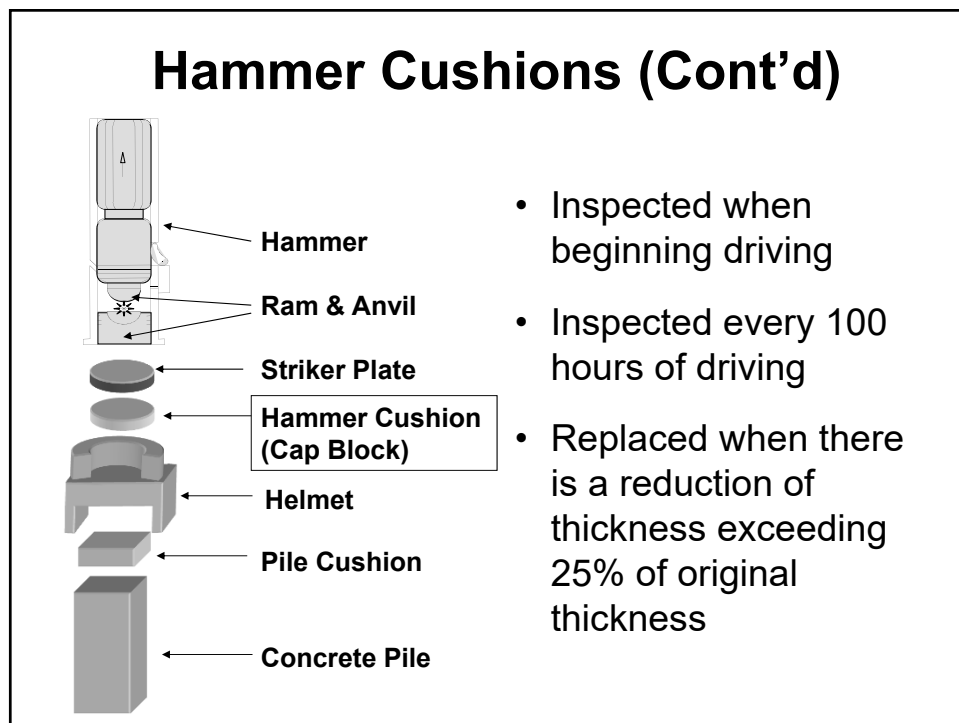
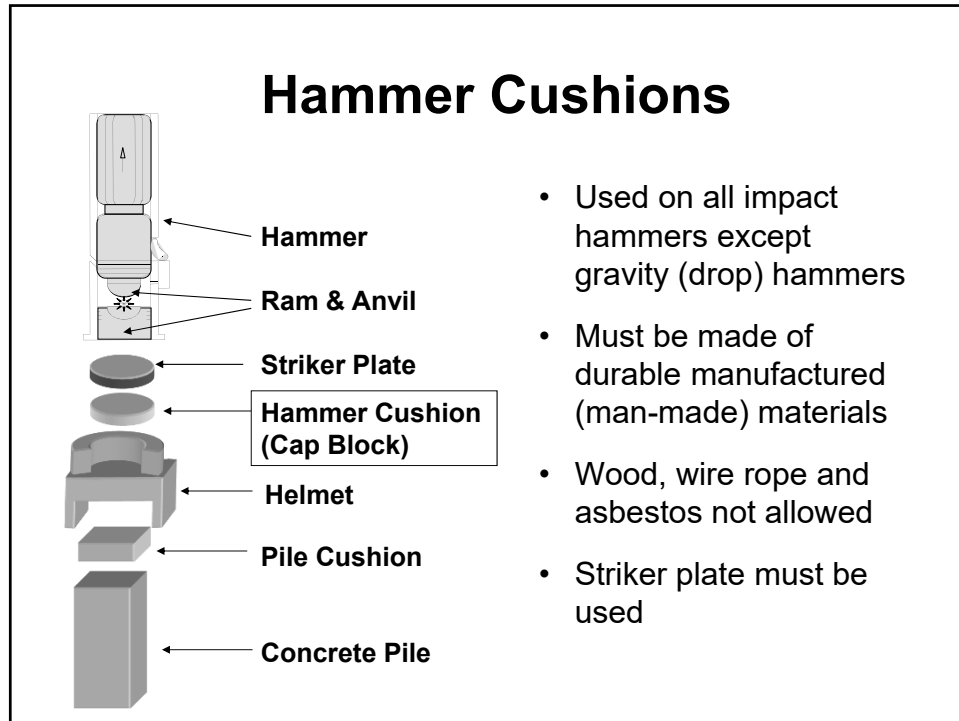
- Advantages
  - Very simple
  - No additional support equipment required
  - Lightest net weight per ft.-lb. of energy
  - Readily available (common)
- Disadvantages
  - Delivered energy variable
  - Less efficient energy transfer
  - Produces higher pile stresses
  - Dirty exhaust spray and smoke
  - Difficult to spot operation problems

## Vibratory Hammer



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

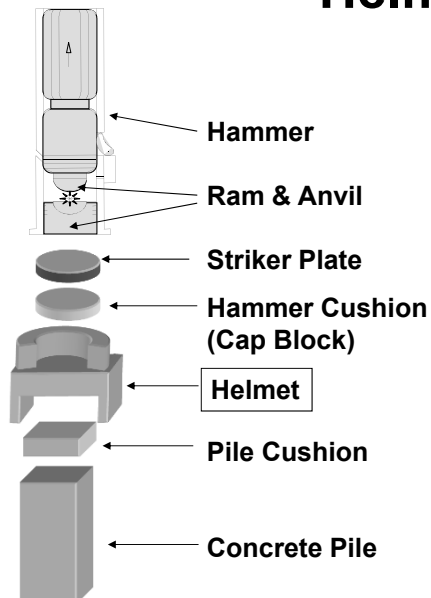
Not impact hammers.



## Hammer Cushions (Cont'd)



## Helmet

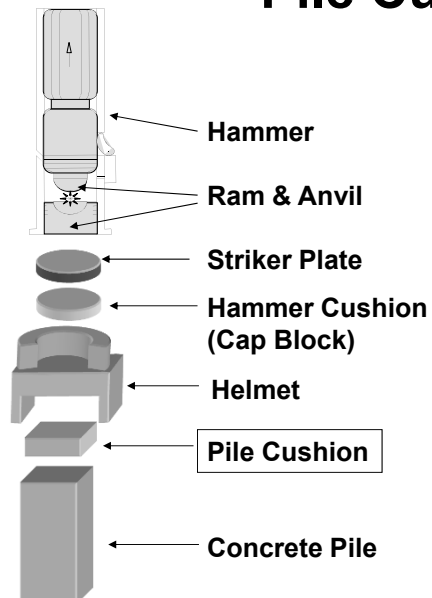


- Guided by leads, not free-swinging
- Must maintain proper alignment of hammer and pile
- Minimum 1 inch larger than pile

## Helmet (Cont'd)

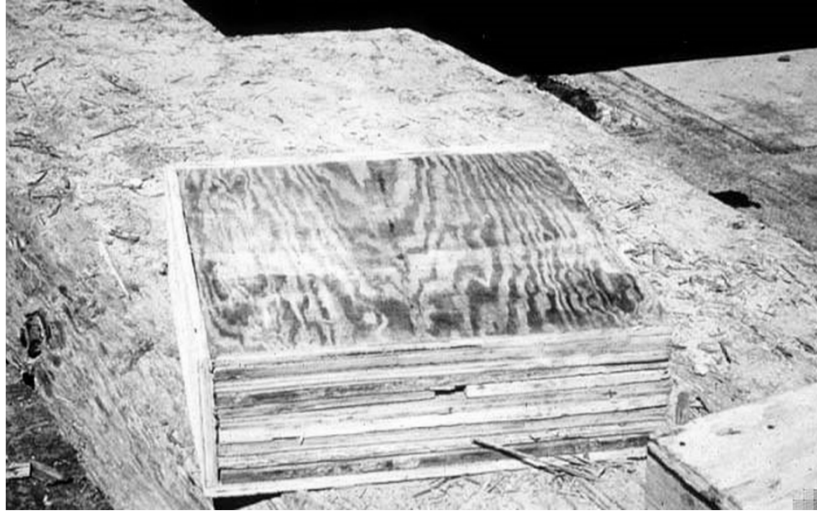


## Pile Cushion



- 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

## Pile Cushion (Cont'd)



## Pile Driving System Components – Leads

*Crane*

*Hammer*

*Cushions*

*Leads* ←

*Template*

*Special Tools*



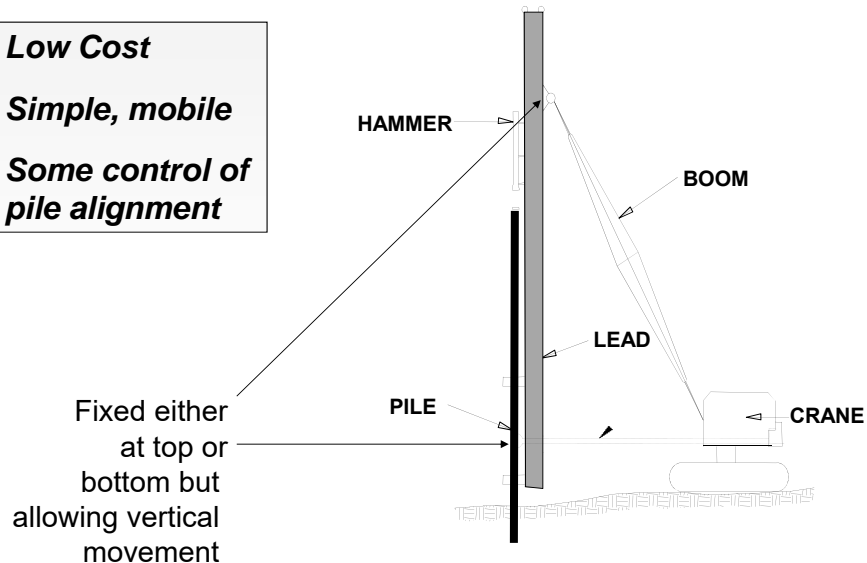
## Fixed Lead System

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



## Semi-fixed Lead System

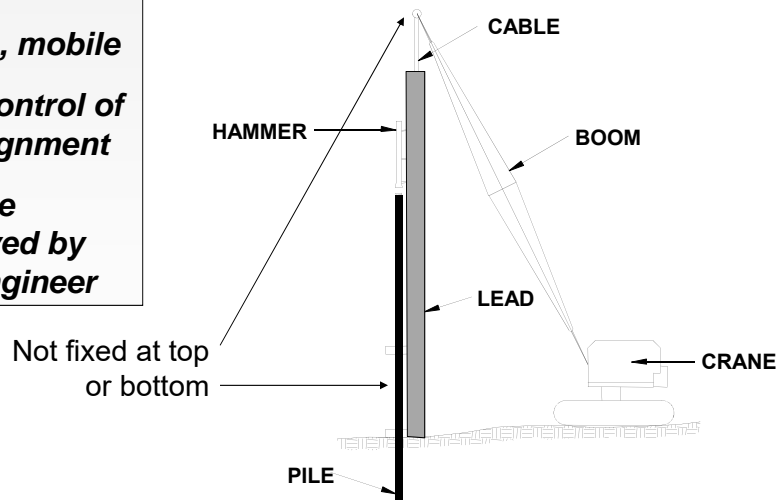
- *Low Cost*
- *Simple, mobile*
- *Some control of pile alignment*





## Swinging Lead System

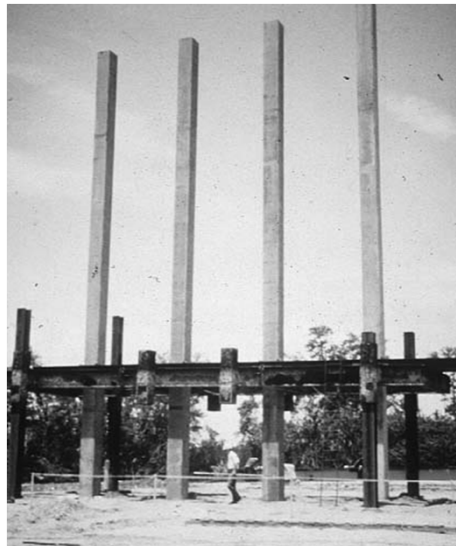
- ***Low Cost***
- ***Simple, mobile***
- ***Less control of pile alignment***
- ***Must be approved by The Engineer***



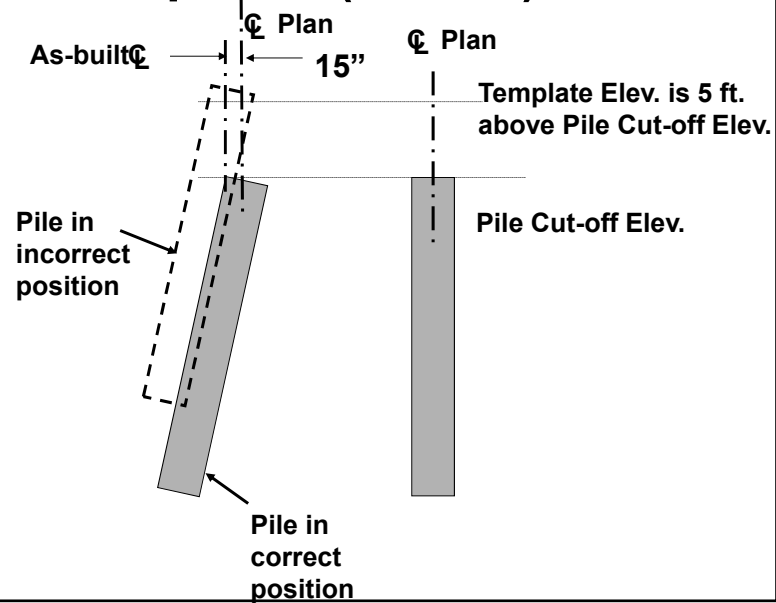
## Templates

Required for offshore leads.

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



## Templates (Cont'd)



## Special Tools

- Jets
- Drills (Preboring)
- Punches
- Followers

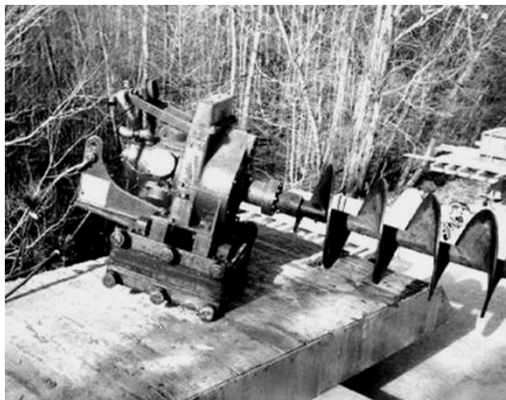


## Jets

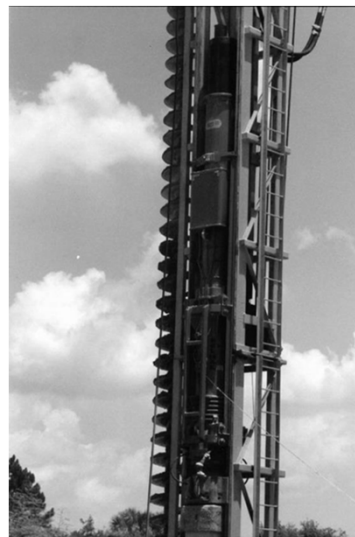


- Permitted when in the plans or approved by the Engineer in writing.
- Jetting plant must provide pressure equal to 100 psi at two  $\frac{3}{4}$  inch jet nozzles.
- Jets must be removed for the final 5 feet of pile penetration.

## Preboring

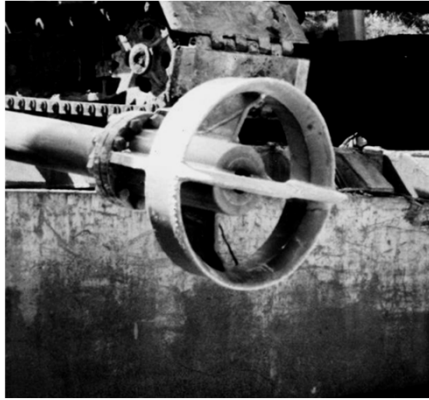


Used only when specified or with approval of the Engineer



## Punches

Aids for advancing pre-drilled holes through hard materials

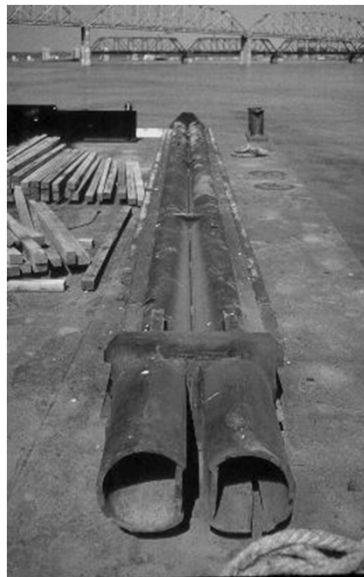


Combination Jet/Punch

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.

## 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

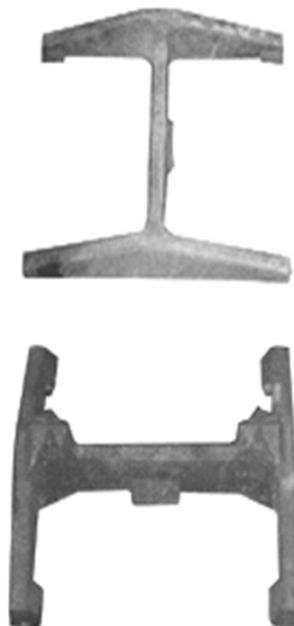
- Utilized mostly for temporary retaining systems, such as shoring, cofferdams and bulkheads
- Driven using either impact or vibratory hammers



## Pile Tip Attachments – Steel H-Pile



See Section 02520.10 (e)  
Reinforced Pile Tips

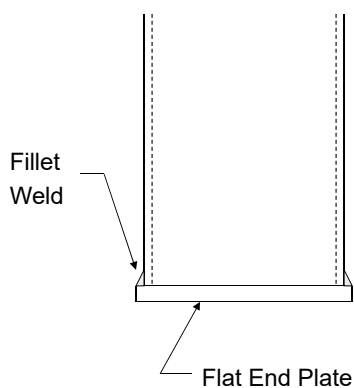


## Pile Tip Attachments – Steel Pipe Pile

See Section 02520.10 (e) Reinforced Pile Tips



## Typical Pipe Pile End Plate



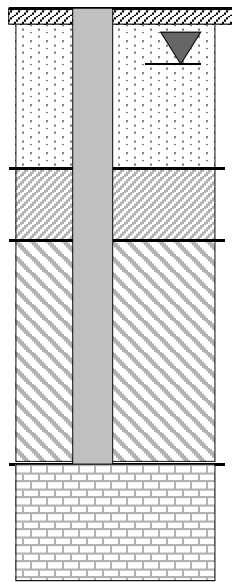


## Subsurface Information

Subsurface Information Available to the Contractor:

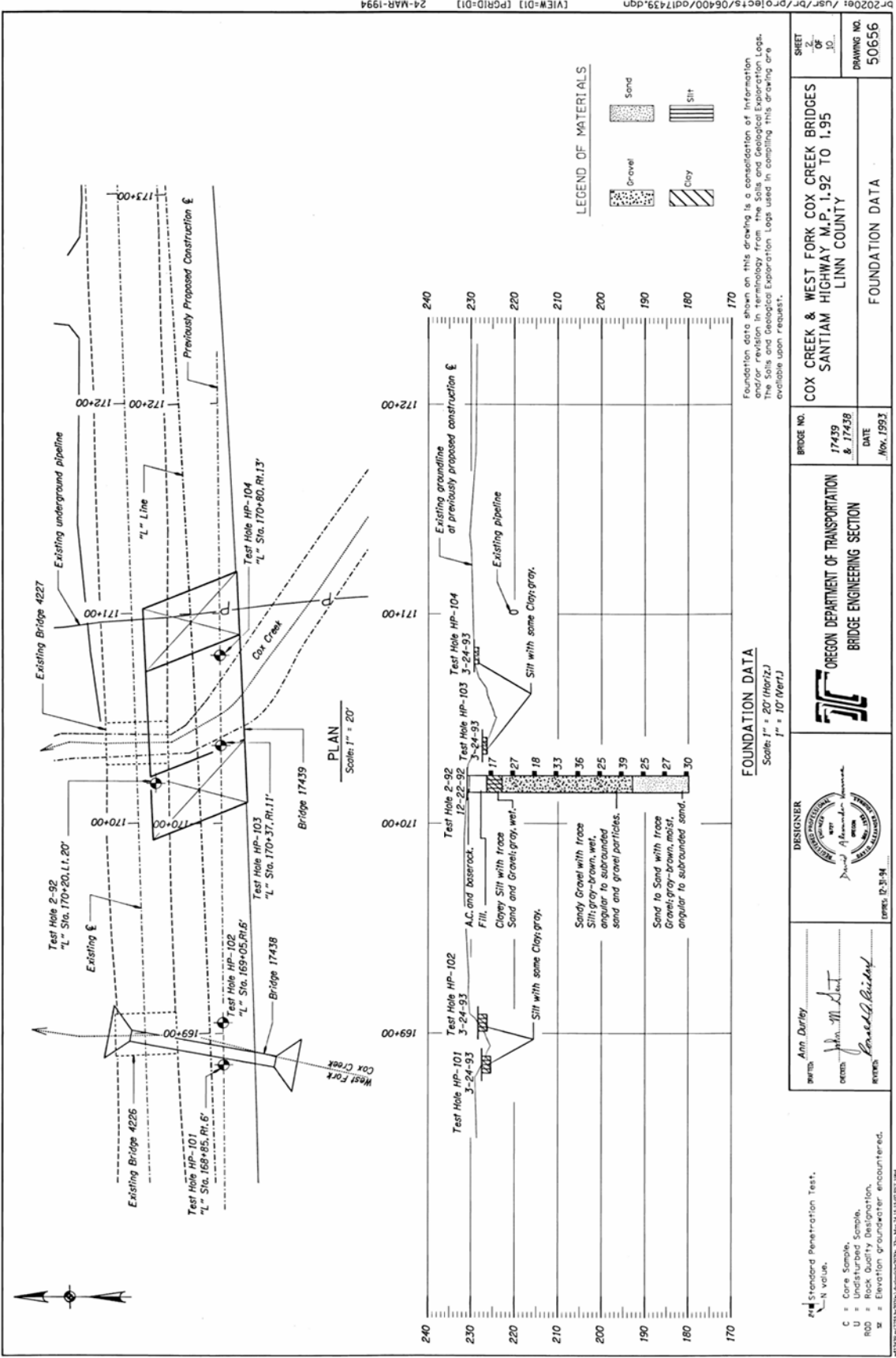
- Foundation Reports
- Foundation Data Sheets
- Drill Logs
- Groundwater Conditions
- Soil & Rock Unit Descriptions
- Material Engineering Properties

## 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

# Foundation Data Sheet



## Page 1 of 1

Project I5: Willamette River Bridge (MP192.75)				Purpose Willamette River Bridge Fnd. Inv.		Hole No.	DH-2-03					
Highway Pacific Hwy 001				County Lane		E.A. No.	PE000721-010					
Hole Location Northing: 267,481.07				Easting: 1,295,707.11		Key No.	13110					
Equipment CME 75				Driller Ernie Phillips		Start Card No.						
Project Geologist Bernie Kleutsch				Recorder John Rehm		Bridge No.	19620					
Start Date March 28, 2003				End Date March 28, 2003		Ground Elev.	131.67m					
				Total Depth 10.95m		Tube Height						
<b>Test Type</b> "A" - Auger Core "X" - Auger "C" - Core, Barrel Type "N" - Standard Penetration "U" - Undisturbed Sample "T" - Test Pit				<b>Rock Abbreviations</b> <u>Discontinuity</u> J - Joint F - Fault B - Bedding Fo - Foliation S - Shear <u>Shape</u> Pl - Planar C - Curved U - Undulating St - Stepped Ir - Irregular <u>Surface Roughness</u> P - Polished Sl - Slicksided Sm - Smooth R - Rough VR - Very Rough				<b>Typical Drilling Abbreviations</b> <u>Drilling Methods</u> WL - Wire Line HS - Hollow Stem Auger DP - Drill Fluid SA - Solid Flight Auger CA - Casing Advancer HA - Hand Auger <u>Drilling Remarks</u> LW - Lost Water WR - Water Return WC - Water Color D - Down Pressure DR - Drill Rate DA - Drill Action				
Depth (meters)	Test Type, No.	Percent Recovery	Soil Driving Resistance	Rock Discontinuity Data Or RQD%	Percent Natural Moisture	<b>Material Description</b> SOIL: Soil Name, USCS, 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.	<b>Unit Description</b>	Graphic Log	Drilling Methods, Size and Remarks	Water Level/ Date	Backfill/ Instrumentation	
0	C1	46.0				C-1 (0.00 - 1.83) GRAVEL and COBBLES up to 3.5 inch size; GW; Gray; Nonplastic; fines washed away; (Alluvium)	0 - 0.91 AC then GRAVEL; GW; gray; nonplastic (Fill);		HQT B coring.			
1							0.91 - 3.35 GRAVEL and COBBLES up to 3.5 inch size; GW; gray; nonplastic; subrounded to subangular (Alluvium);					
2	C2	39.0				C-2 (1.83 - 3.35) GRAVEL up to 3 inch size; GW; Gray; Nonplastic; (Alluvium)	3.35 - 6.39 BASALT; gray to brown; fresh to 6.39m then moderately weathered; (R2) to (R3); wide jointed; spacing up to 4 feet; calcite in joints; silt in joints in last 0.3m (Intrusive Basalt);					
3												
4	C3	100.0	RQD = 98%			C-3 (3.35 - 4.87) BASALT; Gray; Fresh; Medium Hard (R3); RQD = 98%; wide jointed with spacing up to 4 feet; calcite mineralization along healed joints; unconfined compression = 40,274 kPa; Intrusive Basalt	6.39 - 7.3 Interbedded tuffaceous SANDSTONE; brown grading to gray; predominately decomposed to fresh; (R0) to (R3); very close to moderately close jointed (Eugene Fm);					
5	C4	100.0	RQD = 74%			C-4 (4.87 - 6.39) BASALT; Gray to 6.08m then Light Brown; Fresh then Moderately Weathered; Soft (R2); RQD = 74%; wide jointed with spacing to 4 feet to 6.08m then very close jointed; calcite in healed joints; yellow silt in joints below 6.08m; unconfined compression = 9,791 kPa; Intrusive Basalt	7.3 - 10.95 LAPILLI TUFF; green gray; fresh; (R2) to (R3); wide jointed; calcite cemented clasts (Eugene Fm);					
6												
7	C5	100.0	RQD = 70%			C-5 (6.39 - 7.91) Tuffaceous SANDSTONE/SILTSTONE/LAPILLI TUFF to 7.3m 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	10.95 End of Hole					
8	C6	88.0	RQD = 93%			C-6 (7.91 - 9.43) LAPILLI TUFF; Green Gray; Fresh; Medium Hard (R3); RQD = 93%; wide jointed; calcite cemented; unconfined compression = 39,329 kPa; Eugene Fm						
9												
10	C7	100.0	RQD = 100%			C-7 (9.43 - 10.95) LAPILLI TUFF; Green Gray; Fresh; Soft (R2); RQD = 100%; wide jointed; calcite cemented; unconfined compression = 24,105 kPa; Eugene Fm						
11												
12												

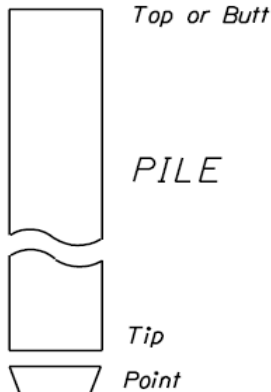
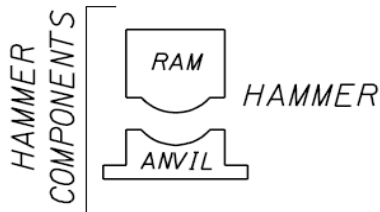
# PILE AND DRIVING EQUIPMENT DATA

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

MATERIAL	THICKNESS (mm.)	AREA (mm <sup>2</sup> )
----------	-----------------	-------------------------

MATERIALS	
TOTAL THICKNESS (mm.)	AREA (mm <sup>2</sup> )
MODULUS OF ELASTICITY (E): (MPa)	
COEFFICIENT OF RESTITUTION (e)	

ALL COMPONENTS	WEIGHT (KN)	MODIFICATIONS
----------------	-------------	---------------

CUSHION MATERIALS		AREA (mm <sup>2</sup> )
NO OF LAYERS	THICKNESS (EACH) (mm.)	TOTAL THICKNESS (mm.)
MODULUS OF ELASTICITY (E): (MPa)		COEFFICIENT OF RESTITUTION (e)

PILE TYPE & SIZE	Weight (KN/m)
LENGTH IN LEADS (m)	
WALL THICKNESS (mm)	TAPER

NOMINAL PILE RESISTANCE (KN)	ACCEPTANCE BY WAVE EQUATION <input type="checkbox"/> Yes <input type="checkbox"/> No
------------------------------	--

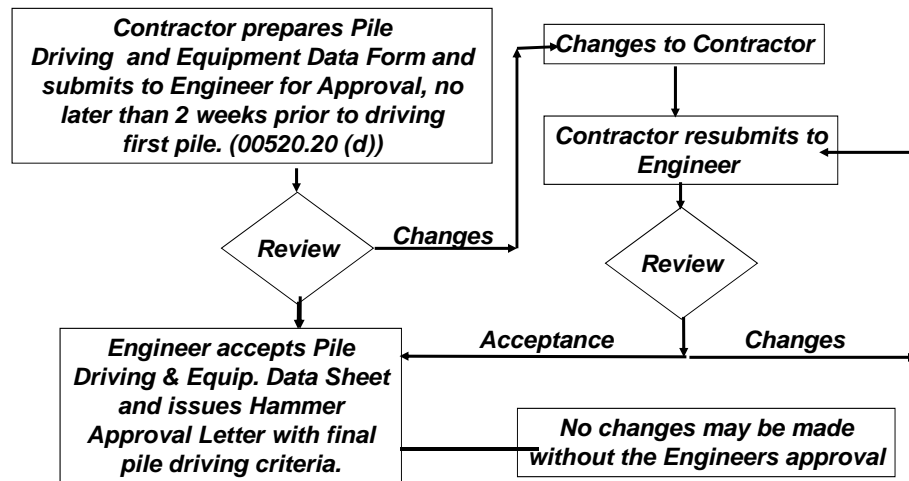
DESCRIPTION OF SPLICE
-----------------------

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
---------------	------

## Pile Hammer Acceptance Process



## 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



## INTEROFFICE MEMO

TECHNICAL SERVICES BRANCH

Bridge Section

Office Phone: (503) 986-4200

Fax Phone: (503) 986-3407

**November 18, 2004**

File Code:

**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) verses 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**

<b>STROKE (ft)</b>	<b>BLOWS/INCH</b>
10	15
10.5	13
11	11
11.5	10

**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**

<b>STROKE (ft)</b>	<b>BLOWS/INCH</b>
7.0 (max)	3
6	4
5.2	5

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 $\frac{3}{4}$  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.*



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01/14/99 11:43:59 AM /usr/bin/ps -ef | grep [PGID=E1] [VIEW=PLAN] 31-MAR-1994

SHEET 1 OF 10	DRAWING NO. 50655
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# General Notes

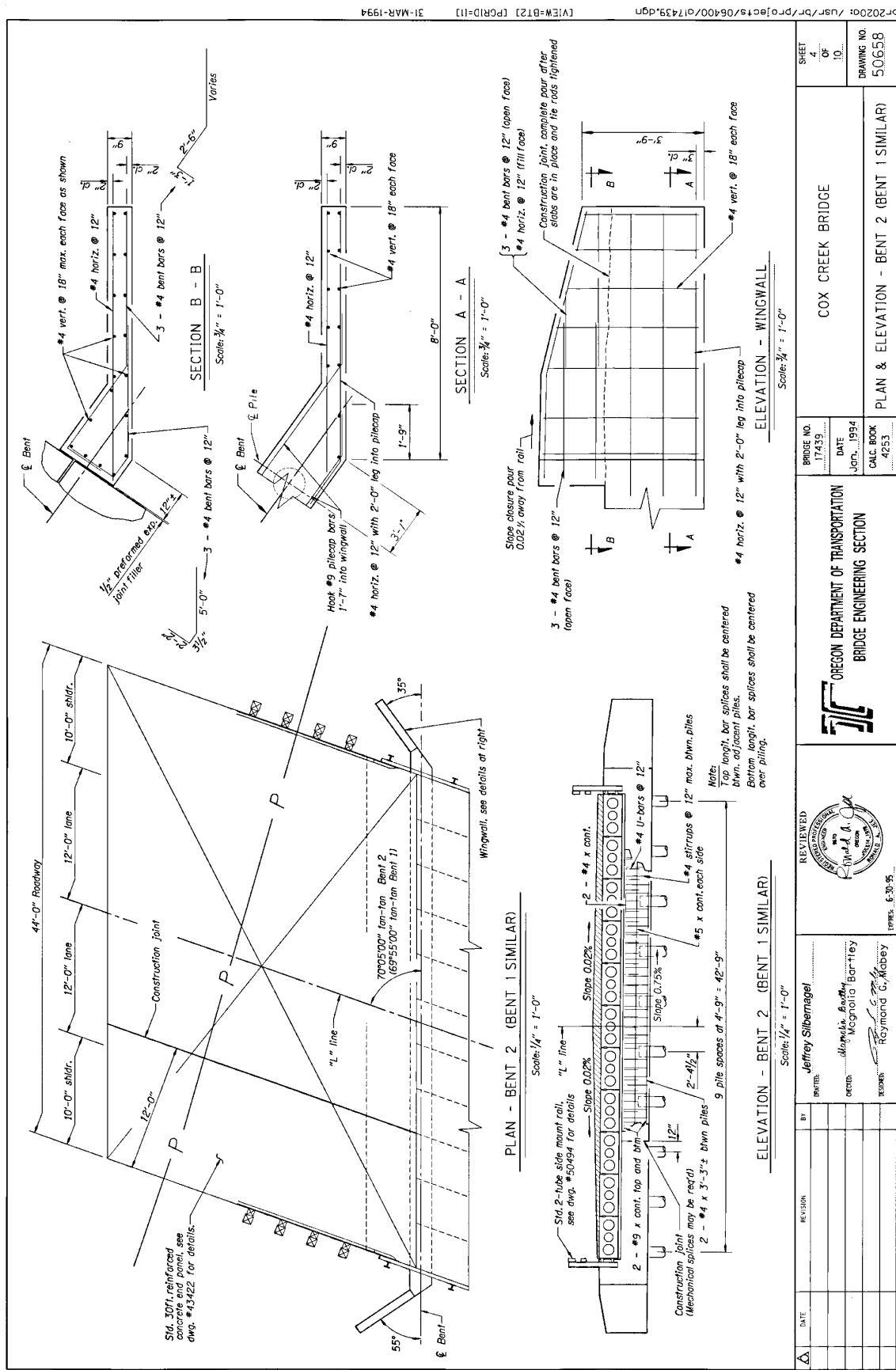
*Steel piling conforming to ASTM 252, grade 3.*

*All piling shall be PP12 $\frac{3}{4}$  x 0.25 driven closed ended to an ultimate capacity of 270 kips per pile.*

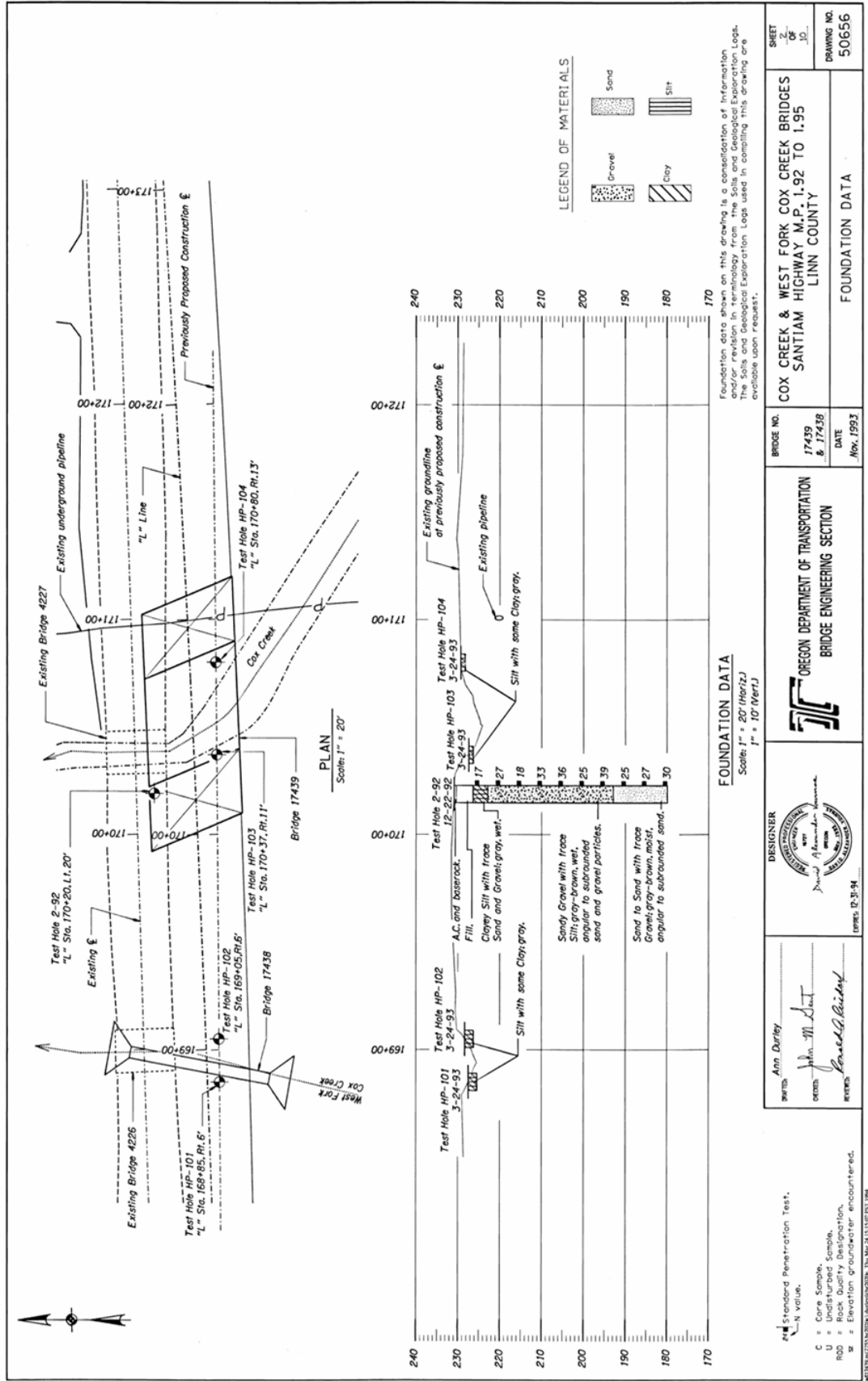
*Pile tip elevation for minimum pile penetration for each bent shall be elevation 210.*

*All piling shall be driven to the ultimate capacity using driving criteria developed from a wave equation analysis.*

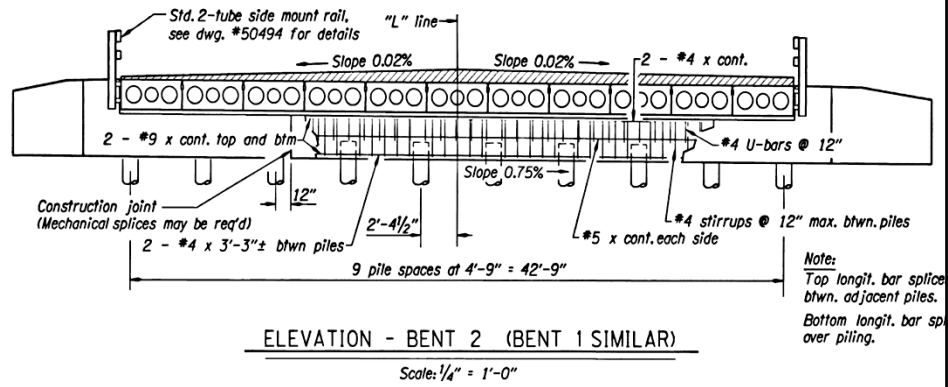
# Plan & Elevation Bent 2 (Pile Layout)



# Foundation Data Sheet



## Bent 2 – Elevation



## Record Keeping

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

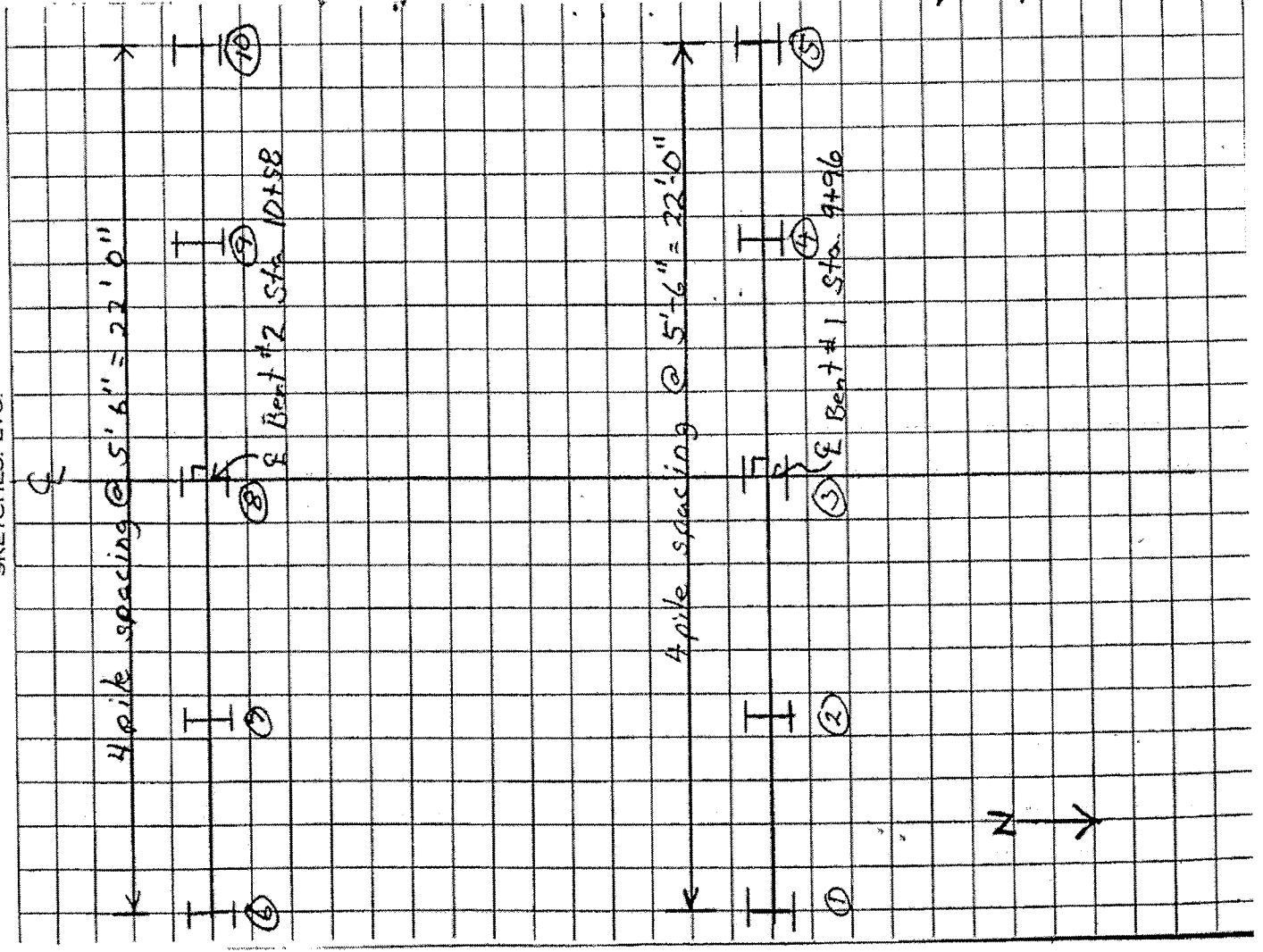


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# Pile Record Book

Shows pile layout and numbering system used.

SKETCHES, ETC.



# 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.

Test Pile Bent #123480 Data

Foot-Feet	Blowcount	SKETCHES, ETC.
0-1	6	
1-2	3	
2-3	2	
3-4	2	
4-5	2	
5-6	2	
6-7	2	
7-8	4	
8-9	3	
9-10	3	
10-11	11	
11-12	10	
12-13	9	
13-14	10	
14-15	11	
15-16	21	
16-17	51	Stopped driving 51 stroke
17-18		
18-19		
19-20		
20-21		
21-22		
22-23		
23-24		
24-25		
25-26		
26-27		
27-28		
28-29		
29-30		
30-31		

Pile # 4  
Date: 1/22/80  
Inspector: RHE  
Recorder: B. Ho





## 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

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

### Piles and Equipment Arrive On Site

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

### Prestressed Concrete Piles (00520.44)

- |                              |                             |                             |  |
|------------------------------|-----------------------------|-----------------------------|--|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | <input type="checkbox"/> NA | 18. During delivery, are the piles being lifted by the correct number of pick points and at the correct locations?   |
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | <input type="checkbox"/> NA | 19. Do the piles have the required information on the pile (stamp, casting date, pile #, length, prestressed yard #)?  |
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | <input type="checkbox"/> NA | 20. Is the casting date older than 21 days for normal installation and 30 days for exposure to seawater and sulfate soils?   |
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | <input type="checkbox"/> NA | 21. Does the length/cross-section/size/prestress configuration match the contract documents?   |
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | <input type="checkbox"/> NA | 22. Did you physically measure the piles?  |
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | <input type="checkbox"/> NA | 23. Are the lifting eyes removed and coated with epoxy?  |
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | <input type="checkbox"/> NA | 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.) |
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | <input type="checkbox"/> NA | 25. Are prestress strands cut off below the surface of concrete?   |
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | <input type="checkbox"/> NA | 26. For storage on job site, is dunnage placed at correct lifting positions and is it placed so that it won't settle?  |
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | <input type="checkbox"/> NA | 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.                           |

## Begin Pile Driving

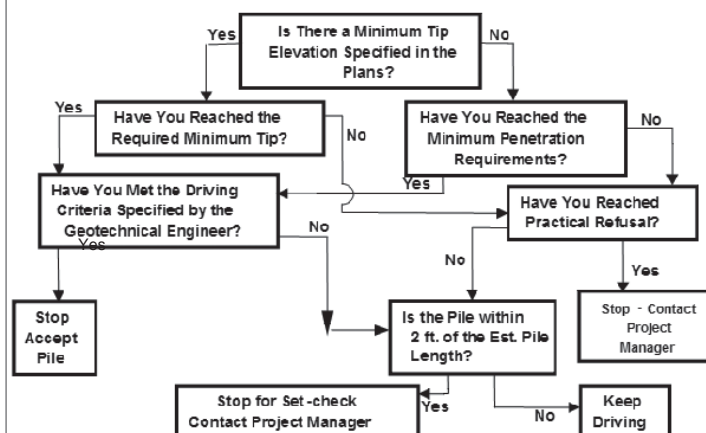
- |                              |                             |                             |   |
|------------------------------|-----------------------------|-----------------------------|---|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | <input type="checkbox"/> NA | 28. Is the Contractor using the approved hammer system provided in the Pile & Driving Equipment Data Sheet?   |
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | <input type="checkbox"/> NA | 29. Has the set period elevation been determined and marked on pile, if required by the contract documents? 00520.42(d)   |
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | <input type="checkbox"/> NA | 30. Have the horizontal and vertical pile positions been verified at the start of driving?  |
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | <input type="checkbox"/> NA | 31. If a set period is specified, has the hammer been warmed up prior to re-driving? 00520.42(d)  |
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | <input type="checkbox"/> NA | 32. If PDA Testing is included, has the end of driving criteria been issued by the Geotechnical Engineer?   |
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | <input type="checkbox"/> NA | 33. Has all available pre-driving data been entered into the Pile Record Book?  |
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | <input type="checkbox"/> NA | 34. Is the saximeter being used to record stroke?   |
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | <input type="checkbox"/> NA | 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? 00520.41(e) |
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | <input type="checkbox"/> NA | 36. If concrete piles require field splicing, is it in accordance with 00520.44?  |
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | <input type="checkbox"/> NA | 37. If steel piles require splicing, is it in accordance with 00520.43(f) and (g)?  |
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | <input type="checkbox"/> NA | 38. If included in the contract documents, is the proper number of test piles being recorded?   |
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | <input type="checkbox"/> NA | 39. If using a pile cushion for concrete pile, does it need to be replaced? 00520.20(c)(1)  |

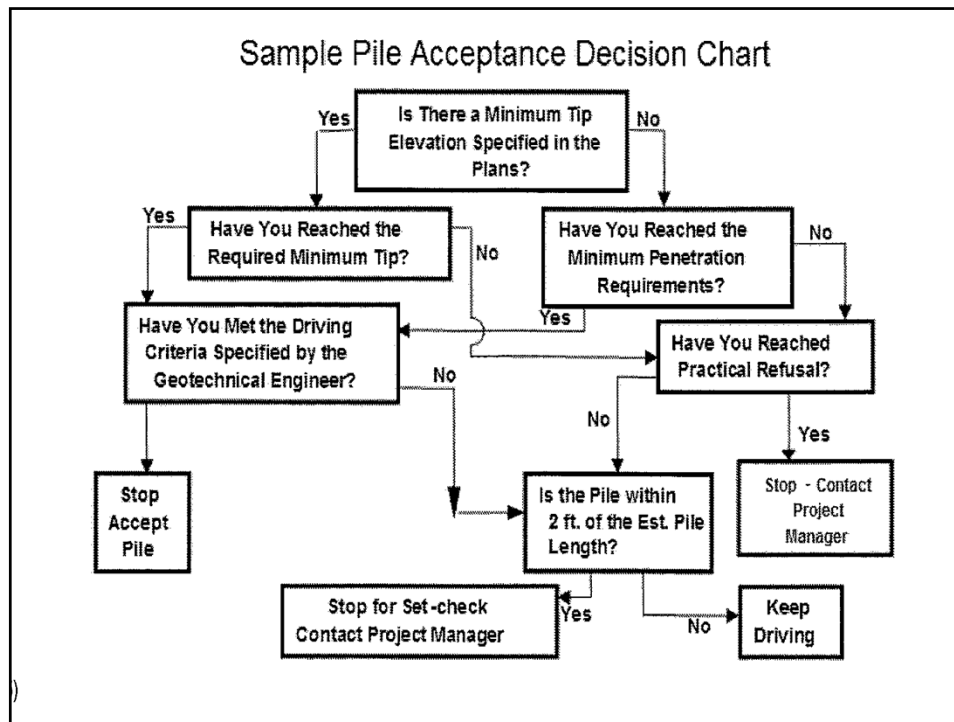
## When to Stop

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

NOTES / COMMENTS

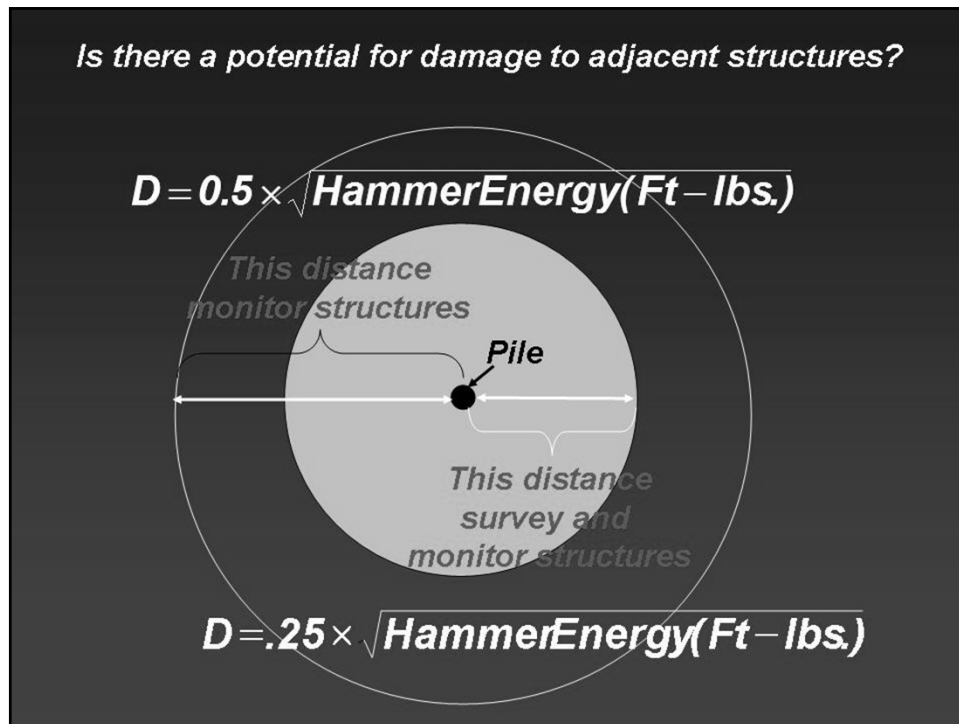
Sample Pile Acceptance Decision Chart





## 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):

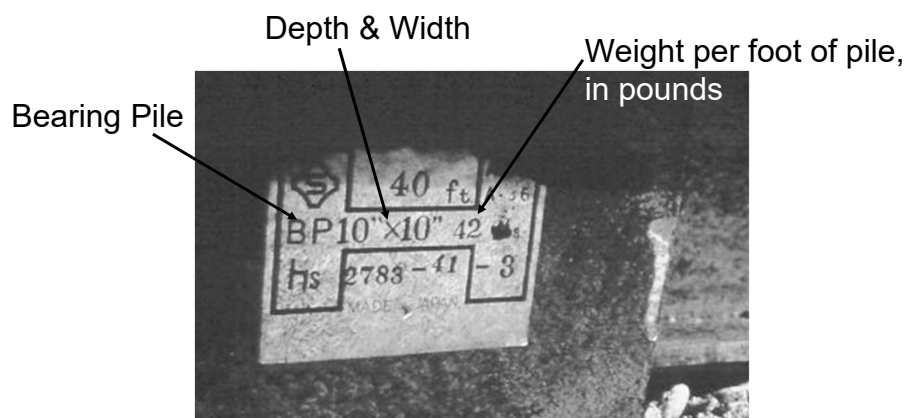
- Axially aligned with the hammer and pile
- Guided by the leads
- Not free-swinging
- Cut squarely for steel and timber
- Plane and perpendicular to longitudinal axis for concrete piles

#### Hammer Cushion:

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

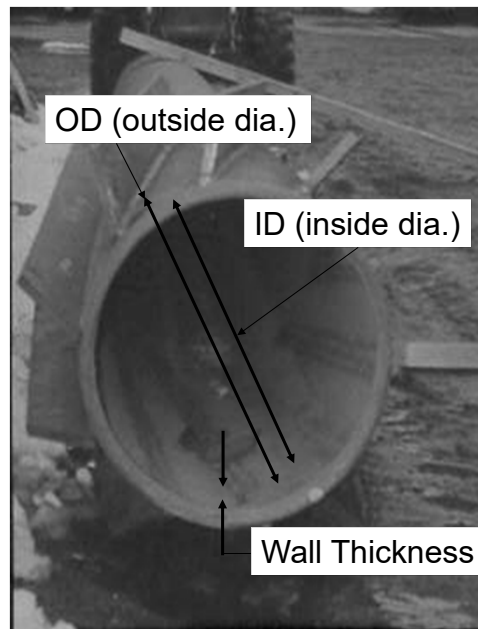
## Steel Piles

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



## Steel Pipe Piles

Compare diameter, length and wall thickness to plan details.



## Steel Pipe Piles

Verify Open End or Closed End.

### **Closed End**

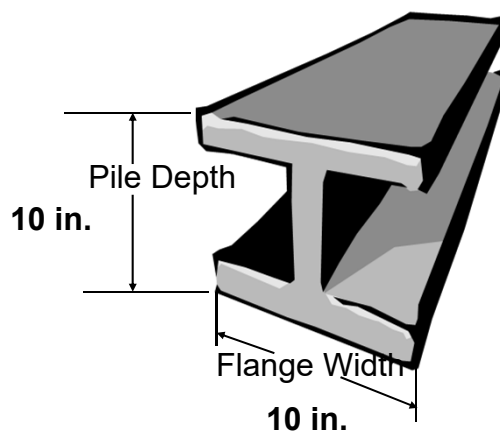
Verify the bottom plate is the correct diameter and thickness and welded per the plans.





## Steel H Piles

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

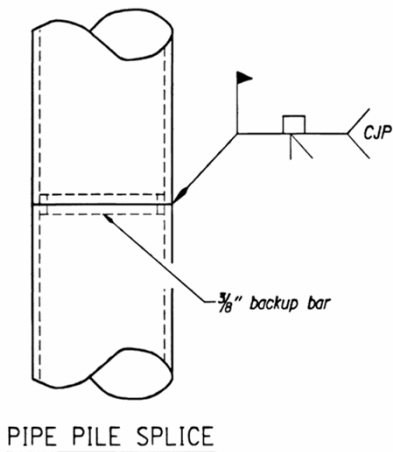


## Steel H Piles



## 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.



Backing Bar  
(rings)



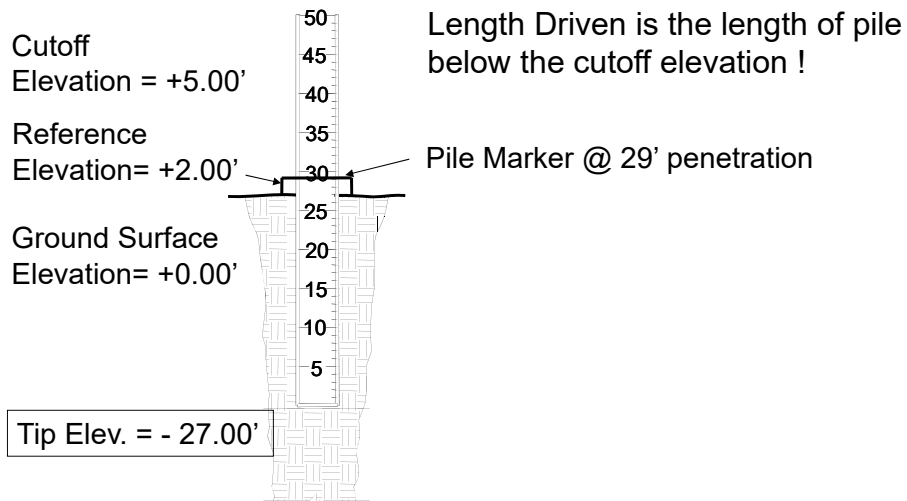
## Pile Splice Measurement 00520.80 (f)(1)

- 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



## Saximeter

Method to determine  
hammer stroke in the  
field



## Calculating Stroke Heights

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

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

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 = 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

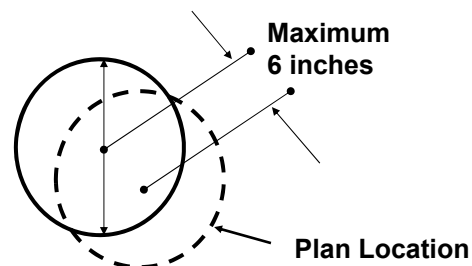
- Tends to result in shorter pile lengths.



## Horizontal Tolerance for Driving 00520.41 (f)

Within 6" of plan location

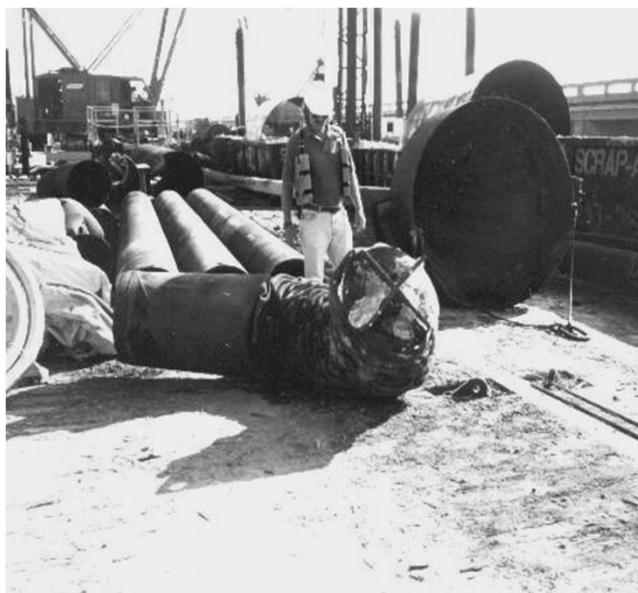
At least 4" from edge  
of cap



## Common Problems – Open End Diesel

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

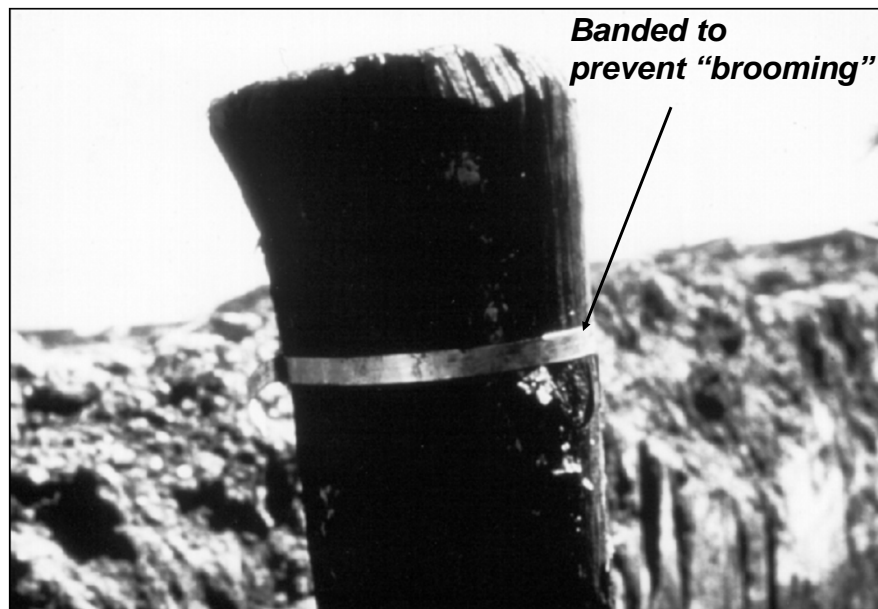
## Steel Piles



## Steel Piles

Typical causes of damage	Possible indicators during driving	Types of damage
<ul style="list-style-type: none"> <li>• Transporting and Lifting</li> <li>• Low Steel Strength</li> <li>• Hard Driving (Compression)</li> <li>• Welding</li> <li>• Splices</li> </ul>	<ul style="list-style-type: none"> <li>• Pile moving out of position during driving</li> <li>• Abrupt blow count change</li> <li>• Observed pile damage near the pile head</li> </ul>	<ul style="list-style-type: none"> <li>• Bending</li> <li>• Buckling</li> <li>• Accordion</li> <li>• Splitting</li> </ul>

## Timber Piles

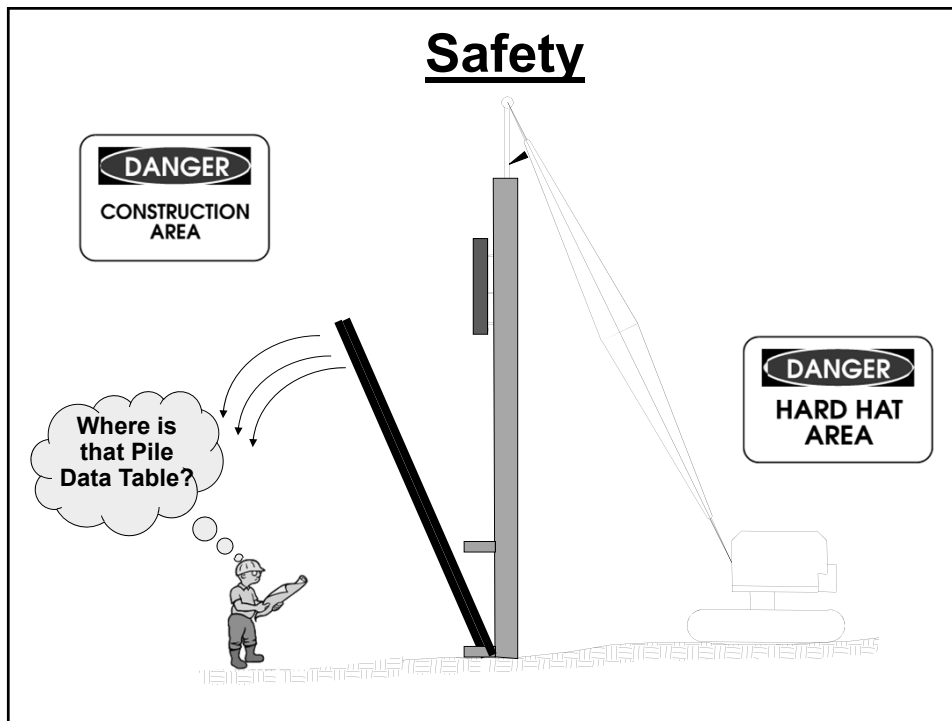




## Timber Piles

Typical causes of damage	Possible indicators during driving	Types of damage
<ul style="list-style-type: none"> <li>• Transporting</li> <li>• Knots and natural defects</li> <li>• Handling</li> <li>• Driving</li> </ul>	<ul style="list-style-type: none"> <li>• Pile moving out of position during driving</li> <li>• Abrupt blow count change</li> <li>• Appearance</li> </ul>	<ul style="list-style-type: none"> <li>• Splintering</li> <li>• Cracking</li> <li>• Shearing</li> <li>• Brooming (head &amp; tip)</li> </ul>

## Safety



## 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? \_\_\_\_\_

**US20: Lake Creek Bridge Section**  
**Grading, Drainage, Structures, Paving & Signing**

**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:

Location	No.	Length (m)	Kind
#19184 Lake Creek Bridge	16	6.61	PP 324 x 9.5 (Grade 3)

**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 preborings 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.



# Oregon

Theodore R. Kulongoski, Governor

Department of Transportation  
Highway Division  
Technical Services  
Geo/Hydro Section  
355 Capitol St. NE, Room 318  
Salem, OR 97301-3871  
Telephone (503) 986-3378  
FAX (503) 986-3407

March 10, 2005

File Code:

TO: Shane Ottosen  
Project Manager

FROM: Bruce Novakovich  
Geotechnical Design Engineer

SUBJECT: US20: Lake Creek Bridge Section  
Lake Creek Bridge (Br. #19184)  
ICE 42-S Pile Driving Hammer  
Contract 13068  
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

Stroke (m)	Stroke (ft)	BLOWS/IN OR 25 mm
2.59	8.5	9
2.44	8.0	11
2.29	7.5	13
2.13	7.0	15

Table 1

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

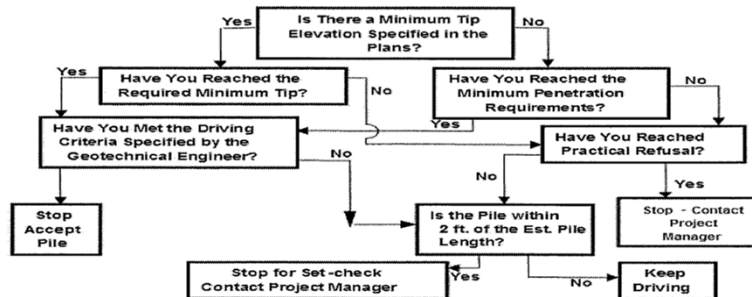
If any problems are encountered during pile driving I can be contacted at 503-986-3378.

c: Matts 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? \_\_\_\_\_

Sample Pile Acceptance Decision Chart



i)

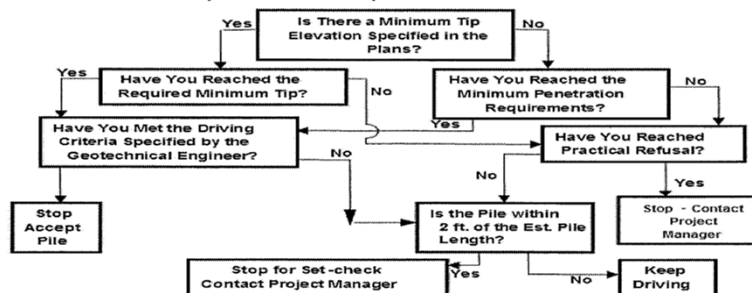
## Pile Driving Example

- 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

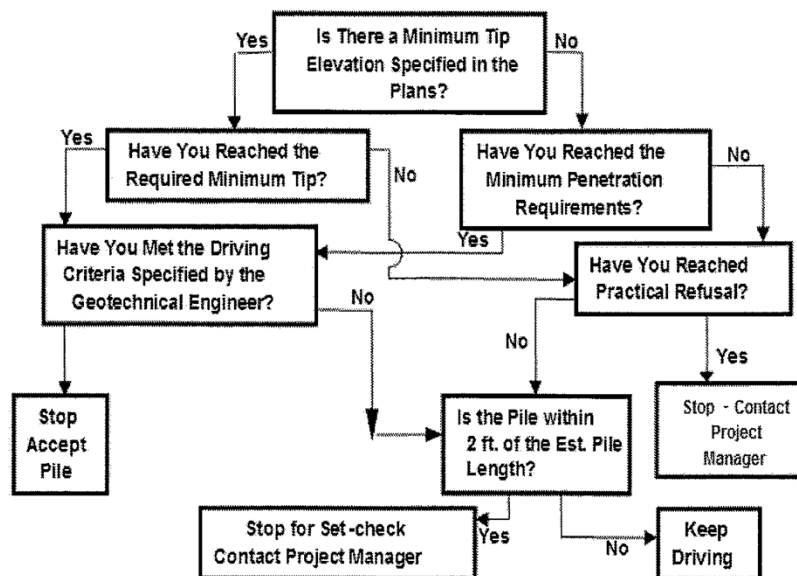
- BPI measured at 10 with required BPI of 13. Pile tip is at minimum tip elevation and is within 2' of estimated pile length. What do you do? \_\_\_\_\_

Sample Pile Acceptance Decision Chart



i)

Sample Pile Acceptance Decision Chart

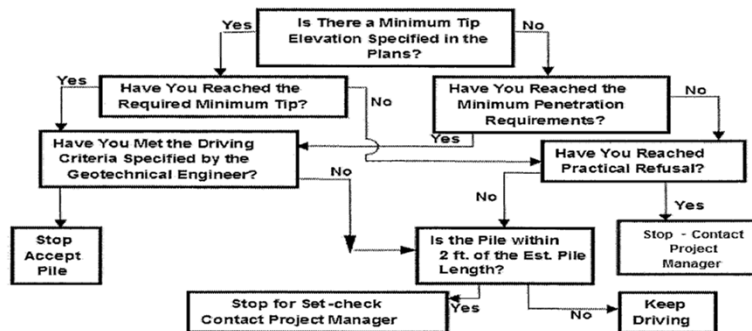


)

## 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



i)



19184

Oregon Department of Transportation



# PILE RECORD BOOK

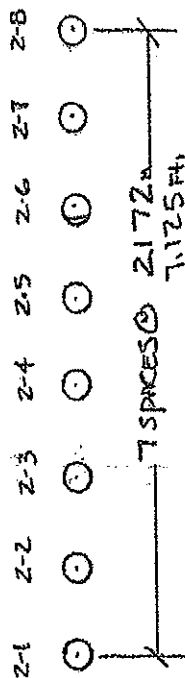
BRIDGE NAME US20: LAKE CREEK		BRIDGE NO. 19184
PROJECT NAME (SECTION) US20: LAKE CR BRIDGE SECTION		CONTRACT NO. C13068
HIGHWAY SANTIAM	COUNTY JEFFERSON	
PROJECT MANAGER SHANE OTTSEN	YEAR 2005-2006	F.A. PROJECT NO. BRF-STP-5016(023)

PP 324 X 9.5 ICE 42-5

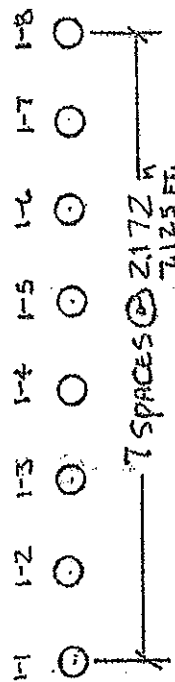
STROKE (M)	STROKE (FT)	BLOWS/11" OR 25 MM
2.59	8.5	9
2.44	8.0	11
2.29	7.5	13
2.13	7.0	15

DRIVEN OPEN ENDED WITH INTERIOR  
PLUG 3 METERS ABOVE TIP

## U520: LAKE CREEK BRIDGE



### BENT 2



### BENT 1

PP 324 X 9.5 ASTM 252, GRADE 3

BENT 1 MIN. TIP = ELEV. 1042.5

BENT 2 MIN. TIP = ELEV. 1044.5

Q<sub>ULT</sub> = 2135 KN PER PILE  
ULTIMATE CAPACITY

BRIDGE OR PROJECT NAME									
U520: LAKE CR BRIDGE									
HAMMER DESCRIPTION (MAKE, TYPE, SIZE)									
ICE MODEL 425 DIESEL SERIAL # 257									
LOCATION	ORIG. ORDER LEN.	REV. ORDER LEN.	DEL. LEN.	FRESH HEAD	LEN. LEADS	SPLICES	CUT OFF	DRIVEN LEN.	
						NO	PAY	NO	PAY
1-1	6.61M		7.62M	25'	25'		1.3M	7.16M	
1-2					25'		2.13M	5.5M	
1-3					25'		1.67M	5.94M	
1-4					25'		2.32M	5.3M	
1-5					25'		2.17M	4.85M	
1-6					25'	2.0M	2.28M	7.62M	
1-7					25'		1.6M	7.01M	
1-8					25'		2.46M	5.16M	

BRIDGE NO.		CONTRACT NO.		INSPECTOR(S)	
19184		C13068		JOHN CEPEDA	
KIND OF PILING		DATE		REMARKS AND SKETCHES	
PP 324 X 9.5 GRADE 3		7/11/05		HEAT # 45225	
CUT-OFF ELEV.	1047.51	SET	15 BPI	INSPECTOR	
TIP ELEV.	1040.35	BEARING	7 <sup>0</sup> STROKE		
			25 BPI	7/8/05	HEAT # 45225
	1047.46		7 <sup>0</sup> STROKE	Kept	
	1041.36		17 BPI	7/8/05	HEAT # 45225
	1047.41		7 <sup>0</sup> STROKE	Kept	
			18 BPI	7-8-05	HEAT # 45225
	1047.34		2 <sup>0</sup> STROKE	Kept	
			15 BPI	7/11/05	HEAT # 45225
	1047.28		7 <sup>0</sup> STROKE	Kept	
			15 BPI	7/11/05	HEAT # 45225
	1047.18		7 <sup>0</sup> STROKE	Kept	spliced 2.28M to 7.62 OR 25 ft
			17 BPI	10-19-05	HEAT # 44652
	1047.07		7 <sup>0</sup> STROKE	Kept	
			20 BPI	10-19-05	HEAT # 44652
	1046.97		7 <sup>0</sup> STROKE	Kept	

BRIDGE OR PROJECT NAME										BRIDGE NO.		CONTRACT NO.		INSPECTOR(S)		
US 20: LAKE C.R. BRIDGE										19184		C13068		JOHN CEPEDA		
HAMMER DESCRIPTION (MAKE, TYPE, SIZE)										KIND OF PILING						
ICE MODEL 425 DIESEL										PP324 X 9.5		GRADE 3				
LOCATION	ORIG. ORDER LEN.	REV. ORDER LEN.	DEL. LEN.	FRESH HEAD	LEN. IN LEADS	SPICES		CUT OFF	DRIVEN LEN.	CUT-OFF ELEV.	1044.5 TIP ELEV.	SET	BEARING	DATE	INSPECTOR	REMARKS AND SKETCHES
						PAY	NO PAY									
2-1	6.61H		7.62H		25'				5.33H	1049.15	1043.82	17 BPI	7° STROKE	7-12-05	Yeph	HEAT # 44652
2-2					25'			2.28H	5.18H		1043.90	18 BPI	7° STROKE	7-12-05	Yeph	HEAT # 45225
2-3					25'			2.43	4.72		1044.25	15 BPI	7° STROKE	7-12-05	Yeph	HEAT # 45225
2-4					25'			2.89		1048.95	1043.56	15 BPI	7° STROKE	7-12-05	Yeph	HEAT # 45225
2-5					25'			2.89	4.72		1044.13	15 BPI	7° STROKE	7-12-05	Yeph	HEAT # 45225
2-6					25'			6.70	6.76		1041.97	15 BPI	7° STROKE	7-12-05	Yeph	HEAT # 45225
2-7					25'			3.42	4.20		1048.65	15 BPI	7° STROKE	10-19-05	Yeph	HEAT # 44652
2-8					25'			2.22	5.40		1048.48	21 BPI	7° STROKE	10-19-05	Yeph	HEAT # 44652

## RECORD PUE

SKETCHES, ETC

Foot	Blind	Stroke
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RECORD FILE 1-6

**SKETCHES, ETC**

FOOT  
BLOW  
/ FT  
SMOKE

NO RECORD DONE ON PILE  
EACH PILE WERE CORDED TO  
MINIMUM TIP BLW. 24" CASING  
WAS INSTALLED THEN PILE  
WAS DRIVEN UNTIL WE ACHIEVED  
MINIMUM TIP BLW.  
CONTRACTOR THEN PLACED CLSM  
BETWEEN PILE AND CASING.