SDDOT Standard Specifications

Section 510

CHAPTER 5
PILE DRIVING

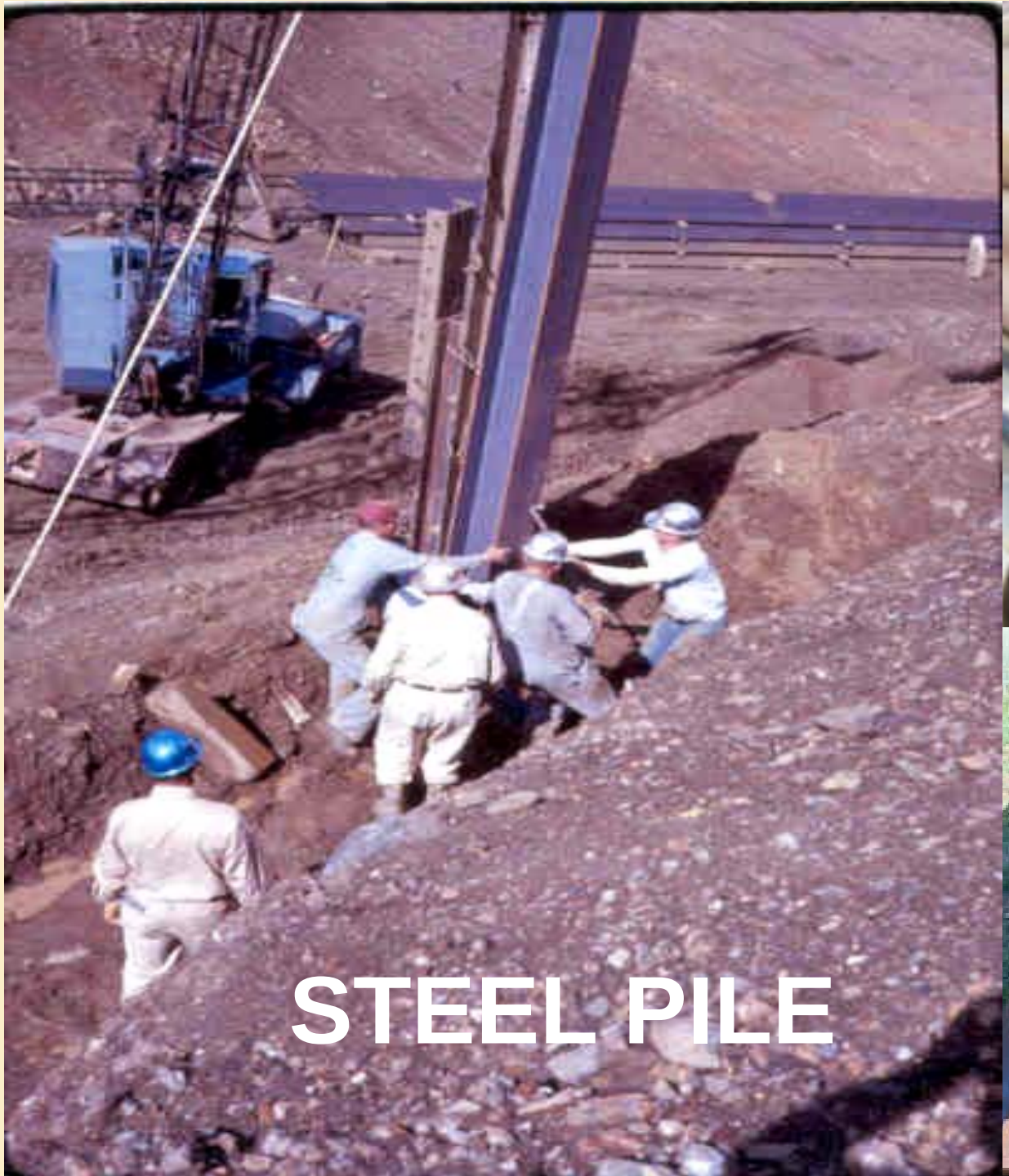
PILE DRIVING CHECKLIST

- U:\op\inspection list
- Structures Manual, Chapter 5
  - Pages 5-54 to 5-96
- USE IT, LEARN IT, KNOW IT!!!!!

PILE TYPES:

- Timber
- Steel
- Concrete

TIMBER PILE


STEEL PILE


Pipe Pile


H-Pile

STEEL PIPE PILE

CONCRETE PILE


10/15/2013

INSPECTION OF STEEL PILES

- Certificate of Compliance/Mill Test Report
  - Chemical and Physical Tests
  - Heat Numbers
  - Made in the USA
  - (Example on pg 5-62, Fig 5.10)
- Visual Inspection
  - Size, Heat #, Defects, etc.
- Document


10/16/2013

CONCRETE PILE INSPECTION

- Should Be Shop Inspected
  - Region Materials inspect @ plant
    - Gage Brothers or SD Concrete
- Visual Inspection
  - Conformance to Plans
  - Cracks 100%
  - Chips > 10%
- Proper lift procedure

10/16/2013

PROPER HANDLING AND LIFTING

PILE DRIVER

- Hammer
- Cap
- Leads

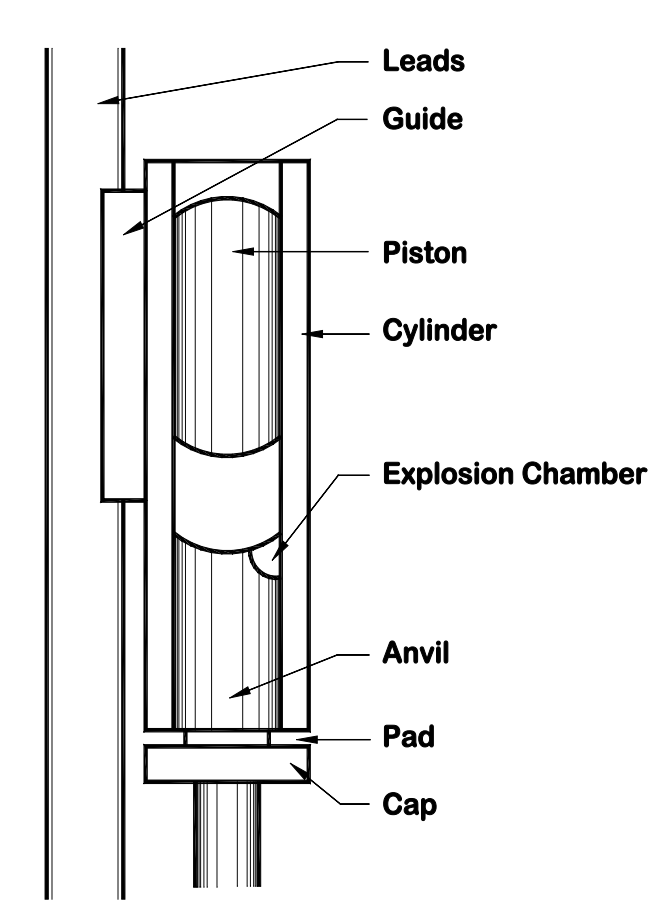
Page 5-64, Figure 5.12

TYPES OF PILE DRIVERS

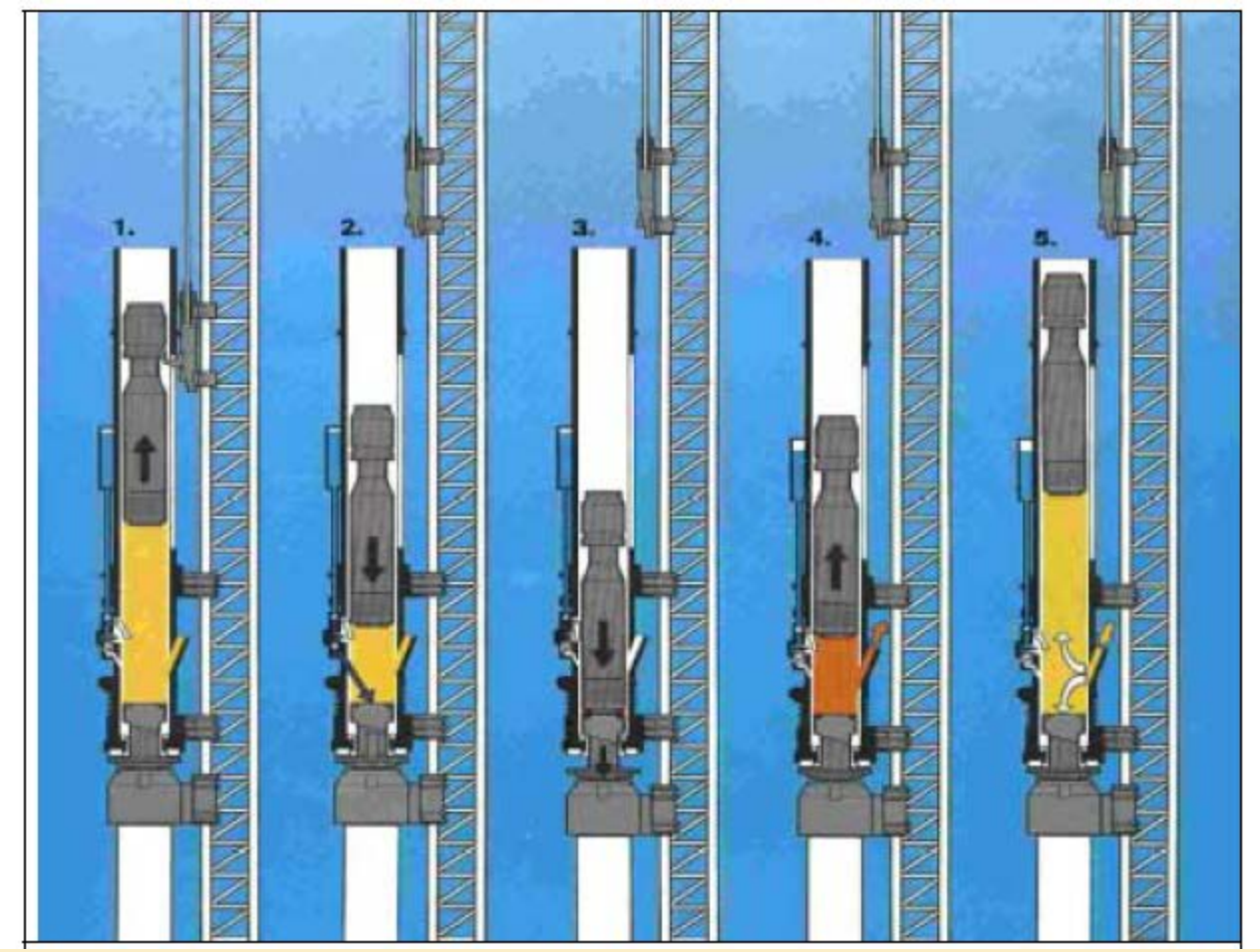
- Single Acting Hammer
- Double Acting Hammer
- Vibratory Hammer (Not Allowed)

SINGLE ACTING HAMMER

- Can be Air, Steam, or Diesel Fueled
- Moving Piston Inside Stationary Cylinder



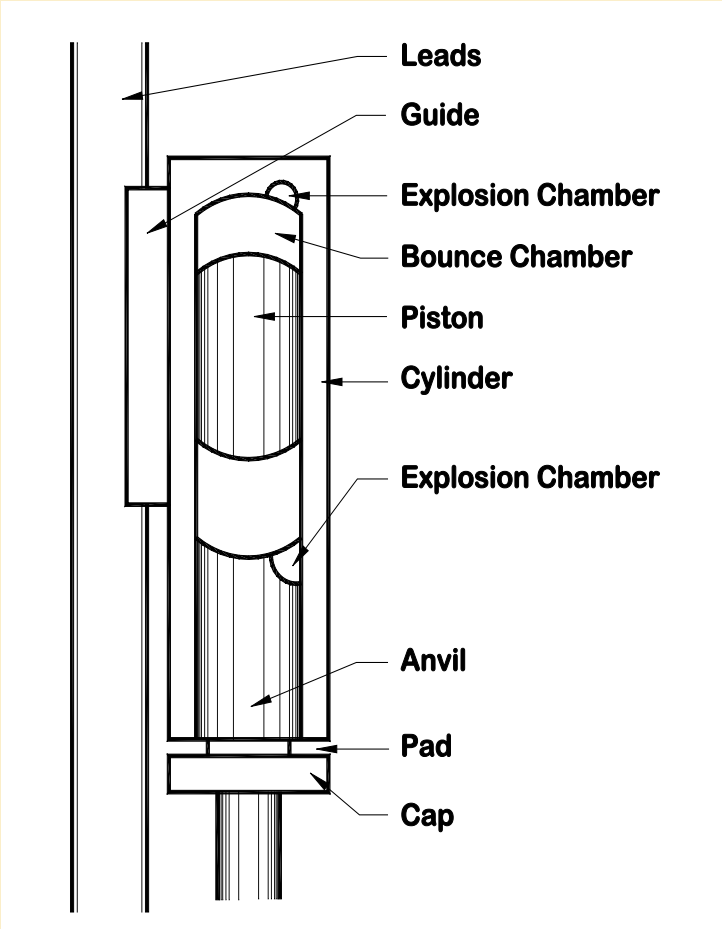
Pg 5-65, Fig 5.13


1.
2.
3.
4.
5.


10/16/2013

DOUBLE ACTING HAMMER

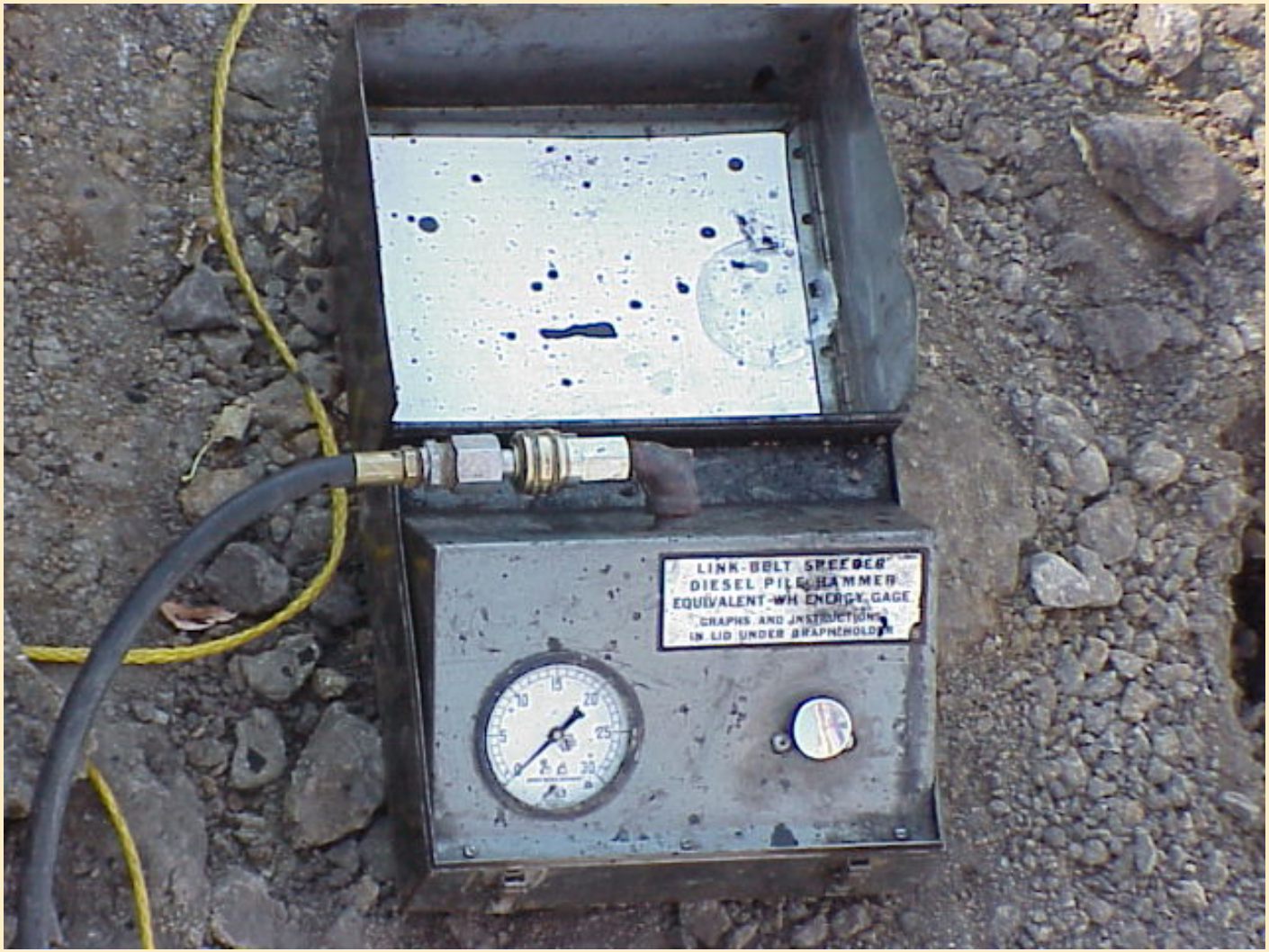
- Bounce Chamber
- Explosion Chamber



(pg 5-64) Table 5.16

10/16/2013

BACK PRESSURE GAGE AND HOSES



ENERGY CHART

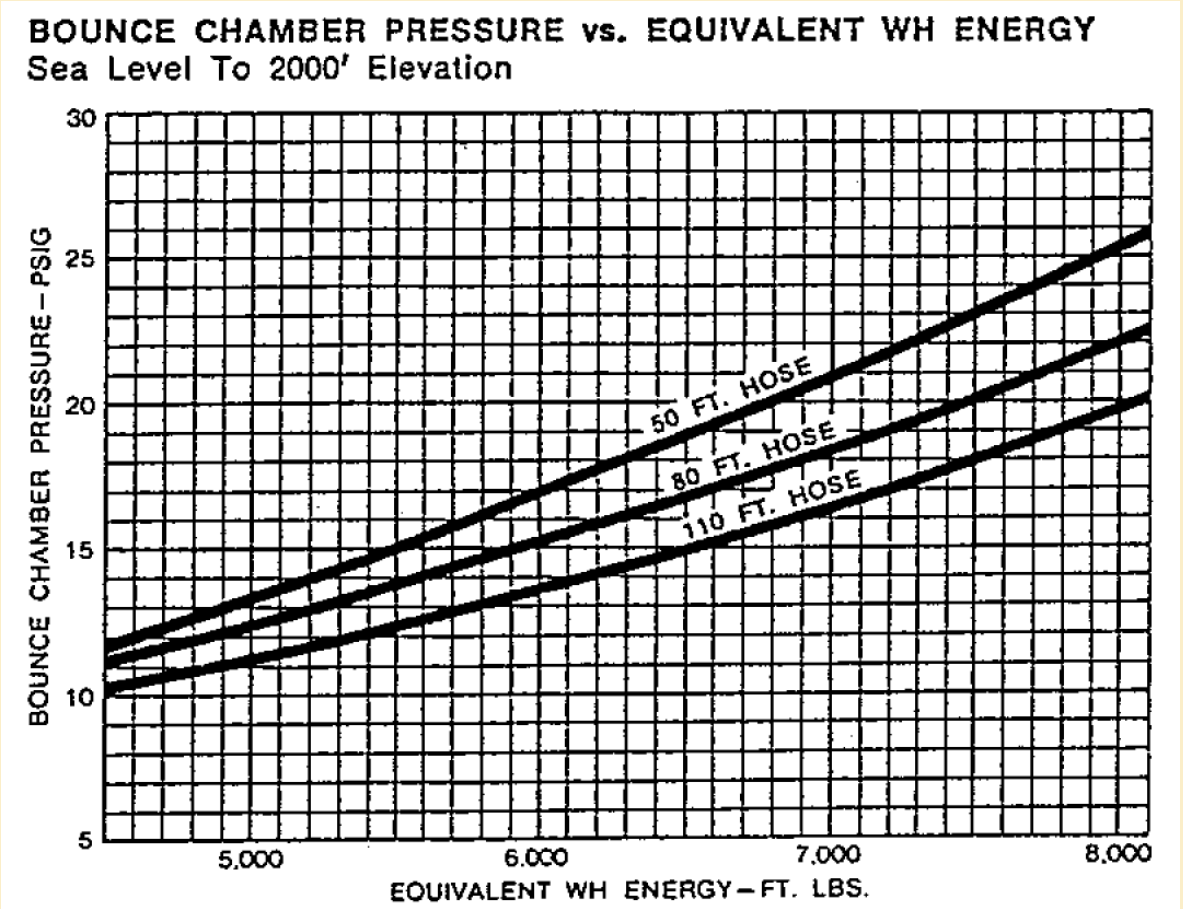
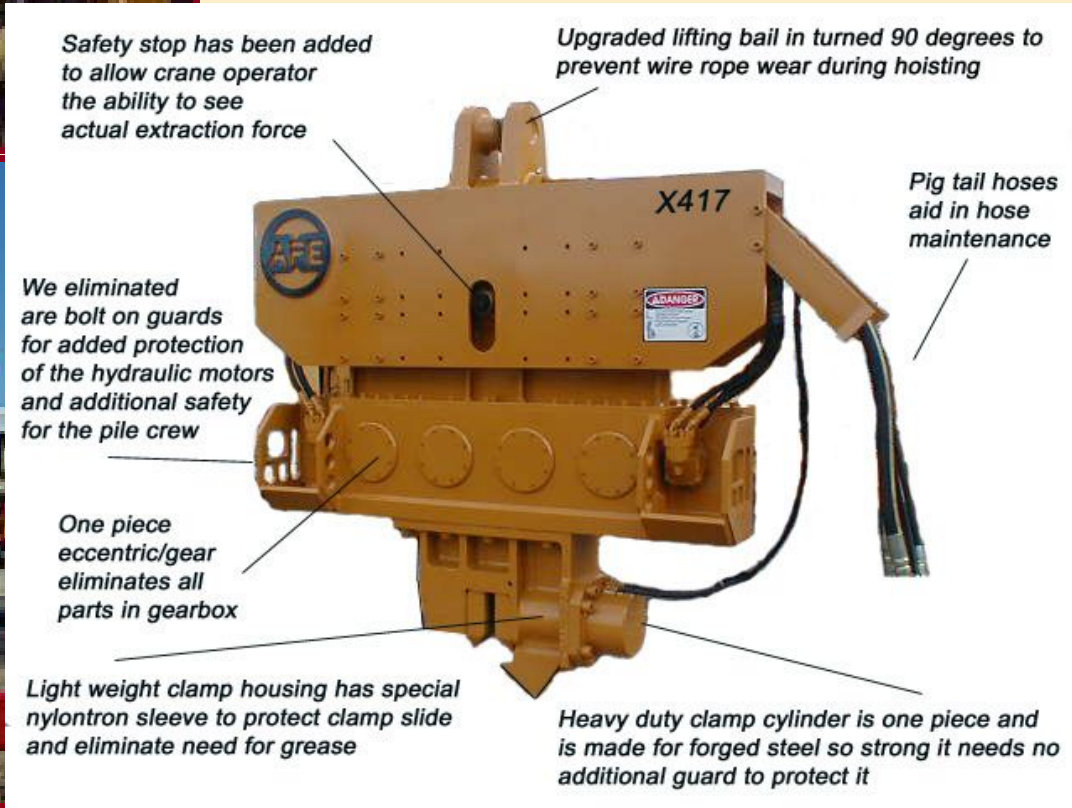


Fig. 3 Energy chart for ICE Model 180 diesel hammer (International Construction Equipment, Inc.). [1 ft = 0.305 m; 1 psi = 6.9 kPa; 1 ft lb = 1.356 J]

Vibratory Pile Driving Hammers



SUBSURFACE INVESTIGATION SHEET

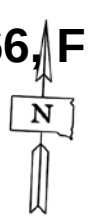
- Upper Half
  - Structure Location
  - Project Centerline
  - Piling Layout
  - Test Hole Locations
- Lower Half
  - Geographic profile
  - Boring Logs
  - Soil Formations
  - Blow per foot graph

Page 5-70
Fig 5.17

Subsurface Investigation Sheet

10/16/2013

Page 5-66, Fig 5.17



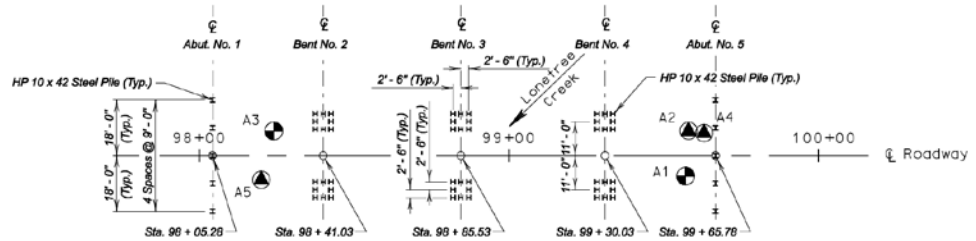
Hole Number	A2
Station	99+58
Depth	28.3 ft
Soil Color	Gray
Classification	Gravel-Sand
Strength (Q_u)	----- psf
Dry Density	----- pcf
Wet Density	----- pcf
Moisture	9.9 %
Pass No. 10	53.7 %
Pass No. 40	14.2 %
Pass No. 200	3.1 %
Sand Content	50.6 %
Silt Content	2.1 %
Clay Content	1.1 %

Hole Number	A2
Station	99+58
Depth	58.7 ft
Soil Color	Gray
Classification	Sand-Clay
Strength (Q_u)	12,494 psf
Dry Density	114.3 pcf
Wet Density	134.0 pcf
Moisture	17.2 %
Pass No. 10	93.7 %
Pass No. 40	82.2 %
Pass No. 200	65.5 %
Sand Content	28.2 %
Silt Content	20.5 %
Clay Content	45.0 %

Hole Number	A4
Station	99+63
Depth	87.0 ft
Soil Color	Gray
Classification	Sand-Clay
Strength (Q_u)	7,103 psf
Dry Density	114.4 pcf
Wet Density	133.9 pcf
Moisture	17.0 %
Pass No. 10	91.1 %
Pass No. 40	78.3 %
Pass No. 200	60.5 %
Sand Content	30.6 %
Silt Content	20.4 %
Clay Content	40.1 %

Hole Number	A5
Station	98+20
Depth	40.00 ft
Soil Color	Gray
Classification	Sand-Gravel
Strength (Q_u)	----- psf
Dry Density	121.8 pcf
Wet Density	133.1 pcf
Moisture	9.3 %
Pass No. 10	46.8 %
Pass No. 40	15.6 %
Pass No. 200	3.1 %
Sand Content	43.7 %
Silt Content	1.7 %
Clay Content	1.4 %

Hole Number	A5
Station	98+20
Depth	81.7 ft
Soil Color	Gray
Classification	Sand-Clay
Strength (Q_u)	11,382 psf
Dry Density	111.7 pcf
Wet Density	132.0 pcf
Moisture	18.1 %
Pass No. 10	97.5 %
Pass No. 40	85.7 %
Pass No. 200	67.9 %
Sand Content	29.6 %
Silt Content	21.1 %
Clay Content	46.8 %



PILING LAYOUT

COFFERDAM DESIGN PARAMETERS:

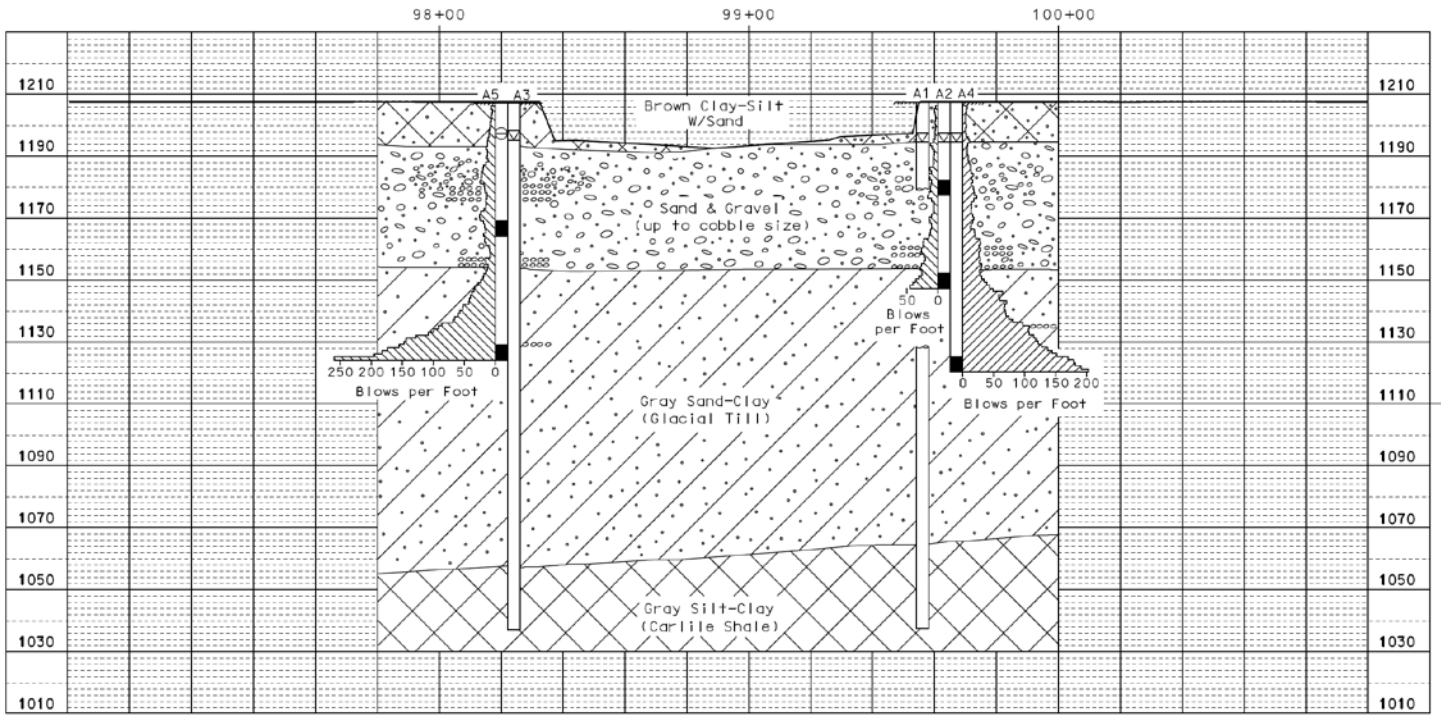
SAND AND GRAVEL:

Friction Angle	ϕ =	32 degrees
Cohesion	c =	0 psf
Wet Unit Weight	γ_w =	133 pcf

COFFERDAM DESIGN PARAMETERS:

SAND-CLAY:

Friction Angle	ϕ =	26 degrees
Cohesion	c =	100 psf
Wet Unit Weight	γ_w =	133 pcf



STATE OF	PROJECT	SHEET NO.	TOTAL SHEETS
S.D.	IM 29-9(00)208	E7	E42

Glaciated Terrain contains all sizes of natural mineral sediment ranging from clay to boulders. Streams originating in or flowing through glaciated topography contain sediment loads derived from glaciated sources. Stream and river crossings contain sediment naturally sorted and randomly concentrated. Alluvial sediment located at this project location may have concentrated coarser gravel such as pebbles, cobbles and boulders. The borings shown only represent material that was found at the exact location of the small diameter drill hole. Coarse granular material may be present in areas not penetrated by the depicted borings.

The Geotechnical Engineering Activity has on file all of the boring logs for this project. These logs and additional results of laboratory test, if any, are available for review at the Central Office in Pierre.

LEGEND

Auger Test
Drive Test
Water
Caved
Sample Zone

Drive test are conducted by dropping a 490 pound hammer 30 inches to drive a $2\frac{7}{8}$ inch drill stem with attached retractable plug sampler for taking undisturbed samples and to measure the resistance to penetration of the soil.

GROUND WATER ELEVATIONS

as of September 2009

A1	1194.5
A2	1194.5
A3	1195.2
A4	1194.5
A5	(Caved) 1197.3

MEASURED SKIN FRICTION

	Elev	psf
A2	1177.2	322
A2	1147.2	289
A4	1120.2	364
A5	1164.1	286
A5	1124.1	700

SUBSURFACE INVESTIGATION AND PILING LAYOUT
FOR
162'-6" CONTINUOUS CONCRETE BRIDGE
36'-0" ROADWAY 0° SKEW
OVER LONETREE CREEK SEC. 3/10-T97N-R58W
STA. 98+04.28 TO 99+66.78 P-BRF 0018(126)387
STR. NO. 34-217-180 HL-93

HUTCHINSON COUNTY
S. D. DEPT. OF TRANSPORTATION
NOVEMBER 2009 (5) OF (18)

DESIGNED BY	DRAWN BY	CHECKED BY	
SN/PW	NN/GW	DV/PW/SN	Kevin N. Goeden
HJCHOOGU	OOGUWAOS		BRIDGE ENGINEER

PRIMARY TYPES OF BEARING "PICKUP"

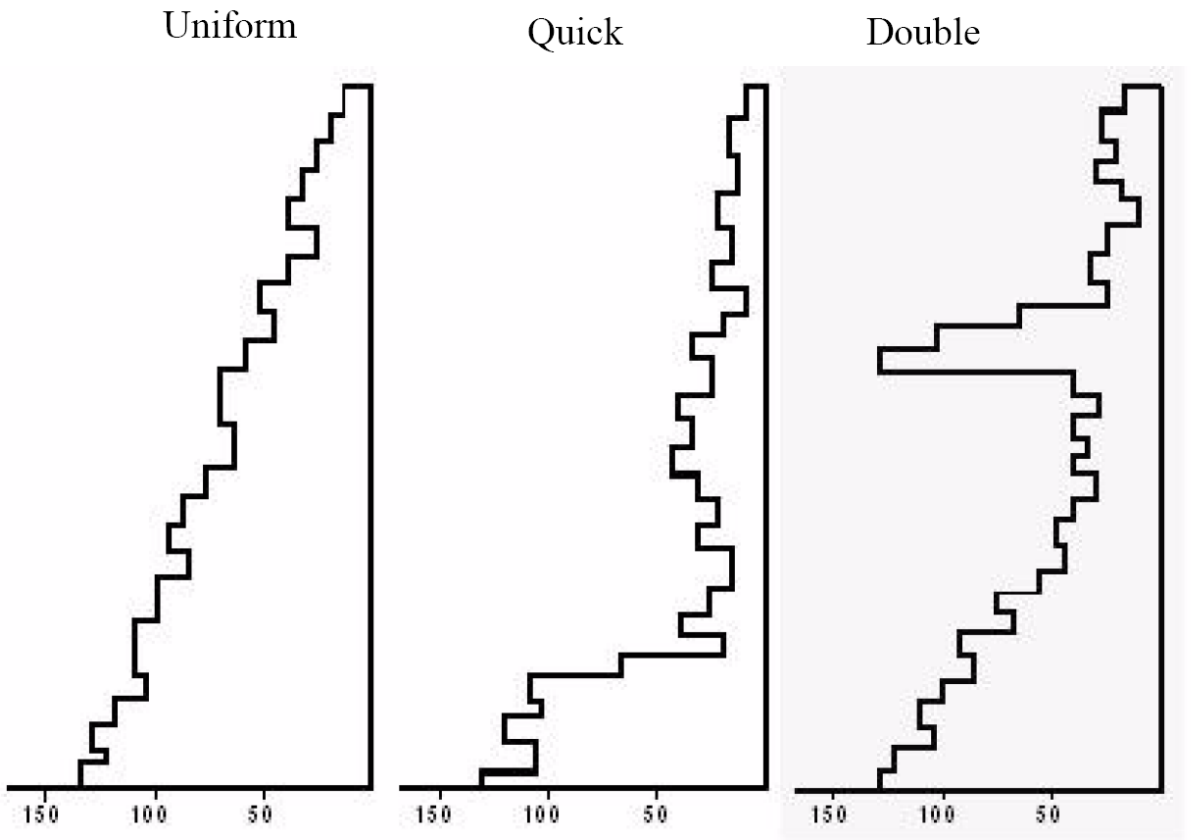
- Uniform Buildup
- Quick Buildup
- Double Buildup

Page 5-71

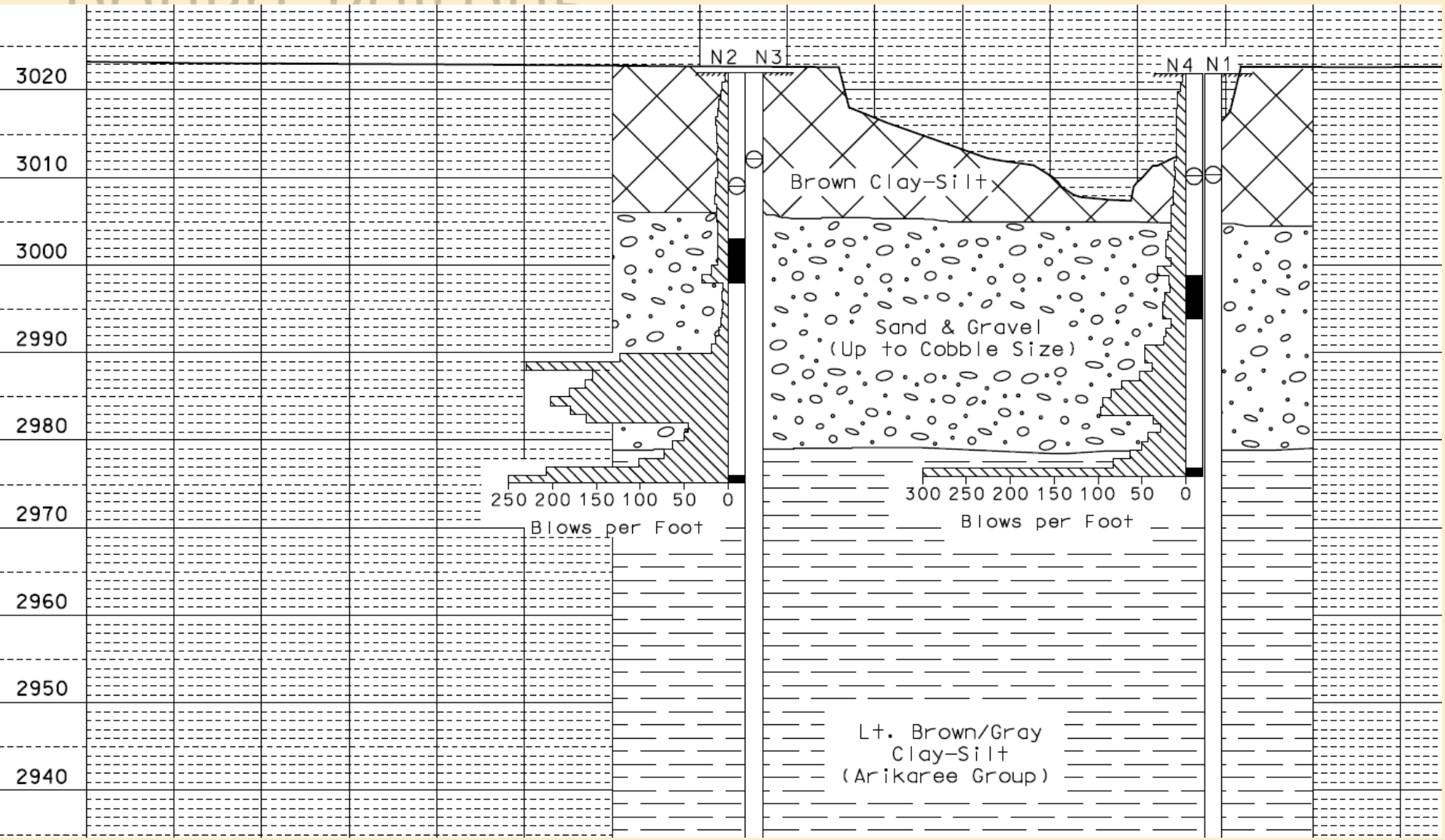
TYPES OF BEARING PICKUP

PAGE 5-71, FIG 5-18

Figure 5.18 Uniform, quick, and double buildup graphs



DOUBLE BUILDUP



DOUBLE BUILDUP ON TEST PILES

- Was the bearing 5-10 Tons more than the required bearing before it dropped off?

- Did the pile have more than the required bearing for at least 3 feet?

PILE REPORTS

- Test Pile Report
  - DOT-203 (Pg 5-73)
- Pile Inspector's Report
  - DOT-204 (Pg 5-74)

GENERAL INFO ON PILE REPORTS

- Project Number
- County
- Date
- Contractor
- Foundation Unit
- Structure Number
- Inspector's Name
- Structure Type
- Location
- Type of Pile
- Bearing Required
- Pile ID No.

DOT-203: PG 5-73, FIG 5.19

DOT-203
(10/02)

DATE
SHEET OF

SOUTH DAKOTA DEPARTMENT OF TRANSPORTATION
INSPECTOR'S TEST PILE REPORT

PROJECT NO. BRF 6599(03) PCEMS 6086 COUNTY Brown STR. # 07-110-356
CONTRACTOR IBI FOUNDATION UNIT Abutment #!
STR. TYPE 85' -0" Bulb Tee ON HWY OVER Foot Creek
TYPE OF PILE HP 10 X 42 INSPECTOR
TYPE AND NO. OF HAMMER Single Acting Diesel STATION
WEIGHT OF STRIKING PART 3,300 lbs
WEIGHT OF CAP 1450 lbs CAP # A 146 WT OF ANVIL 1140 lbs
REQ'D BEARING 192

REMARKS:

TEST PILE NO.	PILE SIZE						ELEVATIONS				PILE LENGTH		PAY QUANTITIES		
	DIAMETER		WT. PER	LENGTH		TOTAL						LENGTH			
	TIP (FT.)	BUTT (FT)	FOOT (LB.)	BEGIN (FT.)	TOTAL (FT.)	WT. (LBS)	FINAL TIP	PLAN CUTOFF	GROUND	WATER	PLAN (FT.)	DRIVEN (FT.)	DRIVE (FT.)	PRE-BORE (FT.)	SPLICE
1C			42	60.0	60.0	2520	1242.87	1295.87	1293.87	1291.00	57.0	53.0	57.0	6.0	

AVG. OF LAST 10 BLOWS						AVG. OF LAST 10 BLOWS						AVG. OF LAST 10 BLOWS					
PILE IN PLACE		DROP	TOTAL	PENT.	BRG.	PILE IN PLACE		DROP	TOTAL	PENT.	BRG.	PILE IN PLACE		DROP	TOTAL	PENT.	BRG.
LENGTH (FT.)	TIME 0:00:00	"H" (FT.)	PENT. (IN.)	"S" (IN.)	"Q" (TONS)	LENGTH (FT.)	TIME 0:00:00	"H" (FT.)	PENT. (IN.)	"S" (IN)	"Q" (TONS)	LENGTH (FT.)	TIME 0:00:00	"H" (FT.)	PENT. (IN.)	"S" (IN.)	"Q" (TONS)
29.0	4:57	4.4	3.50	0.35	299.1	52.5	5:22	5.2	0.75	0.08	78.6						
33.0	5:00	4.3	4.00	0.40	292.3	53.0	5:23	5.4	0.75	0.08	73.4						
35.0	5:02	4.2	2.50	0.25	285.5	53.0	5:24	5.3	0.63	0.06	102.9						
36.5	5:04	4.6	1.50	0.15	312.7	53.2	5:24	5.4	0.63	0.06	146.8						
38.0	5:05	4.5	3.00	0.30	305.9												
39.5	5:06	4.7	2.75	0.28	319.5												
41.0	5:07	4.2	2.75	0.28	285.5												
43.0	5:08	4.6	2.62	0.26	312.7												
45.0	5:10	4.9	2.12	0.21	333.1												
47.0	5:12	4.8	1.75	0.18	326.3												
48.0	5:14	4.9	1.63	0.16	333.1												
49.0	5:16	5.1	1.50	0.15	346.7												
50.0	5:18	5.0	1.13	0.11	339.9												
50.5	5:19	5.1	1.13	0.11	346.7												
51.0	5:20	5.2	1.13	0.11	353.5												
51.5	5:21	5.2	1.00	0.10	353.5												
52.0	5:21	5.2	1.00	0.10	353.5												

NOTE: Sketch footing on reverse side and indicate position of this pile. Where pre-boring is required, use bottom of preboring as ground elevation.

Remarks: Sketch need not be to scale. Show plan view of footing with position of test pile in relation to other piling, centerline of roadway, centerline of substructure unit and north arrow.

DROP “H” VS PENT “S”

		AVG. OF LAST	10	BLOWS			AVG. OF LAST	10	BLOWS
PILE IN PLACE		DROP	TOTAL	PENT.	BRG.	PILE IN PLACE	DROP	TOTAL	PENT.	BRG.
LENGTH	TIME	"H"	PENT.	"S"	"Q"	LENGTH	TIME	"H"	PENT.	"S"	"Q"
(FT.)	0:00:00	(FT.)	(IN.)	(IN.)	(TONS)	(FT.)	0:00:00	(FT.)	(IN.)	(IN)	(TONS)
29.0	4:57:00	4.4	6.00	0.60	61.0	52.5	5:22:00	7.6	3.00	0.30	184.4
33.0	5:00:00	5.1	6.50	0.65	66.0	53.0	5:23	7.8	2.75	0.28	201.9
35.0	5:02:00	5.0	5.50	0.55	74.7	53.0	5:24	8.0	2.50	0.25	221.9
36.5	5:04:00	6.1	4.50	0.45	107.7	53.2	5:24	8.2	2.50	0.25	227.4
38.0	5:05:00	6.0	4.25	0.43	110.9						
39.5	5:06:00	6.2	4.25	0.43	114.6						
41.0	5:07:00	6.5	4.00	0.40	126.2						
43.0	5:08:00	6.5	4.00	0.40	126.2						
45.0	5:10:00	6.7	3.75	0.38	136.9						
47.0	5:12:00	6.8	4.00	0.40	132.0						
48.0	5:14:00	6.7	3.75	0.38	136.9						
49.0	5:16:00	6.9	3.63	0.36	144.7						
50.0	5:18:00	6.9	3.50	0.35	148.8						
50.5	5:19:00	7.0	3.50	0.35	151.0						
51.0	5:20:00	7.2	3.25	0.33	164.4						
51.5	5:21:00	7.2	3.25	0.33	164.4						
52.0	5:21:00	7.4	3.25	0.33	169.0						

●10/16/2013

DOT-204: PG 5-74, FIG 5.20

DOT-204
(10/02)

DATE
SHEET OF

SOUTH DAKOTA DEPARTMENT OF TRANSPORTATION
PILE INSPECTOR'S REPORT

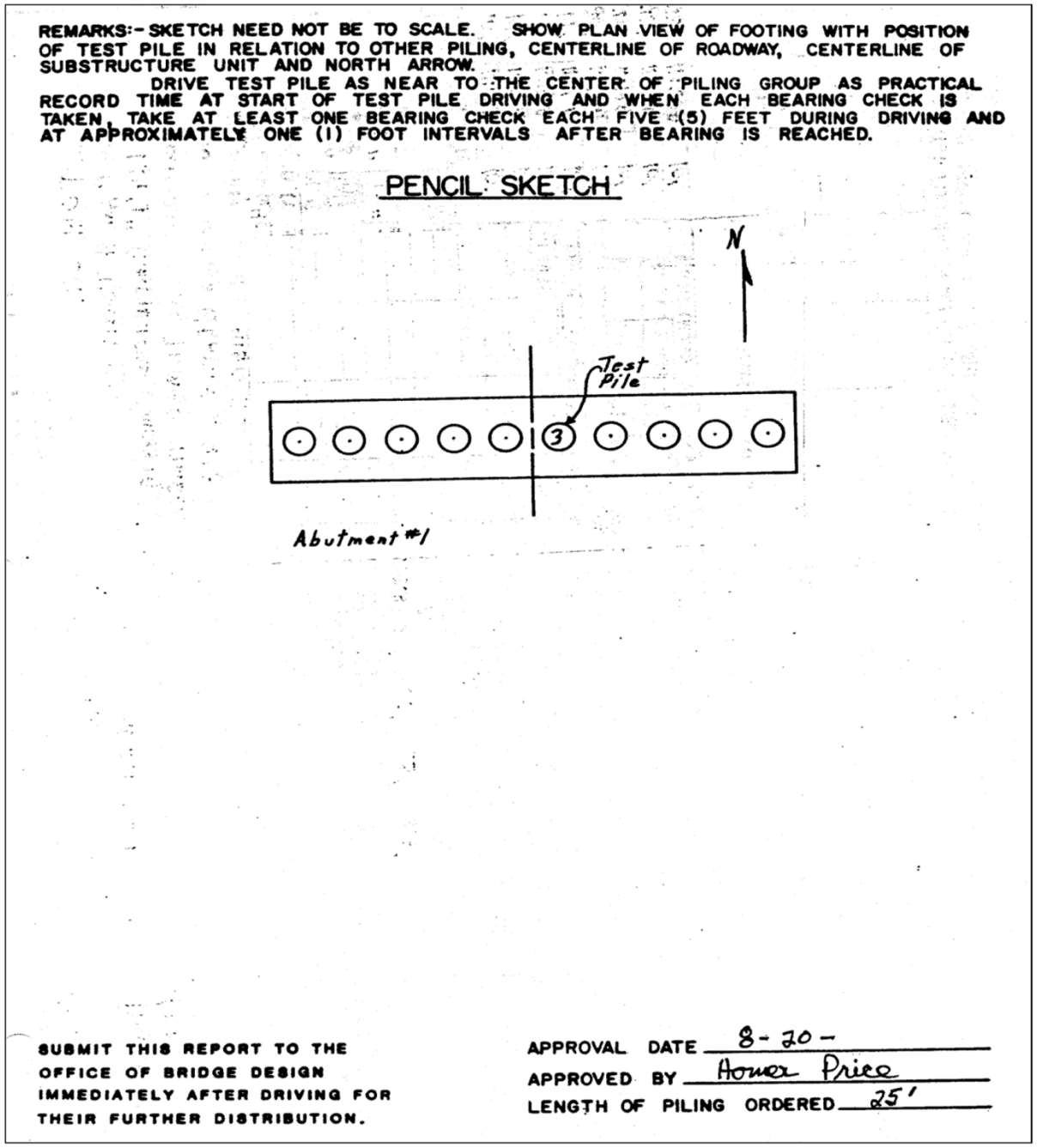
PROJECT NO. Brf 6599(03) PCEMS 6086 COUNTY Brown STRUCTURE # 07-110-356
CONTRACTOR IBI
STR. TYPE 85' bulb T ON HWY OVER Foot Creek

TYPE OF PILE HD 10 X 42 STATION
WEIGHT PER FOOT (piling) 42 lbs/ft
TYPE AND NO. OF HAMMER Single Acting Diesel REQ'D BEARING 192 tons
WEIGHT OF STRIKING PART 3,300 lbs PLAN LENGTH 52.0 ft
WEIGHT OF CAP 1450 lbs CAP # A146 WT OF ANVIL 1140 lbs INSPECTOR

LOCTION OF PILE		PILE SIZE					ELEVATIONS				AVG. OF LAST 10 BLOWS				LENGTH	PAY QUANTITIES			COMMENTS
		DIAMETER		LENGTH (FT)		WT.					DROP	TOTAL	PENT.	BRG.	CUTOFF	DRIVE	PRE-	SPLICE	
SUB-UNIT	NO	TIP	BUTT	BEGIN	TOTAL	(LBS)	TIP	CUTOFF	GRD.	WATER	(FT)	PENT.	"S"	"Q"	(FT)	(FT)	BORE		
A 2	2A			60.0	60.0	2520.0	1239.76	1295.87	1293.87	1291	5.0	0.50	0.05	226.6	3.89	56.1	6.0		
A 2	2B			55.0	55.0	2310.0	1246.15	1295.87	1293.87	1291	5.4	0.94	0.09	194.3	5.28	49.7	6.0		
A 2	2C			55.0	60.0	2520.0	1239.87	1295.87	1293.87	1291	5.0	0.60	0.06	212.4	54	56	6.0		
A 2	2D			55.0	55.0	2310.0	1245	1295.87	1293.87	1291	6.4	1.13	0.11	210.0	4.13	50.9	6.0		
A 2	2E			55.0	60.0	2520.0	1236.57	1295.87	1293.87	1291	5.0	0.58	0.06	215.1	49.7	59.3	6.0		
A 2	2F			55.0	61.0	2562.0	1235.63	1295.87	1293.87	1291	4.8	0.60	0.06	202.9	44.46	60.2	6.0		

c:Bridge Design

Figure 5.21 Example Backside of a Test Pile Report



REMARKS:- SKETCH NEED NOT BE TO SCALE. SHOW PLAN VIEW OF FOOTING WITH POSITION OF TEST PILE IN RELATION TO OTHER PILING, CENTERLINE OF ROADWAY, CENTERLINE OF SUBSTRUCTURE UNIT AND NORTH ARROW.

DRIVE TEST PILE AS NEAR TO THE CENTER OF PILING GROUP AS PRACTICAL RECORD TIME AT START OF TEST PILE DRIVING AND WHEN EACH BEARING CHECK IS TAKEN. TAKE AT LEAST ONE BEARING CHECK EACH FIVE (5) FEET DURING DRIVING AND AT APPROXIMATELY ONE (1) FOOT INTERVALS AFTER BEARING IS REACHED.

PENCIL SKETCH

SUBMIT THIS REPORT TO THE OFFICE OF BRIDGE DESIGN IMMEDIATELY AFTER DRIVING FOR THEIR FURTHER DISTRIBUTION.

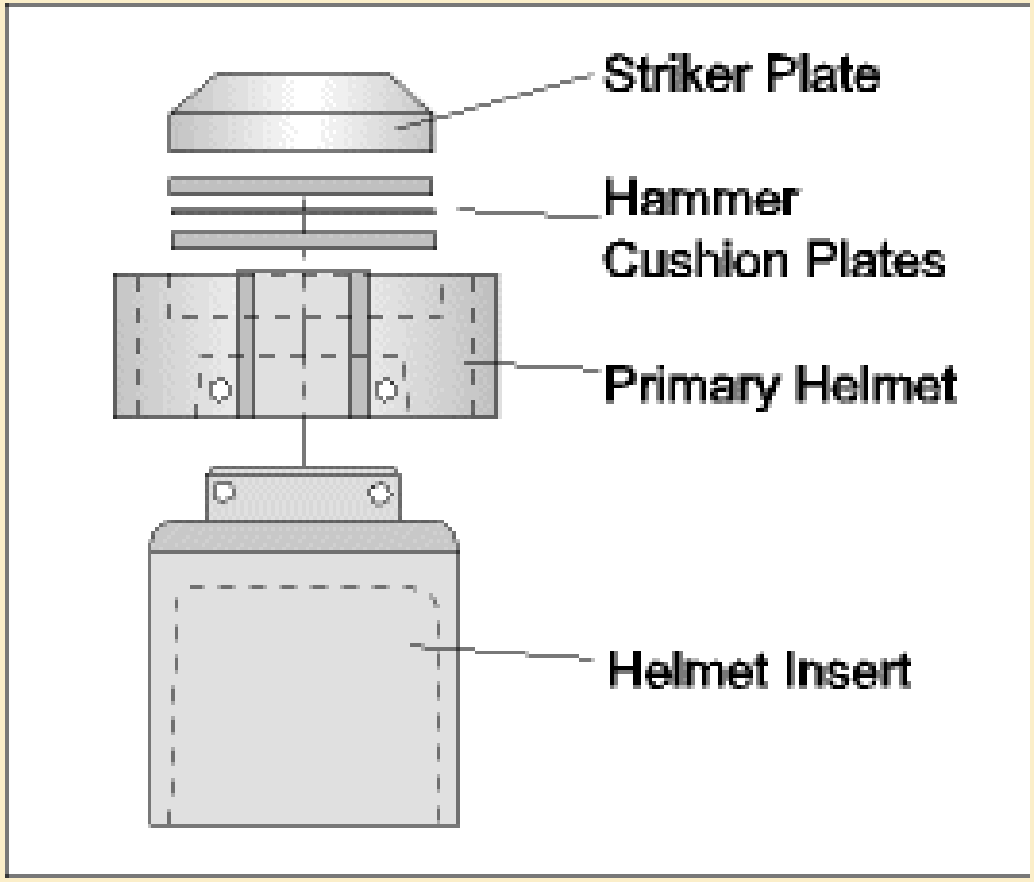
APPROVAL DATE 8-20-
APPROVED BY Homer Price
LENGTH OF PILING ORDERED 25'

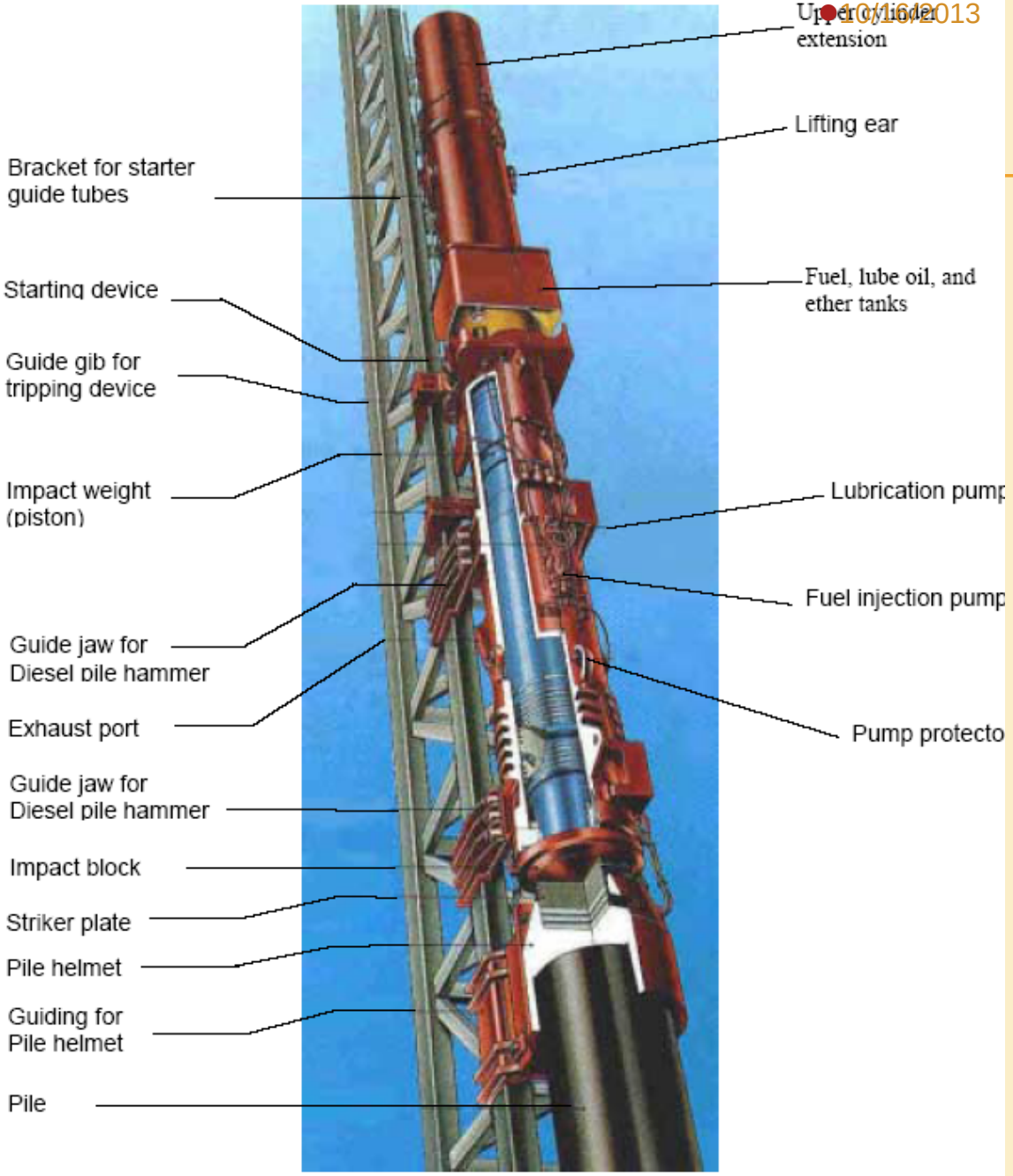
Substructure Sketch

PRELIMINARY DATA NEEDED

- Determine Type and Model No. of Hammer
- Determine Weight of Striking Part
- Determine Weight and No. of Cap
- Determine the Bearing Required
- Determine the Weights of the Piles

HELMET AND INSERT




Upper cylinder extension
Lifting ear
Bracket for starter guide tubes
Starting device
Fuel, lube oil, and ether tanks
Guide gib for tripping device
Impact weight (piston)
Lubrication pump
Fuel injection pump
Guide jaw for Diesel pile hammer
Exhaust port
Pump protecto
Guide jaw for Diesel pile hammer
Impact block
Striker plate
Pile helmet
Guiding for Pile helmet
Pile

10/16/2013


10/16/2013

PREBORING PILING

- Integral Type Abutment Spec 510.3.A.5
- New Fill
- Minimum Size
- Backfill With Coarse Sand

Pile Size	Prebore Size
Timber Pile	Min. 2” Larger than Diameter of Pile
HP 8 Piles	12 Inches
HP 10 Piles	15 Inches
HP 12 Piles	18 Inches
HP 14 Piles	21 Inches

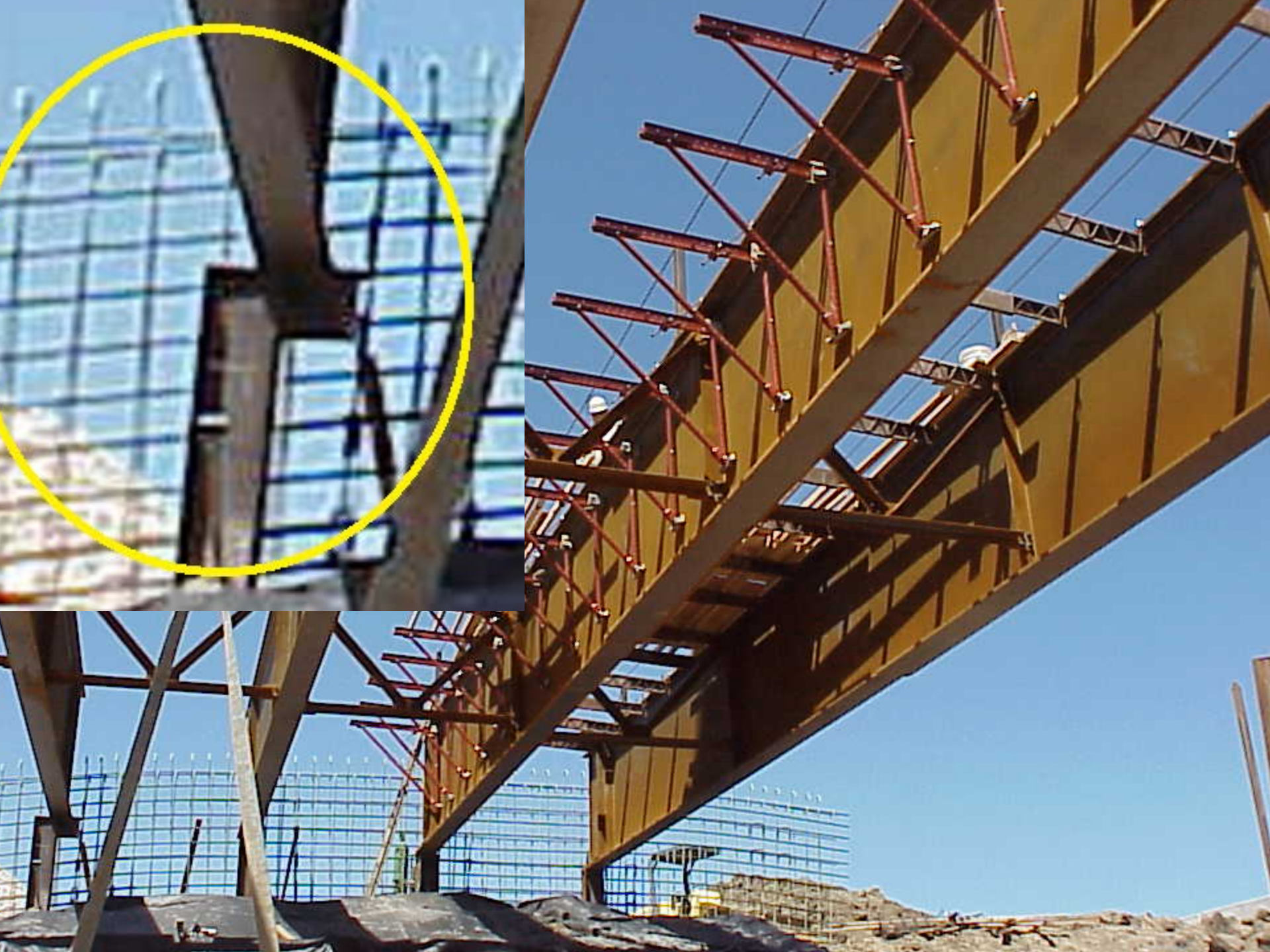
Spec Book 510.3.A.5, page 292

PILE DRIVING

- Remove Excavation
- Contractor Determines Correct Location (Inspector Verified)
- Check and Recheck Position and Batter After First Few Feet

LOCATION AND POSITION SPECIFICATIONS

- Piling are acceptable if they are within 6” of plans position.
- Battered pile must be within 1/4” in 12” of the plans specified batter. (Same for vertical pile)



10/16/2013

Page 5-75:

Figure 5.22

STEEL PILE TIPS

- Normal conditions: Materials ahead of pile tip forms its own point.

- Rocky Material – Rock tip needed
  - Near surface within 10 ft.
  - Large boulders expected

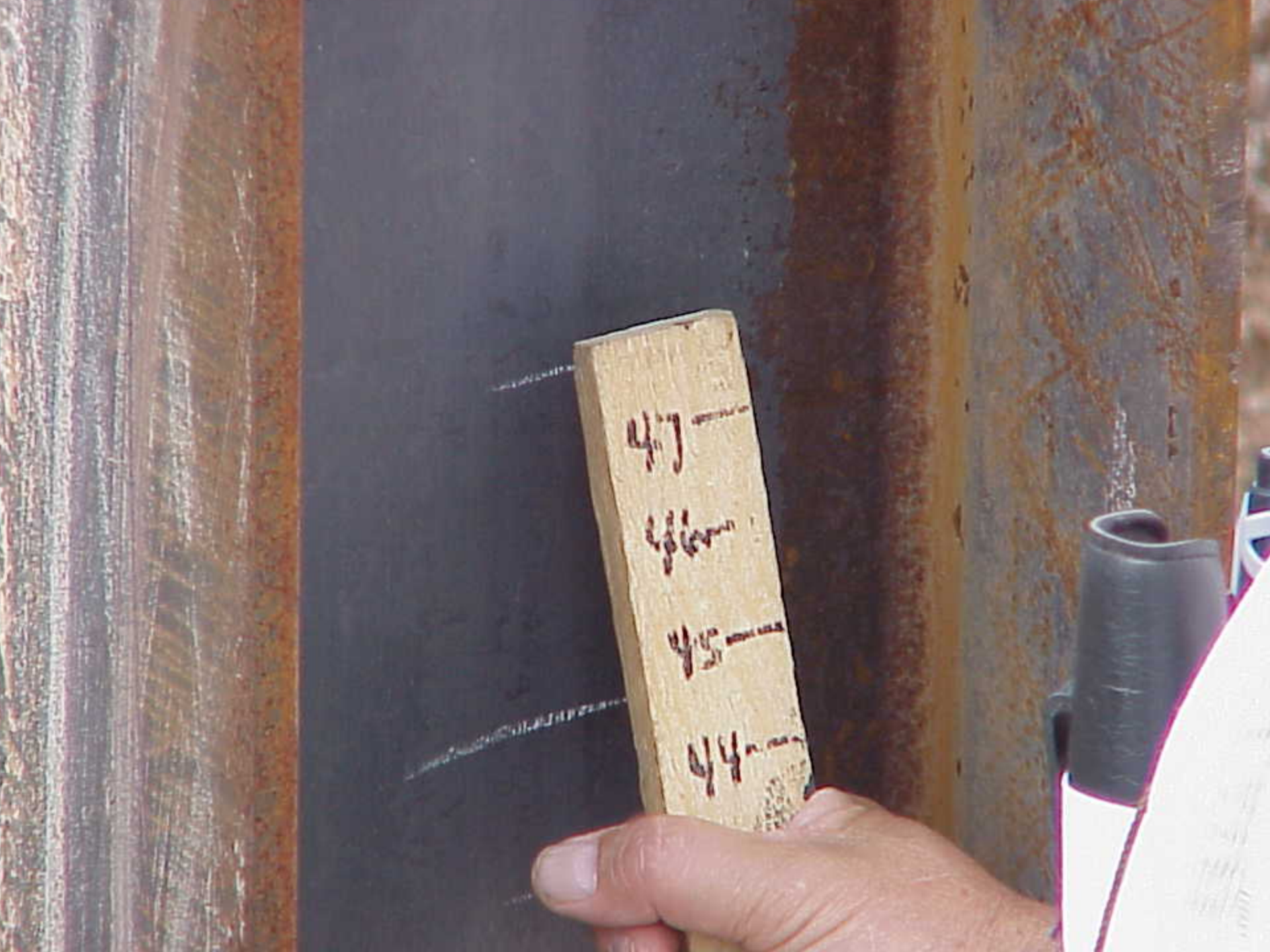
Reinforced Steel pile rock Tips

DRIVING PILE & COMPUTING BEARING

- Only drive pile 10 to 20% , more than plans required bearing.
- Pile need to be plumb or per spec batter
- Set pile, check alignment after a couple of feet.
- Start driving pile into ground
- Take readings every 5 ft & 1 ft after bearing achieved up to 10 – 20% over bearing.

MEASURING PILE PENETRATION

- Place mark on piling.
- Drive the required number of blows
  - 10 blows for Steel Pile
  - 5 blows for Timber Pile
- Place another mark on the piling.
- Measure the distance between the marks.


47
46
45
44

Pile Driving Video

Pile drive measurement sax.MPG


SMOKE
146

HAMMER FALL

- Single & Double Acting Hammers
  - Meets the minimum energy per plans
  - Hammer operating efficiently
  - Uniform driving rates
- Hammers must have the capability to drive 1 inch in 10 blows

NEW PILE DRIVING FORMULA

- LRFD Platform:
- To determine the ultimate bearing capacity of driven piles
- The SDDOT uses the following formulas for timber, concrete, steel H-piling and shell type piles.

BEARING DETERMINATION
SINGLE ACTION STEAM, AIR OR OPEN CYLINDER TOP DIESEL HAMMERS:

$$Q\ (drive) = \frac{10.5WH}{S + 0.1} \times \frac{W}{W + M}$$

Where:

- Q = the nominal pile bearing resistance in tons
- W = the weight of a gravity hammer, or the ram of an energy hammer in tons.
- H = the height of free fall of the hammer or ram in feet.
- M = the weight in tons of the driven mass and shall include the weight of the pile, the weight of the driving cap and the weight of the anvil, if used.
- E = the energy per blow in foot-tons.
- S = the average penetration in inches of the pile per blow for the last five blows or gravity hammers and last 10 blows for energy hammers.

PENETRATION AT BEARING (SINGLE ACTING HAMMERS)

- $S = \{(10.5WH/Q) \times (W/(W+M))\} - 0.1$

- Q = Bearing (0.1 Tons)
- W = Weight of the Hammer (0.01 Tons)
- H = Free Fall of the Hammer (0.1 Feet)
- S = Pile Penetration in 1 Blow (0.01 Inches)
- M = Weight of the Driven Mass (0.01 Tons)

Page 5-85 , Fig 5.32

BEARING DETERMINATION

DOUBLE ACTION STEAM OR AIR HAMMERS AND CLOSED CYLINDER TOP DIESEL HAMMERS:

$$Q\ (drive) = \frac{10.5E}{S + 0.1} \times \frac{W}{W + M}$$

Where:

- Q = the nominal pile bearing resistance in tons
- W = the weight of a gravity hammer, or the ram of an energy hammer in tons.
- H = the height of free fall of the hammer or ram in feet.
- M = the weight in tons of the driven mass and shall include the weight of the pile, the weight of the driving cap and the weight of the anvil, if used.
- E = the energy per blow in foot-tons.
- S = the average penetration in inches of the pile per blow for the last five blows or gravity hammers and last 10 blows for energy hammers.

ENERGY CHART

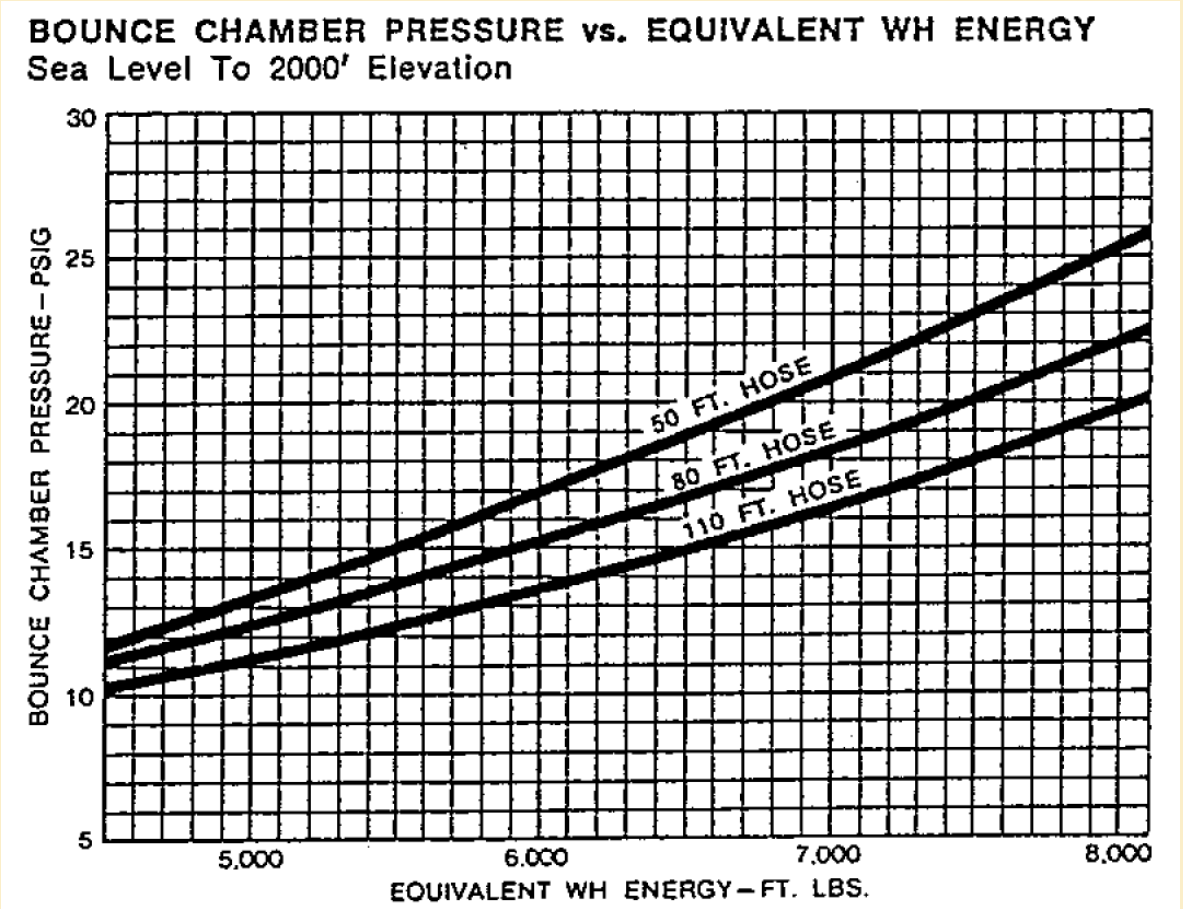


Fig. 3 Energy chart for ICE Model 180 diesel hammer (International Construction Equipment, Inc.). [1 ft = 0.305 m; 1 psi = 6.9 kPa; 1 ft lb = 1.356 J]

PENETRATION AT BEARING (DOUBLE ACTING HAMMERS)

- $S = \{(10.5E/Q) \times (W/(W+M))\} - 0.1$

- Q = Bearing (0.1 Tons)
- W = Weight of the Hammer (0.01Tons)
- E = Energy Per Blow (0.01 Foot-Tons)
- S = Pile Penetration in 1 Blow (0.01 Inches)
- M = Weight of the Driven Mass (0.01 Tons)

Page 5-85 , Fig 5.27

TYPICAL PLAN NOTE

SDDOT's LRFD PILE DRIVING EQUATIONS

To determine the field verified nominal pile bearing resistance of driven piles the SDDOT uses the formulas below for timber, concrete, steel H-piling and shell type piles.

For double action steam or air hammers and closed cylinder top diesel hammers:

$$Q\ (drive) = \frac{10.5E}{S + 0.1} \times \frac{W}{W + M}$$

For single action steam or air hammers and open cylinder top diesel hammers:

$$Q\ (drive) = \frac{10.5WH}{S + 0.1} \times \frac{W}{W + M}$$

Where:

Q = the field verified nominal pile bearing resistance in tons.
W = the weight of a gravity hammer, or the ram of an energy hammer in tons.
H = the height of free fall of the hammer or ram in feet.
M = the weight in tons of the driven mass and shall include the weight of the pile, the weight of the driving cap and the weight of the anvil, if used.
E = the energy per blow in foot-tons.
S = the average penetration in inches of the pile per blow for the last 10 blows for energy hammers.

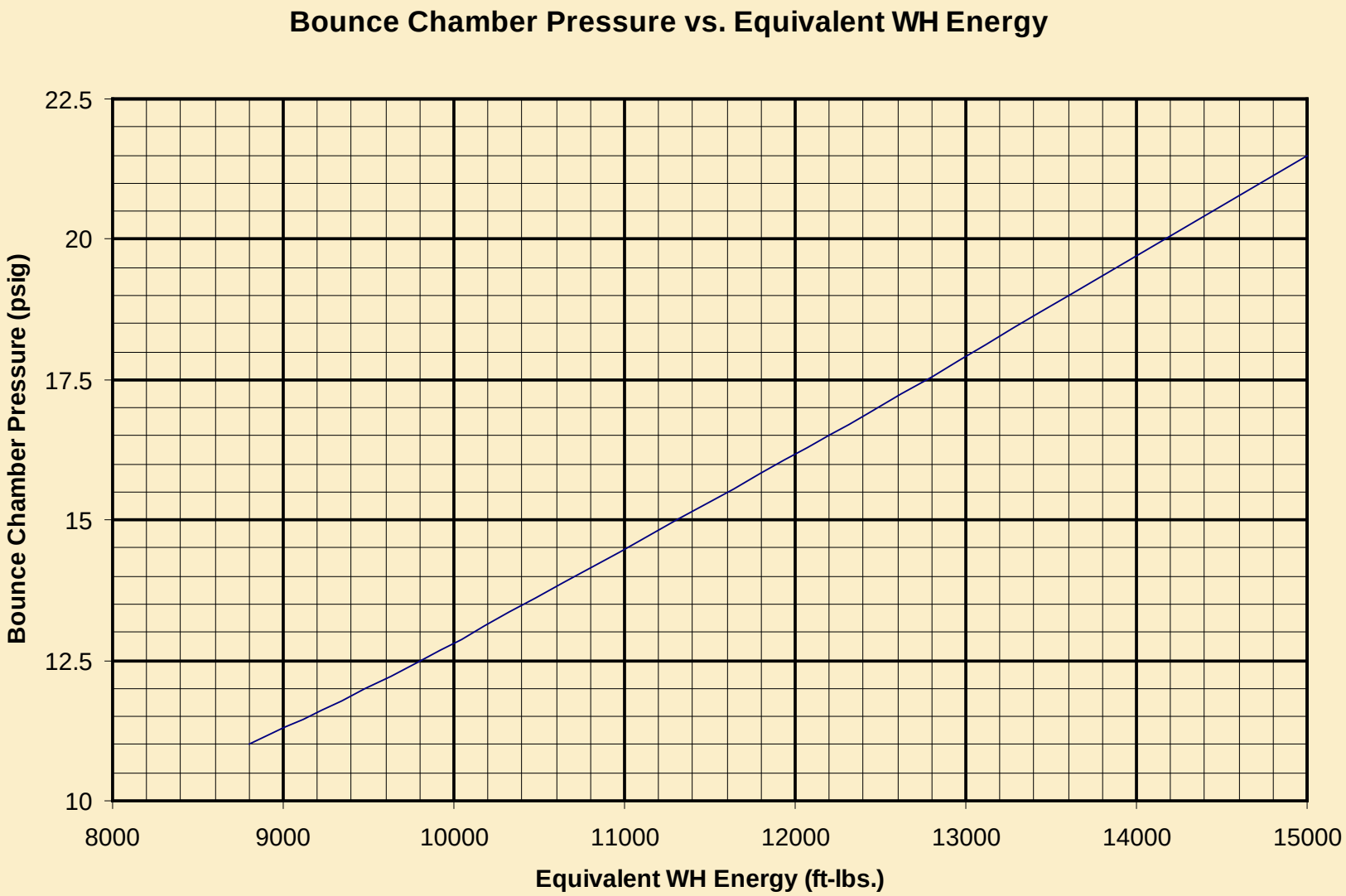
PILE DRIVING

1. A drivability analysis was performed using the wave equation analysis program GRLWEAP. The pile hammers listed below were evaluated and found to produce acceptable driving stresses.
   SP1 D-30
   Delmag D-30-32
   Delmag D-25-32
   Pile hammers not listed will require evaluation and approval from the Office of Bridge Design prior to use.

2. An additional pile hammer with a ram weight of less than 4,500 lbs. will be required to drive one test pile.

3. See Special Provision for Dynamic Pile Monitoring and Static Pile Load Testing.

EXAMPLE: THE BOUNCE CHAMBER PRESSURE MEASURED OFF A DOUBLE ACTING HAMMER WAS 15.5 PSI. WHAT IS THE ENERGY DELIVERED TO THE PILE?



EX: DETERMINE TIMBER PILE WEIGHT.

- Cedar Pile = 25 ft
- Tip Measurements
  - Dia: Min = 8.5 Inches Max = 10 Inches
  - Circumference = 28.5 Inches
- Butt Measurements
  - Dia: Min = 15.5 Inches Max = 17.0 Inches
  - Circumference @ 3ft from End = 50 Inches
- Page 5-56, Fig 5.6
- Page 5-82, Fig 5.30

FIRST COMPUTE DIAMETERS

- Tip Dia: 28.5”/3.14 = 9 Inches
- Butt Dia: 50”/3.14 = 16 Inches
- Wt/Ft = Use Fig 5.30 ???????

Tip / Butt	7	8	9	10	11	12	13	14	15	16
7	13.36	15.36	17.54	19.91	22.46	25.18	28.08	31.18	34.46	37.89
8	15.36	17.46	19.73	22.18	23.84	27.64	30.63	33.82	37.19	40.72
9	17.54	19.73	22.09	24.64	27.36	30.29	33.36	36.64	40.09	43.74
10	19.91	22.18	24.64	27.27	30.09	33.10	36.27	39.62	43.18	46.91
11	22.46	24.84	27.36	30.09	33.00	36.09	39.36	42.82	46.45	50.27
12	25.18	27.64	30.29	33.10	36.09	39.27	42.63	46.18	49.89	53.82
13	28.08	30.63	33.36	36.27	39.36	42.63	46.09	49.71	53.54	57.54
14	31.18	33.82	36.64	39.62	42.82	46.18	49.71	53.45	57.35	61.46
15	34.46	37.19	40.09	43.18	46.45	49.89	53.54	57.35	61.36	65.53
16	37.89	40.72	43.74	46.91	50.27	53.82	57.54	61.46	65.53	69.82
17	41.54	44.45	47.54	50.81	54.27	57.91	61.72	65.72	69.90	74.27
18	45.36	48.35	51.54	54.90	58.45	62.18	66.08	70.17	74.45	78.90
19	49.35	52.54	55.72	59.17	62.81	66.63	70.63	74.81	79.17	83.72
20	53.54	56.72	60.08	63.63	67.36	71.27	75.36	79.63	84.08	88.72

Tip and butt diameters in inches.
Pile weight in pounds per linear foot; based on unit weight of 50 lb. / ft^3.
Obtain total pile weight by multiplying total pile length by factor obtained above.

Page 5-82
Fig 5.30

Wt/Ft =
43.74 lbs/Ft

EXAMPLE PROBLEM #1

A SINGLE ACTION HAMMER WEIGHING 3920 LBS. AND A CAP WEIGHING 485 LBS. IS USED TO DRIVE A 40.0 FOOT LONG TIMBER TEST PILE THAT HAS A TIP DIAMETER OF 10.0 INCHES AND A BUTT DIAMETER OF 13 INCHES. THE HAMMER IS FREE FALLING 7.5 FEET AT A UNIFORM RATE RESULTING IN 6.5 INCH

PENETRATION IN 10 BLOWS. WHAT IS THE COMPUTED BEARING OF THIS PILE?

- Q = (10.5WH/(S+0.10)) x W/(W+M)
- W = _____
- M = _____
- H = _____
- S = _____

- Hint: Use table on page 5-84, Fig 5.30.

SOLUTION FOR EXAMPLE PROBLEM #1:

- Q = (10.5WH/(S+0.10)) x W/(W+M)

- W = 3920 lbs / 2000 lbs/ton = 1.96 tons
- M = {485 lbs + (40.0 lf x 36.27 lbs/lf)} / 2000 lbs/ton = 0.97 tons
- H = 7.5 Ft
- S = 6.5 in /10 blows = 0.65 in/blow

- Q = ((10.5 x 1.96 x 7.5)/(0.65 + 0.1)) x 1.96 / (1.96 + 0.97)

- Q = 205.8 x 0.67 = 137.7 tons

EXAMPLE PROBLEM #2

- A ICE 60S single acting diesel hammer with a piston weight of 7000 lbs is used to drive a 201.7 feet long HP 12 x 74 pile in an abutment to a bearing of 343 tons. The weight of the cap and insert is 1715 lbs and the manufacturer's weight of the anvil is 1246 lbs. If the average drop height is 8.5 feet in 10 blows, what would be the required penetration?

- Equation: $S = \{(10.5WH/Q) \times (W/(W+M))\} - 0.1$

ANSWER TO # 2

- Equation: $S = \{(3WH/Q) \times (W/(W+M))\} - 0.1$
- $Q =$ 343 tons
- $W =$ 7000lbs / 2000lbs/tons = 3.5 tons
- M = 201.7ft x 74 lbs/ft +1715 lbs + 1246 lbs/ 2000 lbs/ton = 8.94 tons
- H = 8.5 ft
- $S = \{(10.5 \times 3.5 \times 8.5 / 343) \times (3.5 / (3.5 + 8.94))\} - 0.1$
- $S = (0.91 \times 0.28) - 0.1$
- S = 0.15 in/ blow or 1.5 inches in 10 blows

EXAMPLE PROBLEM #3

A DOUBLE ACTING DIESEL PILE HAMMER IS DRIVING A 70 FT HP 10X42 TEST PILE WITH A 7000 LB PISTON. THE BACK PRESSURE READING AT THE TIME DRIVING CEASED WAS READ ON THE GAGE TO BE 19.0 PSI USING THE CHART ON PAGE 5-65. THE WEIGHT OF THE ANVIL AND CAP WAS KNOWN TO BE 1500 LBS. THE DESIGN BEARING IS 192 TONS, WHAT WOULD THE NECESSARY PENETRATION FOR OBTAINING 20% ABOVE PLAN BEARING IN 10 BLOWS.

- $S = \{(10.5E/Q) \times (W/(W+M))\} - 0.1$

ANSWER TO #3:

- P:
  - Plan Bearing = 192 tons
  - 20% over bearing = 192 x 1.20 = 230.4 tons
- W = 7000/2000 = 3.50 tons
- M = ((42 x 70) + 1500)/2000 = 2.22 tons
- E = 13600/2000 = 6.8 ft-tons

- S = {(3E/Q) x (W/(W+M))} – 0.1

- S @ 20% over for test pile
  - S = {(10.5x6.8/230.4) x (3.50/(3.50+2.22))} -0.1 = 0.08 in
  - S = 0.31 x 0.61 – 0.1 = 0.09in/blow or 0.9 inches in 10 blows

BATTER FACTORS

- Batter Factor = cosine a - f sin a
- a = Angle between the leads and a vertical line
- f = Coefficient of friction between hammer and surface it slides on (typically 0.1)

Batter Factors

1 on 12	**0.988**
2 on 12	**0.970**
3 on 12	**0.946**
4 on 12	**0.917**
5 on 12	**0.885**
6 on 12	**0.850**

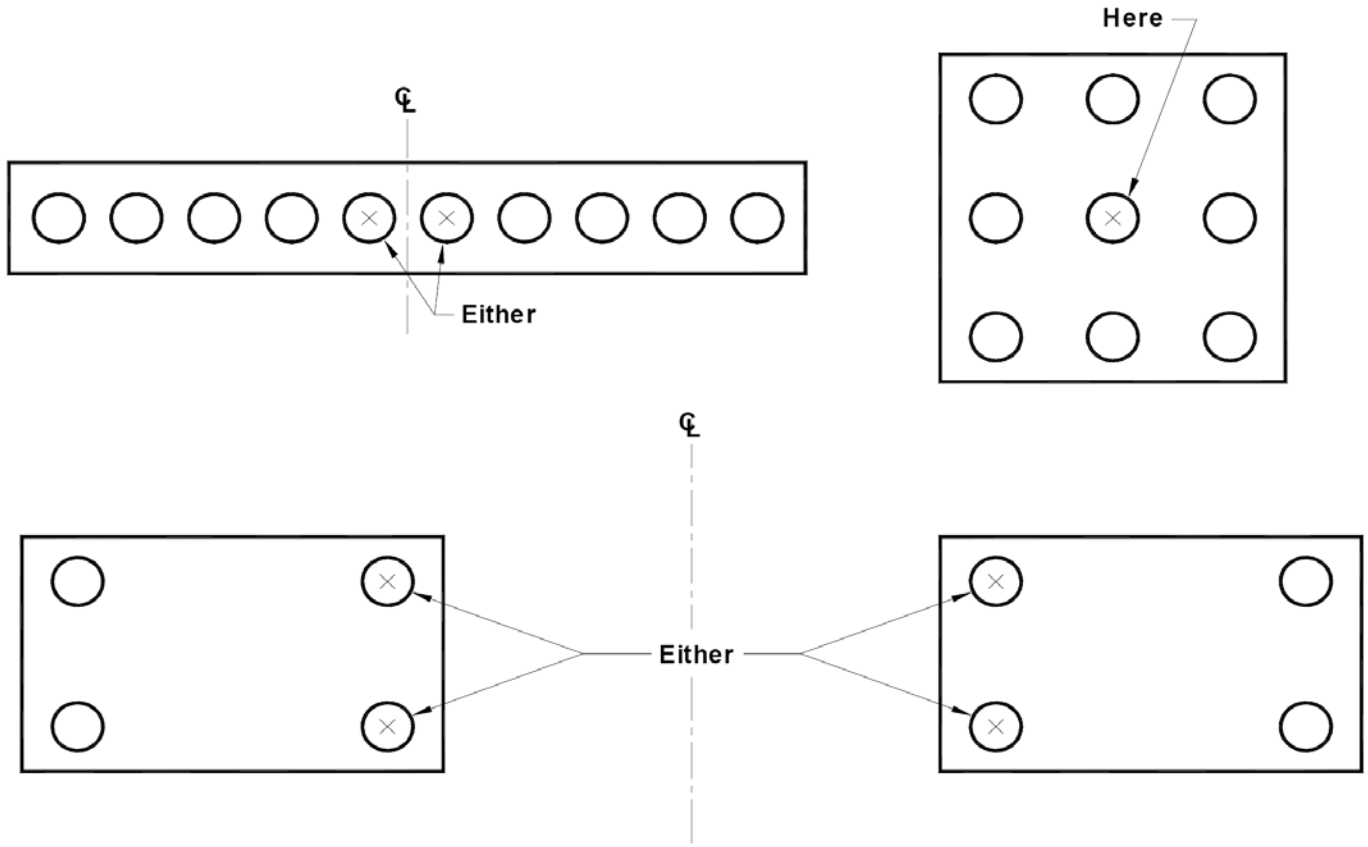
Batter Pile Driving

WHEN TO STOP DRIVING

- Test Pile -
  - 10-20% Over Plans Bearing
  - Location near center of substructure unit
  - Verify Bearing Build-up type & check subsurface investigation sheet
- Bearing Pile -
  - Stop When Bearing is Achieved
  - Prevent overdriving

TEST PILE LOCATIONS:

Figure 5.33 Test Pile Locations



SET-UP EFFECT

- Stop Driving When Pile is Two Feet Above Cutoff Elevation
- Let Set For 24 Hours
- Warm up the Hammer on Another Pile
- Reset the Cap (2-3 Blows)
- Take Measurement on Next 10 Blows

Setup Video: 101_3336a.wmv

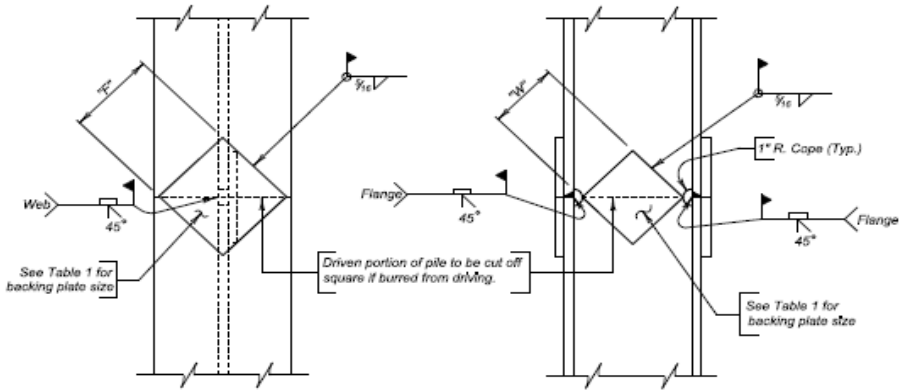
DRIVING PILING NEAR FRESH CONCRETE

- Vibrations Adversely Affect Fresh Concrete
- 24 Hour Waiting Period
- “Glass of Water Method”

PILE SPLICES

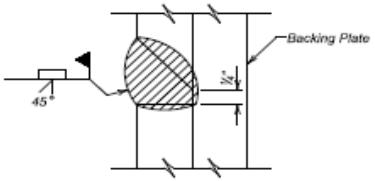
- Timber
  - Snug Fit?
  - Properly Treated?
- Steel
  - Certified Welder Needed? Sec 410 of Standard Specifications
  - Prevent splice in upper 10 ft in an integral abutment or pile frame bent.
- Concrete?

PILE SPLICE STANDARD PLATES



NOTE:
Prepare joint surfaces lower end of upper section on the ground and weld on backing plates; then place upper section on lower section and weld.

COMPLETE JOINT PENETRATION WELD DETAIL



GENERAL NOTES:

1. Steel for backing plates shall conform to ASTM A709 Grade 50.
2. Welding and weld inspection shall be in conformance with AWS D1.5 (Current Year) Bridge Welding Code - Steel.
3. Welder must be certified and registered with the SDDOT.
4. Backing plate shall at a minimum be as thick as the web of the pile being spliced.
5. Web must be coped with 1 inch radius.
6. Submit Welding Procedure Specification (WPS) to Bridge Construction Engineer for approval prior to pile driving.

TABLE 1
(BACKING PLATES)

PILE	10"	12"	14"
"F" FLANGE	6 ½"	8"	10"
"W" WEB	4 ¾"	6 ¼"	7 ½"

December 23, 2012

Published Date: 3rd Qtr. 2013 | SDDOT | STEEL PILE SPLICE DETAILS | PLATE NUMBER 510.40 | Sheet 1 of 1

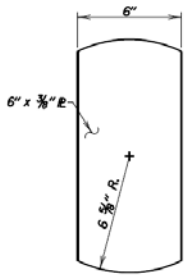
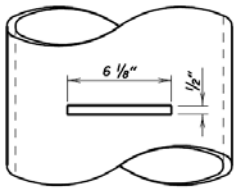
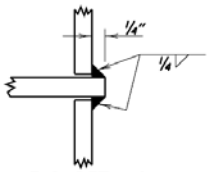


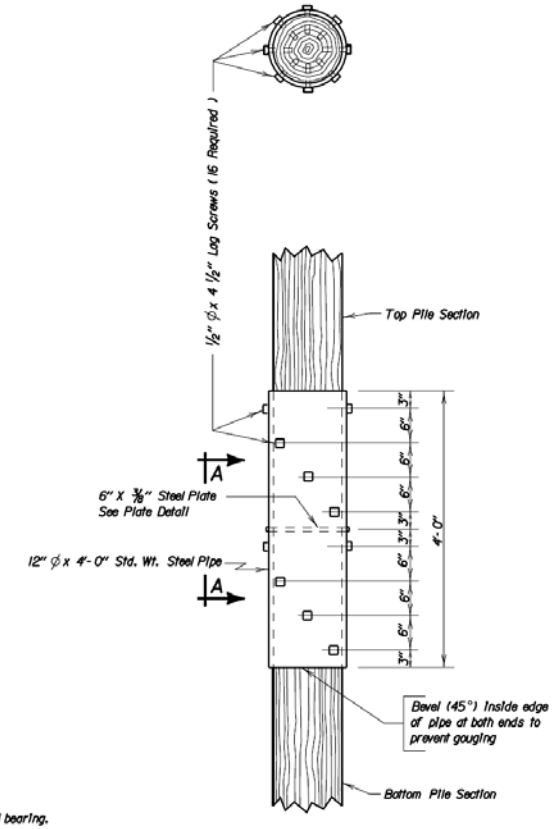
PLATE DETAILS



VIEW A-A



WELD DETAILS



NOTES:

1. All spliced ends shall be square cut and have full bearing.
2. All treated piles shall have spliced end and other cut surfaces field treated in accordance with American Wood Preservers Association Standard M4.
3. Pipe shall conform to ASTM A53, type E or S, Grade "B", and shall be hot dip galvanized in accordance with ASTM A123.
4. Lag screws shall conform to the requirements set forth in Division II, Section 16 of the current AASHTO Standards Specifications for Highway Bridges, and shall be hot dip galvanized in accordance with ASTM A153
5. The ⅜" steel plate shall conform to ASTM A36.
6. The ⅜" steel plate, the holes for the lag screws, the bevel cut at the ends of the pipe and the welds shall be painted with an approved zinc rich paint.
7. The top pile section shall fit snug in the 12" ϕ pipe sleeve with no shimming. The bottom pile section shall have a snug fit in the 12" ϕ pipe sleeve with necessary shimming permitted.

March 31, 2000

Published Date: 1st Qtr. 2007 | SDDOT | TIMBER PILE SPLICE DETAILS | PLATE NUMBER 510.20 | Sheet 1 of 1

PILING CUTOFF

- Shoot with rod and level from benchmark.
- Measure length in place to nearest 0.1 ft.
- No payment for cutoff unless ordered re-driven.

PAYMENT – FURNISH & DRIVE TEST PILE

- Test Piles – Paid to the nearest 1.0 LF.
- Driven greater than plans quantity - pay quantity driven.
- Driven Less than plan quantity– pay plans quantity.

- Section 510.5. page 296

PAYMENT – FURNISH & DRIVE BEARING PILE

- Paid to the 1.0 LF driven.
- Final quantity > plans
  - Pay contract price for driven quantity
  - + 10% of unit price for difference.
- Final Quantity < plans:
  - Pay contract price for driven quantity
  - If driven is underrun by > 5ft x # pile
  - + 20% for entire difference.
- Section 510.5.B.1&2

EXAMPLE:

Ten HP 12x74 required in the contract

Contract Price to Furnish and Drive HP 12x74 = $15.00/LF

Plans quantity: HP 12 x 74 = 250 LF
Driven quantity: HP 12 x 74 = 195 LF
==========
Difference = 55 LF

10 pile x 5ft = 50 ft.

Since the difference was greater than 50 LF, adjust payment as follows:

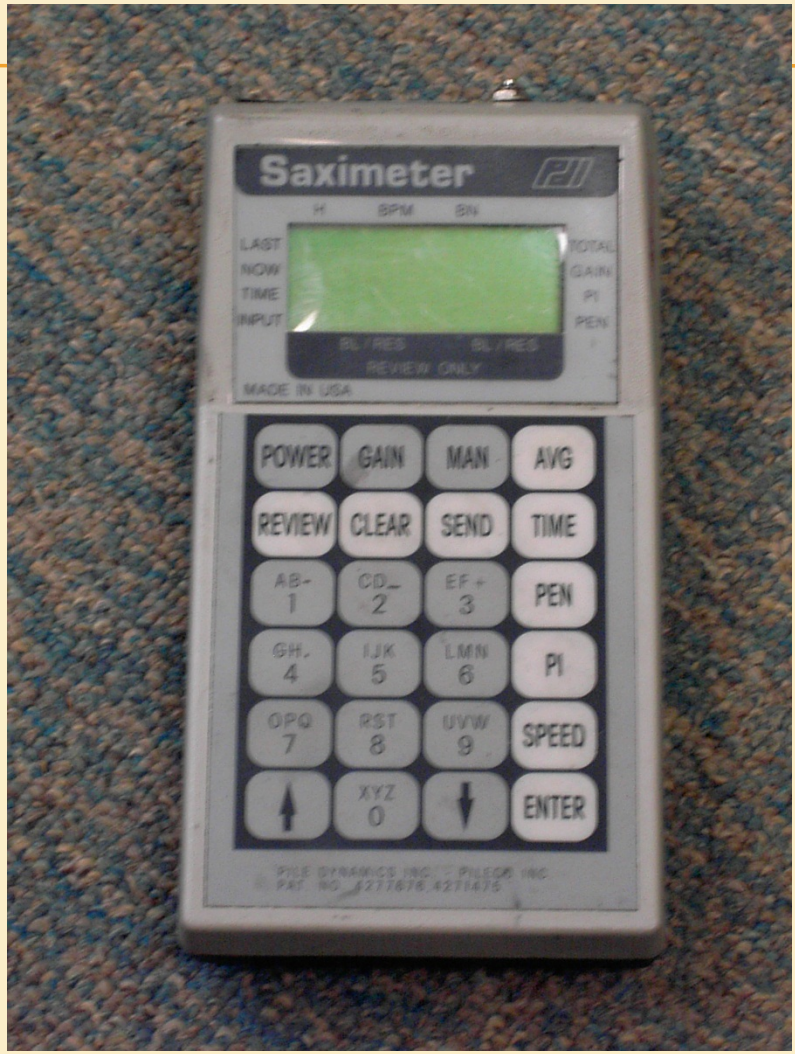
- Pay the quantity driven at the contract price plus:
- 55 LF x $15.00/LF x 0.2 = $165.00

PILE SPLICE PAYMENT:

- Within the specified pile length
  - No payment
- Located at or beyond specified length:
  - Measure per each for payment

SAXIMETER

- Automatically counts the hammer blows and determines blows per minute.
- Automatically calculates the “fall height” for single action hammers.



PILE RESEARCH

Static Load Test and Dynamic Testing

Inspection Requirements

PILE RESEARCH

- Review all contract documents
  - Plans
  - Special Provision
  - Spec Book
  - Shop-plans

STATE OF SOUTH DAKOTA
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
DYNAMIC PILE MONITORING AND
STATIC PILE LOAD TESTING

PROJECT NUMBER, PCN NUMBER
NAME COUNTY

SEPTEMBER 2, 2011

I. DESCRIPTION

This work shall consist of furnishing all labor, equipment, materials and qualified personnel necessary to conduct dynamic monitoring and static load testing of driven piles in accordance with this special provision at locations designated in the plans or as directed by the Engineer.

Dynamic monitoring and static load testing of two HP 12 X 74 steel test piles along with the dynamic monitoring of four HP 12 X 74 steel production piling shall be performed by the Contractor. The purpose of this testing program is to obtain load-deflection and load transfer data required to accurately determine the nominal resistance of the pile under static loading conditions for comparison and correlation with dynamic driving data predictions and subsequent calibration of Load and Resistance Factor Design (LRFD) load factors based on local practice.

The Contractor shall engage the services of a specialty subcontractor experienced in high-strain dynamic monitoring and static load testing of driven piles to perform the tasks listed in this special provision and report results to the Department. The specialty subcontractor shall have at least five years of documented experience in the performance and interpretation of dynamic and static pile testing. The individual responsible for operating the instrumentation shall be under the direct supervision of a licensed Professional Engineer registered in the state of South Dakota and be fully capable of understanding and interpreting the data being collected. The specialty subcontractor shall be selected by the Contractor and submitted for approval, by the Engineer, a minimum of 30 days prior to work beginning. Approval will be based upon qualifications and applicable previous experience on other projects.

PILE RESEARCH

30 days prior to the start of pile driving

- Testing Company information submitted
  - Pre construction wave equation
- Load frame design submitted
  - Including reaction Pile driving sequence and bearing
- Jack and Load Cell calibration certification submitted
  - Both need to be calibrated within 60 days of use

STATIC LOAD TEST

- Test pile must be driven in order as per special provision
- Each test will have different number of days to restrike as per special provision
- SDDOT inspectors will need to locate area for test pile to be driven
- SDDOT inspectors need to witness reaction pile driving to insure proper bearing and placement as per load test frame design

- Inspector will need to provide saximeter and monitor static test piles being driven
- Provide data for each foot of pile being driven or as requested by testing company
- Provide inspector pile report
- Static load test will be ran by testing company
- Inform Foundations when test will be performed

- Dynamic testing will be performed on piles in substructure
- Inspectors will monitor pile driving the same as normal projects
- Testing company will place monitoring equipment on pile when hammer is in place
- Measurement will be done according to test pile section in SDDOT spec. book

10/16/2013

10/16/2013

DYNAMIC TESTING OF PILE

Pile Dynamic Analysis

DYNAMIC TEST

10/16/2013

STATIC LOAD TEST

PILE STATIC LOAD TEST

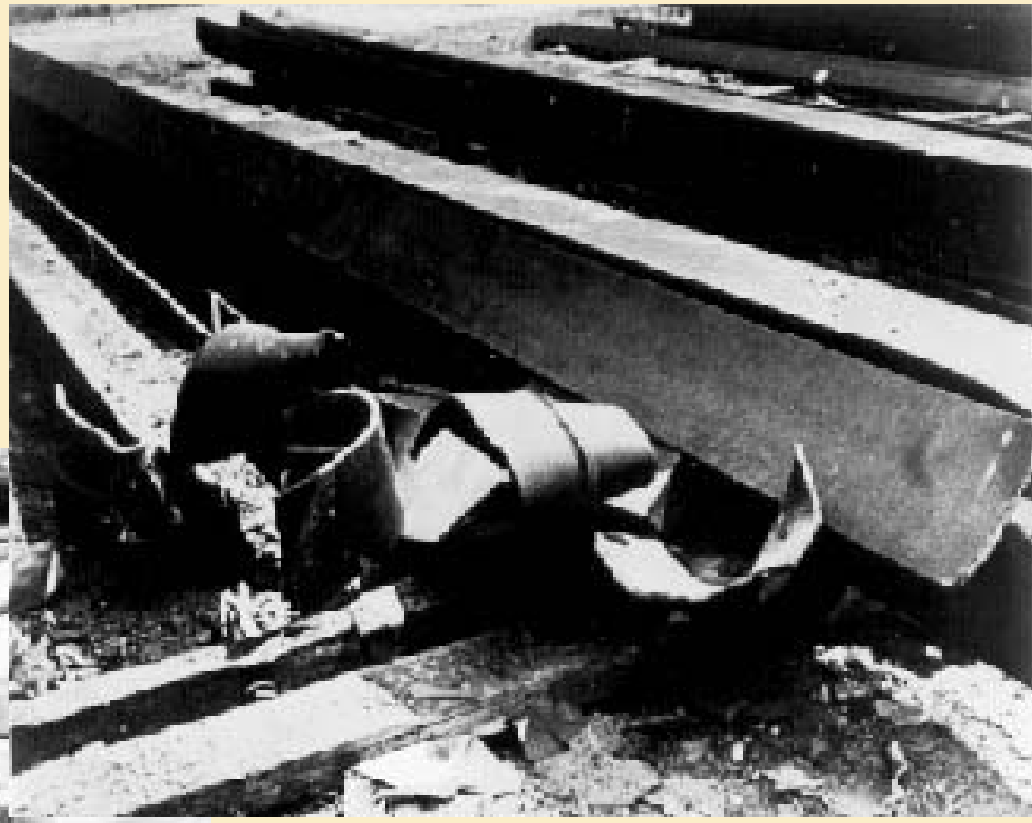
STATIC LOAD TEST

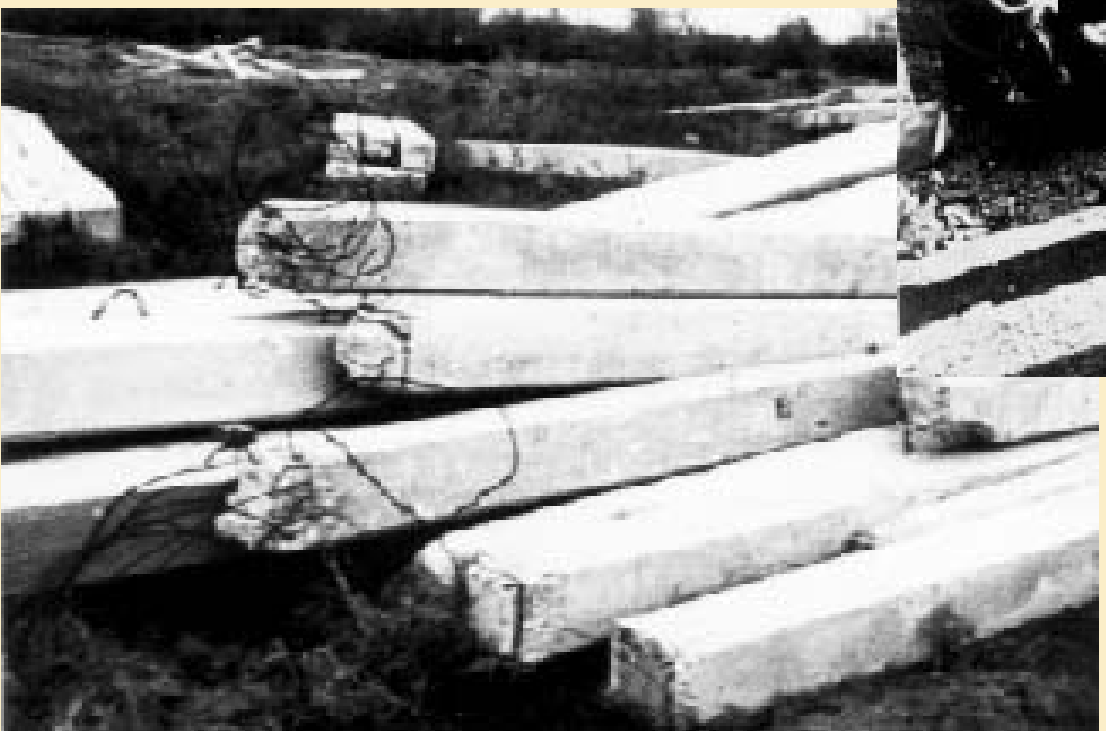
INSTRUMENTATION

STATNAMIC LOAD TEST

- http://www.youtube.com/watch?v=2LlHdpZIwH8

DAMAGED PILE DUE TO OVERDRIVING





PRECAUTIONS IN PILE DRIVING

- Drive Pile Axially
- Prevent Overdriving
- Significant Hammer Energy
- Keep Piston Cable Slack
- Preventing the Hammer from Bouncing
- Hammer operating properly

QUESTIONS

Office of Bridge Design: 605-773-3285

Bridge Construction Engineer: Hadley Eisenbeisz

Office # = 605-773-4452 **Cell: 605-280-4645**