

# Pile Driving Inspection Workbook

Certified Inspector  
Training Program

## **Reasons for Certified Inspector Training (CIT) Training Program**

### **Overview**

The Kansas Department of Transportation (KDOT) has established this training program to educate, test and certify those individuals responsible for performing inspection and testing functions on KDOT construction projects. KDOT's Bureau of Construction and Materials has responsibility for the establishment and administration of the materials portion of the KDOT's Quality Control/Quality Assurance (QC/QA) Program. The Bureau develops standards and specifications for materials, establishes sampling procedures and frequencies, and test procedures used in the laboratory and the field in order to assure compliance with specifications. It performs materials testing to assist each of the six KDOT districts in administering quality assurance functions of the QC/QA Program. Such testing includes tests on materials purchased by contractors or the State for use in maintenance or construction activities. The Bureau also conducts tests on soils, concrete, bituminous mixtures and numerous other specialized materials, the results of which are used by others for a variety of reasons.

Quality control and quality assurance activities involve the routine sampling, testing and analysis of various materials to determine the quality of a given product and to attain a quality product. The goal of the Certified Inspection and Testing Training Program (CIT<sup>2</sup>) is to provide persons engaged in the inspection and/or testing of KDOT construction projects specific training in, but not limited to, soils, aggregates, and concrete and/or asphalt disciplines.

Each student is required to demonstrate specific abilities as defined by the training modules described in the CIT<sup>2</sup> manual. The manual can be found online at: <http://www.ksdot.org/descons.asp#CIT>.

### **Federal Funding**

On projects involving federal funds, KDOT must certify to the Federal Highway Administration as to the quality of each type of material used on each project before the State is completely reimbursed by the federal government.

The certification and training requirements contained in this manual are intended to comply with the requirements of 23 CFR Part 637 which states, "After June 29, 2000, all sampling and testing data to be used in the acceptance decision or the IA (Independent Assurance) program shall be executed by qualified sampling and testing personnel."

### **Reasons for Quality Control/Quality Assurance**

Inspectors fulfill a very important job on any project—they safeguard the public interest in a number of ways.



The primary reason for materials inspection, sampling and testing requirements is to verify that all materials incorporated into the work will meet the requirements of the contract documents, including the plans, specifications, and special provisions.

Plans and specifications are prepared to require the use of certain specific materials known or expected to perform satisfactorily with minimum maintenance throughout the life of the facility or infrastructure project. Any material that deviates appreciably from the specifications requirements will not perform as expected and, in all probability, will shorten the useful life of the facility or add unexpected costs in maintenance. Because there are limited dollars available for transportation infrastructure, the useful life and long-term maintenance costs of every project are critical considerations.

Secondly, all contractors bidding or furnishing materials to a project should be treated equally. That is, the contract documents provide a fair and uniform basis for bidding because they define the requirements to be met—ideally with the least possible difference of interpretation. The contractor commits to furnish materials and complete work that will equal or exceed such requirements. For this reason it is essential that quality assurance be correctly understood and applied uniformly by engineers and inspectors from project-to-project so that all contractors and suppliers are treated alike.

Thirdly, the expenditure of public funds must be documented to substantiate whether taxpayers actually received the quantity and quality of materials specified in exchange for tax dollars spent. Whether or not to pay the costs invoiced by contractors is a decision which relies heavily upon inspection reports and test results. In a fundamental way, inspectors play a key role in serving the public—to justify the expenditure of public monies and the acceptance of any contractor's work. Through the work of knowledgeable, competent and skilled inspectors, KDOT can verify and confirm whether or not the contractor has fulfilled its obligations to build the project as intended.

Finally, the specification requirements for materials are constantly evolving, based on new developments, past performance of material in the field, research and technological innovations. Accurate recordkeeping of materials and test results using consistent inspection practices provides a basis to compare results over time—an indispensable advantage for meaningful research. Data properly collected and recorded by inspectors can confirm whether or not changes in material specifications and testing requirements have, in fact, resulted in a better product, state-wide or in a particular location or application.

All inspectors should review the applicable clauses of the Standard Specifications at regular intervals to refresh their understanding of material and testing requirements.

# Pile Driving Inspection Certification Workbook

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14. Bridge Construction Manual Pile 5.3

## Overview of Pile Foundation Design and Construction



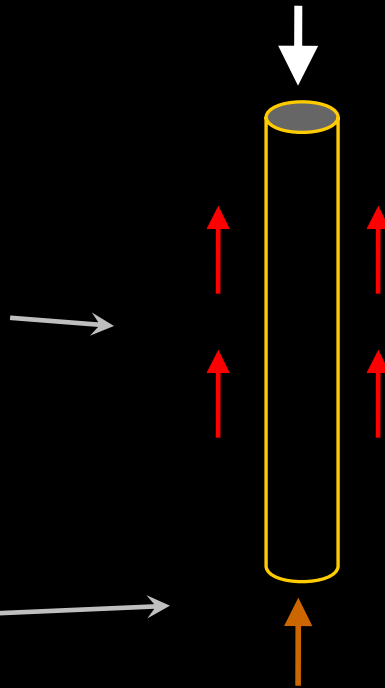
This class is concerned with the installation of **driven pile**.

Driven pile are hammered into the ground, where they develop resistance from the soil or rock.



The bridge load is transferred to the soil or rock by resistance along the length of the pile...

...and resistance from the tip.



Piles which get most of their resistance from friction along the side are commonly called **friction piles**.

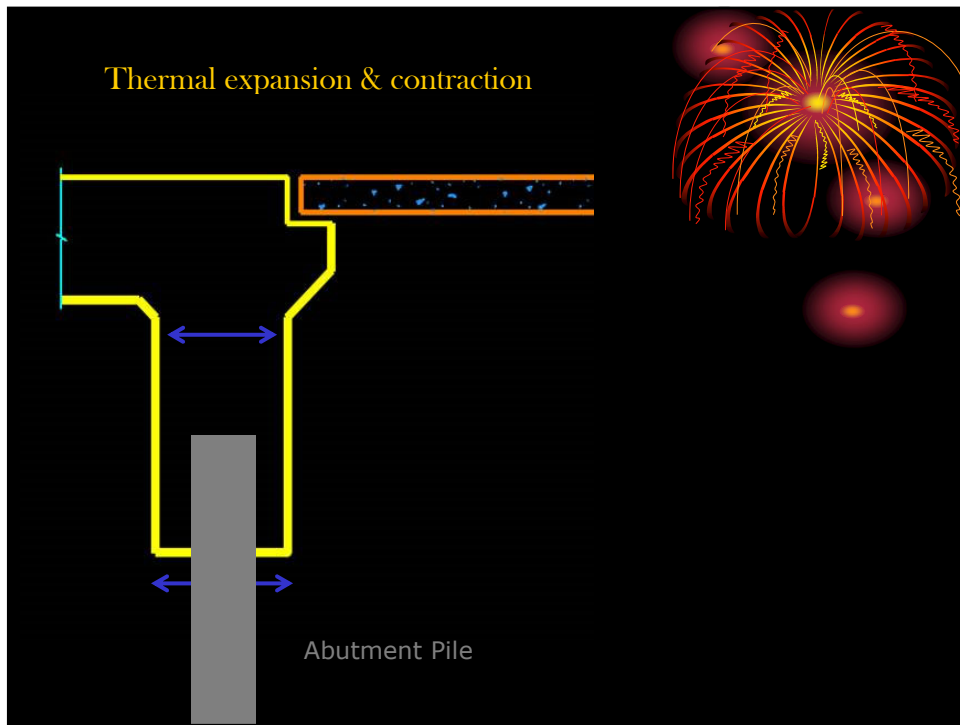
Piles which get most of their resistance from the tip are referred to as **end-bearing piles**.

Pile foundations are used for bridges in two general ways:

1) Abutments of most KDOT bridges

Current KDOT design practice prefers piling for abutments. Pile abutments tend to flex better with changes in temperature, putting less strain on the spans.



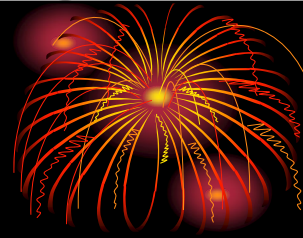


Pile foundations are used for bridges in two general ways:

2) Both Abutments and Piers of bridges in many parts of the state.

In central and western Kansas, bedrock is often too deep to use spread footings or drilled shafts.

This means you will  
be driving piles:



to a required resistance  
(usually)

**or** to a predetermined depth  
(occasionally, to get below a certain  
elevation in case some of the soils get  
scoured away during a storm)

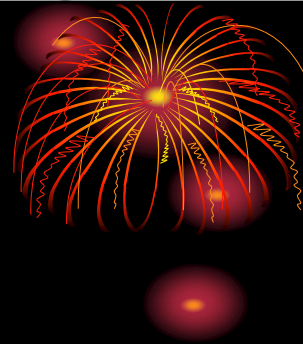
**At the same time, you will be  
expected to make sure we:**

**Don't damage the piling**

**Avoid expensive overruns by  
driving more than necessary**



# Unfortunately...



There is a complex interaction between the pile and the surrounding soil. And so things can get complicated in the field.



Smith County—Missouri Pacific bridge pile, circa 1880





Dolla Dolla  
Billz,  
y'all !!

But if it was easy,  
anyone could do it.  
Then they wouldn't  
have to give us so  
much money.

**Knowledgeable and  
diligent  
construction  
*supervision* and  
*inspection* are vital  
to proper  
installation  
of piling.**



So what  
are we  
trying to  
learn  
here?



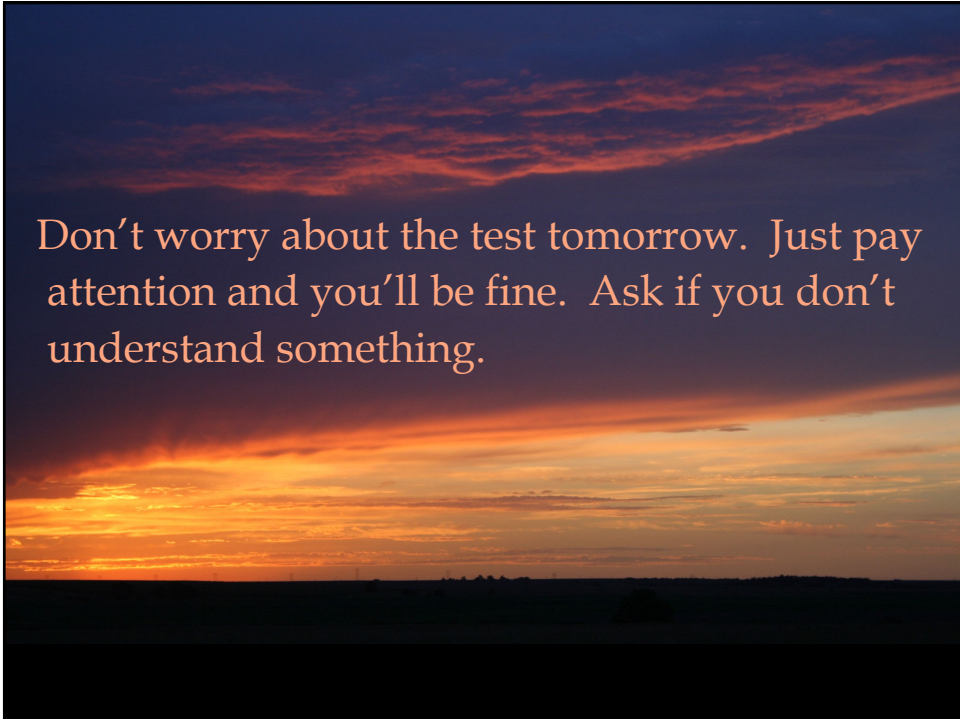
Pile driving terms and equipment  
How to prepare for a piling project  
How to calculate resistance

Where to find what you need in KDOT  
specifications and manuals



What to do in the field, and where to start if you have problems

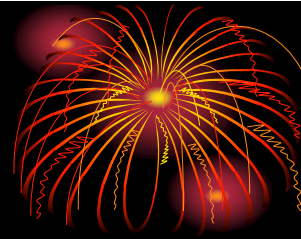
How to read the appropriate plan sheets like a veteran



Don't worry about the test tomorrow. Just pay attention and you'll be fine. Ask if you don't understand something.



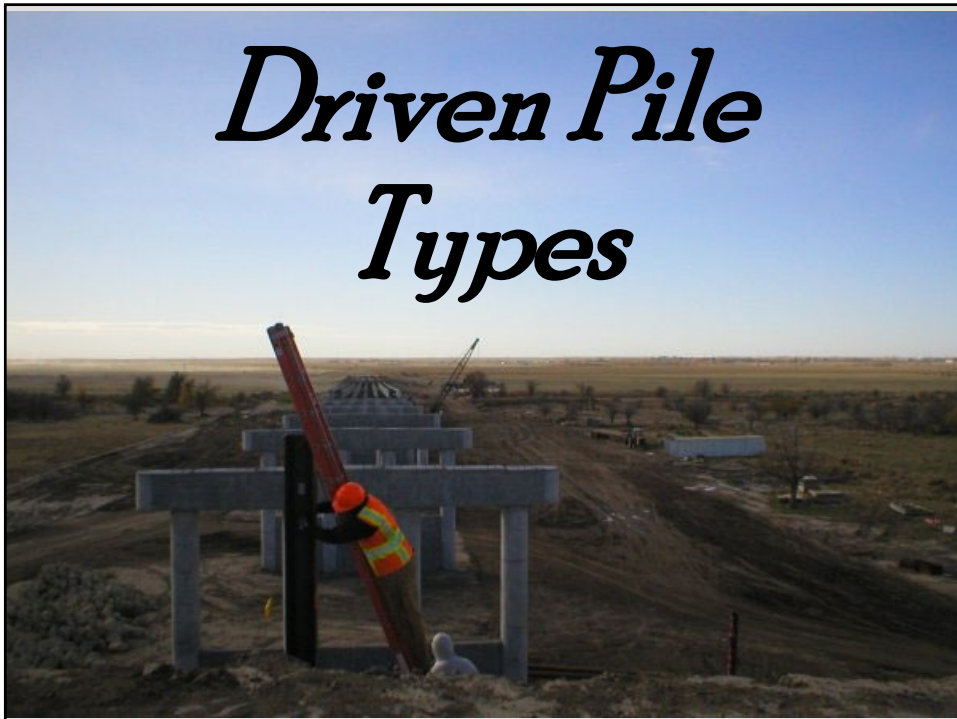
*We will make  
the things we  
cover practical  
and as  
interesting as  
possible.*



*Let's get started.*



# *Driven Pile Types*



## **General Pile Types**

- **Foundation piles**
  - Structural Support
  
- **Sheet pile**
  - Retention

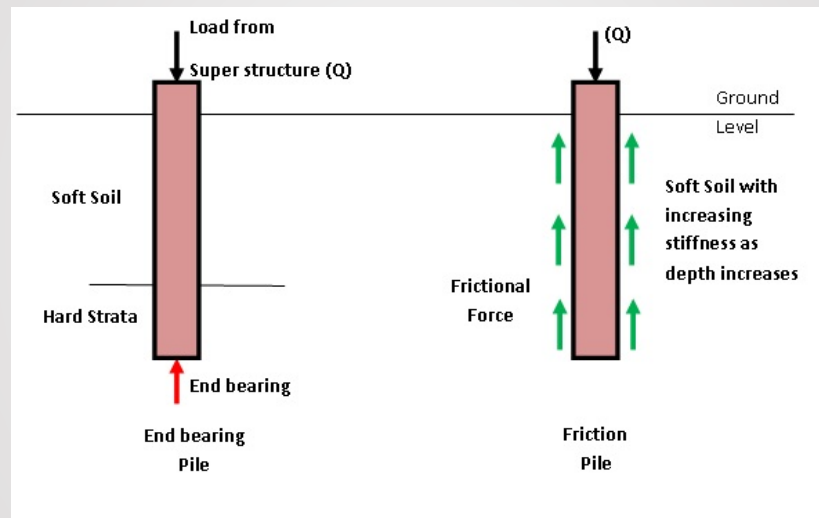


## General Pile Types

- **Foundation piles**
  - Structural Support
- **Sheet pile**
  - Retention



## Pile Design Designation





## Pile Arrangement

### ➤ Pile Bents



### ➤ Pile Groups

## Pile Arrangement

### ➤ Pile Bents

- Pile extends into the superstructure
- Usually a single row of piles
- Encased in concrete wall





## Pile Arrangement

### ➤ Pile Bents

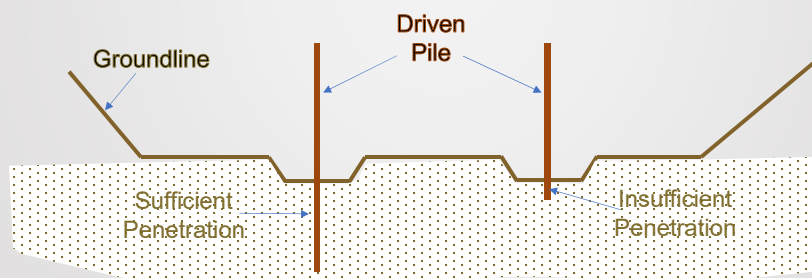
- Pile extends into the superstructure
- Usually a single row of piles
- Encased in concrete wall



## Pile Arrangement

### ➤ Pile Bents cont.

- Pile within the bents shall penetrate not less than  $\frac{1}{3}$  the unsupported length or not less than 10 feet into hard cohesive or dense granular material



## Pile Arrangement

### ➤ Pile groups

- Piles are driven to bearing in groups
  - Usually 6 or more per group, 9 common
- Cutoff elevation is below ground
  - And usually below scour line



## Pile Arrangement

### ➤ Pile groups cont.

- Pile cap is constructed on top of the group
- Pier column built on top of pile cap to support the superstructure





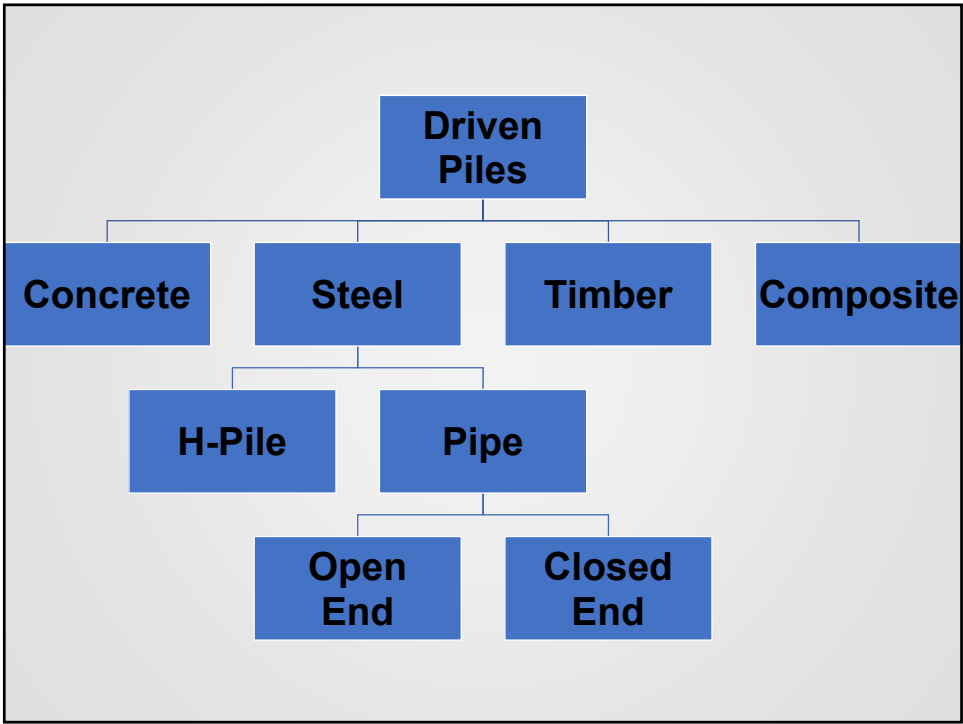














## Timber Piles

Only used for False Work, which is not inspected by KDOT



## H-Pile

- Most common pile type used by KDOT
- Typical lengths range from 15 to 130 feet
- Typical design loads 45 to 225 tons
- Material Specs:  $F_y = 50$  ksi
- Suited for either end or friction bearing





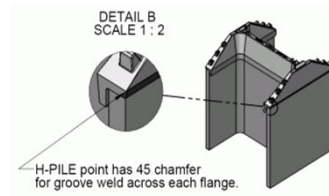


**Battered Pile K-4 over Delaware River  
Valley Falls, Kansas**

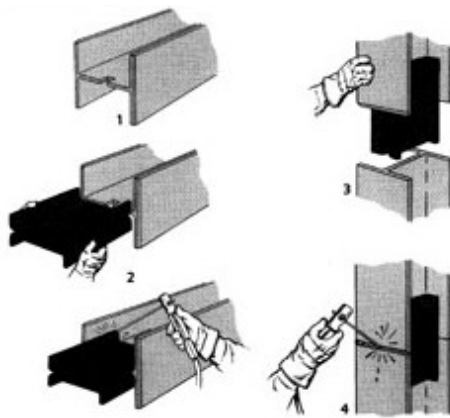


## H-Pile With Tips

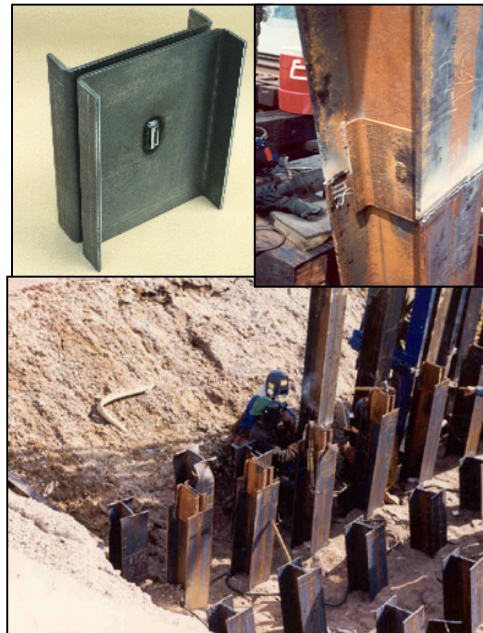
- Embedding into hard bedrock
- Encountering obstructions
  - Help protect tip



## H-Pile Splice



**KDOT does not use  
this method**



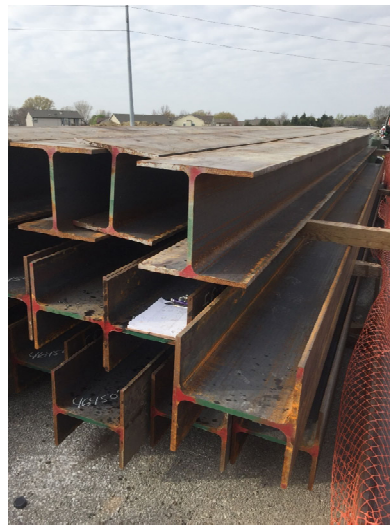
## Usual KDOT H-Pile Splice

- Butt weld with no plate
- Certified Welder
- Grind both ends of pile to form a bevel recess
- Square and level two pile ends
- Weld all the way around the pile with a full penetration welds



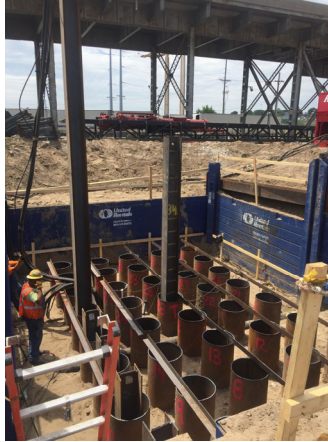
## H-Pile Advantages

- Available in Various Lengths and Sizes
- Easy to Splice and to Cutoff
- High Capacity
- Close Spacing
- Low Soil Displacement
- Deep Penetration



## H-Pile Disadvantages

- Vulnerable to Corrosion When Exposed
- Can Deflect Easily if Obstructions Are Encountered
- Not Recommended as Friction Pile in Granular Soils



## Closed End Pipe Pile

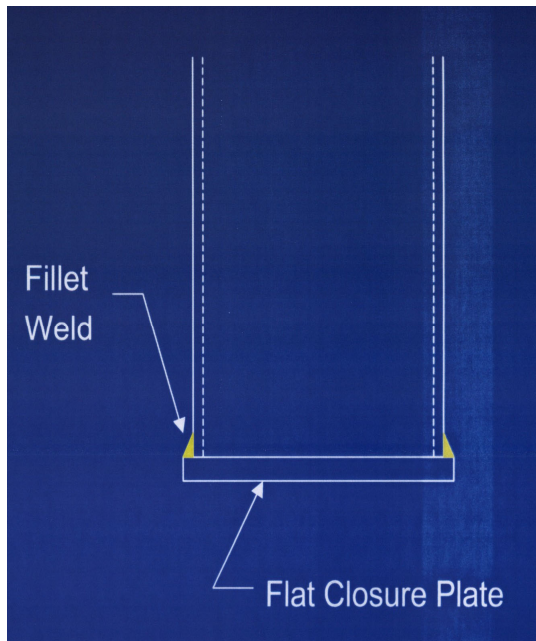
- **Typical Lengths: 15 to 120 feet**
- **Material Specs:  $F_y = 45$  ksi**
- **Typical Design Loads 40 to 300 tons**







## Typical KDOT Pipe Pile Plate



# Closed End Pipe Pile

## Using Conical Points



Drive fit point for pipe piles. Taper swages pipe to a friction joint so welding is not required.

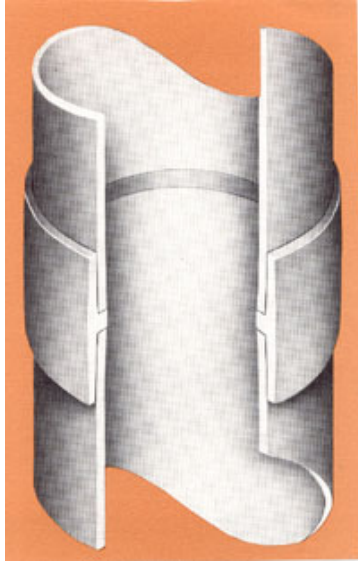


Rib reinforced point for tough driving to deep penetration in difficult soils.





## Pipe Pile Splice



**Splicing Rings---KDOT  
Does Not Use**



## Usual KDOT Pipe Pile Splice

- Butt weld with no plate
- Grind both ends of pile to form a bevel recess
- Square and level two pile ends
- Weld all the way around the pile with a full penetration weld



## Pipe Pile Advantages

- Available in Various Lengths, Diameters & Wall Thickness
- Easy to Splice
- High Capacity Potential
- High Bending Resistance Where Unsupported
- Length is Loaded Laterally



## Pipe Pile Disadvantages

- Vulnerable to Corrosion
- Could Hinder Required Penetration Depth
- Susceptible to Bending or Mushrooming at Head
- High Soil Displacement





## Composite Piles

- Two different materials
- Good qualities are taken advantage of
- Used in special circumstances
- Preferential Use
  - Geology
  - Structure
  - Durability
  - Cost



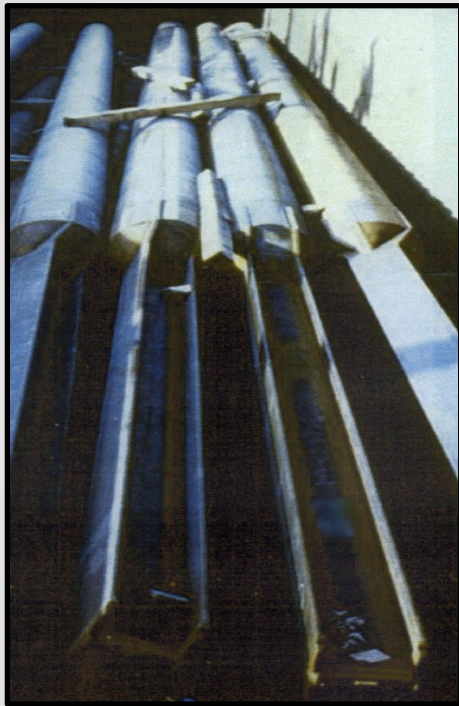
## Composite Pile Variations

- Concrete and H-pile
- Steel pipe and H-pile
- Steel pipe and concrete
- Concrete filled pipe



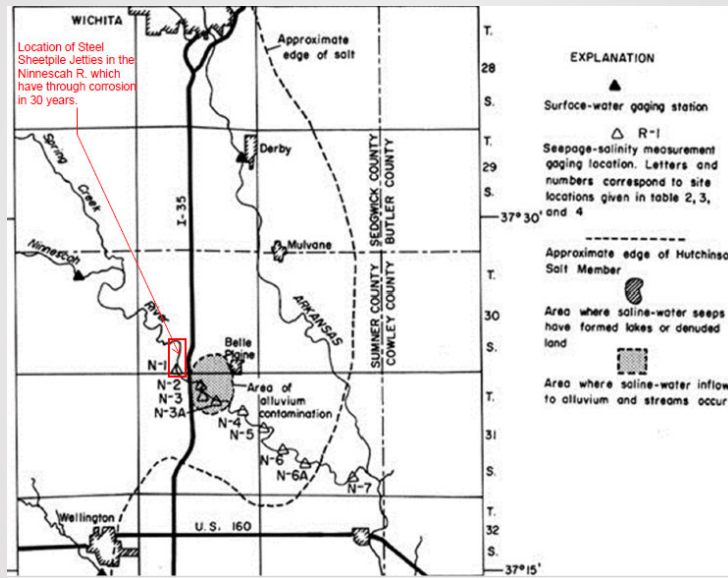
## Composite Pile Variations Cont.

- Fiberglass
- Fiberglass shell filled with concrete
- Corrugated shell and timber
- Numerous others



**Pipe & H-pile**

# High Salinity Location



# Need for Composite Pile



## Composite Piles

- Typical Lengths 50 to 200 feet
- Maximum Design Stress: Dependent upon pile material
- Stresses Driving Stress: Dependent upon pile material
- Design Loads 30 to 200 tons
- Remarks Weakest material governs allowable stresses and capacity

## Composite Piles

### Advantages:

- May be applied in unusual design or installation situations
- High capacities possible but dependent on materials
- Could reduce foundation cost
- Some types offer corrosion protection

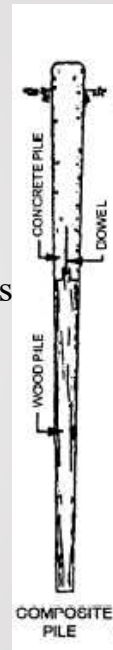




## Composite Piles

### Disadvantages:

- May be difficult to splice
- May be difficult to attain good joint between materials
- Vulnerable to decay above water unless treated



## Concrete Piles Overview

Typical Lengths: 30 to 130 feet

Design Loads: 45 to 500 tons

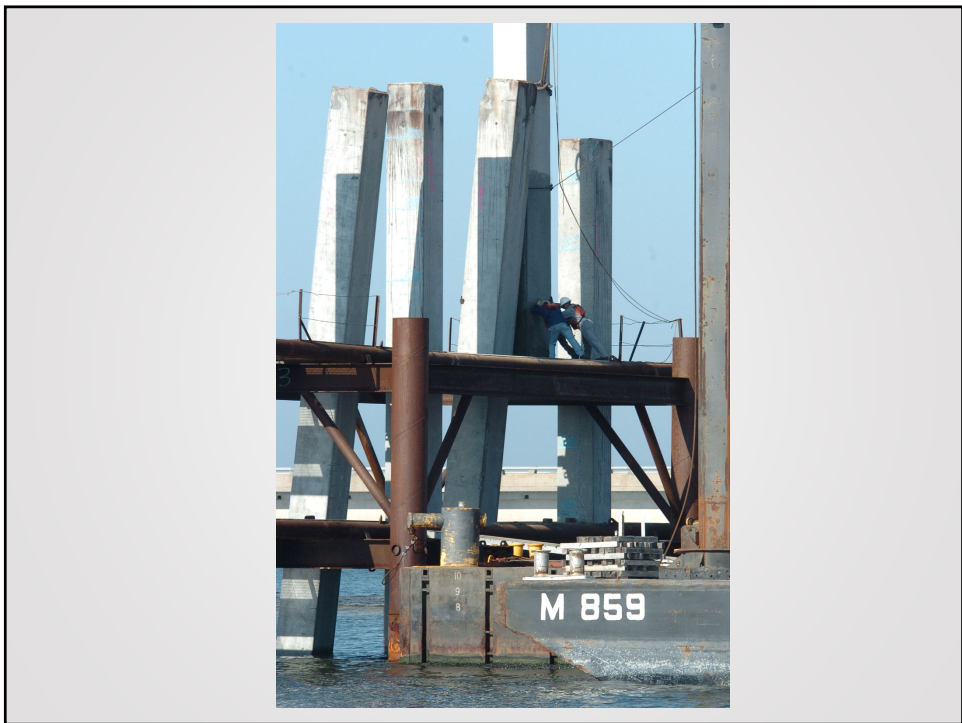
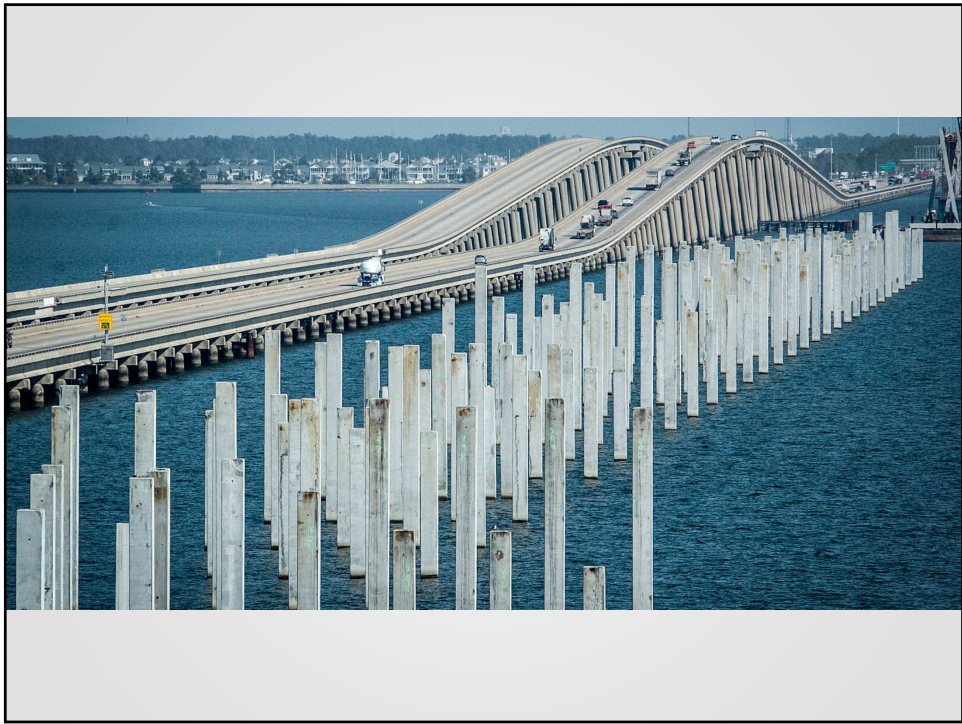


## Concrete Piles



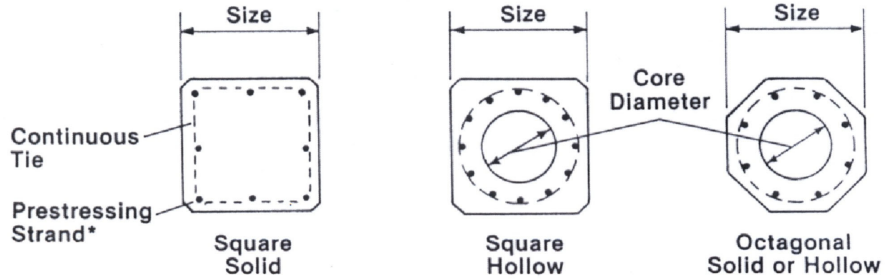
## Concrete Pile Bent







## Concrete Pile Detail



**Size: 10" and up**

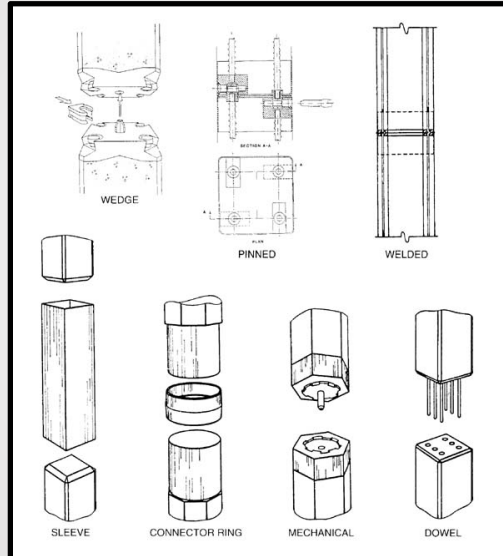
**20 to 36"**  
**could have 11**  
**to 18" hollow**  
**center**

**10 to 24"**  
**could have**  
**11 to 15"**  
**hollow center**

## Concrete Pile Cushion



## Concrete Pile Splice



## Concrete Pile Splice



24 inch octagon

## Concrete Pile Splice

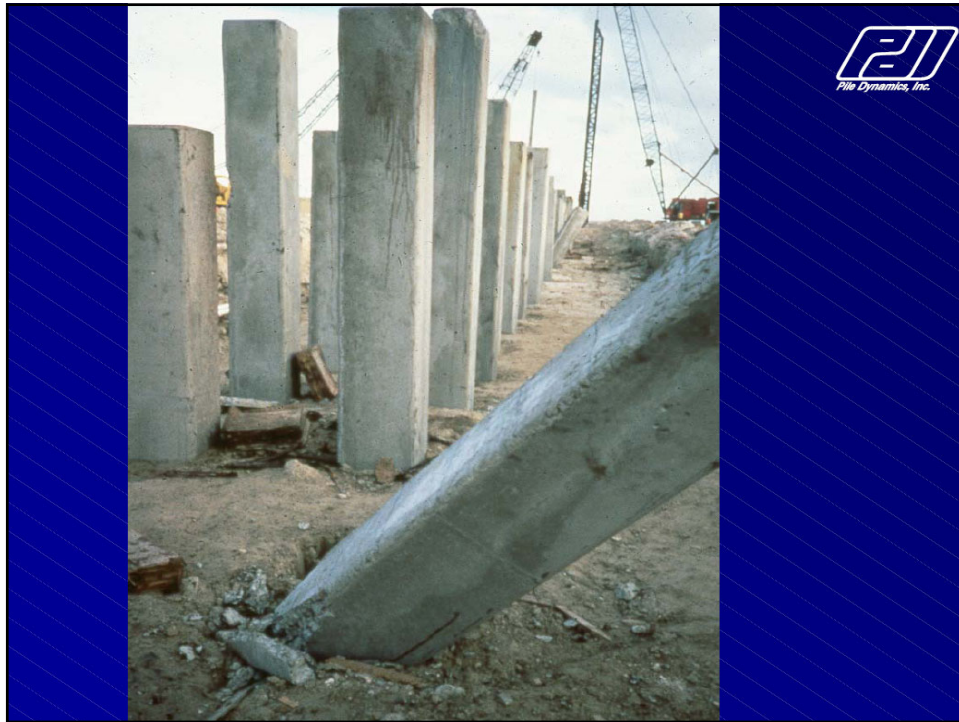


30 inch square  
Male/Female ends



## Concrete Pile Damage





## Concrete Pile Advantages

- High load capacity
- Can be made for corrosion resistance
- Hard driving possible
- Cylinder piles suited for bending resistance





## Concrete Pile Disadvantages

- Relatively high breakage
- Unless pre-stressed, vulnerable to handling damage
- Considerable soil displacement
- Difficult to splice
- High initial cost



## Other Types of Driven Pile



## Tapertube Piles



## Mono Tube Pile



## **Cylinder Concrete Pile**



***Questions?  
Comments!***

## *Pile Driving Equipment*



The task of successfully installing piles involves selecting the most **cost-effective equipment** to drive each pile to its **specified resistance or depth** **without damage** in the least amount of time.





# THE LEADS

- Keep the hammer and pile aligned during driving
- Guide the hammer
- Brace long piles until they are driven enough to support themselves

## SWINGING LEADS

Swinging Leads are widely-used because they're:

Simple

Lightweight

Low cost



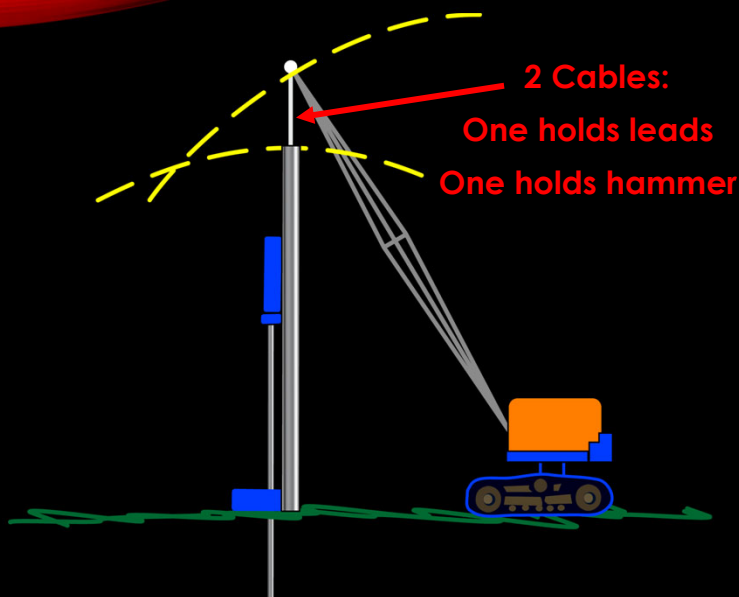
## SWINGING LEADS

Swinging leads can be moved easily to align the hammer and the pile head, without moving the crane

## SWINGING LEADS

Swinging leads are lightweight, which gives the crane a large operating radius. In other words, the contractor doesn't need to move the whole crane for every pile.

### Most common setup for swinging leads



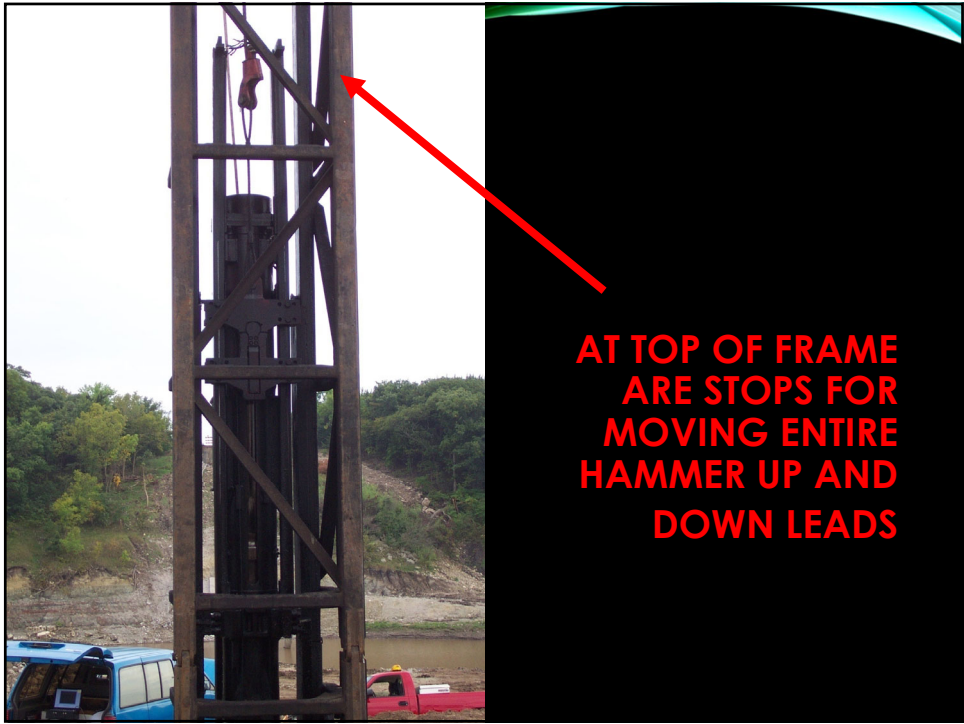
**CRANE  
WITH  
SWINGING  
LEADS**



**CABLE ATTACHED  
TO A FRAME**

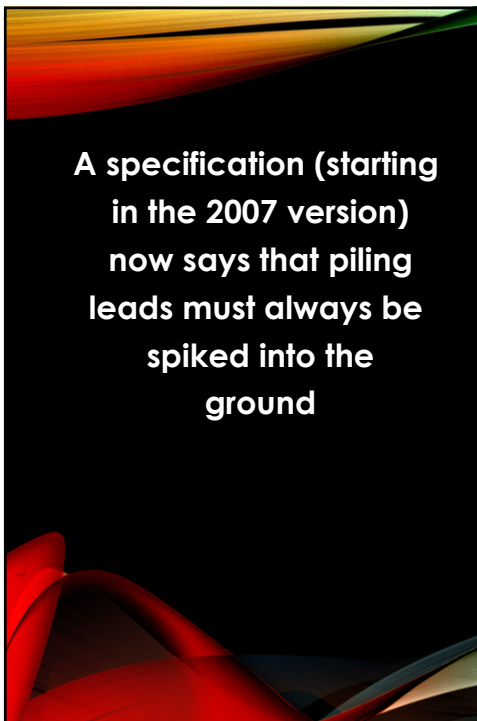
**HAMMER SLIDES  
ALONG FRAME**







**For years and years, KDOT contactors could leave swinging leads hanging in the air**



**A specification (starting in the 2007 version) now says that piling leads must always be spiked into the ground**





**It helps with hammer-pile alignment, and is also a safety matter**



**This is an extreme example from summer 2013.**

**Long piles, short leads, Western winds.....**

**Lots of alignment trouble.**



**This is from 2015**



**And this is from 2019**

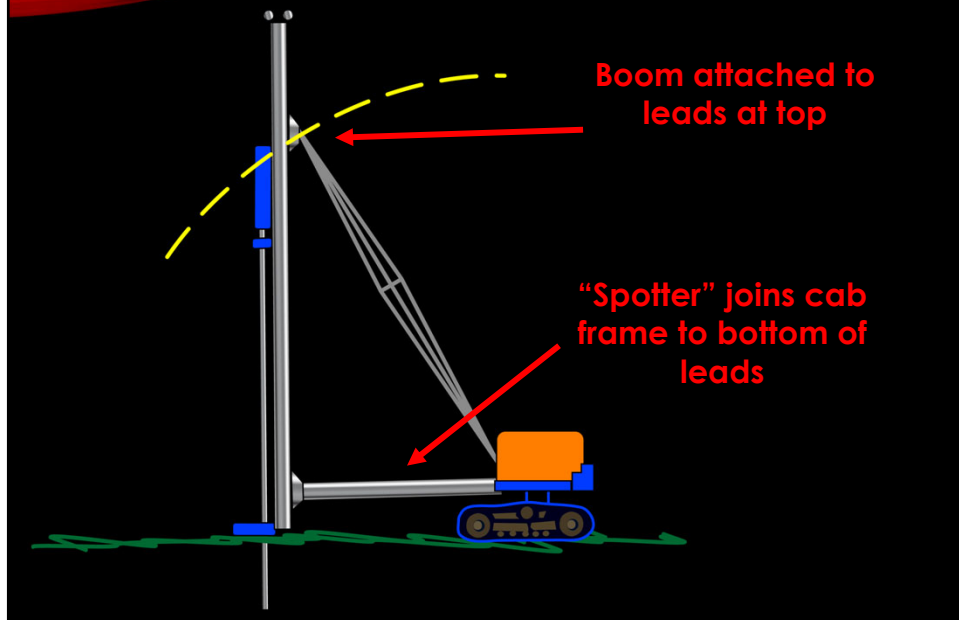


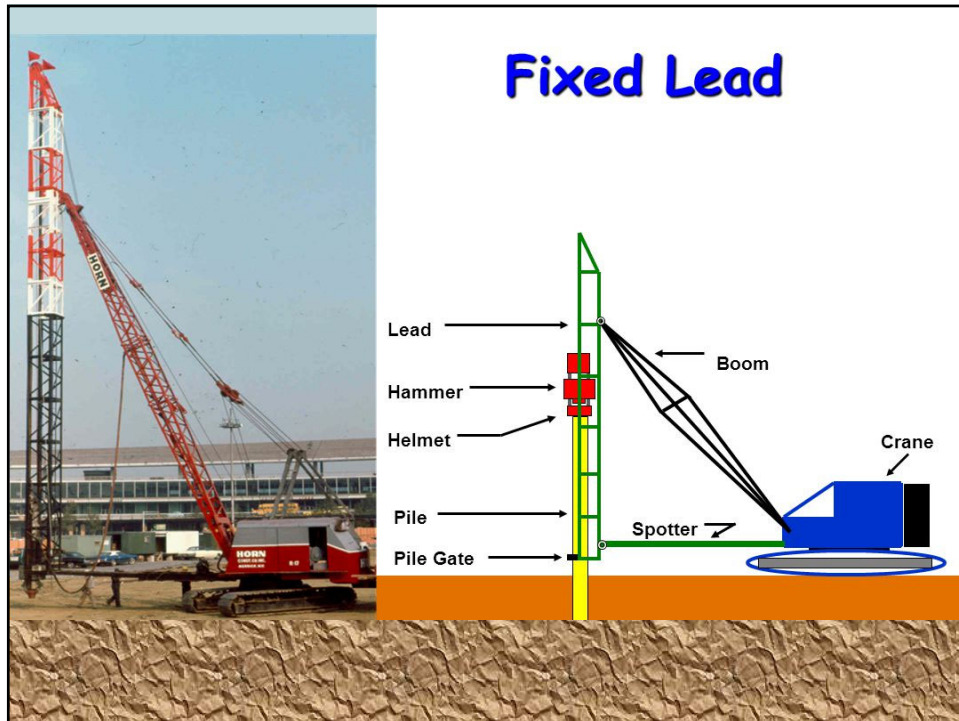


# FIXED LEADS

Fixed Leads are attached to the crane boom, and have a brace running from the bottom of the leads to the crane frame.

# FIXED LEADS





## FIXED LEADS

Fixed leads hold the pile in a more true alignment during driving, but require much more time to set up.

## FIXED LEADS

Fixed leads are used for large piling on large projects.

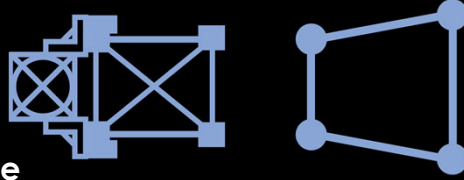
You will rarely see fixed leads on Kansas bridge projects.

## COMMON TYPES OF LEADS

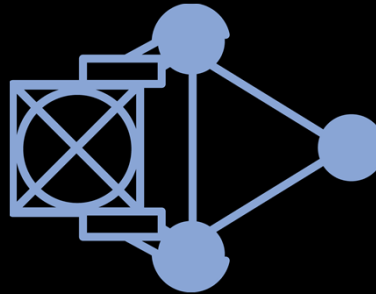
Truss  
Triangular  
Box  
H-Beam  
Pipe

## Truss Lead

Square and Round Tube

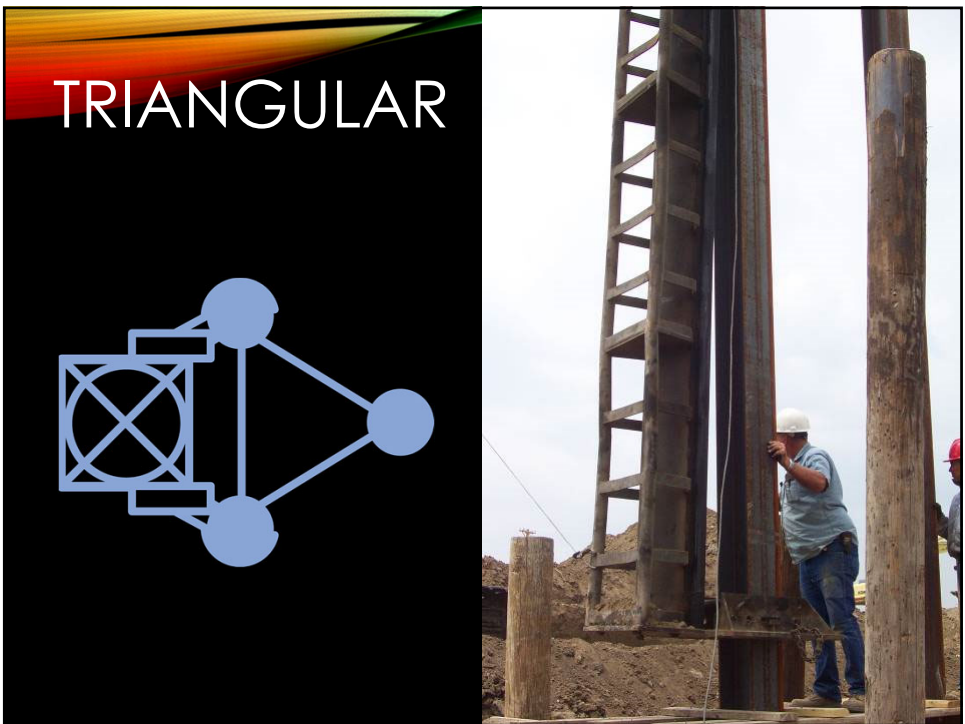
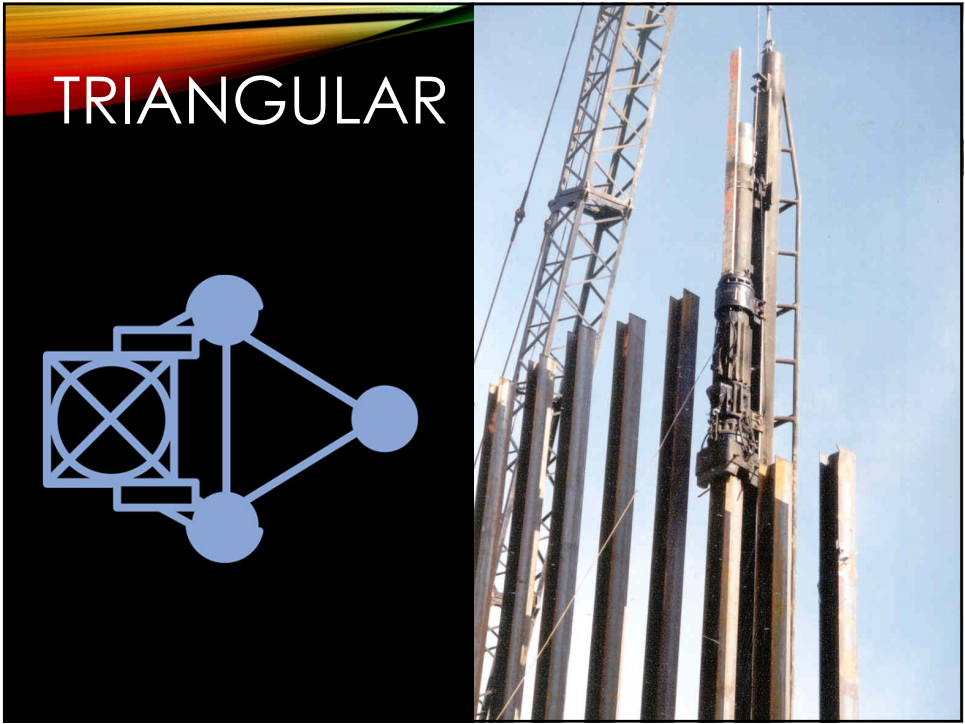


## Triangular Lead

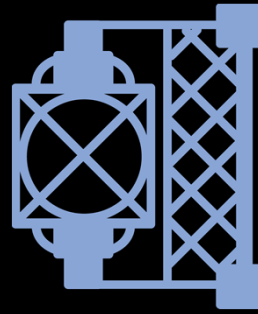


Truss Leads

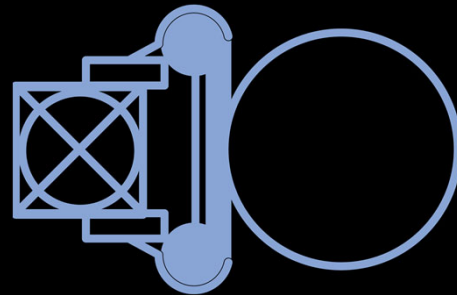




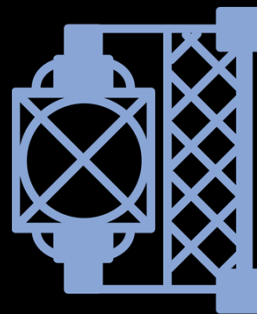
**Box Lead**



**Pipe Lead**

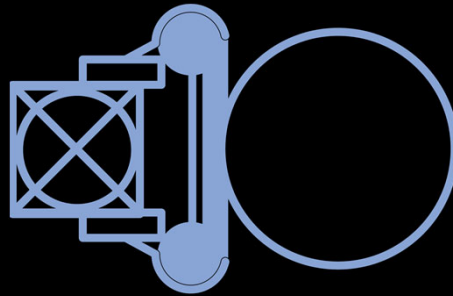


**Box Lead**



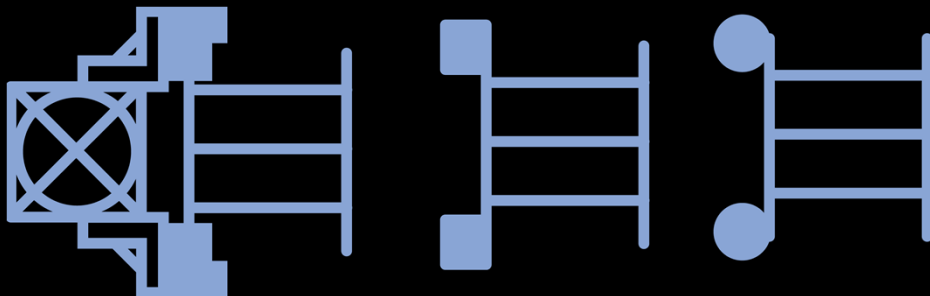


## Pipe Leads With Ladder Frame



## H-Beam Lead

Square and Round Tube





## Pile Gate

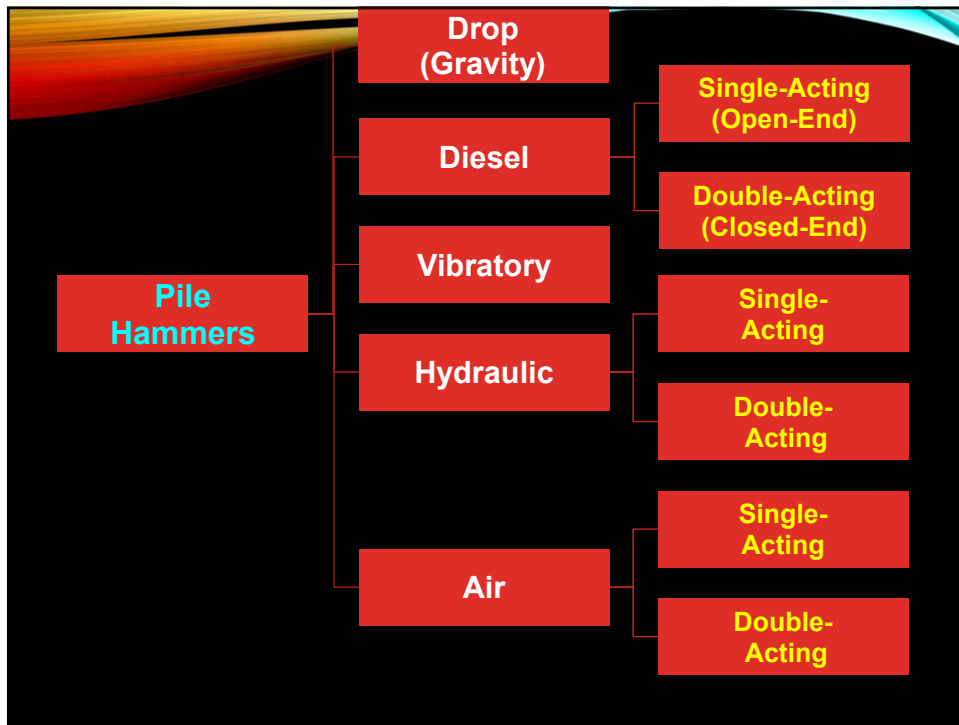
At bottom of leads

Used to keep lower portion of the pile centered in the leads



## PILE GATE





## Drop (Gravity) Hammer

Suitable for all types of piling except concrete

Very high dynamic forces can break concrete piling in easy driving if drop is not controlled





## Drop (Gravity) Hammer

Cheap to Buy

Cheap and easy to maintain

## Problems with using gravity hammers

If they're cheap, why don't we use them everywhere?

They're slow

Low productivity  
(Only 4 to 8 blows per minute on average)

Also.....

It can be hard to control the fall height of the weight

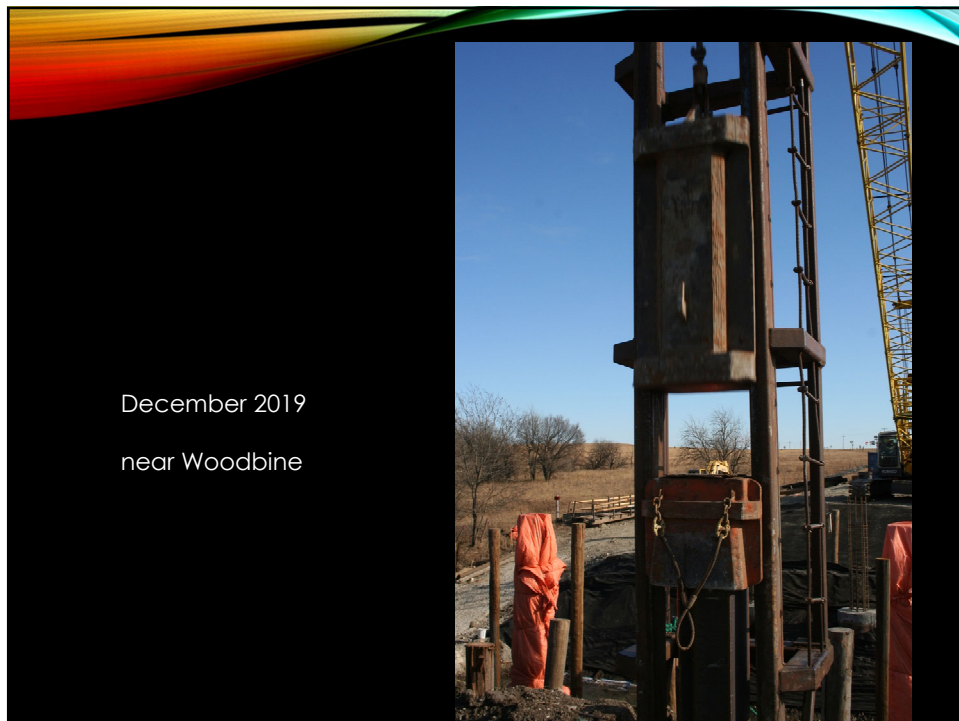
On KDOT projects, mainly used to start pile



# Drop (Gravity) Hammer

You will occasionally still see all piling on a bridge driven with a gravity hammer

Usually short pile stopping on a hard limestone or sandstone



# Vibratory Hammer



# Vibratory Hammer



# Vibratory Hammer

Don't require leads

Fastest way to install a pile

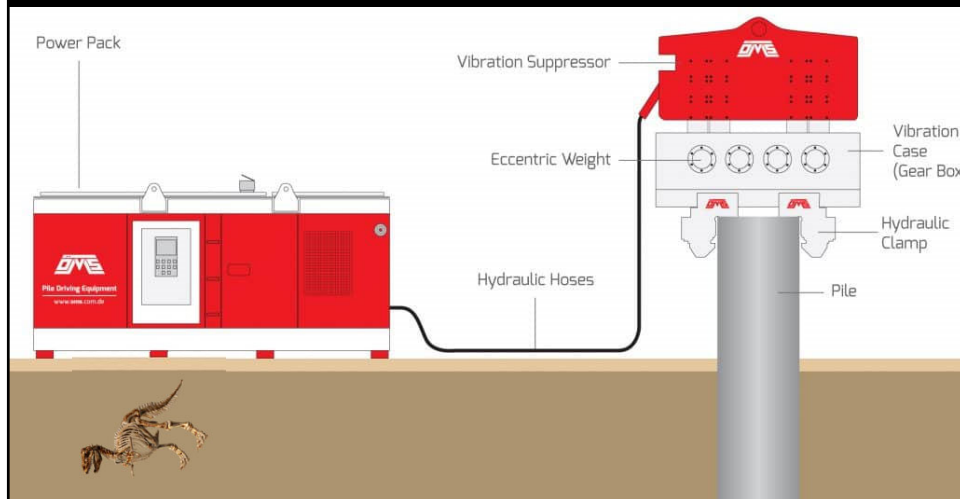
12 to 30 pulses per second—eccentric weights

High initial cost

High maintenance cost

Needs a separate power supply—runs on electricity or hydraulics (usually hydraulics)

# Vibratory Hammer



# Vibratory Hammer

Suitable for steel H-pile, pipe pile, and sheet pile.

No good for concrete piles. Not at all.

A vibratory hammer would shake apart a concrete pile in about 3 seconds.

# Vibratory Hammer

Suitable for end-bearing

Not recommended for friction piles

Very useful in granular soils

Not too effective in stiff, clayey soils

Can be used for driving or pulling piles



# Vibratory Hammer

How do you know when to stop it?

Have to use another method to confirm  
pile capacity

## Single-Acting (open-end) Diesel Hammer

Suitable for all types of pile

40 to 60 blows per minute

Carry their own fuel—they power themselves

**Stroke of the piston is directly related to pile  
resistance**

## **Single-Acting (open-end) Diesel Hammer**

**Expensive to buy**

**Fairly easy to maintain**

**Pollutes the air and gets diesel fuel all over you**

**Low blows per minute at high pile resistances**

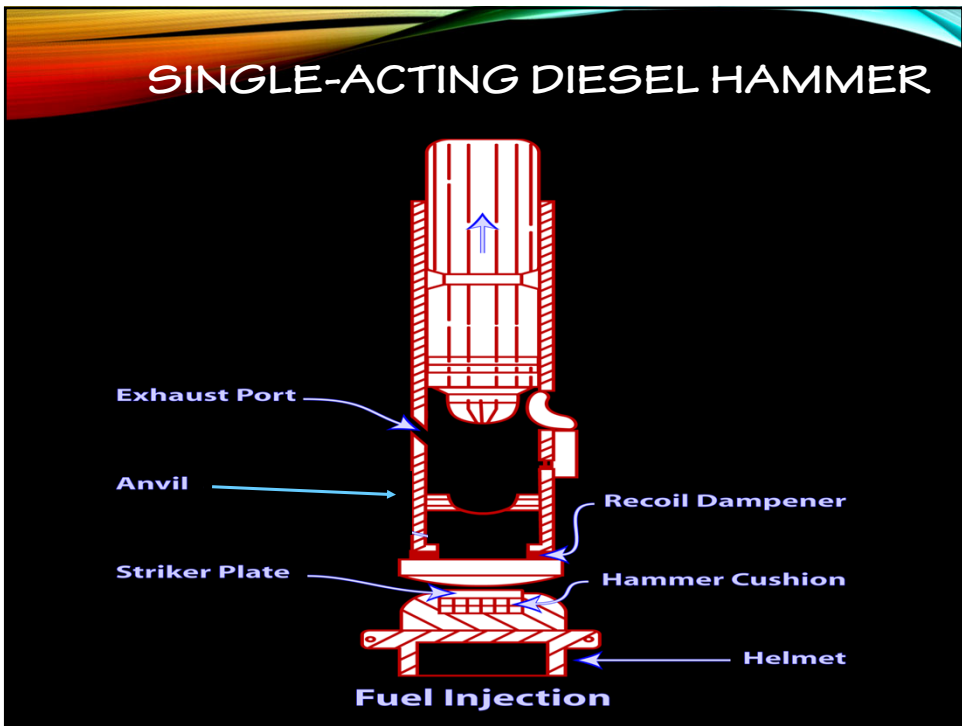
**Most popular hammer on KDOT projects**

**Most diesel hammers on our projects carry between 5 and 20 gallons of fuel.**

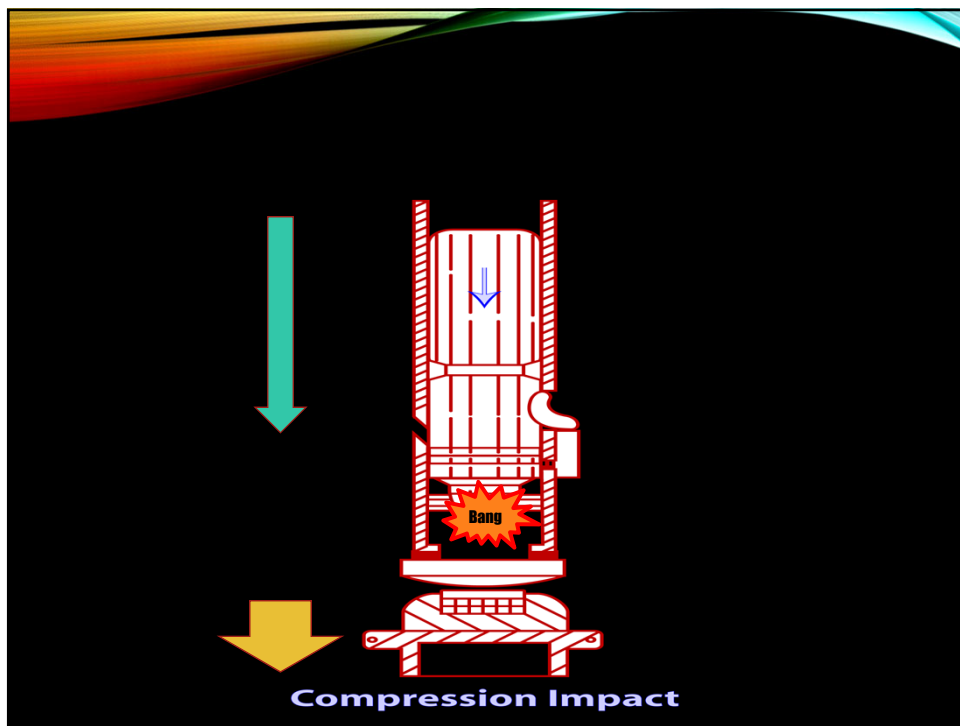
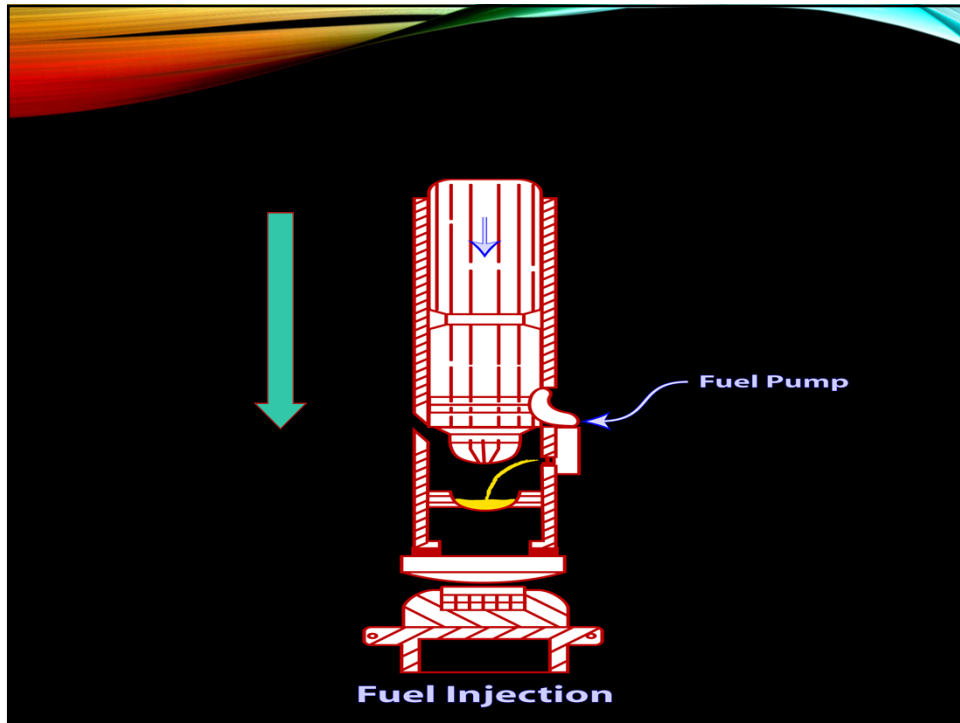
**The capacity is such that a hammer can work all day on one tank.**

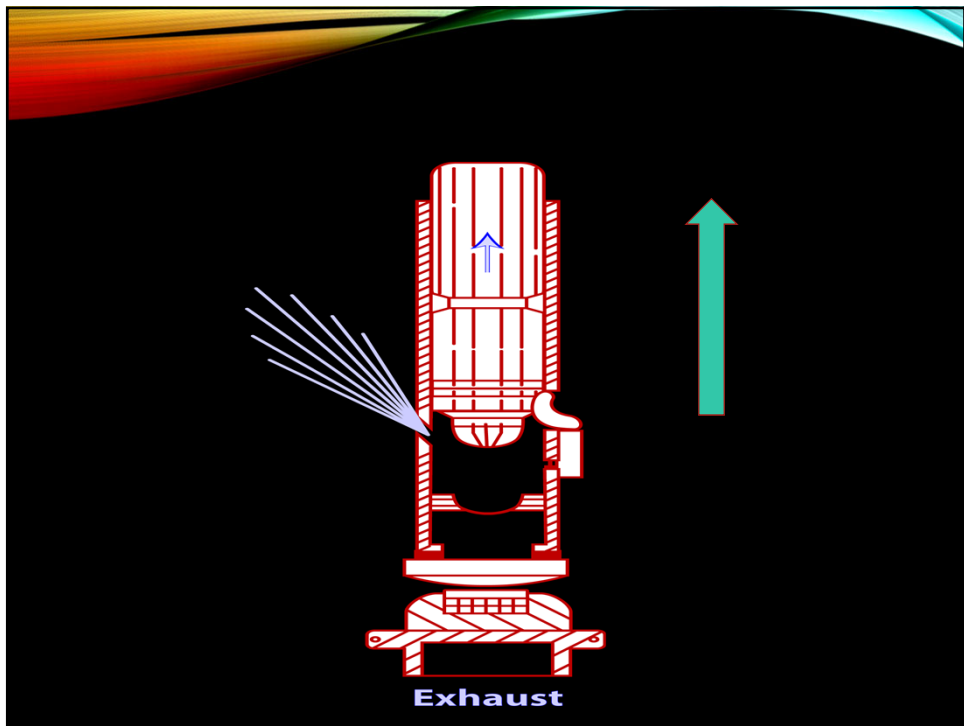
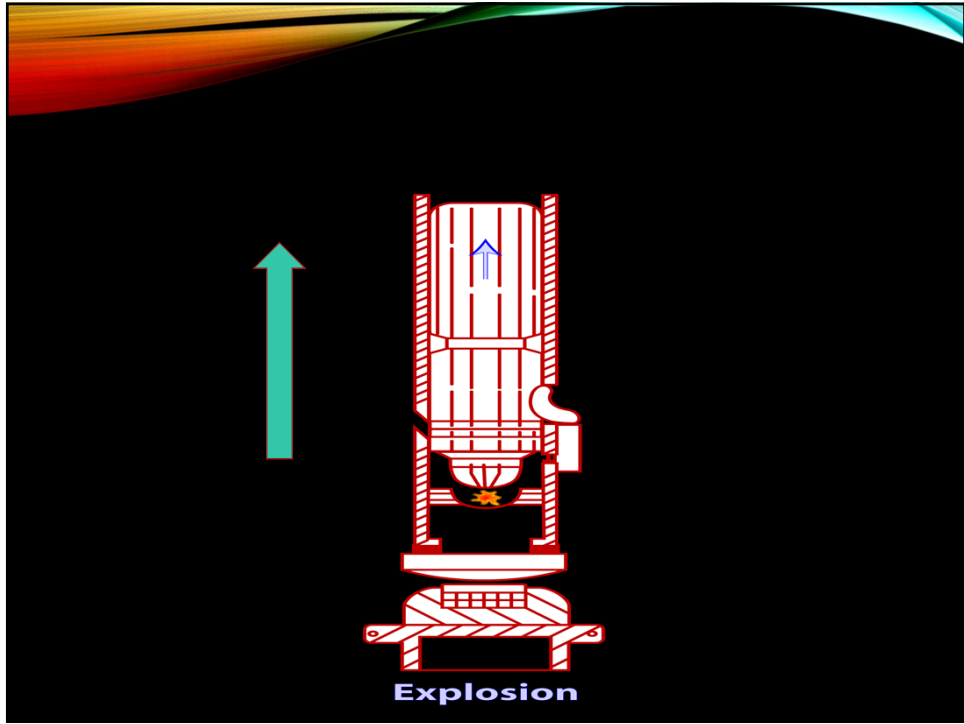
**They also carry lubricating oil. The two tanks are side-by-side.**

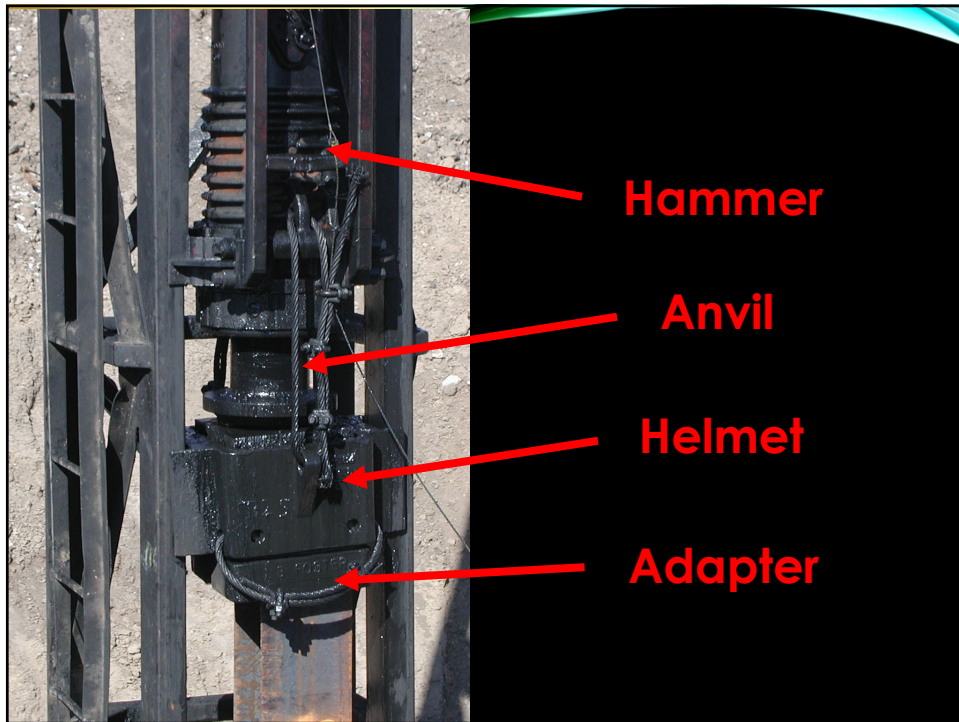
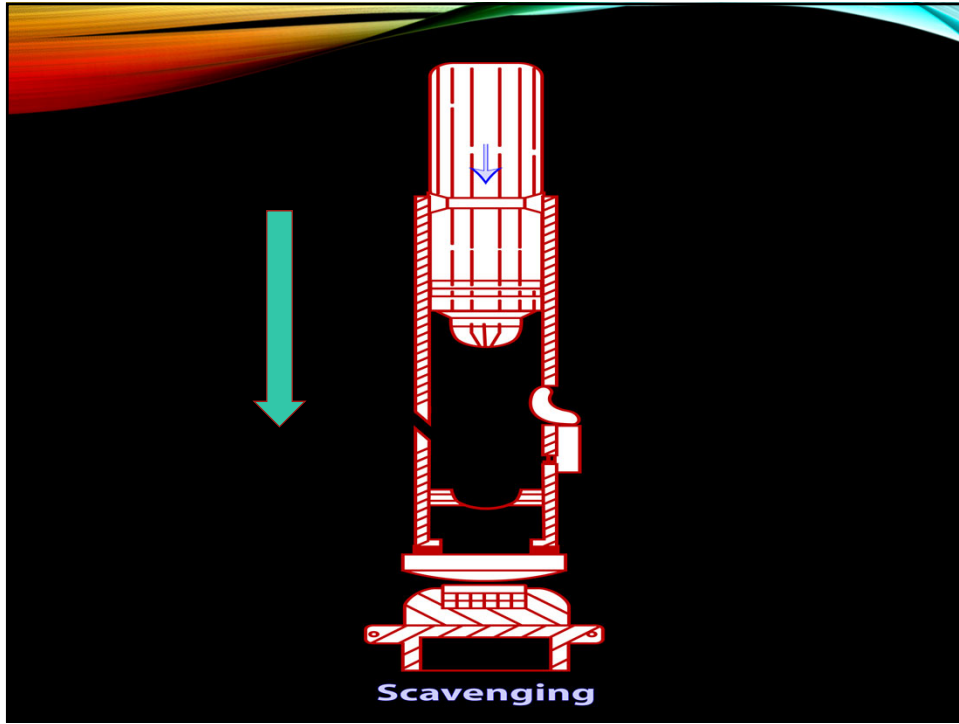






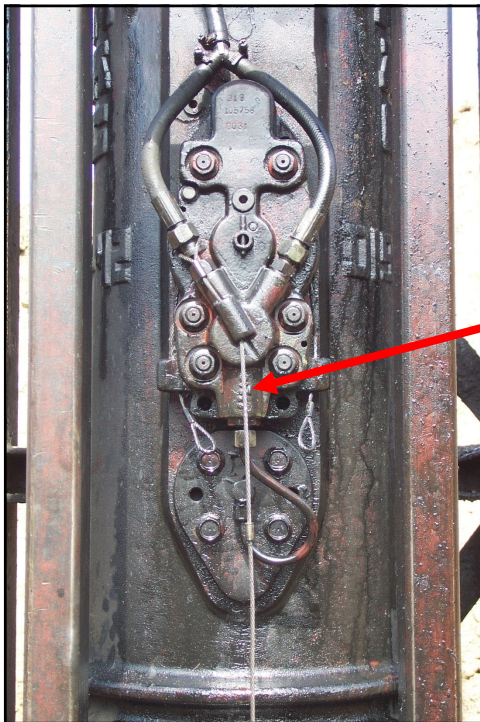






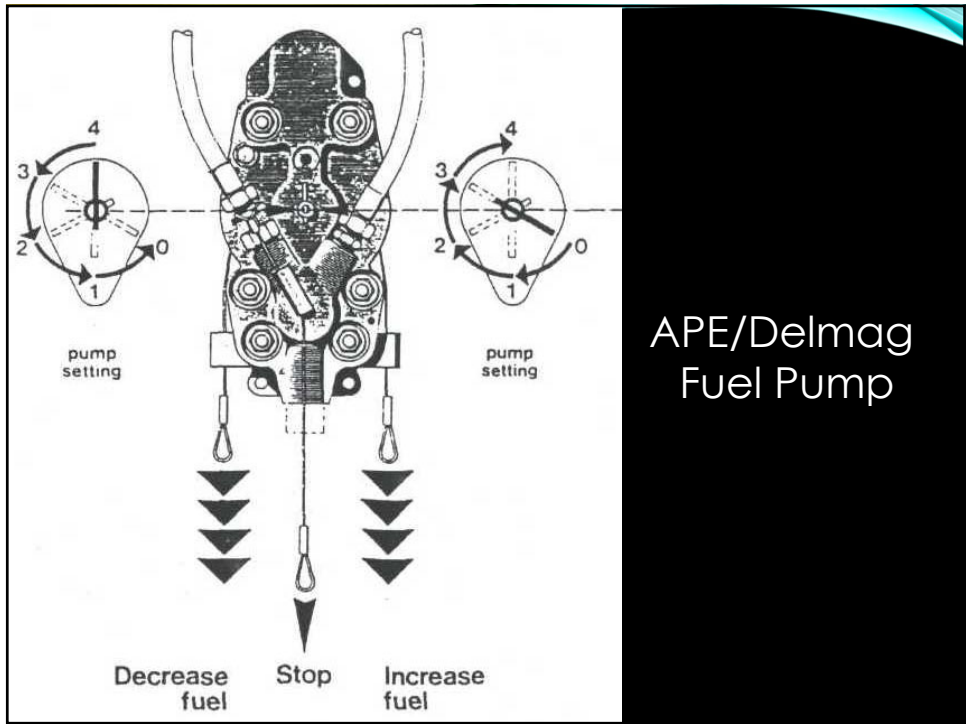
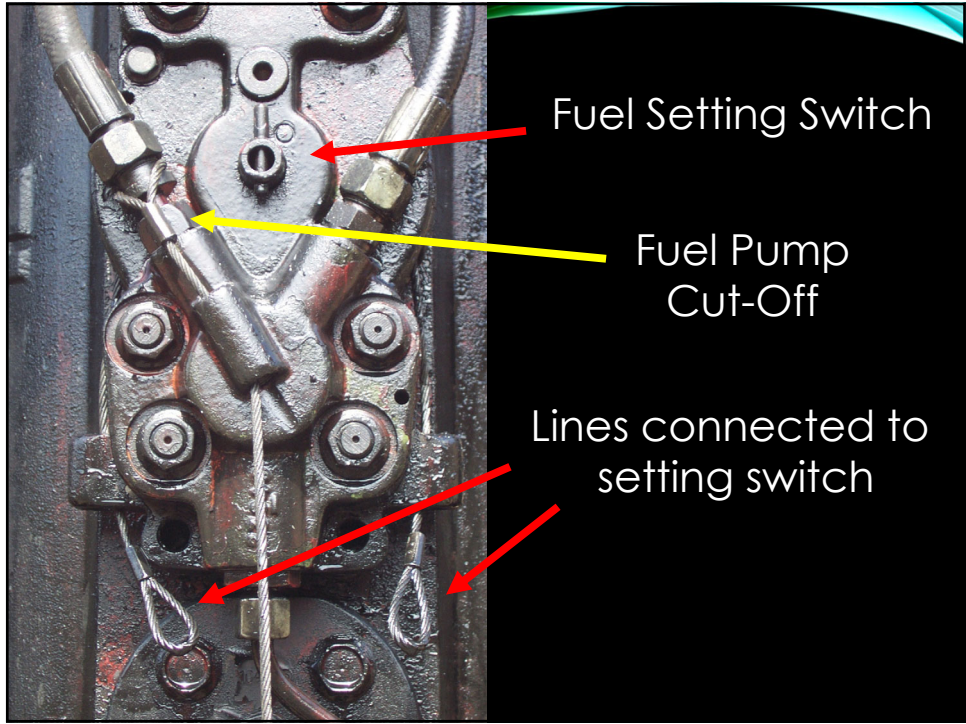


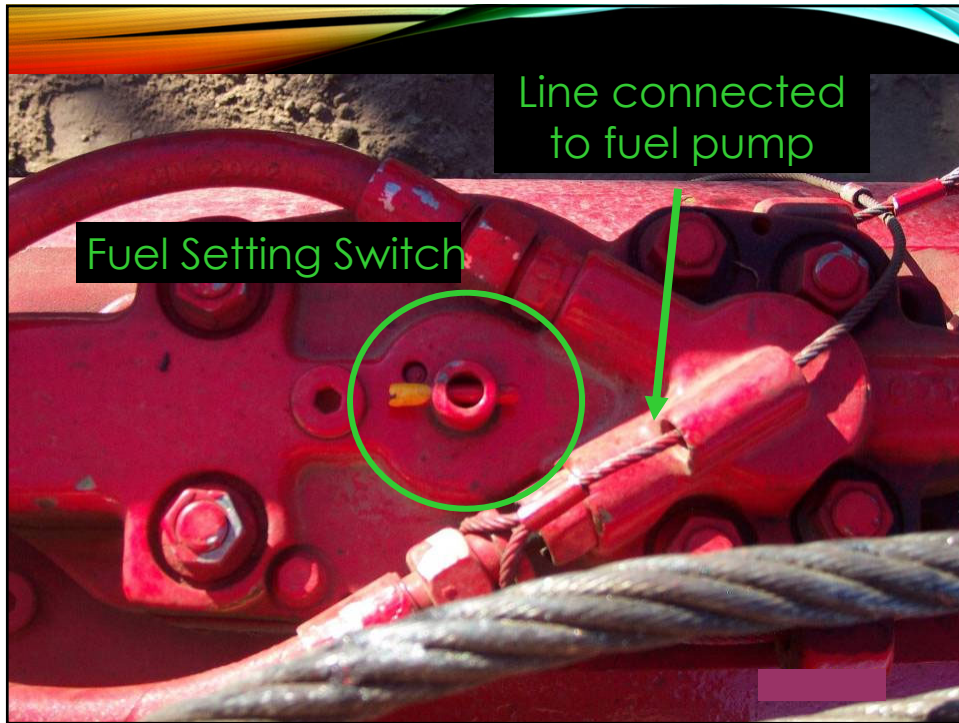
Rope  
connected  
to fuel pump



Rope connected  
to fuel pump







Use the highest setting in most cases



## Range of Energy per Blow, by Pump Setting:

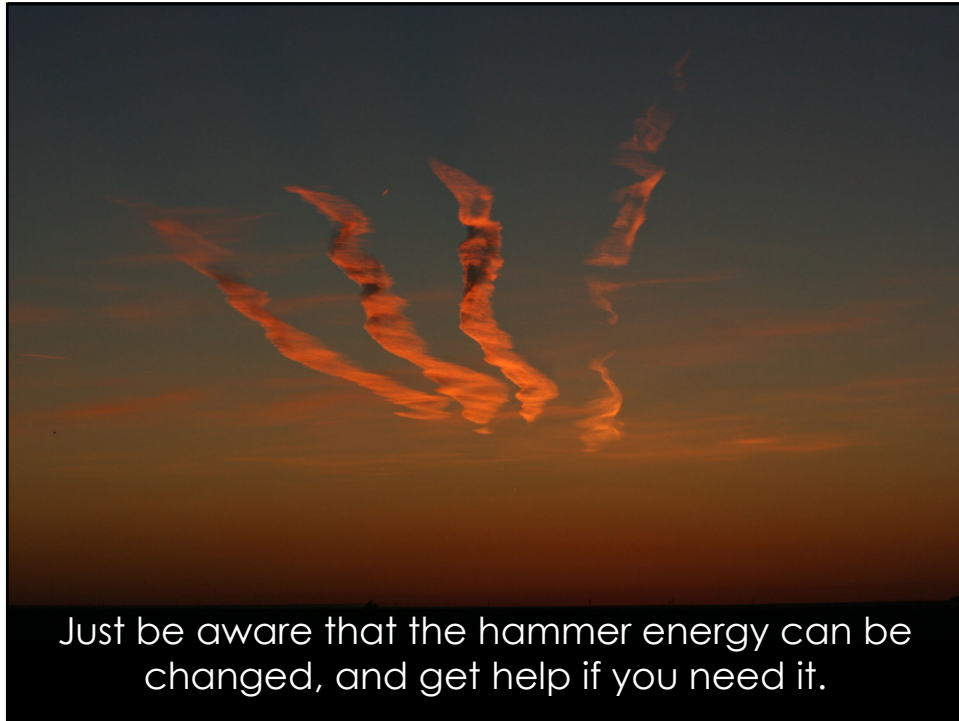
### Example: Delmag D19-42

Position 4:	100 % = 42,800 ft-lbs
Position 3:	88 % = 37,660 ft-lbs
Position 2:	67 % = 28,680 ft-lbs
Position 1:	48 % = 20,540 ft-lbs









Just be aware that the hammer energy can be changed, and get help if you need it.



Questions or  
comments  
so far?





Ouija  
Graduated Rod  
Jump Stick  
Yardstick  
  
Make up your own  
name



Piston at top  
of rebound





## Hydraulic Hammer

Suitable for all types of pile

30 to 50 blows per minute (single-acting)

40 to 90 blows per minute (double-acting)

Energy is adjustable





Hydraulic  
Hammer



Hydraulic  
Hammer



## Hydraulic Hammer

## Hydraulic Hammer

Double-acting can be used for underwater driving

Expensive to buy

More complex maintenance than other hammers

Must use another method to confirm pile capacity

## Hydraulic Hammer

Not allowed on KDOT projects

Can't stop it fast enough

## Air Hammer

Suitable for all types of pile

35 to 60 blows per minute (single-acting)

95 to 300 blows per minute (double-acting)

Double-acting can be used for underwater driving



Air  
Hammer



Air  
Hammer





Air  
Hammer



Air  
Hammer

# Air Hammer

Only moderately expensive to buy

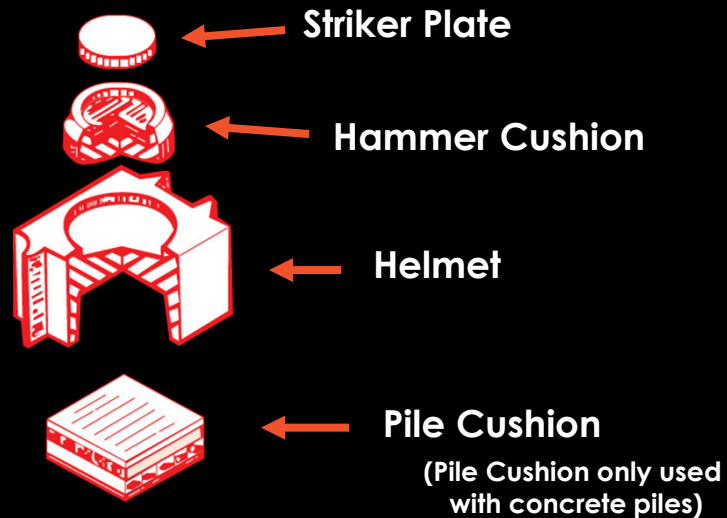
Fairly easy to maintain

Need air compressor to run it

Heavy compared to most diesel hammers

Rarely seen on KDOT projects

# PILE HELMET



# Pile Helmet



# Bottom of Helmet



Top of H-Pile goes here



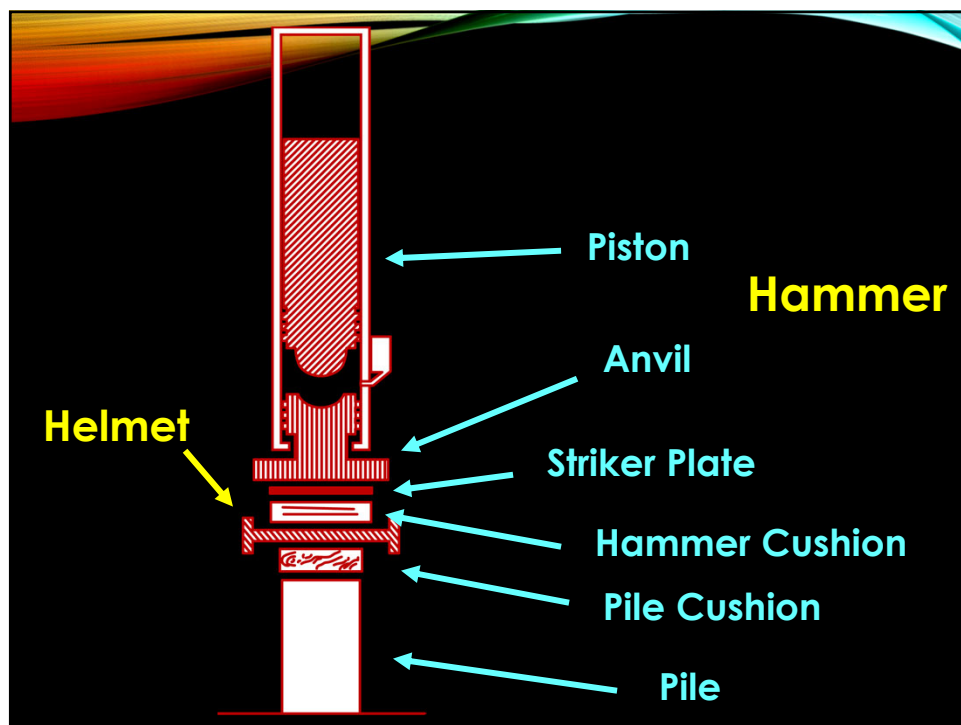




The bearing formula asks for the weight of the **cap** and **anvil**.

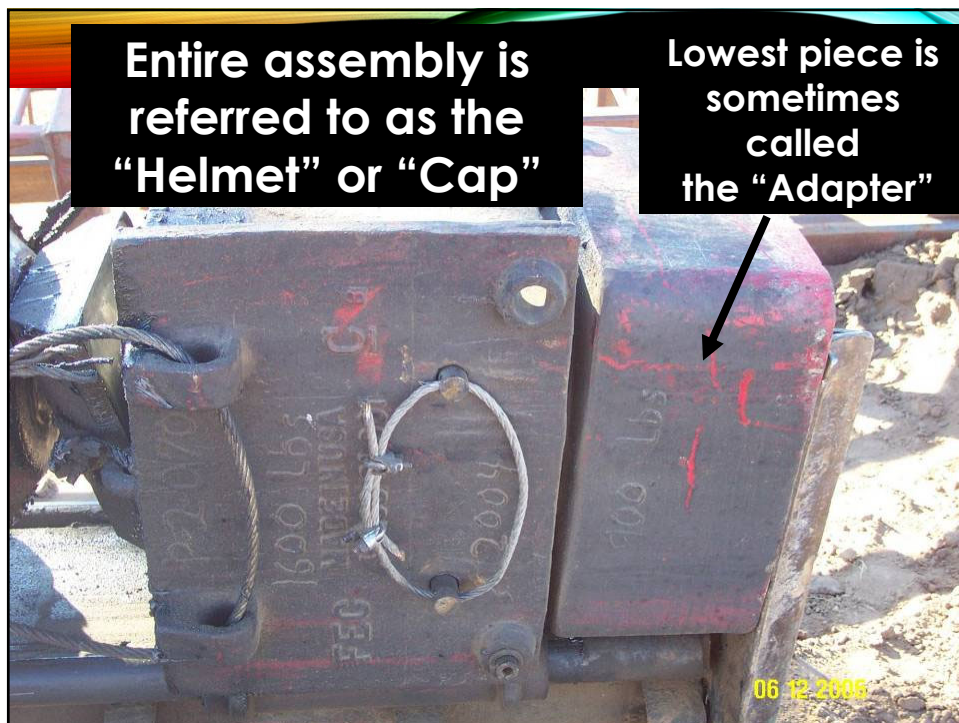
The “cap” is the pile helmet.

The “anvil” is the lowest piece of the hammer.



Normally, we call this piece the **Helmet**, because “**pile cap**” is also a structural term.

We don't need to confuse things any more than they already are.





Hammer-helmet-pile alignment *must* be maintained, especially when driving concrete pile and thin-walled steel pipe piles.

## Hammer Cushions

A hammer cushion is used between the hammer and the helmet to absorb some of the impact shock. This protects the hammer.

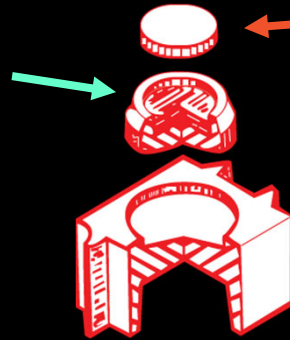
Sometimes also called a "cushion block"





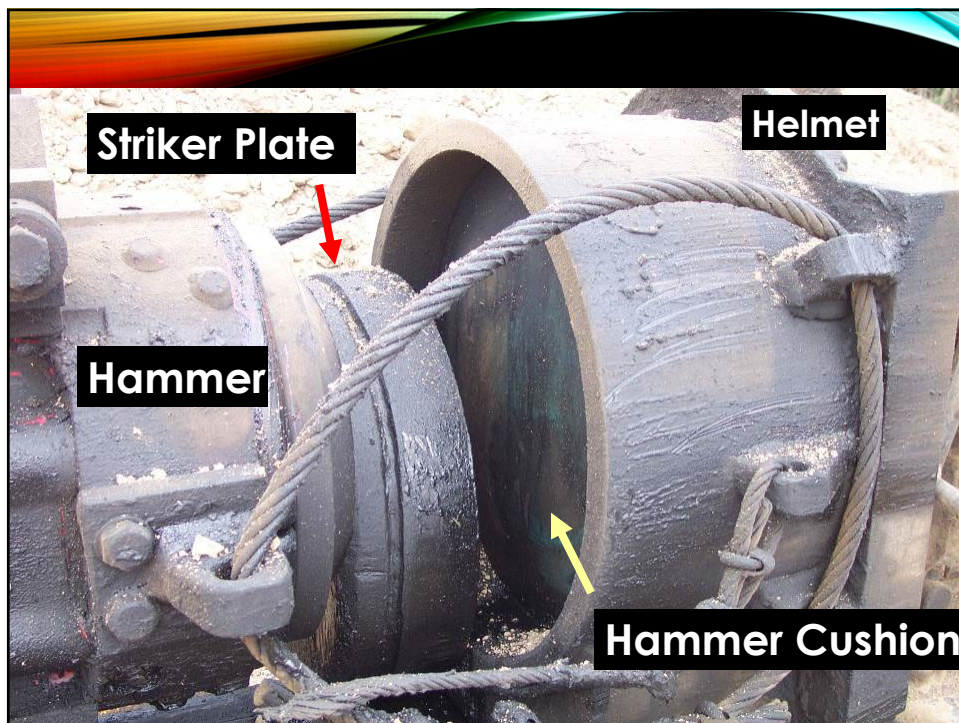
# HAMMER CUSHION

Between  
Striker Plate  
and Helmet



Striker Plate

Helmet



Striker Plate

Helmet

Hammer

Hammer Cushion

## Worn-out hammer cushions cause bad things to happen...

Damage to the hammer, helmet or even the  
pile itself

Result in lower transferred energy to pile

Can result in increased bending stresses on  
pile

## Acceptable Hammer Cushion Material

Micarta (phenolic fiber and aluminum)

Replace when it starts to powderize



## Acceptable Hammer Cushion Material

Micarta and Aluminum



## Acceptable Hammer Cushion Material

Reinforced Phenolic Resin



## Acceptable Hammer Cushion Material

Nylon (usually blue)

Replace when you see horizontal cracks (vertical cracks OK)



## Acceptable Hammer Cushion Material

Nylon (usually blue)

Replace when you see horizontal cracks





## Acceptable Hammer Cushion Material

Nylon (usually blue)

Conbest is a popular brand of nylon cushion



Why is everyone looking at me?....

## Acceptable Hammer Cushion Material

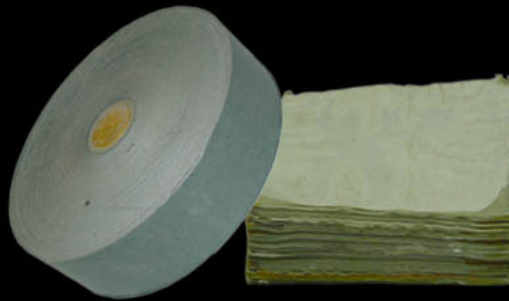
Hammortex (a reel of fiber or Kevlar sheeting backed with aluminum)

Replace when it begins disintegrating



## Acceptable Hammer Cushion Material

Hammortex



## Acceptable Hammer Cushion Material


Urethane materials

Polymer materials

Aluminum may be present in laminations in hammer cushions, but only acts to transfer heat out of the cushion. This prolongs its life.

Wood, wire rope, and asbestos are *not* acceptable as a hammer cushion on KDOT projects.

(Wood can be used on gravity hammers)



No matter what the material, KDOT requires the contractor to replace a hammer cushion when it looks like it's deteriorating, or when it's lost 25% of the original thickness.

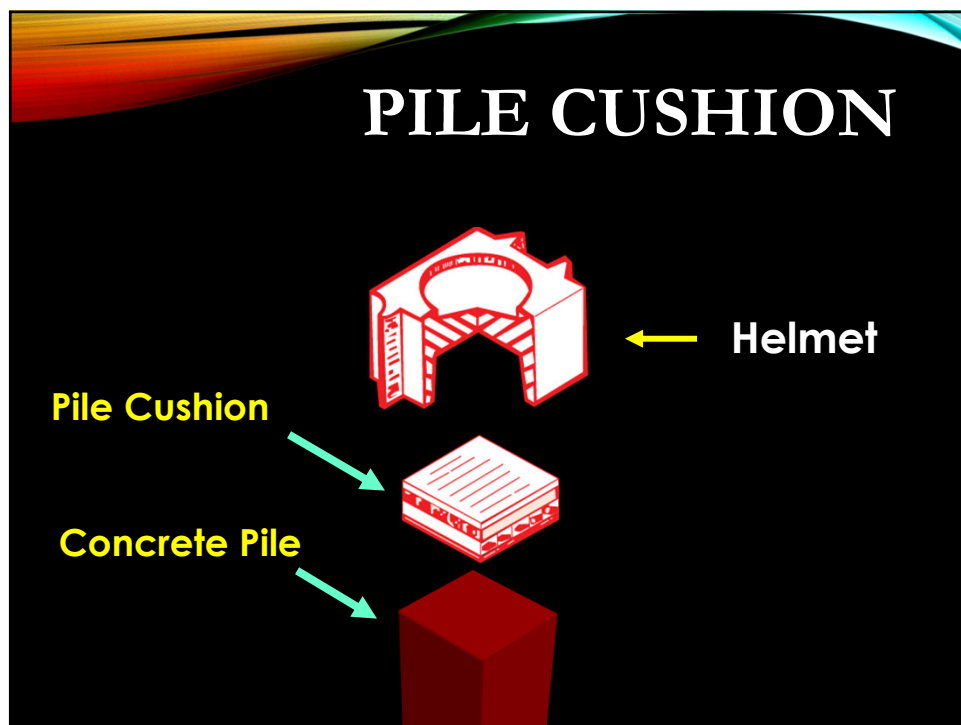


Most hammers on KDOT projects need cushions that are 2" to 3" thick.

It is OK to use 2 thinner cushions to make up the needed thickness.

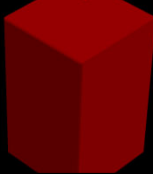


It's not uncommon to have 2 thinner cushions of different materials, such as nylon and Micarta.



# PILE CUSHION

Concrete Pile

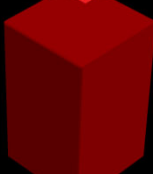


A **pile cushion** is required for concrete piles **only**

This protects the concrete from driving stresses

# PILE CUSHION

Concrete Pile



It will almost always consist of a stack of plywood sheets cut to fit inside the helmet.

It will try to catch fire after the hammer heats up during driving. Keep an eye on it.

## Follower

Used as an extension of the pile between the hammer and the pile head



## Follower



## Problems with followers

The follower will have a different weight per unit length from the pile

Hard to keep aligned

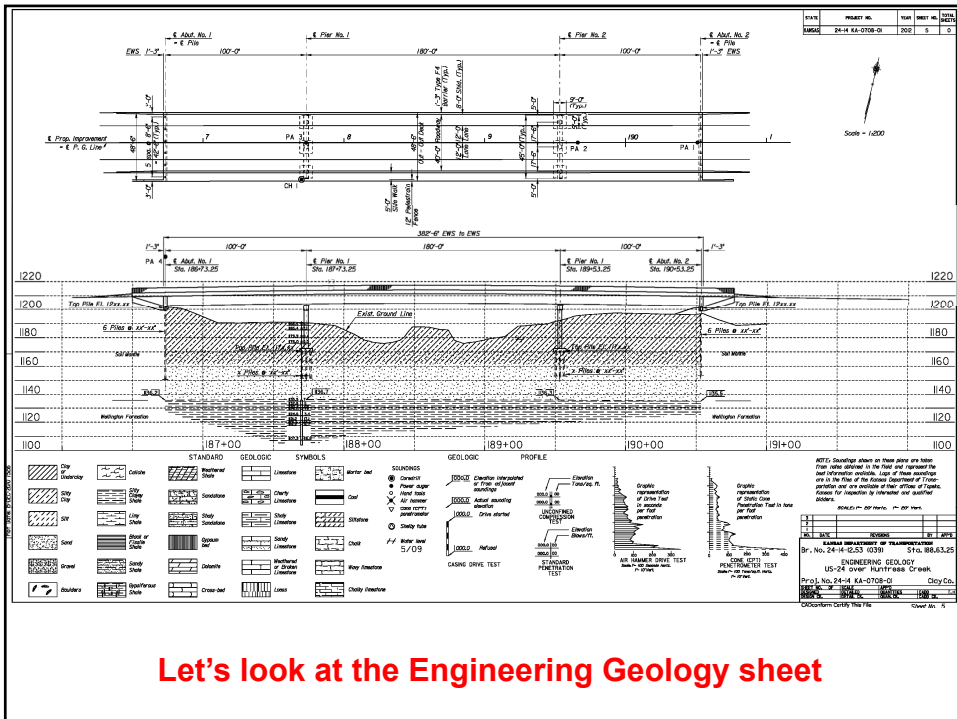
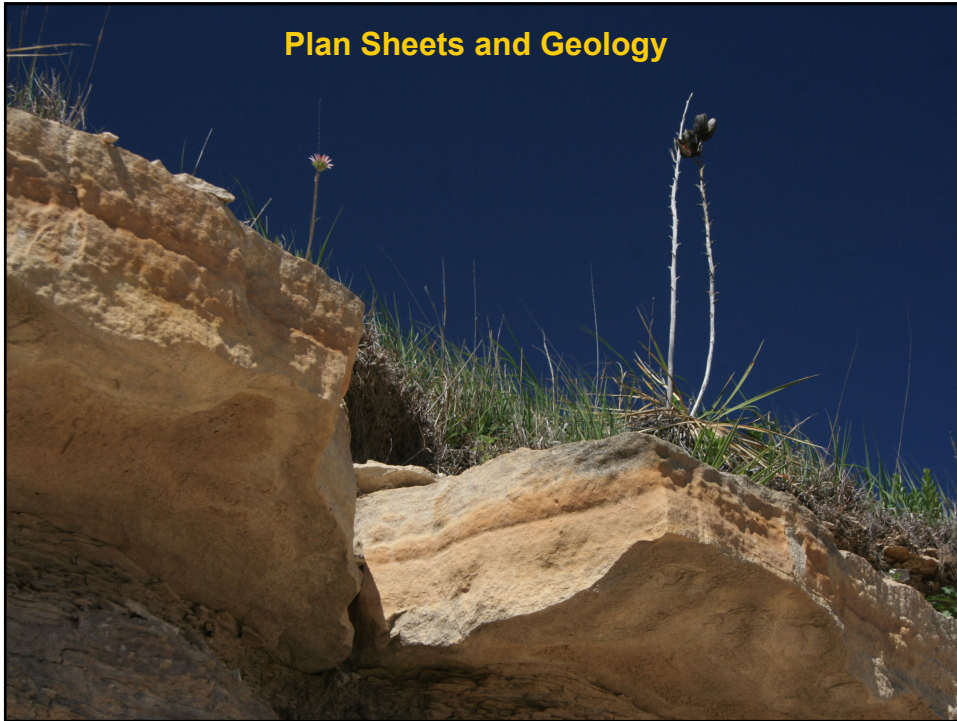
Allows for additional energy loss due to the compression of the follower and energy losses at the connections

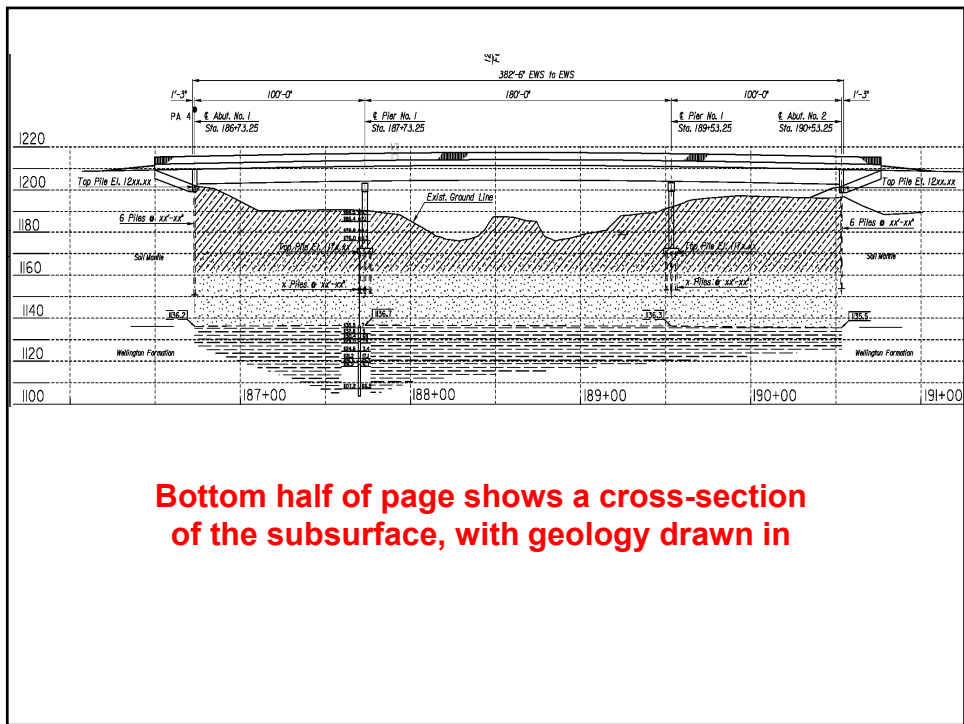
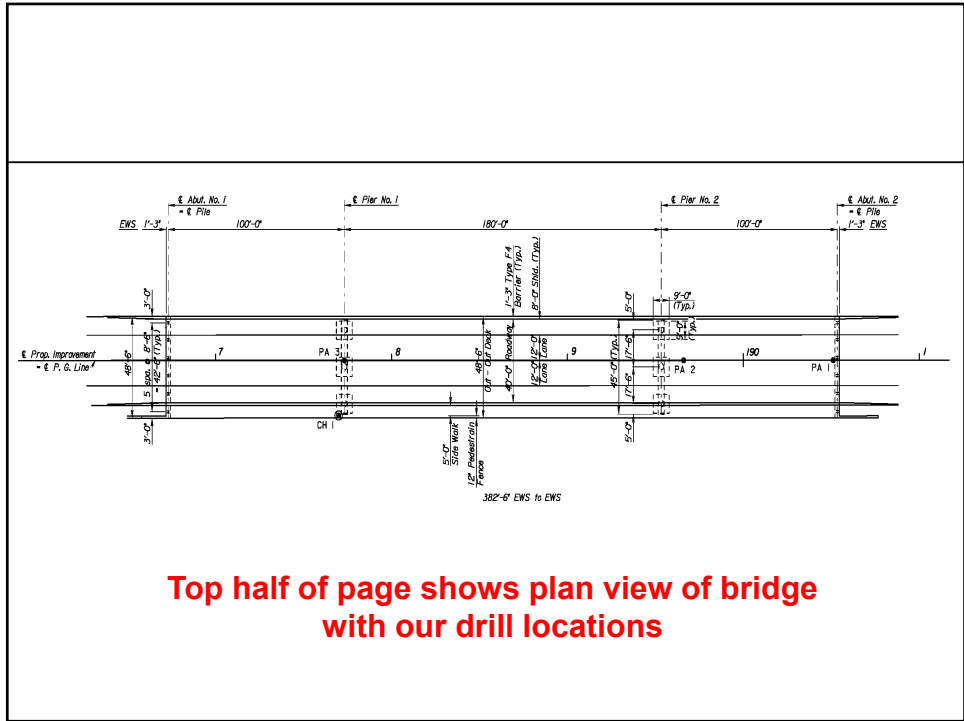
For these reasons, followers are not allowed on KDOT projects, except with the written permission of the Engineer

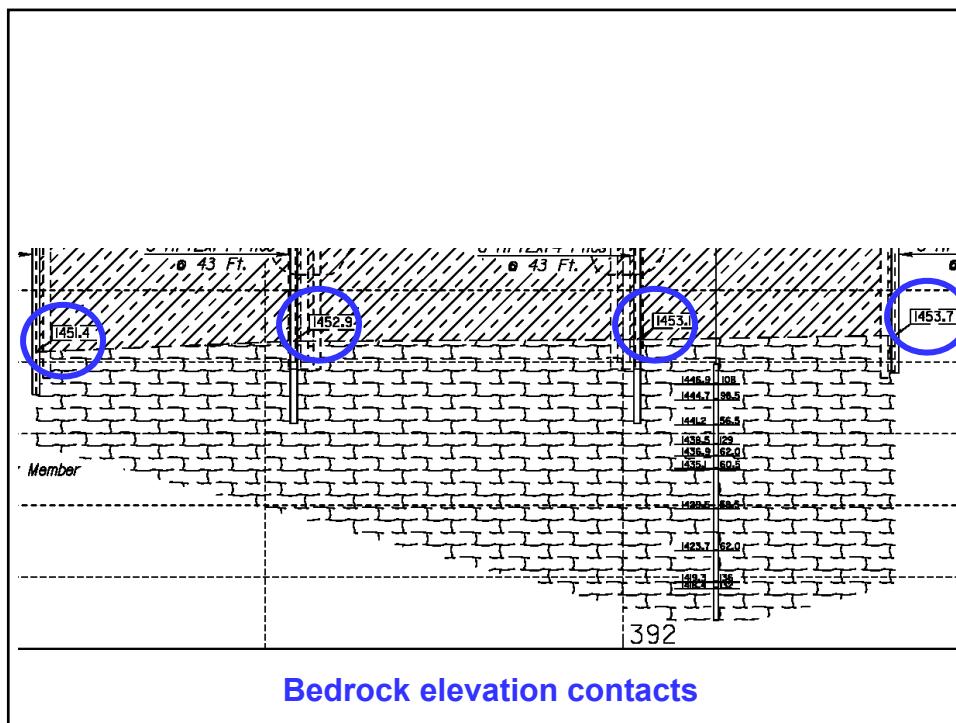
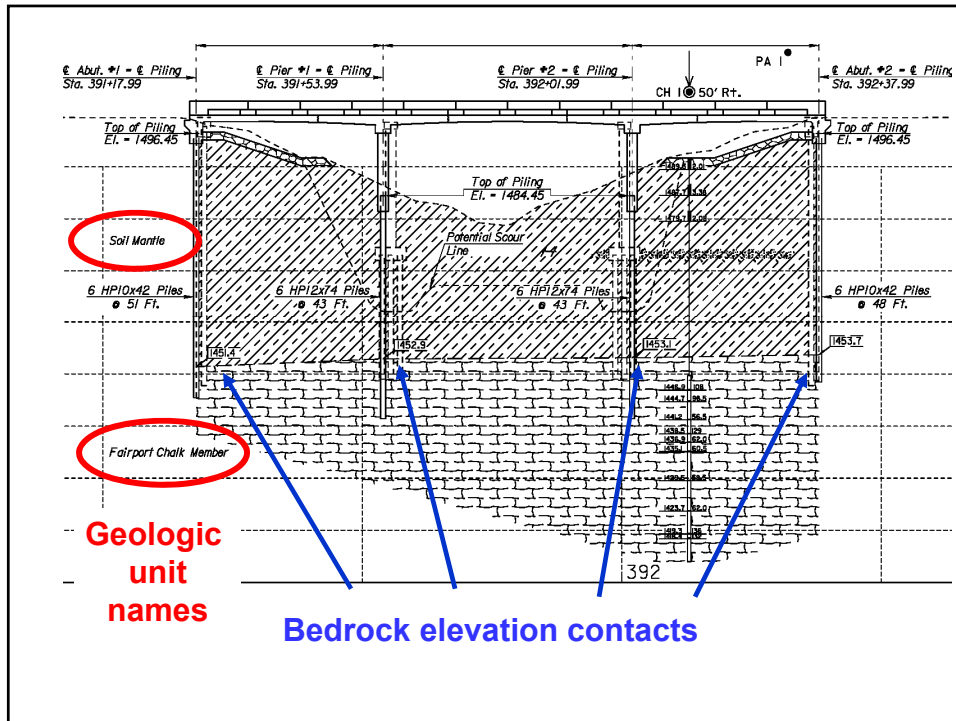




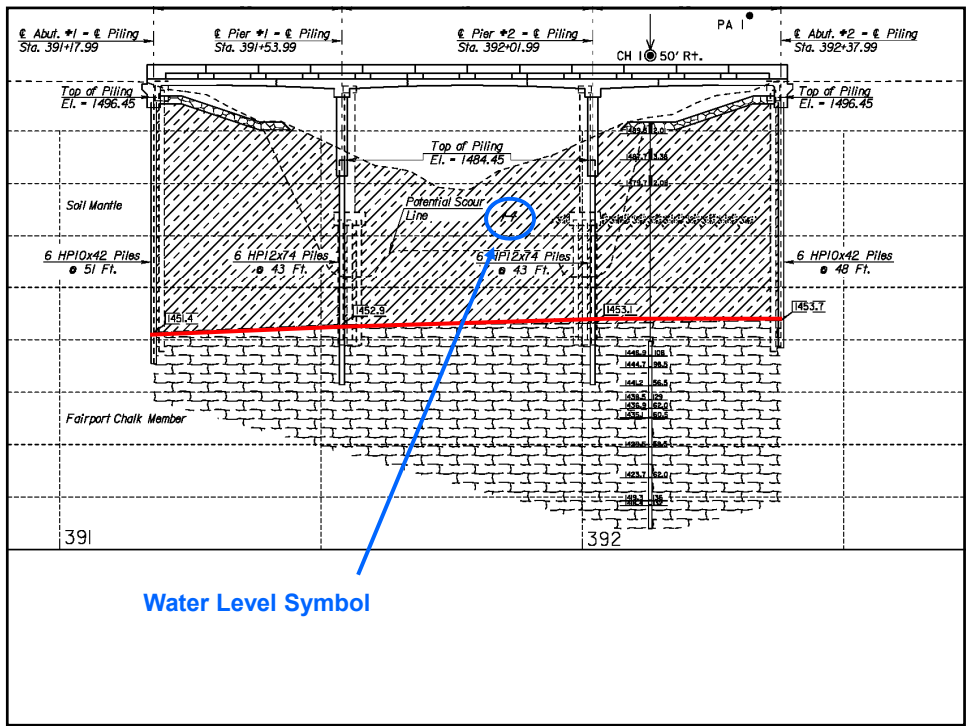
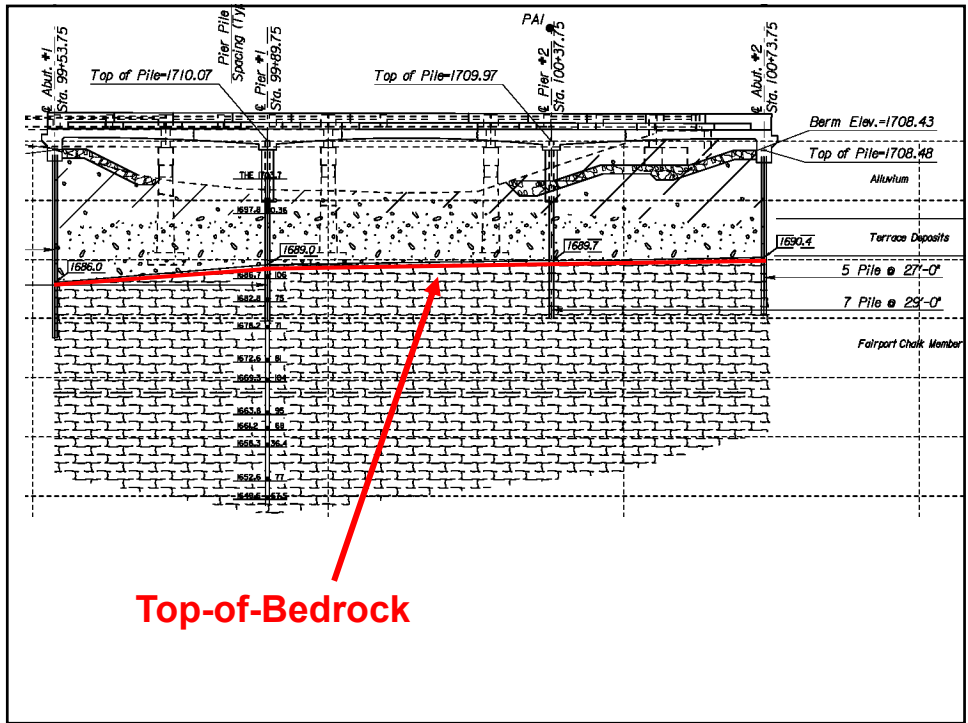
## Plan Sheets and Geology











		STANDARD	GEOLOGIC	SYMBOLS
	Clay or Underclay			
	Silty Clay			
	Silt			
	Sand			
	Gravel			
	Boulders			
	Caliche			
	Silty Clayey Shale			
	Limy Shale			
	Black or Fissile Shale			
	Sandy Shale			
	Gypsiferous Shale			

**Standard Geology Symbols**

**Lower left corner of Engineering Geology sheet**

**SOUNDINGS**

- Coredrill
- Power auger
- Hand tools
- Air hammer
- Cone (CPT) penetrometer
- Shelby tube
- Water level  
3099.9

000.0 Elevation interpolated or from adjacent soundings

000.0 Actual sounding elevation

**UNCONFINED COMPRESSION TEST**

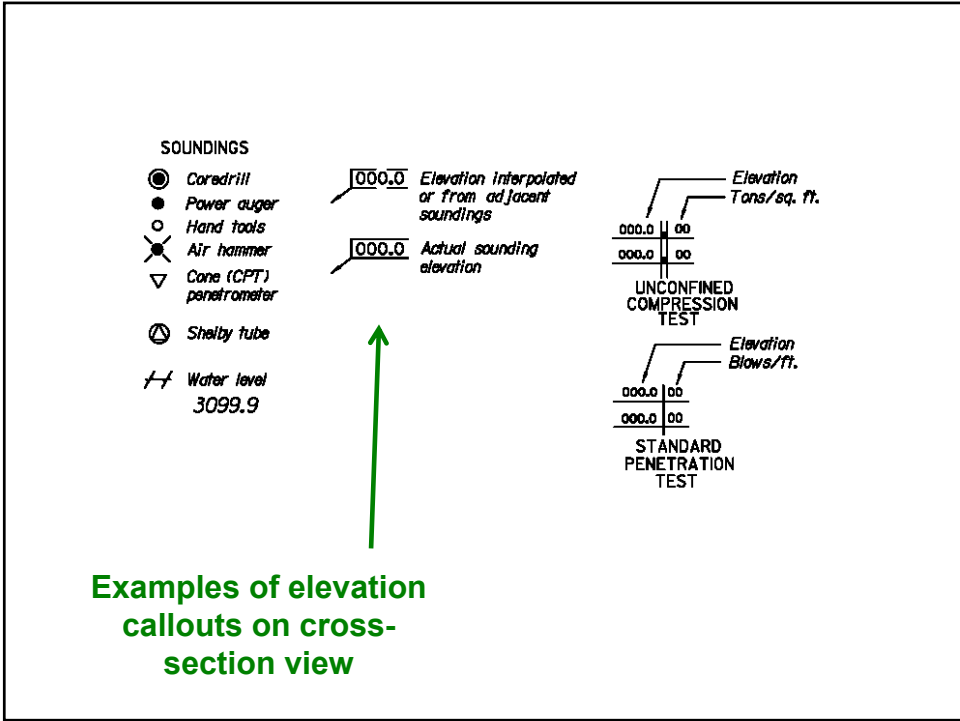
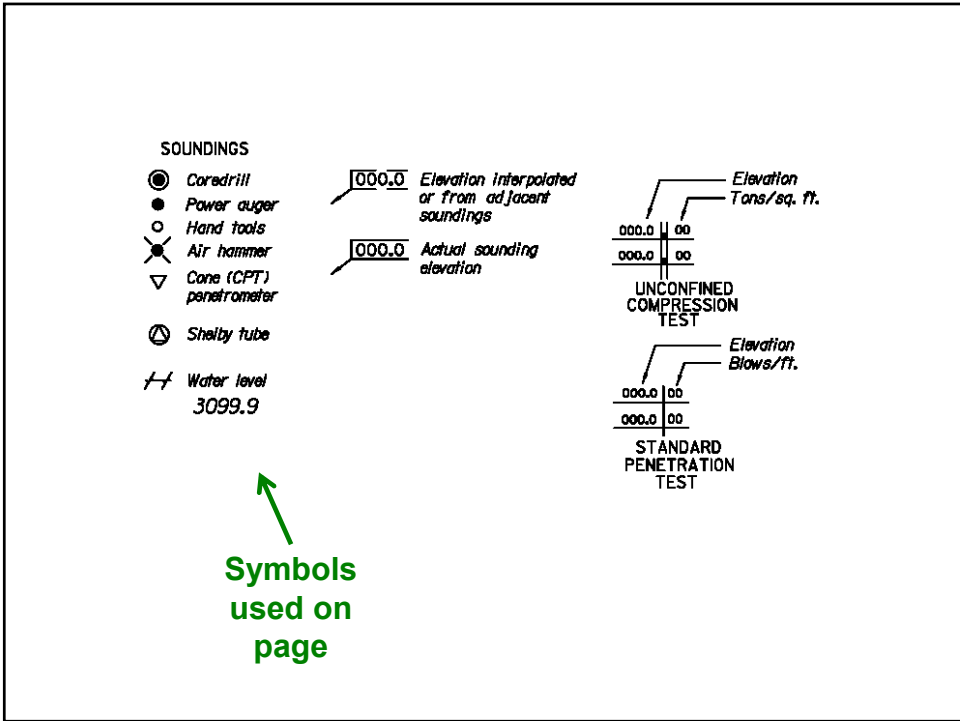
Elevation Tons/sq. ft.

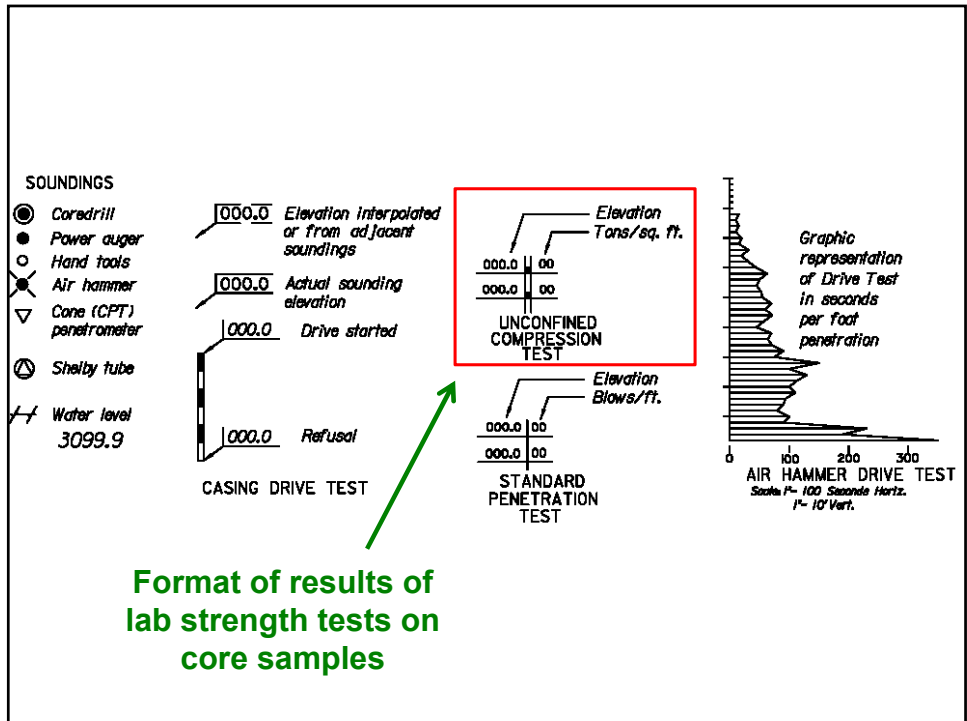
**STANDARD PENETRATION TEST**

Elevation Blows/ft.

**Legend**

**Bottom of Engineering Geology sheet**



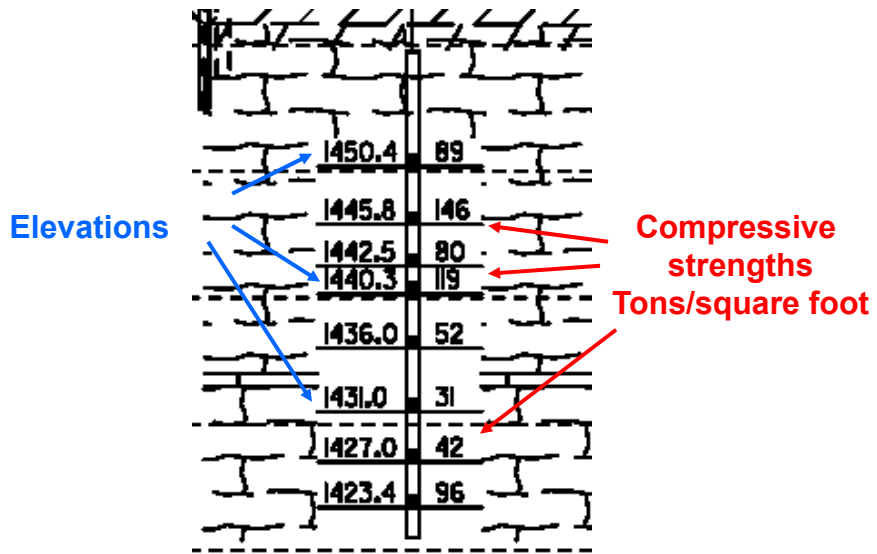


# Cores





**“Core Tree” on Engineering Geology Sheet  
Results of lab tests on soil and rock samples**



**SOUNDINGS**

- Coredrill
- Power auger
- Hand tools
- ⊗ Air hammer
- ▽ Cone (CPT) penetrometer
- ⊙ Shelby tube
- ⊕ Water level  
3099.9

000.0 Elevation interpolated or from adjacent soundings

000.0 Actual sounding elevation

Elevation  
Tons/sq. ft.

000.0 | 00

000.0 | 00

UNCONFINED  
COMPRESSION  
TEST

Elevation  
Blows/ft.

000.0 | 00

000.0 | 00

STANDARD  
PENETRATION  
TEST

**Format of standard  
penetration test  
results**



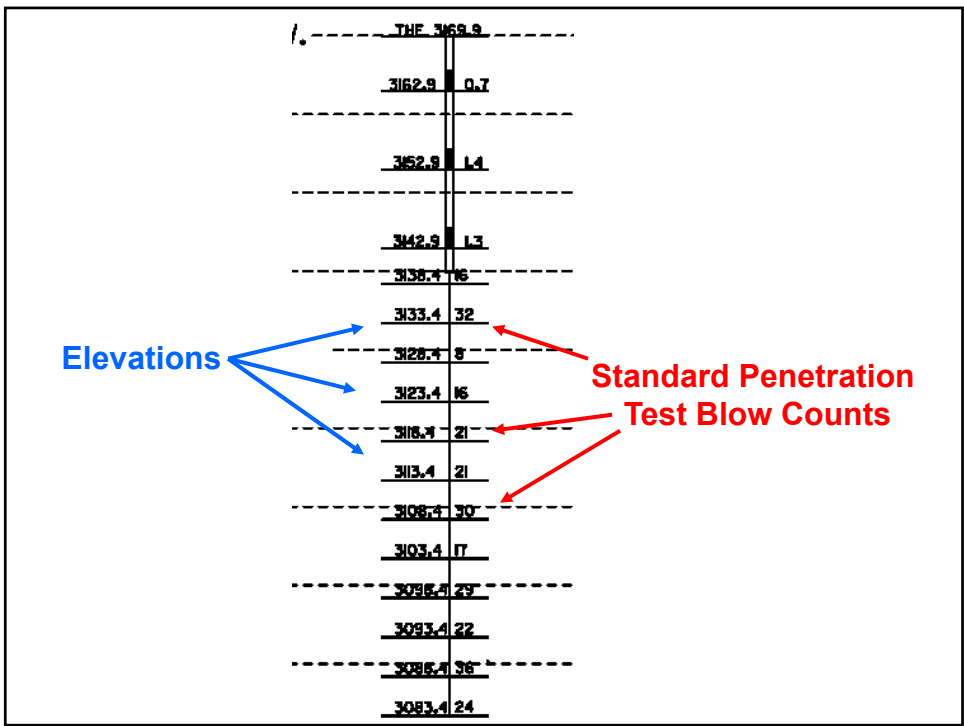
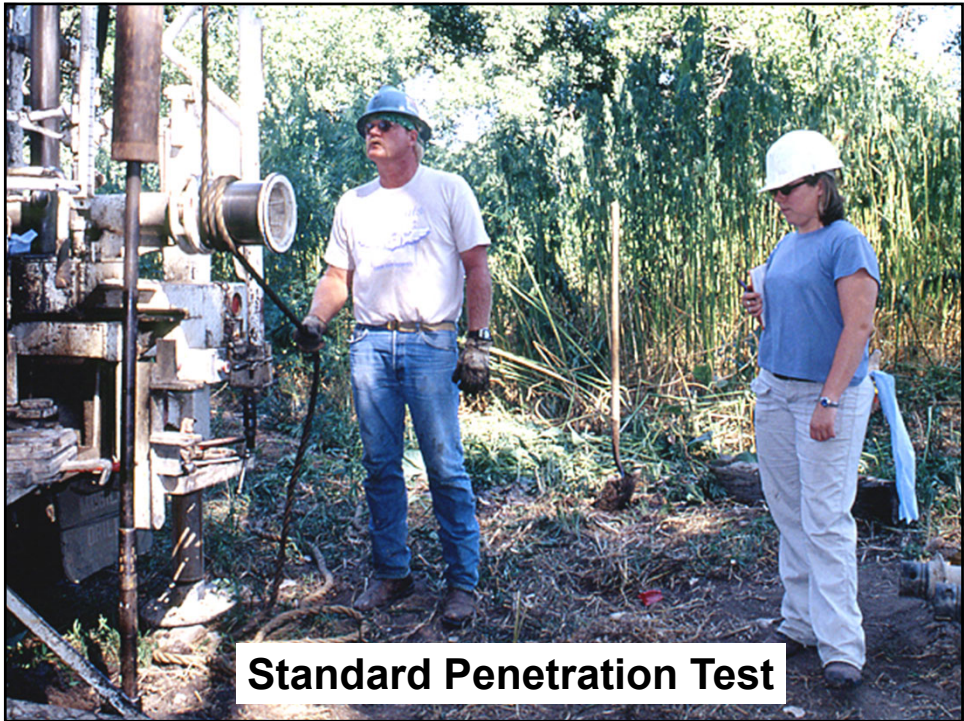
## Standard Penetration Test

Gives both a relative resistance of the soil and a sample of it

Been around since the 1920's

Used all over the world







# Core Drill with Water Truck







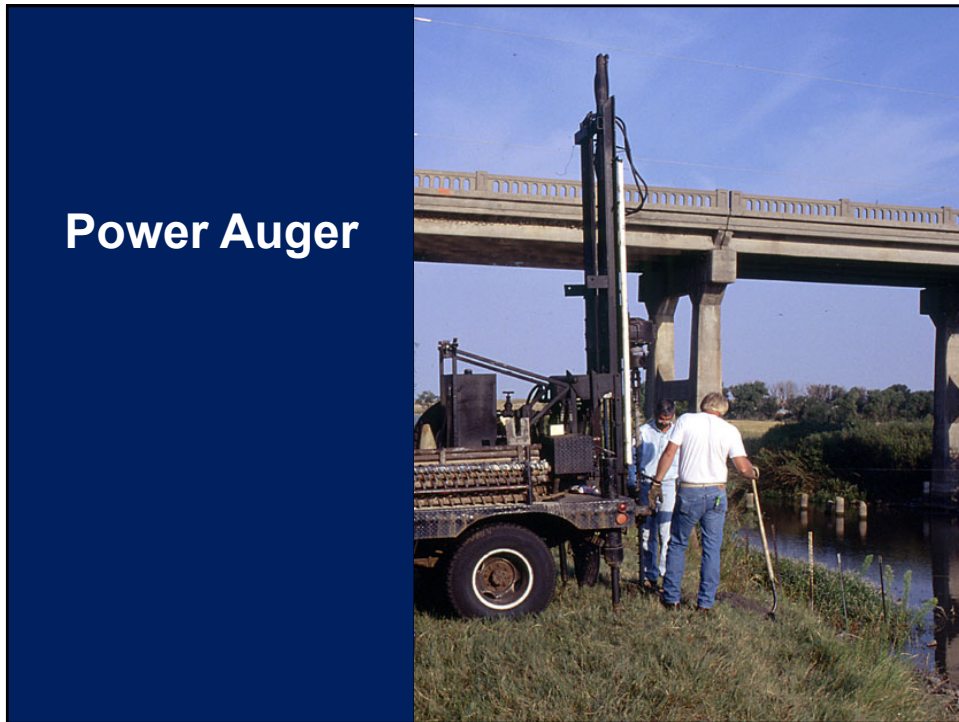
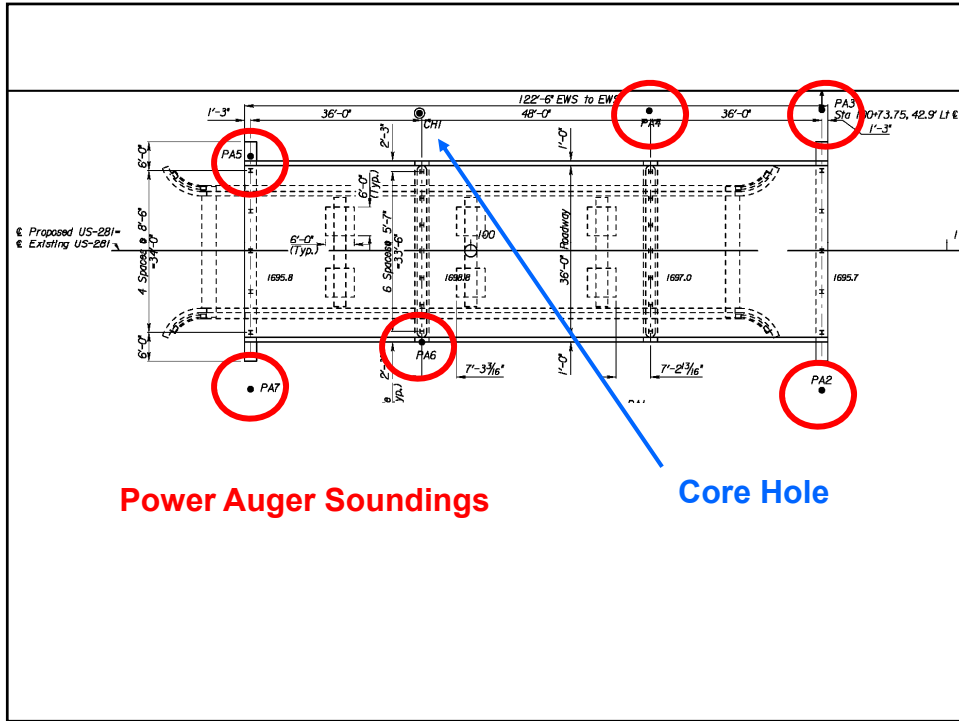
# Cores



## Cores

1.87"  
diameter



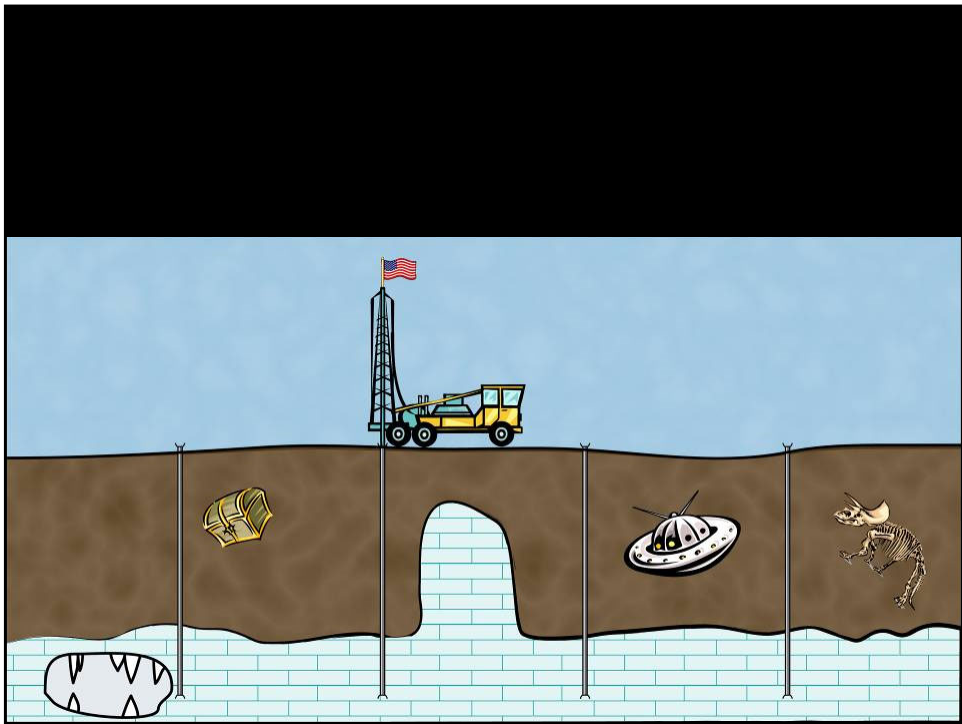


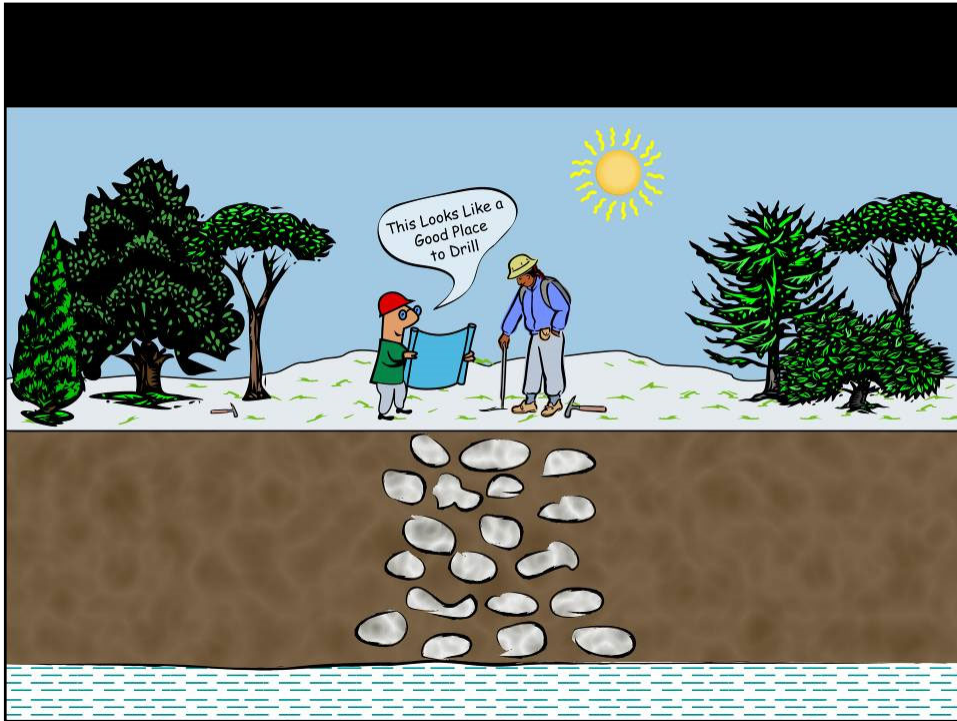


**Power Auger**









Item	Quantity	Unit	Material	Notes
1.0	1.00	cu. yd.	Concrete	Class 40
2.0	1.00	sq. ft.	Formwork	18" x 18" x 1/2"
3.0	1.00	lb.	Reinforcing Steel	Grade 60
4.0	1.00	sq. ft.	Formwork	12" x 12" x 1/2"
5.0	1.00	lb.	Reinforcing Steel	Grade 60
6.0	1.00	sq. ft.	Formwork	18" x 18" x 1/2"
7.0	1.00	lb.	Reinforcing Steel	Grade 60
8.0	1.00	sq. ft.	Formwork	12" x 12" x 1/2"
9.0	1.00	lb.	Reinforcing Steel	Grade 60
10.0	1.00	sq. ft.	Formwork	18" x 18" x 1/2"
11.0	1.00	lb.	Reinforcing Steel	Grade 60
12.0	1.00	sq. ft.	Formwork	12" x 12" x 1/2"
13.0	1.00	lb.	Reinforcing Steel	Grade 60
14.0	1.00	sq. ft.	Formwork	18" x 18" x 1/2"
15.0	1.00	lb.	Reinforcing Steel	Grade 60
16.0	1.00	sq. ft.	Formwork	12" x 12" x 1/2"
17.0	1.00	lb.	Reinforcing Steel	Grade 60
18.0	1.00	sq. ft.	Formwork	18" x 18" x 1/2"
19.0	1.00	lb.	Reinforcing Steel	Grade 60
20.0	1.00	sq. ft.	Formwork	12" x 12" x 1/2"
21.0	1.00	lb.	Reinforcing Steel	Grade 60
22.0	1.00	sq. ft.	Formwork	18" x 18" x 1/2"
23.0	1.00	lb.	Reinforcing Steel	Grade 60
24.0	1.00	sq. ft.	Formwork	12" x 12" x 1/2"
25.0	1.00	lb.	Reinforcing Steel	Grade 60
26.0	1.00	sq. ft.	Formwork	18" x 18" x 1/2"
27.0	1.00	lb.	Reinforcing Steel	Grade 60
28.0	1.00	sq. ft.	Formwork	12" x 12" x 1/2"
29.0	1.00	lb.	Reinforcing Steel	Grade 60
30.0	1.00	sq. ft.	Formwork	18" x 18" x 1/2"
31.0	1.00	lb.	Reinforcing Steel	Grade 60
32.0	1.00	sq. ft.	Formwork	12" x 12" x 1/2"
33.0	1.00	lb.	Reinforcing Steel	Grade 60
34.0	1.00	sq. ft.	Formwork	18" x 18" x 1/2"
35.0	1.00	lb.	Reinforcing Steel	Grade 60
36.0	1.00	sq. ft.	Formwork	12" x 12" x 1/2"
37.0	1.00	lb.	Reinforcing Steel	Grade 60
38.0	1.00	sq. ft.	Formwork	18" x 18" x 1/2"
39.0	1.00	lb.	Reinforcing Steel	Grade 60
40.0	1.00	sq. ft.	Formwork	12" x 12" x 1/2"
41.0	1.00	lb.	Reinforcing Steel	Grade 60
42.0	1.00	sq. ft.	Formwork	18" x 18" x 1/2"
43.0	1.00	lb.	Reinforcing Steel	Grade 60
44.0	1.00	sq. ft.	Formwork	12" x 12" x 1/2"
45.0	1.00	lb.	Reinforcing Steel	Grade 60
46.0	1.00	sq. ft.	Formwork	18" x 18" x 1/2"
47.0	1.00	lb.	Reinforcing Steel	Grade 60
48.0	1.00	sq. ft.	Formwork	12" x 12" x 1/2"
49.0	1.00	lb.	Reinforcing Steel	Grade 60
50.0	1.00	sq. ft.	Formwork	18" x 18" x 1/2"
51.0	1.00	lb.	Reinforcing Steel	Grade 60
52.0	1.00	sq. ft.	Formwork	12" x 12" x 1/2"
53.0	1.00	lb.	Reinforcing Steel	Grade 60
54.0	1.00	sq. ft.	Formwork	18" x 18" x 1/2"
55.0	1.00	lb.	Reinforcing Steel	Grade 60
56.0	1.00	sq. ft.	Formwork	12" x 12" x 1/2"
57.0	1.00	lb.	Reinforcing Steel	Grade 60
58.0	1.00	sq. ft.	Formwork	18" x 18" x 1/2"
59.0	1.00	lb.	Reinforcing Steel	Grade 60
60.0	1.00	sq. ft.	Formwork	12" x 12" x 1/2"

**GENERAL NOTES:**

- CONCRETE: Superstructure concrete is to be Class 40.
- FORMWORK: Formwork shall be Class 12 or Class 18.
- REINFORCING STEEL: All reinforcing steel shall be Grade 60.
- PILE DRIVING: Piles shall be driven to refusal.
- FOUNDATION: Foundations shall be Class 40.
- BRIDGE: Bridge structure shall be Class 40.
- TRUCK LOAD: Truck load shall be 15 kips per foot.
- GENERAL NOTES AND QUANTITIES: See the Report of Scope, Stability and Settlement Investigation.

**TRUCK DATA - 10000**

AXLE 1 (8000)	350
AXLE 2 (1500)	400
GVW	175
P	60/40
T	100

**DESIGN DATA**

DESIGN SPECIFICATIONS: ASD/70 Specifications, 2017 Edition, Load and Resistance Factor Design.

DESIGN LOADING: ASD/70

DESIGN DATA TABLE:

Grade	Area	Force	Moment
Grade 40	4000 sq ft	40000 lb	400000 ft-lb
Grade 60	4000 sq ft	40000 lb	400000 ft-lb
Grade 80	4000 sq ft	40000 lb	400000 ft-lb
Grade 100	4000 sq ft	40000 lb	400000 ft-lb
Grade 120	4000 sq ft	40000 lb	400000 ft-lb
Grade 140	4000 sq ft	40000 lb	400000 ft-lb
Grade 160	4000 sq ft	40000 lb	400000 ft-lb
Grade 180	4000 sq ft	40000 lb	400000 ft-lb
Grade 200	4000 sq ft	40000 lb	400000 ft-lb
Grade 220	4000 sq ft	40000 lb	400000 ft-lb
Grade 240	4000 sq ft	40000 lb	400000 ft-lb
Grade 260	4000 sq ft	40000 lb	400000 ft-lb
Grade 280	4000 sq ft	40000 lb	400000 ft-lb
Grade 300	4000 sq ft	40000 lb	400000 ft-lb

# "General Notes and Quantities" page

Excavation Boundary Plane of Class I and Class II Excavation; Class I above the plane, Class II below the plane. See the "Bridge Excavation" sheet for the limits of pay excavation.

BACKFILL COMPACTION: Backfill compaction shall be required at abutments.

**PILING:** Drive all piling to penetrate or bear upon the Smoky Hill Chalk Member formation. Driving shall stop when in the opinion of the Engineer additional driving may damage the piling. Drive all piling to the Pile Driving Formula Load of:

Abutment No. 1	58.1 Tons
Pier No. 1	163.5 Tons
Pier No. 2	163.5 Tons
Abutment No. 2	58.1 Tons

As a minimum drive each pile to the load and penetration, but in no case shall the pile be driven to more than 110% of Pile Driving Formula Driving Load. At any location where problems are experienced, pile damage is suspected, or the Pile Driving Formula Load occurs significantly above the design pile tip elevation, the Engineer may require that the Pile Driving Analyzer (PDA)

Plot Location: Bridge

REINFORCING  
wi  
PILING  
we  
No  
(B  
CAMBER  
var  
for  
if  
bec  
tak  
bet  
de  
the  
flo  
mi  
Pr  
gr  
ca  
pla

**Look for the " PILING: " note on this page. It will have the numbers you need for driving.**

**PILING:** Drive all piling to penetrate or bear upon the Smoky Hill Chalk Member formation. Driving shall stop when in the opinion of the Engineer additional driving may damage the piling. Drive all piling to the **Pile Driving Formula Load** of:

Abutment No. 1	58.1 Tons
Pier No. 1	163.5 Tons
Pier No. 2	163.5 Tons
Abutment No. 2	58.1 Tons

**This is what you're interested in.**

er than 1%, abatement shall be performed  
ations. Results less than 1% require



DESIGN LOADING:  
HL-93

Design Dead Load includes an allowance of 15 psf for a future wearing surface.

UNIT STRESSES:

Concrete (Grade 4.0)	$f'c =$	4,000 psi
Concrete (Grade 4.0)(AE)	$f'c =$	4,000 psi
Concrete (Grade 4.0)(AE)(SW)	$f'c =$	4,000 psi
Prestressed Beam Concrete	$f'c =$	5,000 psi
Reinforcing Steel (Grade 60)	$f_y =$	60 ksi
Steel Pile	$f_y =$	50 ksi
Prestressed Strand	$1/2" \text{ } \emptyset$ Grade 270 uncoated 7-wire,	low relaxation strand.

LRFD DESIGN PILE LOAD:			
Design Loading (Tons/Pile)	Strength I	Service I	Phi
Abutments No. 1 & 2	58.1	38.1	0.55
Piers No. 1 & 2	163.5	114.8	0.65

**Do NOT get this confused with the Design Pile Load, which is usually just above the title block.** Klaven!

CTURES: Removal of existing  
the bid item, "Removal of  
Sum. All materials removed  
e shall become the property of  
s material from the site.  
rap at the abutments shall  
lary to the bid item "Removal

	RATING FACTORS	
	Inventory	Operating
Truck HS-20 (36T)	1.52	2.54
Type HET (110T)	<del>1.52</del>	1.40
2002 LFD Rating, 17th Edition AASHTO		
HL-93 Loading	1.33	2.60
2017 Manual for Bridge Evaluation		

NO.	DATE	REVISIONS	BY	APP'D
KANSAS DEPARTMENT OF TRANSPORTATION				
Br. No. 9-69-25,18 (088)		Sta. 373+96.50		
GENERAL NOTES AND QUANTITIES				
K-9 over Big Timber Creek				
Proj. 9-69 KA-3094-01			Norton Co.	
SHEET NO. 1 OF 2	SCALE	APP'D		
DESIGNED	CEM DETAILED	CEM QUANTITIES	CEM ICADD	R-3H
DESIGN CK.	SUB DETAIL CK.	SUB QUAN. CK.	KMC ICADD CK.	CEM

CADconform Certify This File Sheet No. 25

ETE: Use air entrained concrete with  
specified in the Special Provisions.  
28 day strength requirements  
lans. Submit mix designs to  
nd Research for approval.

KS: After the abutment and pier  
before setting any prestressed  
to the Engineer that the  
match plan elevation ( $\pm 1/4"$ ).

N: See the General Notes on the  
sheet.

Design Dead Load includes an allowance of 15 psf for a future wearing surface.

UNIT STRESSES:

Concrete (Grade 4.0)	$f'c =$	4,000 psi
Concrete (Grade 4.0)(AE)	$f'c =$	4,000 psi
Concrete (Grade 4.0)(AE)(SW)	$f'c =$	4,000 psi
Prestressed Beam Concrete	$f'c =$	5,000 psi
Reinforcing Steel (Grade 60)	$f_y =$	60 ksi
Steel Pile	$f_y =$	50 ksi
Prestressed Strand	$1/2" \text{ } \emptyset$ Grade 270 uncoated 7-wire,	low relaxation strand.

LRFD DESIGN PILE LOAD:			
Design Loading (Tons/Pile)	Strength I	Service I	Phi
Abutments No. 1 & 2	58.1	38.1	0.55
Piers No. 1 & 2	163.5	114.8	0.65

**This is structural engineering info.**

**It is there for the designers' reference.**

**During construction, we use it with the PDA.**

	RATING FACTORS	
	Inventory	Operating
	1.52	2.54
	<del>1.52</del>	1.40
17th Edition AASHTO		
	1.33	2.60
2017 Manual for Bridge Evaluation		

NO.	DATE	REVISIONS	BY	APP'D
KANSAS DEPARTMENT OF TRANSPORTATION				
Br. No. 9-69-25,18 (088)		Sta. 373+96.50		
GENERAL NOTES AND QUANTITIES				
K-9 over Big Timber Creek				
Proj. 9-69 KA-3094-01			Norton Co.	
SHEET NO. 1 OF 2	SCALE	APP'D		
DESIGNED	CEM DETAILED	CEM QUANTITIES	CEM ICADD	R-3H
DESIGN CK.	SUB DETAIL CK.	SUB QUAN. CK.	KMC ICADD CK.	CEM

CADconform Certify This File Sheet No. 25



\*\* Quantities are included in the Superstr. Total Quantity.

\* NOTE: Only steel pile HPI2X53 shall be used on this project.

†Summary of Piling (Bridge 103):  
 Abutment No. 1: 7 @ 55 ft.  
                   1 @ 61 ft.  
 Pier No. 1: 16 @ 37 ft.  
 Pier No. 2: 15 @ 37 ft.  
                   1 @ 44 ft.  
 Abutment No. 2: 8 @ 58 ft.

†Summary of Piling (Bridge 104):  
 Abutment No. 1: 8 @ 54 ft.  
 Pier No. 1: 15 @ 37 ft.  
                   1 @ 43 ft.  
 Pier No. 2: 16 @ 36 ft.  
 Abutment No. 2: 7 @ 56 ft.  
                   1 @ 62 ft.

AADT (2012)	3,600
AADT (2032)	5,200
DHV	9%
D	55/45
T	18.4%

Rating Level	Inventory	Operating
Truck (36T)	2.797	4.672
Type HET (110T)		1.639
2002 LFD Rating, 17th Edition AASHTO		
HL-93 Loading	1.580	2.048
2008 Manual for Bridge Evaluation		

GENE

**PILING:** Drive all piling to penetrate or bear upon the Wellington Formation. Driving shall stop when in the opinion of the Engineer additional driving may damage the piling. Drive all piling to the Pile Driving Formula Load of:

Abutment No. 1: 85 Tons  
 Pier No. 1: 88 Tons  
 Pier No. 2: 88 Tons

**BRIDGE EXCAVATION:** All excavation shall be Class III. See the Bridge Excavation sheet for the limits of pay excavation.

**TEST PILE SPECIAL:** Drive the test pile special at the locations directed by the Engineer/Geologist or as on the Plans. Use (Pile Driver Analyzer) (PDA) equipment.

**Sometimes there is also a summary of piling type and length on this page.**

uired  
n

**PILING SPLICE LOCATION:** Integral pile splice locations and weld testing criteria for Abutments 1 and 2 will follow the "Standard Pile Details" Sheet (BR110).

place cast in place shear bolts, coil inserts, or other devices used as falsework support in the columns without the approval of the Engineer. Do not remove column formwork without the approval of the Engineer. Curing shall continue after the formwork is removed as required by the KDOT Specifications.

Plotted By: #USERNAME##  
 File: #####/#####/#####  
 Plot Date: #####/#####/#####

For years at KDOT, we drove piling to the Allowable Load.

Now it is called the Pile Driving Formula Load.

*If necessary, we can drive to 110 % of the Pile Driving Formula Load.*

That's usually *not* necessary.

Most of the time, you should drive to the pile driving formula load and then stop.

*If necessary, we can drive to 110 % of the Pile Driving Formula Load.*

If you are driving to a certain depth, then the 110 % rule can be handy.

On most projects, going over the specified load is wasting money at best.

At worst, you could damage the pile.

**Make sure you have a good reason for driving much past the specified load.**

Let's take another example....

Plotted By: ##USERNAME## Plot Location: #JUN#

File: #####DGN#SPEC#####

Plot Date: ##SYTIME##

*PILING: Drive all piling to penetrate or bear upon the Wellington Formation. Driving shall stop when in the opinion of the Engineer additional driving may damage the piling. Drive all piling to the Pile Driving Formula Load of:*

Abutment No. 1:	86 Tons
Pier No. 1:	88 Tons
Pier No. 2:	88 Tons
Abutment No. 2:	86 Tons

*As a minimum drive each pile to the load and penetration, but in no case shall the pile be driven to more than 110% of Pile Driving Formula Driving Load. At any location where problems are experienced, pile damage is suspected, or the Pile Driving Formula Load occurs significantly above the design pile tip elevation, the Engineer may request that the Pile Driving Analyzer (PDA) equipment be used.*

Abutment No. 1	86	Tons
Pier No. 1	88	Tons
Pier No. 2	88	Tons
Abutment No. 2	86	Tons

Let's do Abutment 2....

**86 tons x 1.1 = 94.6 tons**

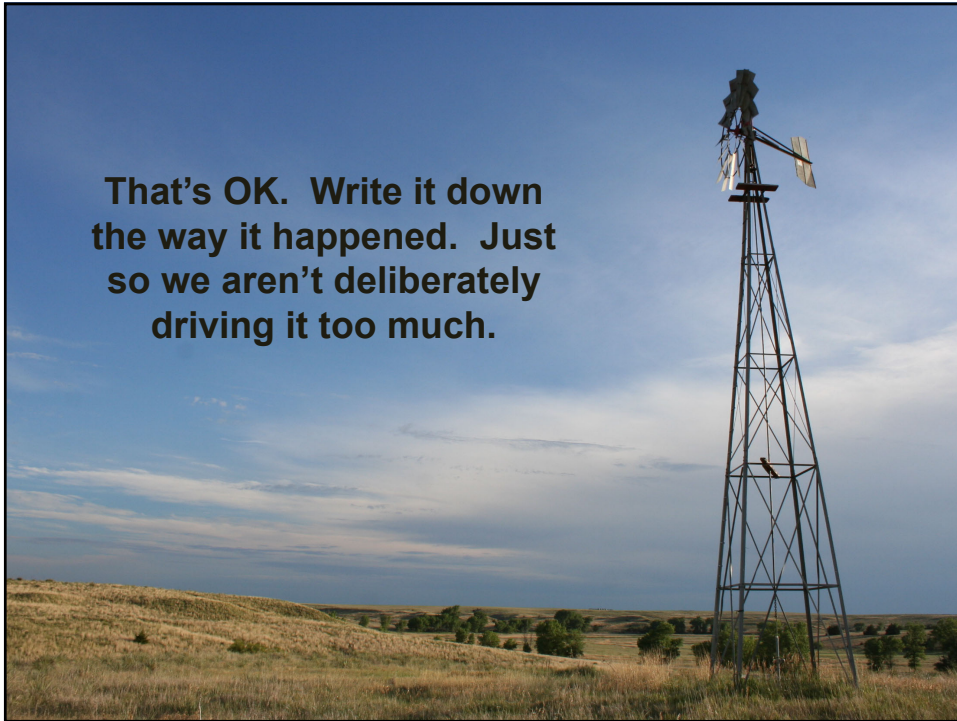
**So we'd drive to 86 tons. If necessary,  
we could go to 95 tons.**

**Sometimes you will go a little over the  
110% when checking the resistance 20  
blows at a time.**

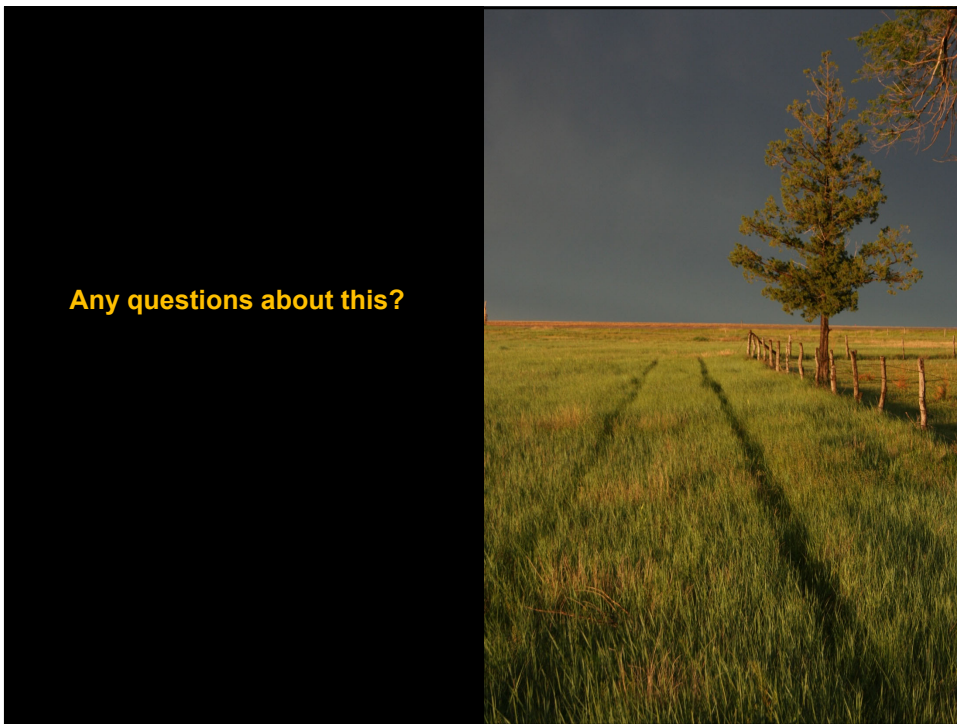




**That's OK. Write it down  
the way it happened. Just  
so we aren't deliberately  
driving it too much.**



**Any questions about this?**



**BRIDGE FOUNDATION GEOLOGY REPORT**

Bridge Replacement Project  
36-79 KA-2085-01  
Bridge No. 15.84 (069)  
US 36 over Riley Creek  
Republic County

**Bridge Foundation  
Geology Report**

ROBERT W. HENTHORNE, P.G.  
CHIEF GEOLOGIST

By

Jeffrey W. Geist, P.G., Professional Geologist II  
Neil M. Croxton, P.G., CPG, Regional Geologist

November, 2012

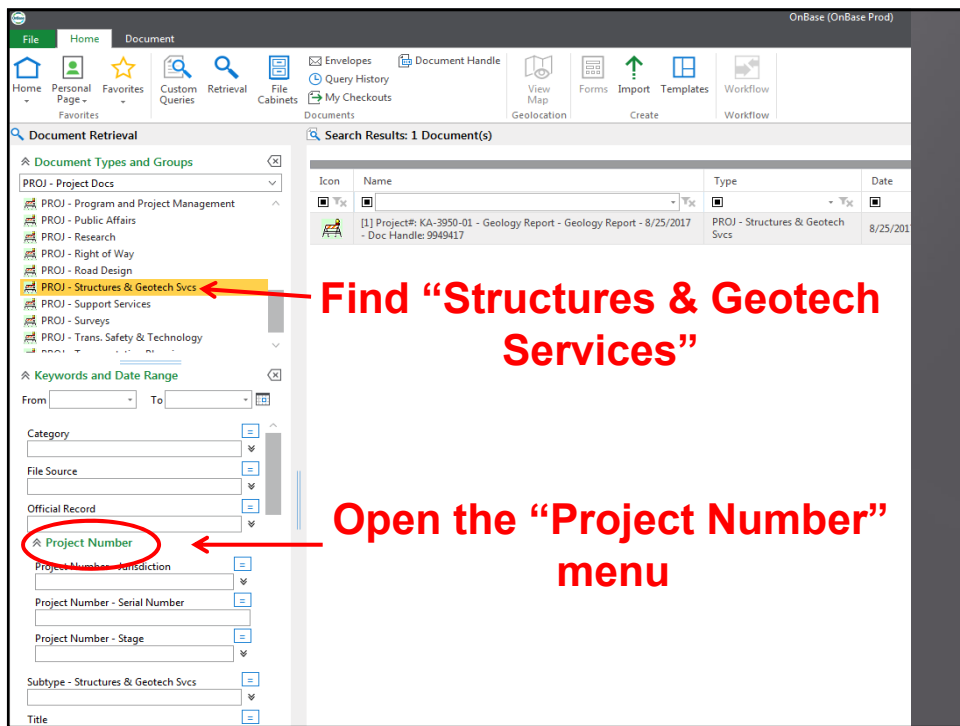
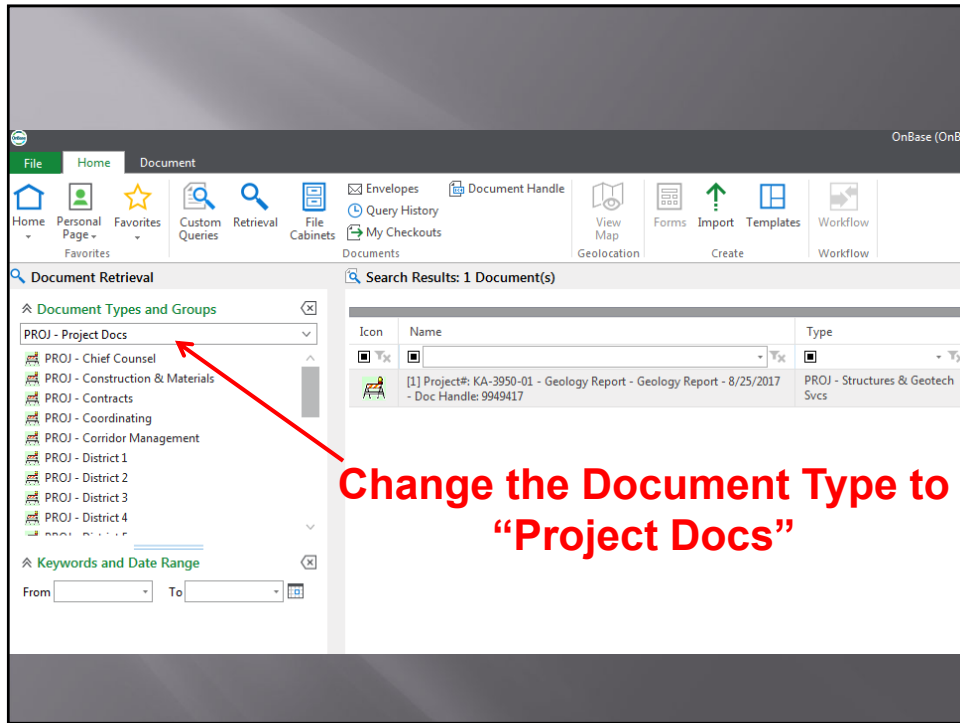


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Project Number - Serial Number 3963

Project Number - Stage 01

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Keywords and Date Range

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Category

File Source

Official Record

Project Number

Icon	Name	Type	Date
[1]	Project#: KA-3094-01 - Bridge Foundation Geology Report - Bridge Foundation Geology Report - 6/16/2015 - Doc Handle: 9271906	PROJ - Structures & Geotech Svcs	6/16/2015
[1]	Project#: KA-3094-01 - Geology, Geotechnical Memos - Geology Report - 4/29/2014 - Doc Handle: 6564833	PROJ - Structures & Geotech Svcs	4/29/2014

Double-click on the "Bridge Foundation Geology Report" and it will open for you










To find Geology Reports from an outside computer:

<https://www.ksdot.org>

“Letting Information for Highway Contractors”

“Exploratory and Project Reports”

 <p>redirecting traffic for a highway closure is hearing complaints from motorists.</p> <p><a href="#">Read More...</a></p>  <p><a href="#">KDOT announces Kansas airport improvement projects</a> <i>January 29, 2020</i></p> <p>Twenty-three projects have been selected for Kansas Airport Improvement Program (KAIP) funding according to the Kansas Department of Transportation.</p> <p><a href="#">Read More...</a></p> <p><a href="#">[Read More News]</a></p>	<p><a href="#">Kansas Highway Pothole Reporting</a></p>	<p><a href="#">Informational Webinar</a></p> <p><a href="#">Application</a></p> <p><a href="#">FAQS</a></p>
<p><b>YOUR KANSAS</b></p> <p>Click the map to view information, news, and projects specific to your area.</p>  <p><b>OTHER AVAILABLE VIEWS</b> <a href="#">District Areas</a>   <a href="#">Metro Areas</a></p>	 <p><b>Traffic Safety</b> For information about traffic fatalities and traffic safety efforts.</p>	 <p>Tolling Legislation: New lanes, options to fund</p> <p><a href="#">Legislation</a></p> <p><a href="#">Improving U.S. 69 Corridor</a></p> <p><a href="#">How Express Lanes Work</a></p>
 <p><a href="#">Working for KDOT</a></p> <p><a href="#">Current Openings</a></p>	 <p><b>Letting Information for Contractors</b></p> <p>For lettings and proposal information, policies, specifications and manuals, materials, highway flagger information and more.</p>	

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### KDOT'S CURRENT LETTING INFORMATION

**AS OF THE MAY 2019 LETTING - KDOT FORM 259 (REQUEST FOR APPROVAL OF SUBCONTRACTOR) HAS BEEN UPDATED. THE ONLY ACCEPTABLE FORM IS REVISION 04-19 AND MUST BE SUBMITTED IN EXCEL FORMAT.**

**WARNING: AS OF MARCH 01, 2018 KDOT WILL NO LONGER ACCEPT PAPER PAYROLLS AND SUBCONTRACTOR PAYMENT FORM 1010. AASHTOWARE CRL WILL BE THE ONLY ACCEPTABLE FORMAT.**


\* To submit letting/project related questions to KDOT and view the answers, please either visit [bidx.com](http://bidx.com) or select [Proposal Information](#).

[Turner Diagonal Request for Qualification \(RFQ\)](#)

<a href="#">Proposal Information</a> (View Plans, Bid Holders List, Non-Bid Holders List, View Proposal Forms, Addendum, Early & Late Start Dates) <a href="#">Summary of Quantities &amp; DBE Goal Percentages</a> <a href="#">Exploratory and Project Reports</a> <a href="#">Earliest/Latest Start Date Archive</a> <a href="#">Audio Broadcast of Bid Letting</a> <a href="#">As Read Bids (Last Letting)</a> <a href="#">Bid Tabs (Awarded Contracts)</a> <a href="#">Disadvantaged Business Enterprises</a> <a href="#">Kansas Turnpike Projects</a>	<a href="#">Specifications</a> <a href="#">Kansas Highway Wage Determinations</a> <a href="#">Fuel Adjustment Price Index</a> <a href="#">Asphalt Adjustment Price Index</a> <a href="#">Bid Item List</a> <a href="#">Pre-Qualified Materials (PQL)</a> <a href="#">Pre-Qualified Contractors Questionnaire</a> <a href="#">Pre-Qualified Contractors List</a> <a href="#">Information for Highway Contractors</a> <a href="#">Highway Contractors' Help Terms</a> <a href="#">Preliminary Plans &amp; 3D Models</a>
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[Turner Diagonal Request for Qualifications \(RFQ\)](#)

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## PROJECT LETTING

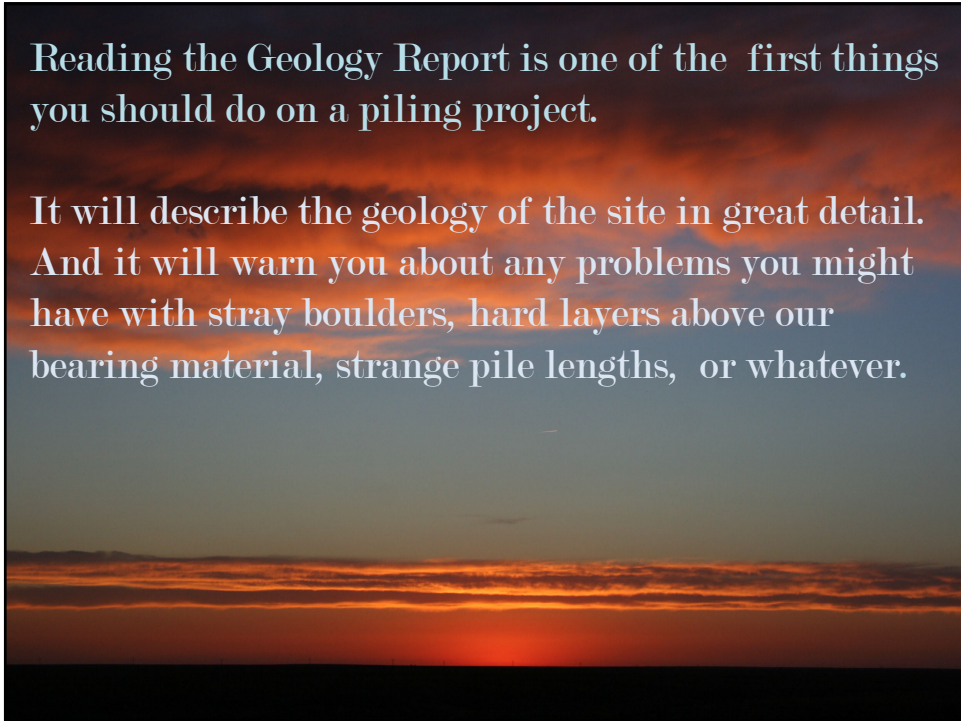
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--	---	---	--	---	---

Reading the Geology Report is one of the first things you should do on a piling project.

It will describe the geology of the site in great detail. And it will warn you about any problems you might have with stray boulders, hard layers above our bearing material, strange pile lengths, or whatever.

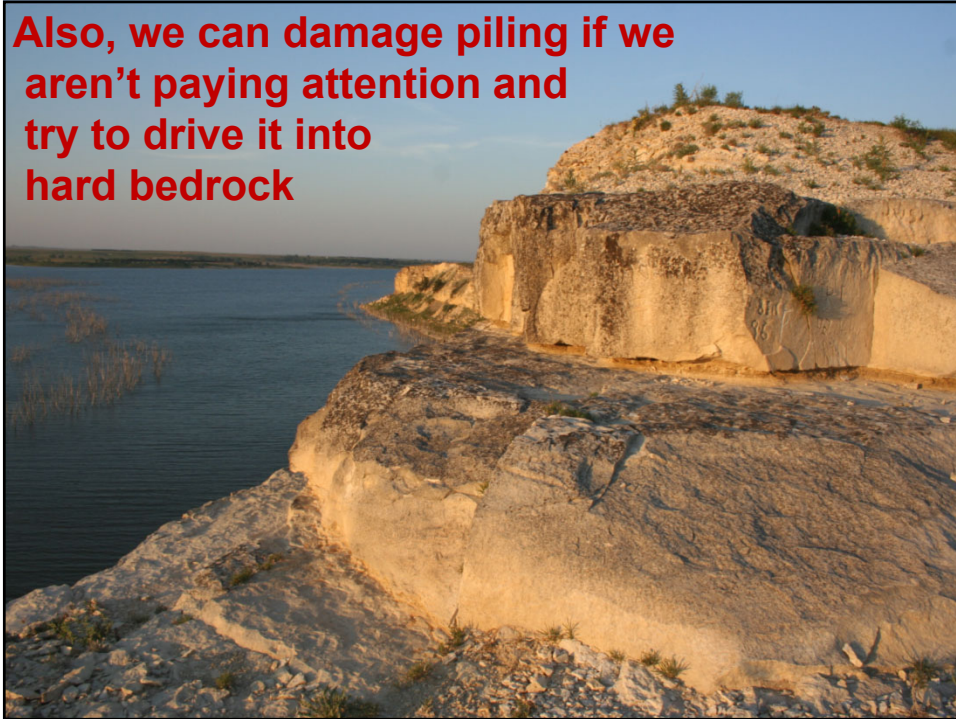


**Anyone have a weird-geology piling story?**





**Also, we can damage piling if we aren't paying attention and try to drive it into hard bedrock**



**If you don't believe me, ask the inspector on this project...**







Call your Regional Geologist with any questions about how the geology of your project will affect pile driving.



Never too busy to help inspectors....



# **The Pile Driving Formula & Problems with Dynamic Formulas**

## List of the Formulas

- **Standard Specifications**
- **Version July 2015**
- **Section 704**
- **Table 704-1 Pile Formulas**
- **Page 700-19**

## List of the Formulas

- **Bridge Construction Manual**
- **Version Oct 2009(updated 5-21-13)**
- **Chapter 5.3 Driven Pile**
- **Section 5.3.8.2 Pile Driving Formulas**
- **Page 39**

**TABLE 704-1: PILE FORMULAS**

Hammer	Pile Type	Formula
Gravity	Steel Steel Shell Steel Sheet	$P = \frac{3}{S+0.35} \frac{W H}{(W+X)}$
Air/Steam (Single Acting)	All Types	$P = \frac{2}{S+0.1} \frac{W H}{S}$
Air/Steam (Double Acting)	All Types	$P = \frac{2}{S+0.1} \frac{E}{S}$
Delmag and McKierman-Terry*	All Types	$P = \frac{1.6}{S+0.1} \frac{W H}{\left(\frac{X^{**}}{W}\right)}$
Link-Belt*	All Types	$P = \frac{1.6}{S+0.1} \frac{E}{\left(\frac{X^{**}}{W}\right)}$

\*diesel hammers

\*\* For diesel hammers, the quantity X/W shall not be less than 1.

P = safe bearing power in pounds

W = weight in pounds, of striking part of hammer

H = height of fall in feet

E = energy of ram in foot-pounds per blow

S = the average penetration in inches per blow for the last 5 blows for gravity hammers and the last 20 blows for air/steam or diesel hammers

X = weight in pounds of the pile plus the weight of any cap and/or anvil used on the pile during driving



## Computer Version of the Pile Driving Formulas

---

- Field Pile Driving Guide
- Download from Forms Warehouse
- Form 217b (new forms)

## Pile Driving Formula (aka) ENR Formula

$$P = \frac{1.6 W H}{S + [0.1(X / W)]} \quad (\text{Delmag Diesel Hammer})$$

**P=** Bearing in pounds

**W=** Weight of hammer ram in pounds

**H=** Fall height of the ram (stroke) in feet

**S=** Average set per blow in inches

**X=** Pile weight + anvil weight + cap weight in pounds

- For diesel hammers (x/w) is dropped if less than one
- Most commonly used formula on KDOT jobs
- Also known as the Engineering News Record (ENR) formula

## Using the Pile Driving Formula

---

- Piles should be driven to a minimum load of the Pile Driving Formula Load listed in the plans
- For LRFD projects 110% of the pile driving formula load will be the maximum allowed

## Determining Max. Capacity

---

Pile driving formula load listed is 55 tons

- Using the pile driving formula, the **minimum** bearing capacity needed is     tons
- The **maximum** capacity the pile can be driven to is  $55 \text{ tons} \times 110\% = \underline{\quad \text{tons}}$

## Determining Max. Capacity

Pile driving formula load listed is 55 tons

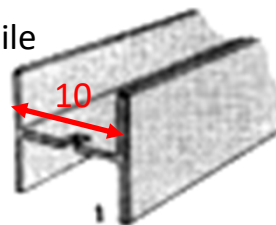
- Using the pile driving formula, the minimum bearing capacity needed is 55 tons
- The maximum capacity the pile can be driven to is  $55 \text{ tons} \times 110\% = \underline{60.5 \text{ tons}}$

## Pile Call Out

What do the numbers on H-pile represent?

### Size and Weight

- **For H-pile HP10x42**
  - The **10** represents the width of the web in inches
  - **42** represents the weight of the pile per linear foot (pounds/ft)
  - Calculate the weight of 35 ft. long pile



## Class Problem using the Pile Driving Formula For A Deisel Hammer

$$P = \frac{1.6 W H}{S + [0.1(X / W)]}$$

- You are driving HP 10 x 42 using a Delmag D12 hammer.
- Hammer ram weight is 2820 pounds (from contractor)
- Cap + Anvil weight is 2710 pounds (from contractor)
- 24 feet of pile placed in the leads
- PDF Load is 55 tons (max is 55 x 110% = 60.5 tons)
- You have a stroke of 7.5 feet
- You record 3 inches of movement in 20 blows

$$P = \frac{1.6 W H}{S + 0.1(X / W)}$$



- You are driving HP 10 x 42 using a Delmag D12 hammer.
- Hammer ram weight is 2820 pounds (from contractor)
- Cap + Anvil weight is 2710 pounds (from contractor)
- 24 feet of pile placed in the leads
- PDF load is 55 tons (max. is 55 x 110% = 60.5 tons)
- You have a stroke of 7.5 feet
- You record 3 inches of movement in 20 blows

$$P = \frac{1.6 W H}{S + 0.1(X / W)}$$

W = Weight of Hammer Ram = **2820 pounds**  
 H = Stroke of Hammer = **7.5 feet**  
 S = Set per blow (3 inches/20 blows) = **.15 inch**  
 Cap + Anvil weight = **2710 pounds**  
 Pile weight (24 feet x 42 pounds) = **1008 pounds**  
 X = Cap + Anvil + Pile weight = 2710 + 1008 = **3718 pounds**  
 X/W = 3718/2820 = **1.32**

W= ram weight = **2820 lbs**  
 H= stroke height = **7.5 feet**  
 S= average set per blow = **.15 inch**  
 X= Cap + Anvil + Pile weight = **3718 pounds**  
 $X/W = 3718/2820 = \mathbf{1.32} \geq 1.0$   
 Pile Driving Formula load = **55 tons**  

$$P = \frac{1.6 (2820)(7.5)}{0.15 + (0.1 \times 1.32)} = \frac{33840}{0.15 + 0.13}$$
  

$$P = \frac{33840}{0.28} = 120857 \text{ Pounds}$$
  

$$P = \frac{120857}{2000} \text{ (to get to tons)}$$
  
 P= 60 tons (Minimum Bearing Needed is 55 tons)

**You Have the Required Bearing**

## Class Problem

You are inspecting a pile driving operation in which the contractor is using a Delmag D15 open end diesel hammer to drive 12 X 53 H-pile that is 50 feet long. The contractor has supplied you with the following hammer specification information:

Ram (piston) weight	3300 pounds
Cap weight	1323 pounds
Anvil weight	311 pounds
Total hammer weight	6603 pounds

With a pile penetration depth of 42.5 feet you record a pile movement of 3.5 inches in 20 blows and observe a hammer stroke of 6.5 feet. Using the KDOT bearing formula for a Delmag hammer what is the bearing capacity of the pile at that time?

$$P = \frac{1.6 W H}{S + 0.1(X / W)}$$

P = bearing capacity in pounds                      W = weight of ram in pounds

H = height of stroke in feet,                      S = set per blow in inches

X = weight of pile, anvil, and cap in pounds

W= Mass of ram = 3300 pounds

H= Stroke or fall height = 6.5 feet

S= set per blow = 3.5 inches/20 blows = .175 inch

X= weight of anvil + cap + pile = 311+1323+(50 X 53)  
 = 311+1323+2650 = 4284 pounds

X/W = 4284/3300 = 1.298 > 1.0

$$P = \frac{(1.6)(3300)(6.5)}{0.175 + [0.1(1.298)]} = \frac{34320}{0.175 + .1298}$$

P=  $\frac{34320}{0.3048}$  = 112598.4252 pounds

P=  $\frac{112598.4252}{2000}$  = 56 tons

## Other uses of the Pile Driving Formula

---

- Checking the size of the hammer
- Calculating the required set in 20 blows

### **Checking the size of the Hammer**

The inspector should check to see if the contractors hammer is big enough to drive the pile

---

To do this you will need the hammer specs  
(these are provided by the contractor)

Assume a practical refusal of **1** inch in 10 blows

Use the maximum stroke the hammer can achieve

Plug the number into the pile driving formula

Your answer should be

- Pile Driving Formula Load < P < 110% of PDFL

## Where to find an example

- Bridge Construction Manual
- Version Oct 2009(updated 2012)
- Chapter 5.3 Driven Pile
- Section 5.3.6.2 Preparing to Drive Pile
- Pages 19-20

## Checking the size of the hammer

Driving 40 feet of 10x42 H-pile using a Delmag D12

Piston weight = **2750** pounds (**W**)

Cap and anvil weight = 2690 pounds

Pile weight = 40 feet x 42 lbs./ft = 1680 lbs.

Weight of pile + weight of cap and anvil=  $P = \frac{1.6 W H}{S + 0.1(X / W)}$   
2690 + 1680 = **4370** pounds (**X**)

Maximum stroke = **8.17** feet (**H**)

1inch/10blows = **0.1** inch/blow (**S**)

P= Pile Driving Formula Load = 112,000 pounds or 56 tons.

110% of design load is 123,200 pounds or 62 ton



W= 2750 pounds      X= 4370 pounds

H= 8.17 feet      S= 0.1 inch

X/W= 1.6

Pile Driving Formula Load=112,000 pounds or 56 tons  
110% = 123,200 pounds or 62 tons

$$P = \frac{1.6 W H}{S + 0.1(X / W)} = \frac{(1.6)(2750)(8.17)}{0.1 + [(0.1)(1.6)]}$$



P=138,261 pounds = 69 tons

112,000 pounds < 138,261 pounds > 123,200 pounds

56 tons < 69 tons > 62 tons

However use caution as the Hammer is Capable  
of overdriving the pile

## Calculating the required set in 20 blows

---

Now that the hammer has been found to be okay you can calculate the actual average penetration required for the last 20 blows needed to achieve bearing



$$P = \frac{1.6 W H}{S + 0.1(X/W)}$$

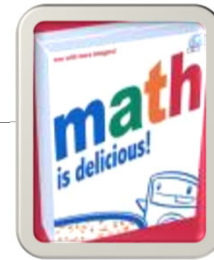
$$S = \frac{1.6 W H}{P} - 0.1(X/W)$$

$$S = \frac{(1.6)(2750)(8.17)}{112,000} - 0.1(1.589)$$

$$S = 0.321 - 0.159 = 0.16 \text{ inch/blow}$$

This means that for the last 20 blows the pile should be driven down 3.2 inches (0.16inch per blow x 20 blows) or less.

If the pile is driven further than 3.2 inches for 20 blows, then the pile does **NOT** have the required bearing yet.



## Problems with Dynamic Formulas

**Dynamic formulas are based on physics and transfer of energy with built in assumptions**

## Formula components

---

- 1. Driving system**
- 2. Soil resistance**
- 3. Pile**

## 1. The Driving System

---

Dynamic formulas offer a poor representation of the driving system and the energy losses of the drive system components

## The Driving System

---

- Equipment performance variability is typically not considered
  - Driving systems include many elements in addition to the ram such as the anvil, helmet, hammer cushion, and pile cushion
- These components affect the hammer energy at and after impact which influences the magnitude and duration of peak force
- Peak force and duration determines the ability of the driving system to advance the pile into the soil.

## Formula components

---

- 1. Driving system**
- 2. Soil resistance**
- 3. Pile**



## 2. The Soil Resistance

---

- Assumes soil resistance is a constant force
  - This assumption neglects obvious characteristics of real soil behavior
- Dynamic soil resistance is the resistance of the soil to rapid penetration produced by a hammer blow
  - This resistance is not equal to static soil resistance
  - Most dynamic formulas consider the resistance during driving to be equal to static resistance or pile capacity
    - In most cases capacity will increase or decrease with time due to soil set up or relaxation

## Formula components

---

- 1. Driving system**
- 2. Soil resistance**
- 3. Pile**

### 3. The Pile

---

- The dynamic formulas assume a rigid pile
  - Piles have flexure allowing them to penetrate the soil
  - Pile also have elastic properties
    - These compressive waves are responsible for advancing the pile into the ground
- Some formulas do not take the weight of the pile into account
  - KDOT's formula does

### Case Histories

---

Take a look at a couple of cases where dynamic formulas gave inaccurate results

- 2 KDOT projects
  - ENR formula doublechecked by the Pile Driving Analyzer (PDA)

## Case 1

---

- H-pile 14x73
- Pile pre-drilled to scour line
- Driven through silty sand and gravel into the Ogallala Formation
- Pile Driving formula load 91 tons; 100 tons (max)
- Re-strike test 24 hours later

## Case 1 Results

---

- End of Drive
  - ENR Formula     **73 tons (need 91 tons)**
  - PDA               **185 tons**
- 24 hour re-strike
  - ENR Formula     **93 tons**
  - PDA               **207 tons**
- In this case:
  - Pile Driving formula under predicted capacity by 2.2 to 2.5

## Case 2 KDOT

---

- H-pile 10x42
- Driven through silty sand at south abutment of highway 400 over Arkansas River near Dodge City
- Pile driving formula load 70 tons; 77 tons (max)
- Re-strike test 24 hours later

## Case 2 Results

---

- End of Drive
  - Bearing Formula **51.6 tons** (need **70 tons**)
  - PDA **102 tons**
- 24 hour re-strike
  - Bearing Formula **69 tons**
  - PDA **170 tons**



- The pile driving formula is still a good tool for KDOT inspectors to use to calculate bearing
- Will be conservative in most cases for Kansas Native Soil types
- Could over predict if relaxation occurs
- Should always consider options before just splicing on more pile to drive deeper
  - Can the pile set for a period of time and see what the bearing is after a restrike
  - Are there other pile drive records in the area for review
  - Consult the Engineer in charge

## LRFD

- Load and Resistance Factor Design (LRFD) does require more test pile and the use of the PDA:
  - 26 to 50 piles in the bridge structure
    - 1 to 3 piles (2-5% of total piles)
  - 51 to 100 piles in the bridge structure
    - 1 to 5 piles (2-5% of total piles)

# Questions?

---



Rail Road Steam Pile Driver 1912

# Record Keeping

## The Form 217

Either Way You Look At It,  
It Has To Be Done!



## Explanation of the Forms are Found

- **Bridge Construction Manual**
  - Chapter 5.3 Driven Pile\* Updated 10-21-09
  - Section 5.3.8 Log of Pile Driving
  - Page 26 through 36
  
- **Forms Warehouse**
  - **Form 217a 271b (English and Metric both available)**

where to find form 217  
kdotweb-forms warehouse-search-form  
number-217  
217a is the form and 217a-1 is the  
instructions

SCM by FSG Ltd. - Microsoft Internet Explorer provided by KANSAS Dept. of Transportation  
https://k2prodas.kdot.org/scm/Default.aspx

Search Other Links Help Logout

Monday, January 28, 2013

Contents of folder 'All Forms'

Form #	Form Name	Agency
DOT 0217a English	Log of Pile Driving (English)	Design
DOT 0217a Metric	Log of Pile Driving (Metric)	Design
DOT 0217a-1 English	Log of Pile Driving Instructions (English)	Design
DOT 0217a-1 Metric	Log of Pile Driving Instructions (Metric)	Design
DOT 0217aa	Pile and Driving Equipment Data	Design
DOT 0217b Guide-English	Field Pile Driving Guide (English)	Design
DOT 0217b Guide-Metric	Field Pile Driving Guide (Metric)	Design
DOT 0217b Guide-1 English	Field Pile Driving Guide Instructions (English)	Design
DOT 0217b Guide-1 Metric	Field Pile Driving Guide Instructions (Metric)	Design

Results per page 25 9 items in 1 pages

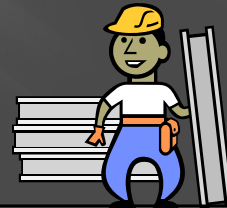






## General Information

- ▣ County, Project Number, Bridge No. and Station for the structure
- ▣ Enter number the of the Abutment or Pier where the pile was driven
- ▣ Type and size of pile – enter entire description
  - Some Examples:
    - ▣ Pile (steel) HP10 x 42
    - ▣ Test Pile Special (steel) HP12 x 53
    - ▣ Pile (prestressed concrete) 12 inch

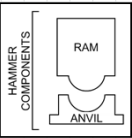



## General Information

- ▣ Type of hammer
  - Type, brand, model & size
  - Example: Diesel-Delmag D15
- ▣ Weight of the hammer (piston/ram)
  - Denoted on the hammer specification plate furnished by the contractor
  - Or look up in the reference chart in the Bridge Construction Manual
  - Online at:  
<http://www.ksdot.org/Assets/wwwksdotorg/bureaus/burStructGeotech/ConstructionManual/pile.pdf>



## 217-aa Pile driving and Equipment data

Notice to Contractors		
Pile and Driving Equipment Data		
Test Pile/Test Pile (Special), Section 704, Division 700, 2007 Standard Specifications		
Project No.	County	
Contract No.	Structure Name/No.	
Pile Contractor or Subcontractor		
	Manufacturer	Model
	Type	Serial No.
	Rated Energy (ft-lb)	@ Length of Stroke (ft)
	Fuel Setting	
	Modifications	
	Material	
	Thickness (inches)	Area (in <sup>2</sup> )
	Modulus of Elasticity (E) (psi)	
	Coefficient of Restitution (e)	

## General Information

- ▣ **Weight of the Cap and/or Anvil**
  - Supplied by the contractor
  - May be welded on, or listed on a plate
- ▣ **Energy rating of the hammer**
  - Denoted on the hammer specification plate
  - Can look it up in the Bridge Construction Manual
  - Online at:  
<http://www.ksdot.org/Assets/wwwksdotorg/bureaus/burStructGeotech/ConstructionManual/pile.pdf>





designate the Excavation Boundary Plane of Class I and Class II Excavation; Class I above the plane, Class II below the plane. See the Bridge Excavation sheet for the limits of pay excavation.

**BACKFILL COMPACTION:** Compact backfill at the abutments.

**PILING:** Drive all piling to penetrate or bear upon the alluvial sediments. Driving shall stop when in the opinion of the Engineer additional driving may damage the piling. Drive all piling to the minimum computed bearing value equal to the Allowable Pile Load:

Abutment No. 1      77 Tons  
 Pier No. 1            77 Tons  
 Pier No. 2            77 Tons  
 Abutment No. 2      77 Tons

When using the pile driving formula in the KDOT Specifications, drive the pile to the Allowable Load and penetration, but in no case shall the pile be driven to MORE THAN 115 Tons. At any location where problems are experienced, pile damage is suspected, or apparent refusal occurs significantly above the design pile tip elevation, the Engineer may request that the Pile Driving Analyzer (PDA) equipment be used.

**CORRAL RAIL:** Build the corral rail after the falsework is struck.

**ABUTMENT STRIP DRAIN:** See the General Notes on the 'Abutment Strip Drain' sheet.

**BRIDGE BACKWALL PROTECTION SYSTEM:** See the General Notes on the 'Abutment Strip Drain' sheet.

**TEST PILE (Special):** Two test piles shall be driven prior to production driving. The test pile will be monitored by the Pile Driving Analyzer. Contact the Geology Section as soon as a tentative schedule has been established for driving the test pile. The Geology Section reserves the right to request a 24-hour restrrike of the test pile.

**LRFD DESIGN PILE LOAD:**

	Loading	Design Load (Tons per Piling)	Allowable Load (Tons per Piling)
Abut.	Service I -	49.6	77
Piers.	Service I -	71.6	77

3					
2					
1	06-26-06	Current Release		JRU	KFH
NO.	DATE	REVISIONS		BY	APP'D
<b>KANSAS DEPARTMENT OF TRANSPORTATION</b>					
Proj. No.				Co.	
SHEET NO.	1 OF 12	DATE	APP'D	QUANTITIES	TRACED
DESIGNED		DETAILED		QUANLCK.	TRACE CK.
DESIGN CK.		DETAIL CK.			

**General Notes for LRFD Pile Design:**

**PILING:** Drive all piling to [penetrate or bear upon the \_\_\_\_\_ formation](or)[a minimum elevation of \_\_\_\_\_]. Driving shall stop when in the opinion of the Engineer additional driving may damage the piling. Drive all piling to the **Pile Driving Formula Load** of:

Abutment No. 1      \_\_\_\_\_      Tons  
 Pier No. 1            \_\_\_\_\_      Tons  
 Pier No. 2            \_\_\_\_\_      Tons  
 Abutment No. 2      \_\_\_\_\_      Tons

As a minimum drive each pile to the load and penetration, but in **no case shall the pile be driven to MORE THAN 110%** of Pile Driving Formula Driving Load. At any location where problems are experienced, pile damage is suspected, or the Pile Driving Formula Load occurs significantly above the design pile tip elevation, the Engineer may request that the Pile Driving Analyzer (PDA) equipment be used.

\*\*\* The Designer will fill in the above blanks in Tons with the controlling Strength I Limit State\*\*\*

\*\*\*When the PDA is used, the piles are driven to a Strength/phi resistance value.



## More General Information

Information in blue circle comes from plan sheet.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC																	
Abutment 1													Pier																																
Type of Hammer													D-19																																
Wt. of Hammer													3750.00 lbs																																
Wt. of Cap and/or Anvil													420.00 lbs																																
Energy Rating													ft-lbs																																
Number, Individual Length, and Total Length of Pile:													9 @ 25 = 225 norm; 8 @ 52 = 416 bat. Test 1 @ 28, 1 @ 55																																
Plan Cutoff Elev. (ft) =													986.150 ft																																
Wt. per foot piling (lbs/ft):													42 lbs/ft																																
Type of Cushion Mat I:																																													
County													Riley																																
Project													K-XXXX-01103																																
(Br. No.) and/or Sta													(103) 10+513.17																																
Type of Pile													HP 12x53																																
Min. Bearing Required													65 ton																																
Max. Bearing Allowed													71.5 ton																																
Bearing Formula Used:													1.6 W H S + 0.1 ( X/W **)																																
Footing Sketch (Please Complete)													<table border="1"> <tr> <td>A1</td><td>A2</td><td>A3</td><td>A4</td><td>A5</td><td>A6</td><td>A7</td><td>A8</td><td>A9</td><td>A10</td> </tr> <tr> <td>B1</td><td>B2</td><td>B3</td><td>B4</td><td>B5</td><td>B6</td><td>B7</td><td>B8</td><td>B9</td><td>B10</td> </tr> </table>													A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
A1	A2	A3	A4	A5	A6	A7	A8	A9	A10																																				
B1	B2	B3	B4	B5	B6	B7	B8	B9	B10																																				

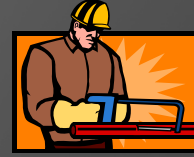
## General Information

□ **Number, Individual Length and Total Length of Pile**



- Enter the total length for the abutment or pier represented
- Also give a breakdown of the number and the length of piles used
  - Example: 4@50 ft. and 4@42 ft. = 368 ft.
  - This will not change if driven length is different.

## General Information



- ▣ Plan cutoff elevation as shown on plans
  - Enter top of pile elevation as shown on plans
- ▣ Type of cushioning material used for the hammer or pile
  - Example: Conbest, micarta
  - Maybe plywood for a pile cushion on concrete pile

## General Information

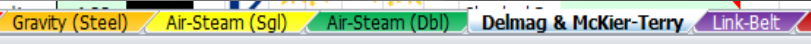


- ▣ Weight per unit length of pile
  - For H-pile HP10x42
    - The 10 represents the width of the web in inches
    - 42 represents the weight of the pile per foot (pounds/ft)
  - For steel pipe pile
    - weight per length can be found on the mill test/lading ticket from the supplier

## General Information

- ▣ Weight per unit length of pile
  - For pre-stressed concrete
    - ▣ Weight per length should be given in test report
    - ▣ Or one can use a density of 150 lbs/ft<sup>3</sup> to calculate a theoretical weight per unit length
      - 12" square = 150 lbs/ft.
      - 14" square = 204.22 lbs/ft.
      - 16" octagonal = 219.6 lbs/ft.

## General Information

- ▣ Bearing formula
    - Bearing formula is automatically entered based on type of hammer used.
- 
- ▣ Footing sketch
    - Draw a sketch of the footing with piles numbered to represent the numbers listed in the "Pile No." column on the form
    - A north arrow must be shown







## Driving Information

- ▣ 1. “Actual Length Placed in Leads”
  - This is the length the Contractor opts to use
  - It is used to calculate weight of pile for use in the bearing formula
  - When driving first starts, the “Actual Length Placed in Leads” is equal to the length picked up in the leads
    - ▣ can change as driving progresses if splices are made

## Driving Information

- ▣ 2. “Actual Length Placed in Leads”
  - a. If bearing is not achieved and a splice is required, the **new** value for “Actual Length Placed in Leads” becomes:
    - ▣ The original length placed in the leads **plus** the length of pile spliced onto it.

## Example 1

- ▣ 45 feet picked up to start.
- ▣ 15 feet spliced on and driven to achieve bearing.
- ▣ 60 feet = “Actual Length Placed in Leads”

## Driving Information

- ▣ 3. “Actual Length Placed in Leads”
  - b. If bearing is achieved prior to splicing and the splice is made solely to achieve plan cutoff (no more driving to be done on the pile), the “Length Placed in Leads” remains the original length in the leads
    - ▣ In this situation the “Ordered and Accepted Length” (original length + splice length) is greater than the “Length Placed in Leads”

## Situations in which the “Ordered and Accepted” length will differ from the plans

### ▣ 4. Ordered and Accepted

2015 Specifications 704.3a

The order list is the same as the estimated quantity (number and length of piles) shown in the Contract Documents.

## Driving Information

### ▣ 5. Ordered and Accepted

- Typically is the length the Engineer instructs the Contractor to use
  - ▣ i.e. the length of pile indicated on the plans
- But in situations the “Ordered and Accepted” length will differ from the plans

## Example 2

- ▣ 25 feet picked up and driven to bearing
- ▣ 2 feet spliced on to bring the pile top up to cut off elevation but no more driving occurred
- ▣ “Actual Length Placed in Leads” = 25 feet
- ▣ “Ordered and Accepted Length” = 27 feet
- ▣ “Length Left in Foundation” = 27 feet

Pile No.	Test Pile	Date	Varied Plan Cutoff Elev.	Actual Length in Leads	Ordered & Accepted	Spliced After Drive	Actual Cutoff	Pay Splices	Length Left in Footing	Pile Tip Elev.	Stroke (Drop of Hammer)	Average Penetration (inches)	Computed Bearing Power	Range
A1		3/20	1000.000	30.00	25.00		5.25		24.75	975.25	9.00	0.2500	77.1	High
A2		3/20		28.00	26.75		1.25	1	26.75	959.40	9.50	0.3000	71.3	OK
A3	y	3/20		29.00	28.00		3.25		25.75	960.40	10.00	0.2000	100.0	High
A4		3/20		25.30	25.30		0.00		25.30	960.85	10.00	0.3500	66.7	OK
A5		3/20		25.00	25.00		1.50		23.50	962.65	10.00	0.2500	85.7	High
A6		3/20		25.00	25.00		3.00		22.00	964.15	11.00	0.3000	82.5	High
A7		3/20		25.00	25.00		1.70		23.30	962.85	9.50	0.3000	71.3	OK
A8		3/20		25.00	25.00		1.70		23.30	962.85	10.00	0.3500	66.7	OK
A9		3/20		25.00	27.00	2.00	0.00	1	27.00	959.15	10.00	0.2500	85.7	High
A10		3/20		25.50	25.00		1.40		24.10	962.05	10.00	0.2500	85.7	High
B1		3/20		52.00	52.00		1.90		50.10	936.05	10.00	0.2500	85.7	High
B2		3/20		52.00	52.00		3.50		48.50	937.65	11.00	0.2500	94.3	High
B3		3/24		52.00	52.00		4.00		48.00	938.15	9.00	0.3000	67.5	OK
B4		3/24		52.00	52.00		5.00		47.00	939.15	10.00	0.3000	75.0	High
B5		3/24		52.00	54.00	2.00	0.00	1	54.00	932.15	10.00	0.3500	66.7	OK
B6		3/24		52.00	52.00		1.55		50.45	935.70	10.00	0.2500	85.7	High
B7		3/24		52.00	52.00		1.70		50.30	935.85	10.00	0.2500	85.7	High
B8	y	3/25		75.00	55.00		23.80		51.20	934.95	11.00	0.1500	123.5	High
B9		3/25		52.30	52.00		1.90		50.40	935.75	11.00	0.2500	94.3	High

*Ordered and Accepted*

## Situations in which the “Ordered and Accepted” length will differ from the plans

### ▣ 3. Ordered and Accepted

- ▣ a. If the length listed on the plans is too short and additional pile length is needed, the contractor is authorized to add the additional length.
  - ▣ “Ordered and Accepted” length is now equal to the original length on the plans **plus** the additional length authorized to be spliced on

### Example 3

- ▣ 45 feet listed on plans picked up and driven but bearing is not achieved
- ▣ 15 feet authorized to be spliced on
- ▣ 60 feet = “Ordered and Accepted Length”
- ▣ 60 feet = “Actual Length Placed in Leads”



## Situations in which the “Ordered and Accepted” length will differ from the plans

### ▣ 4. Ordered and Accepted

- ▣ b. If the Contractor opts to use a longer pile than called for and the additional length, in whole or part, is needed to achieved bearing and “Plan Cutoff Elevation”, the “Ordered and Accepted” length is equal to the length of pile left in place.
  - ▣ Now “Ordered and Accepted” length and “Length Left in Foundation” are equal.

## Example 4

- ▣ 45 feet called for on the plans
- ▣ Contractor picks up a 50 footer to drive
- ▣ 48 feet was needed to achieve bearing
- ▣ “Ordered and Accepted Length” =  
“Length Left in Foundation” = 48 feet
- ▣ “Actual Length Placed in Leads” = 50 feet



## Driving Information

- ▣ 6. Actual Measured Cutoff
  - a. The “Actual Measured Cutoff” may not equal “Pay Cutoff”
    - ▣ If the Contractor elects to use a longer pile than was specified, the length in excess of the length specified is considered “Non Pay Cutoff”

## Driving Information

- ▣ 7. Splicing Cutoff on another pile
  - The “Actual Measured Cutoff” from one pile may be spliced in part, or in whole, to another pile.
    - ▣ It may become part of the “Ordered and Accepted Length” on the pile that received the splice
      - This depends on the length of pile the Contractor was directed to use.

Be sure to track where the cutoff came from and where it is going to. If the cutoff from one pile is used in a different bent, then you will need to address that in the remarks of both locations.

Pile No.	Test File	Date	Varied Plan Cutoff Elev.	Actual Length in Leads	Ordered & Accepted	Spliced After Drive	Actual Cutoff	Pay Splices	Length Left in Footing	Pile Tip Elev.	Stroke (Drop of Hammer)	Average Penetration (inches)	Computed Bearing Power	Range
A1		3/20	1000.000	30.00	25.00		5.25		24.75	975.25	9.00	0.2500	77.1	High
A2		3/20		28.00	26.75		1.25	1	26.75	959.40	9.50	0.3000	71.3	OK
A3	y	3/20		29.00	28.00		3.25		25.75	960.40	10.00	0.2000	100.0	High
A4		3/20		25.30	25.30		0.00		25.30	960.85	10.00	0.3500	66.7	OK
A5		3/20		25.00	25.00		1.50		23.50	962.65	10.00	0.2500	85.7	High
A6		3/20		25.00	25.00		3.00		22.00	964.15	11.00	0.3000	82.5	High
A7		3/20		25.00	25.00		1.70		23.30	962.85	9.50	0.3000	71.3	OK
A8		3/20		25.00	25.00		1.70		23.30	962.85	10.00	0.3500	66.7	OK
A9		3/20		25.00	27.00	2.00	0.00	1	27.00	959.15	10.00	0.2500	85.7	High
A10		3/20		25.50	25.00		1.40		24.10	962.05	10.00	0.2500	85.7	High
B1		3/20		52.00	52.00		1.90		50.10	936.05	10.00	0.2500	85.7	High
B2		3/20		52.00	52.00		3.50		48.50	937.65	11.00	0.2500	94.3	High
B3		3/24		52.00	52.00		4.00		48.00	938.15	9.00	0.3000	67.5	OK
B4		3/24		52.00	52.00		5.00		47.00	939.15	10.00	0.3000	75.0	High
B5		3/24		52.00	54.00	2.00	0.00	1	54.00	932.15	10.00	0.3500	66.7	OK
B6		3/24		52.00	52.00		1.55		50.45	935.70	10.00	0.2500	85.7	High
B7		3/24		52.00	52.00		1.70		50.30	935.85	10.00	0.2500	85.7	High
B8	y	3/25		75.00	55.00		23.80		51.20	934.95	11.00	0.1500	132.0	High
B9		3/25		52.30	52.00		1.90		50.40	935.75	11.00	0.2500	94.3	High
				754.10	730.05	4.00	62.40		695.70					

**Length Left  
in Foundation**

## Driving Information


- 8. Length left in foundation:
  - Is **The Pay Length**: The length of pile left after any cutoff is removed or the addition of a splice is made after driving to achieve the desired elevation. If splice is made after bearing is achieved, the new “Order and Acceptance” length is equal to pay length provided the new length is equal to or greater than the plan length.







# Totals

	754.10	730.05	4.00	62.40	695.70		
					*****Contract Line Item Number*****	27	
Total Accepted Length =	730.05	ft	Remarks:				
Production Pile Pay Length =	618.75	ft	Pile A1 thru A10 are normal pile				
Test Pile Pay Length =	79.20	ft	Pile B1 thru B9 are battered at 15 degrees				
Production Pile Pay Cutoff =	24.30	ft	Pile A3 and B8 are test pile				
Non Pay Cutoff =	5.30	ft	Used 13.2 feet of B8 test pile non-pay cutoff to make pile B9				
Test Pile Cutoff =	23.25	ft	Used 3.8 ft. test pile cutoff B8 on B9				
No. of Test Pile Splices =	0		3 unplanned splices made at to A2, A9, B5				
No. of Pay Splices =	3		A9 used 2 ft. of pay cutoff from A6 to make elevation				
			B5 used 2 ft. from B3 to make elevation				
CUTOFF ADJUSTMENTS			Reg	Test	Inspected By: _____		
Non Pay Cutoff used for Splice =	1.75		3.80	Checked By: _____			
Pay Cutoff used for Splice =	4.00			Submitted By: _____			
Total Cutoff used for Splice =	5.75		3.80				
Refer to 704.4 Measurement and Payment							

## Driving Information

- 13. “Totals” -- Total each column
  - “Actual length placed in leads”
  - “Ordered and accepted”
  - “Actual measured cutoff”
  - “Length left in foundation”



## Driving Information

- ▣ 15. “Non Pay Cutoff”
  - ▣ Represents the length of pile in excess of the length specified and was cutoff
  - ▣ Equals the “Actual Measured Cutoff” column minus any “Pay Cutoff”

*Non Pay Cutoff used for Splice*

*Pay Cutoff used for Splice*

*Cutoff used for Splice*

Total Accepted Length =	730.0	ft	
Production Pile Pay Length =	618.7	ft	
Test Pile Pay Length =	79.20	ft	
Production Pile Pay Cutoff =	24.30	ft	
Non Pay Cutoff =	5.30	ft	
Test Pile Cutoff =	23.25	ft	
No. of Test Pile Pay Splices =	0		
No. of Pay Splices =	3		


  

***** At Line Item Number ***** 27	
Pile A3 and B8 are test pile	
Used 13.2 feet of B8 test pile non-pay cutoff to make pile B9	
Used 3.8 ft. test pile cutoff B8 on B9	
3 unplanned splices made at to A2, A9, B5	
A9 used 2 ft. of pay cutoff from A6 to make elevation	
B5 used 2 ft. from B3 to make elevation	

CUTOFF ADJUSTMENTS	Reg	Test
Non Pay Cutoff used for Splice =	1.75	3.80
Pay Cutoff used for Splice =	4.00	
Total Cutoff used for Splice =	5.75	3.80

Refer to 704.4 Measurement and Payment


 Inspected By: \_\_\_\_\_  
 Checked By: \_\_\_\_\_  
 Submitted By: \_\_\_\_\_

## Driving Information

- 16. “Non Pay Cutoff Used for Splice”
  - Is the length of pile that was originally considered part of “Non Pay Cutoff”, but was spliced to another pile to achieve “Plan Cutoff Elevation” and/or bearing

## Example 9

- 45 feet called for on the plans
- Contractor picks up a 50 footer to drive
- 45 feet was needed to achieve bearing
  - Contractor cuts off the other 5 feet as “Non Pay Cut Off”
- This 5 feet is spliced to another pile and becomes “Non Pay Cut Off Used For Splice”



## Driving Information

### ▣ 17. Pay cutoff used for splice

- Is the length that was originally considered part of the “Pay Cutoff” from one pile but was spliced to another pile to achieve “Plan Cutoff Elevation” and/or bearing.
- Since this cutoff was previously considered “Pay Cutoff” deduct it from the “Pay Cutoff” total so it is not paid for as “Pay Length” and “Pay Cutoff”.
- If came from different location, the first report will need to be amended to track pile cutoff to new location.

## Example 10

- ▣ 45 feet listed on plans picked up and driven but bearing is not achieved
- ▣ 15 feet authorized to be spliced on but only 10 feet can be driven
- ▣ 5 feet has to be cut off as “Pay Cut Off”
- ▣ This 5 feet is spliced on another pile and becomes “Pay Cut Off Used For Splice” and is now “Pay Length”

## Example 10 con't

- Since this cutoff was previously considered “Pay Cutoff” deduct it from the “Pay Cutoff” total so it is not paid for as “Pay Length” and “Pay Cutoff”.

## Driving Information

- ▣ 18. “Cutoff Used for Splice”
  - Equals the “Non Pay Cutoff Used for Splice” **plus** “Pay Cutoff Used for Splice”

# Number of Pay Splices

	730.05	4.00	62.40	695.70		27
Total Accepted Length =	730.05	ft			Remarks:	
Production Pile Pay Length =	618.75	ft			Pile A1 thru A10 are normal pile	
Test Pile Pay Length =	79.20	ft			Pile B1 thru B9 battered at 75 degrees	
Production Pile Pay Cutoff =	24.30	ft			Pile A1 thru A10 are normal pile	
Non Pay Cutoff =	5.30	ft			used 3.8 ft. of pay cutoff from A6 to A9	
Test Pile Cutoff =	23.25	ft			used 3.8 ft. of pay cutoff from B1 to B9	
No. of Test Pile Pay Splices =	0				planned splices made at to A2, A9, B5	
No. of Pay Splices =	3				A9 used 2 ft. of pay cutoff from A6 to make elevation	
					B5 used 2 ft. from B3 to make elevation	
CUTOFF ADJUSTMENTS		Reg	Test	Inspected By:		
Non Pay Cutoff used for Splice =	1.75	3.80	Checked By:			
Pay Cutoff used for Splice =	4.00		Submitted By:			
Total Cutoff used for Splice =	5.75	3.80				

Refer to 704.4 Measurement and Payment Department of Transportation

## Driving Information

- ▣ 19. “Number Pay Splices”
  - Total number of splices ordered by KDOT to extend the pile beyond the original “Ordered and Accepted Length”
  - Splices made for contractor’s convenience are not considered pay splices

# Driving Information


- 20. “Pay Length”
  - Equals the total from the “Length Left in Foundation” column
  
- 21. “Pay Cutoff” equals the
  - “Ordered & Accepted Length”
  - minus “Length Left in Foundation”
  - minus “Test & Non Pay Cutoff”

# Remarks

	754.10	730.05	4.00	62.40	695.70	
*****Contract Line Item Number*****						27
Total Accepted Length = 730.05 ft Production Pile Pay Length = 648.75 ft Test Pile Pay Length = 9.20 ft Production Pile Pay Cutoff = 4.30 ft Non Pay Cutoff = 5.30 ft Test Pile Cutoff = 23.25 ft						
No. of Test Pile Pay Splices = 0 No. of Pay Splices = 3						
CUTOFF ADJUSTMENTS      Reg      Test						
Non Pay Cutoff used for Splice = 1.75      3.80						
Pay Cutoff used for Splice = 4.00      3.80						
Total Cutoff used for Splice = 5.75      3.80						
Refer to 704.4 Measurement and Payment						Inspected By: _____ Checked By: _____ Submitted By: _____

Remarks:

- Pile A1 thru A10 are normal pile
- Pile B1 thru B9 are battered at 15 degrees
- Pile A3 and B8 are test pile
- Used 13.2 feet of B8 test pile non-pay cutoff to make pile B9
- Used 3.8 ft. test pile cutoff B8 on B9
- 3 unplanned splices made at to A2, A9, B5
- A9 used 2 ft. of pay cutoff from A6 to make elevation
- B5 used 2 ft. from B3 to make elevation



# Driving Information

- ▣ 22. “Remarks”—provide a recap of **all** splicing information and unique information
  - a. Indicate if it was pay or non-pay splice (i.e. was it ordered by KDOT or was it the Contractors option)
  - b. Which pile the splice came from
  - c. Which pile the splice was spliced to
  - d. The length of the splice pile
  - e. Indicate if the splice was made after bearing was achieved
  - f. Other information as you see fit

		Abutment		1		Pier				Project		K-XXXX-01 (103)	
										(Br. No.) and/or Sta		(103) 10+513.17	
Pile No.	Total Pile Length	Length Driven From	To	Number of Blows (Blow Count)	Drop of Hammer (Stroke) (ft.)	Average Penetration (in.)	Computed Resistance (tons)	Computed vs. Specified					
70	A4	25.3	1.50	4.50	10	6.00	3.60	4.9	Low				
71	A4	25.3	4.50	7.00	15	6.00	2.00	8.6	Low				
72	A4	25.3	7.00	11.00	20	6.50	2.40	7.8	Low				
73	A4	25.3	11.00	14.50	20	7.00	2.10	9.5	Low				
74	A4	25.3	14.50	17.00	20	7.50	1.50	14.1	Low				
75	A4	25.3	17.00	19.00	20	8.00	1.20	18.5	Low				
76	A4	25.3	19.00	20.00	20	8.50	0.60	36.4	Low				
77	A4	25.3	20.00	21.50	20	8.50	0.90	25.5	Low				
78	A4	25.3	21.50	22.50	20	9.00	0.60	38.6	Low				
79	A4	25.3	22.50	23.15	20	10.00	0.39	61.2	Low				
80	A4	25.3	23.15	23.70	20	10.00	0.33	69.8	Ok				
81	A4	25.3	23.70										
82	A4	25.3											
83	B5	52.1	3.00	9.00	10	5.00	7.20	2.1	Low				
84	B5	52.1	9.00	15.00	15	6.00	4.80	3.7	Low				
85	B5	52.1	15.00	20.00	20	6.00	3.00	5.8	Low				
86	B5	52.1	20.00	24.50	20	7.00	2.70	7.5	Low				
87	B5	52.1	24.50	29.00	20	9.00	2.70	9.6	Low				
88	B5	52.1	29.00	33.00	20	10.00	2.40	12.0	Low				
89	B5	52.1	33.00	37.00	20	10.00	2.40	12.0	Low				
90	B5	52.1	37.00	41.00	20	10.00	2.40	12.0	Low				
91	B5	52.1	41.00	44.00	20	10.00	1.80	15.8	Low				
92	B5	52.1	44.00	47.00	20	10.00			Low				
93	B5	52.1	47.00	50.00	20								
94	B5	52.1	50.00	53.00	20								
95	B5	52.1	53.00	56.00	20								
96	B5	52.1	56.00	59.00	20								
97			X.XX										

Log of Continuous Pile Driving and/or Test Pile Sheet



## Driving Information

- ▣ 23. Log of Continuous pile driving and/or test pile
  - Record a continuous pile driving record for a representative pile on each abutment and pier footing on the structure
  - The record should be inclusive from the beginning of drive to the final bearing

## When filling out the “Log of Continuous pile driving”

- ▣ For structures under 755 feet in length, a continuous pile driving record is required on 2 footings, one in the abutment and one in the pier (opposite ends)
- ▣ For structures over 755 feet in length a continuous pile driving record is required on 3 footings, one abutment and two pier footings
- ▣ If the piers have no piling then information will be recorded on one pile from each abutment

## When filling out the “Log of Continuous pile driving”

- a. Record any “set” length
  - Pile set with a gravity hammer from 0 to 16 feet
  - After pile is set, record 1 foot increments
  - Record the fractional increment just prior to achieving final bearing
    - 47 to 47.3 feet

## When filling out the “Log of Continuous pile driving”

- b. Record the number of blows per 1 foot increments
- c. Record the observed hammer stroke

## When filling out the “Log of Continuous pile driving”

- d. Record Average penetration per blow
  - The total 1 foot increment divided by the number of blows for that foot
  - Example: from 6.0 to 7.0 ft. you had 16 blows  
 $1.0 \text{ ft}/16 \text{ blows} = 12 \text{ inches}/16 \text{ blows} = .75 \text{ inch/blow}$
- e. Record Computed bearing capacity of pile

## When filling out the “Log of Continuous pile driving”

- f. Under the last entry (the fractional increment)
  - Record: 1. movement in the last 20 blows (.55 ft)
  2. average penetration per blow (0.33 in)
  3. the associated bearing (69.8 tons)

		Abutment		1		Pier		Project		K-XXXX-01 (103)	
								(Br. No.) and/or Sta		(103) 10+513.17	
Pile No.	Total Pile Length	Length Driven		Number of Blows (Blow Count)	Drop of Hammer (Stroke) (ft.)	Average Penetration (in.)	Computed Resistance (tons)	Computed vs. Specified			
		From	To								
67											
68											
69											
70	A4	25.3	1.50 4.50	10	6.00	3.60	4.9	Low			
71	A4	25.3	4.50 7.00	15	6.00	2.00	8.6	Low			
72	A4	25.3	7.00 11.00	20	6.50	2.40	7.8	Low			
73	A4	25.3	11.00 14.50	20	7.00	2.10	9.5	Low			
74	A4	25.3	14.50 17.00	20	7.50	1.50	14.1	Low			
75	A4	25.3	17.00 19.00	20	8.00	1.20	18.5	Low			
76	A4	25.3	19.00 20.00	20	8.50	0.60	36.4	Low			
77	A4	25.3	20.00 21.50	20	8.50	0.90	25.5	Low			
78	A4	25.3	21.50 22.50	20	9.00	0.60	38.6	Low			
79	A4	25.3	22.50 23.15	20	10.00	0.33	69.8	Ok			
80	A4	25.3	23.15 23.70	20	10.00	0.33	69.8	Ok			
81	A4	25.3	23.70 24.00								
82	A4	25.3									

# Driving Information

- 24. Distribution list--Copies to appropriate personnel
- 25. Signatures--Always
  - The individual that inspected the pile drive operation
  - The individual that checked any computations

Abutment		Pier		County		Project		Riley			
Type of Hammer		D-19		(Br. No.) and/or Size		K-XXXX-011033		1033 10+513.17			
Wt. of Hammer		3750.00 lb.		Type of Pile		HP 12x53					
Cap and/or Shell Energy Rating		420.00 ft-lb		Min. Bearing Required		45 ton					
Number, Individual Length, and Total Length of Pile: a Cutoff Elev. (ft) -		986.150 ft		Max. Bearing Allowed		71.5 ton					
Type of Capping Mat'l:		42		Driving Formula Used:		1.6 WH		S+0.1(N/W)			
				Piling Sketch (Please Complete)							
Pile No.	Test	Welded Pipe Cutoff Elev.	Actual Elev.	Order of Drive	Order of Drive	Depth of Drive	Depth of Drive	Depth of Drive	Depth of Drive	Remarks	
A2	8888	28.00	28.75	1.25	1	24.75	375.25	9.88	8.2588	77.1	High
A3	8888	28.00	28.00	0.00		28.75	368.48	10.88	8.3888	74.3	OK
A4	8888	25.98	25.98	0.00		25.98	369.85	10.88	8.3588	188.8	High
A5	8888	25.00	25.00	0.00		25.00	362.65	10.88	8.2588	66.7	OK
A6	8888	25.00	25.00	0.00		25.00	364.15	11.88	8.3888	82.5	High
A7	8888	25.00	25.00	1.78		25.00	362.85	9.58	8.3888	74.3	OK
A8	8888	25.00	25.00	1.78		25.00	362.85	10.88	8.3588	66.7	OK
A9	8888	25.00	27.00	2.00	1	27.00	355.15	10.88	8.2588	85.7	High
A10	8888	25.58	25.88	1.48		24.18	362.85	10.88	8.2588	85.7	High
B1	8888	52.00	52.00	0.00		52.00	356.85	10.88	8.2588	85.7	High
B2	8888	52.00	52.00	0.00		52.00	357.65	11.88	8.2588	54.3	High
B3	3724	52.00	52.00	4.88		48.88	358.15	9.88	8.3888	67.5	OK
B4	3724	52.00	52.00	5.88		47.88	355.15	10.88	8.3888	75.8	High
B5	3724	52.00	54.88	2.88	1	54.88	352.15	10.88	8.3588	66.7	OK
B6	3724	52.00	52.00	1.55		50.45	355.78	10.88	8.2588	85.7	High
B7	3724	52.00	52.00	1.78		50.28	355.85	10.88	8.2588	85.7	High
B8	3725	52.00	55.88	3.88		51.28	354.95	11.88	8.1588	192.8	High
B9	3725	52.98	52.88	1.98		50.48	355.75	11.88	8.2588	54.3	High
Total		754.18	738.85	4.88	62.48	655.78					27
Total Production											27
Total Production											27
Non Pay Cutoff -		5.50 ft									Used 17 feet of E8 test pile non-pay cutoff to make pile B9
Test Pile Cutoff -		27.05 ft									3 unplanned spllices made at to AC, A9, B5
No. of Test Pile		3									Measure of pile cut off to make elevation
No. of		3									Make elevation
CU											Inspected By:
Non Pay Cutoff		5.50									Checked By:
Pay Cutoff		27.05									Submitted By:
Total Cutoff for Splice -		5.75									0.00
Refer to T04.4 Measurement and Paym											Department of Transportation
Abutment		1		Pier				County		Riley	
								Project		K-XXXX-011033	
								(Br. No.) and/or Sta		1033 10+513.17	

Completed  
Form 217

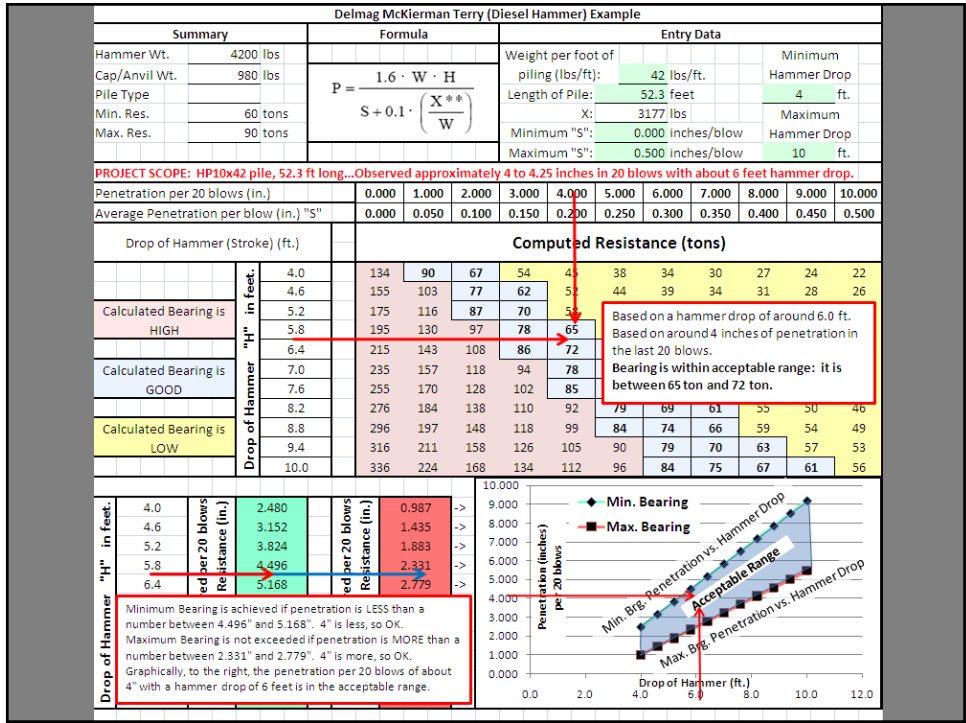
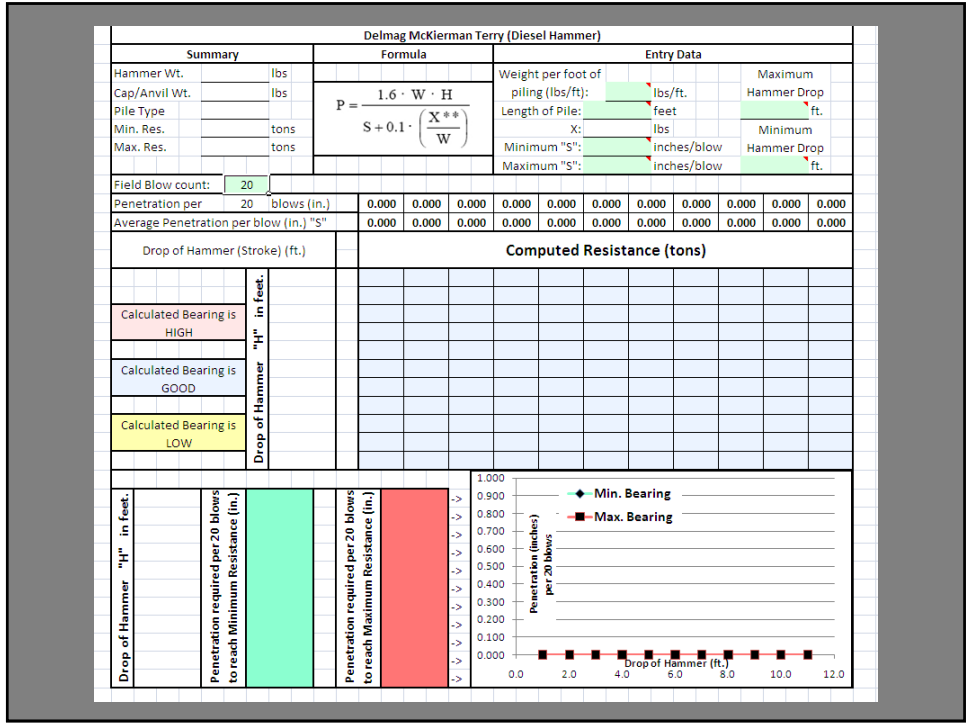
Pile No.	Total Pile Length	Length Driven		Number of Blows (Blow Count)	Drop of Hammer (Stroke) (ft.)	Average Penetration (in.)	Computed Resistance (tons)	Computed vs. Specified	
		From	To						
70	A4	25.3	1.50	4.50	10	6.00	3.60	4.9	Low
71	A4	25.3	4.50	7.00	15	6.00	2.00	8.6	Low
72	A4	25.3	7.00	11.00	20	6.50	2.40	7.8	Low
73	A4	25.3	11.00	14.50	20	7.00	2.10	9.5	Low
74	A4	25.3	14.50	17.00	20	7.50	1.50	14.1	Low
75	A4	25.3	17.00	19.00	20	8.00	1.20	18.5	Low
76	A4	25.3	19.00	20.00	20	8.50	0.60	36.4	Low
77	A4	25.3	20.00	21.50	20	8.50	0.90	25.5	Low
78	A4	25.3	21.50	22.50	20	9.00	0.60	38.6	Low
79	A4	25.3	22.50	23.15	20	10.00	0.39	61.2	Low
80	A4	25.3	23.15	23.70	20	10.00	0.33	69.8	Ok
81	A4	25.3	23.70						
82	A4	25.3							
83	B5	52.1	3.00	9.00	10	5.00	7.20	2.1	Low
84	B5	52.1	9.00	15.00	15	6.00	4.80	3.7	Low
85	B5	52.1	15.00	20.00	20	6.00	3.00	5.8	Low
86	B5	52.1	20.00	24.50	20	7.00	2.70	7.5	Low
87	B5	52.1	24.50	29.00	20	9.00	2.70	9.6	Low
88	B5	52.1	29.00	33.00	20	10.00	2.40	12.0	Low
89	B5	52.1	33.00	37.00	20	10.00	2.40	12.0	Low
90	B5	52.1	37.00	41.00	20	10.00	2.40	12.0	Low
91	B5	52.1	41.00	44.00	20	10.00	2.40	15.8	Low
92	B5	52.1	44.00	47.00	20	10.00	2.40	15.8	Low
93	B5	52.1	47.00	48.50	20	10.00	2.40	35.3	Low
94	B5	52.1	48.25	49.00	20	10.00	0.45	54.5	Low
95	B5	52.1	49.00	49.60	20	11.00	0.36	71.7	Ok

Completed  
Log of Continuous Pile Drive

## Form 271 B-the chart-make before you begin to drive pile

Field Pile Driving Guide	
Enter known data in all available cells.	
General Information	
If you can not see colored tabs for different hammers at the bottom of the window, go to "View" tab, "Arrange All", and hit "OK" in the window that pops up.	
(This information is common to all sheets in the Workbook)	
Hammer Information	PROJECT INFORMATION
Type of Hammer <input style="width: 80%;" type="text"/>	County <input style="width: 80%;" type="text"/>
Hammer Weight <input style="width: 80%;" type="text"/> lbs	(Br. No.) and/or Sta <input style="width: 80%;" type="text"/>
Cap and/or Anvil Weight <input style="width: 80%;" type="text"/> lbs	Type of Pile <input style="width: 80%;" type="text"/>
Energy Rating <input style="width: 80%;" type="text"/> ft-lbs	Plan Note Overdrive % <input style="width: 80%;" type="text"/> %
	Min. Resistance Required <input style="width: 80%;" type="text"/> tons
	Max. Resistance Allowed <input style="width: 80%;" type="text"/> tons
Guide to COMPLETING the Field Pile Driving Guide - Form 217B	
1 All formulas use exactly what is entered in the cells.	
2 Hover the mouse cursor over any red triangle to read information concerning what needs to be entered in the cell. Refer to the "Delmag Example" tab to view sample entry data.	

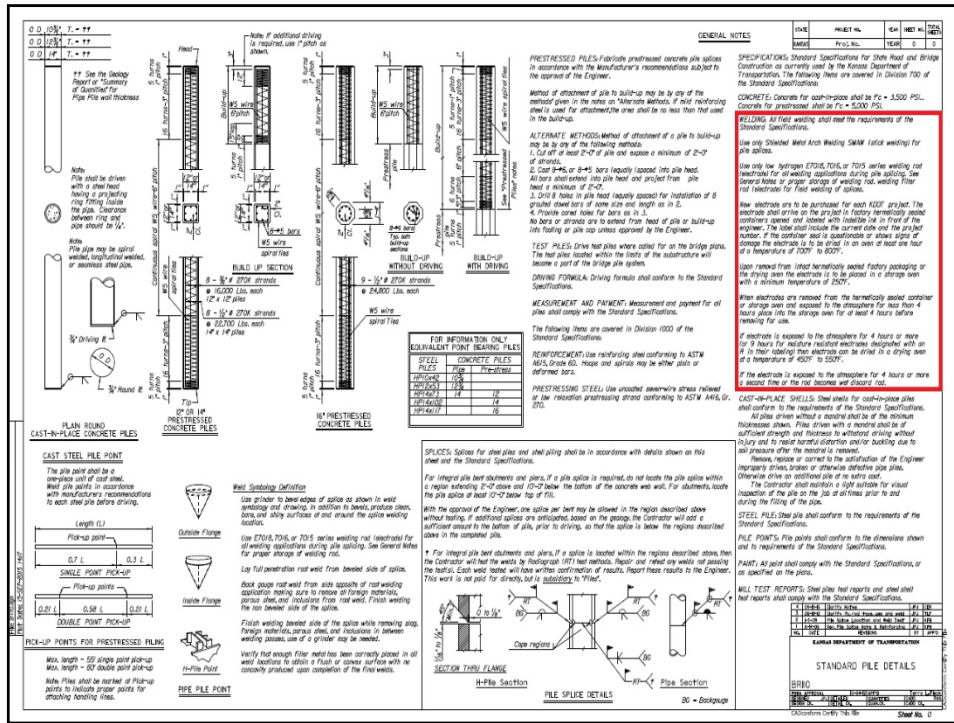




# Questions







for 4 hours or more of rod.	If the electrode is exposed to the atmosphere for 4 hours or more a second time or the rod becomes wet discard rod.	If the electrode is exposed to the atmosphere for 4 hours or more a second time or the rod becomes wet discard rod.
requirements of the	<b>WELDING:</b> All field welding shall meet the requirements of the Standard Specifications.	<b>WELDING:</b> All field welding shall meet the requirements of the Standard Specifications.
stick welding) for	Use only Shielded Metal Arch Welding SMAW (stick welding) for pile splices.	Use only Shielded Metal Arch Welding SMAW (stick welding) for pile splices.
series welding rod	Use only low hydrogen E7018, T016, or T015 series welding rod (electrode) for all welding applications during pile splicing. See General Notes or proper storage of welding rod (electrode) for field welding of splices.	Use only low hydrogen E7018, T016, or T015 series welding rod (electrode) for all welding applications during pile splicing. See General Notes or proper storage of welding rod (electrode) for field welding of splices.
pile splicing. See		
d. welding filler		
KDOT project. The	New electrode are to be purchased for each KDOT project. The electrode shall arrive on the project in factory hermetically sealed containers opened and labeled with indelible ink in front of the engineer. The label shall include the current date and the project number. If the container seal is questionable or shows signs of damage the electrode is to be dried in an oven at least one hour at a temperature of 700°F to 800°F.	New electrode are to be purchased for each KDOT project. The electrode shall arrive on the project in factory hermetically sealed containers opened and labeled with indelible ink in front of the engineer. The label shall include the current date and the project number. If the container seal is questionable or shows signs of damage the electrode is to be dried in an oven at least one hour at a temperature of 700°F to 800°F.
hermetically sealed		
containers opened and		
labeled with indelible ink		
in front of the		
engineer. The label shall		
include the current date and		
the project		
number. If the container		
seal is questionable or		
shows signs of		
damage the electrode is		
to be dried in an oven		
at least one hour		
at a temperature of 700°F		
to 800°F.		
factory packaging or	Upon removal from intact hermetically sealed factory packaging or the drying oven the electrode is to be placed in a storage oven with a minimum temperature of 250°F.	Upon removal from intact hermetically sealed factory packaging or the drying oven the electrode is to be placed in a storage oven with a minimum temperature of 250°F.
in a storage oven		
hermetically sealed container	When electrodes are removed from the hermetically sealed container or storage oven and exposed to the atmosphere for less than 4 hours place into the storage oven for at least 4 hours before removing for use.	When electrodes are removed from the hermetically sealed container or storage oven and exposed to the atmosphere for less than 4 hours place into the storage oven for at least 4 hours before removing for use.
exposed to the atmosphere		
for less than 4		
hours before		
removing for use.		
4 hours or more	If electrode is exposed to the atmosphere for 4 hours or more (or 9 hours for moisture resistant electrodes designated with an R in their labeling) then electrode can be dried in a drying oven at a temperature of 450°F to 550°F.	If electrode is exposed to the atmosphere for 4 hours or more (or 9 hours for moisture resistant electrodes designated with an R in their labeling) then electrode can be dried in a drying oven at a temperature of 450°F to 550°F.
designated with an		
R in their labeling) then		
electrode can be dried		
in a drying oven		
at a temperature of 450°F		
to 550°F.		
for 4 hours or more	If the electrode is exposed to the atmosphere for 4 hours or more a second time or the rod becomes wet discard rod.	If the electrode is exposed to the atmosphere for 4 hours or more a second time or the rod becomes wet discard rod.
of rod.		
requirements of the	<b>WELDING:</b> All field welding shall meet the requirements of the Standard Specifications.	<b>WELDING:</b> All field welding shall meet the requirements of the Standard Specifications.

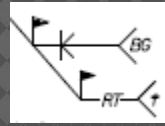
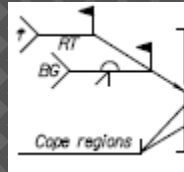








# WELD SYMBOLS MEANING



Solid Flag pointing away from work area

•Field Weld Symbol

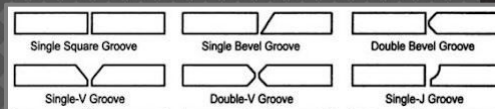
Half circle

•Filled is: Melt Through

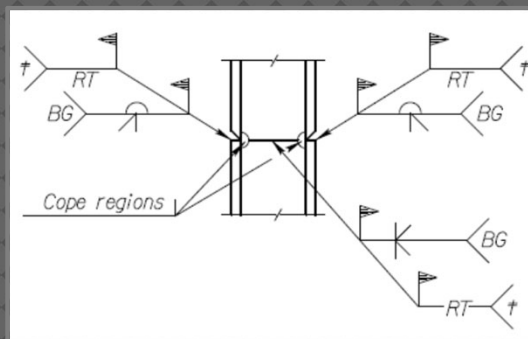
•Unfilled is: Backing or Backgouge

 : Single Bevel Groove

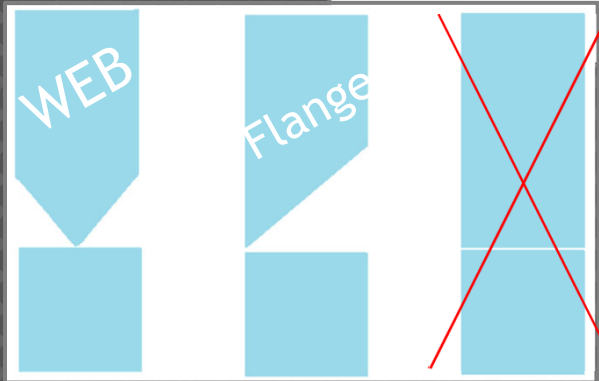
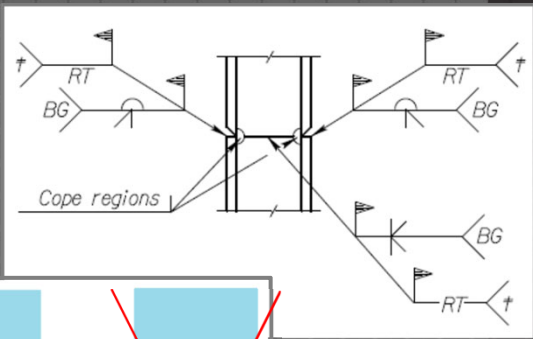
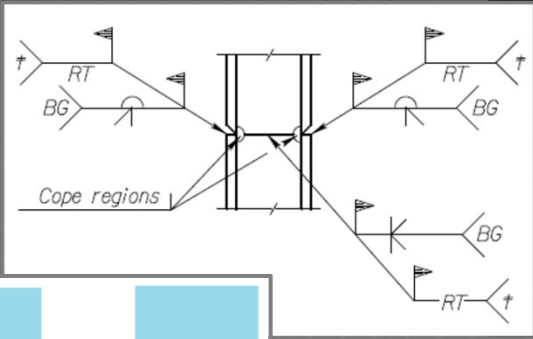
 : Double Bevel Groove



Location	Significance		
	SQUARE	V	Bevel
Arrow Side			
Other Side			
Both Sides			



# WEB? FLANGE?



Single Square Groove      Single Bevel Groove      Double Bevel Groove

Single-V Groove      Double-V Groove      Single-J Groove

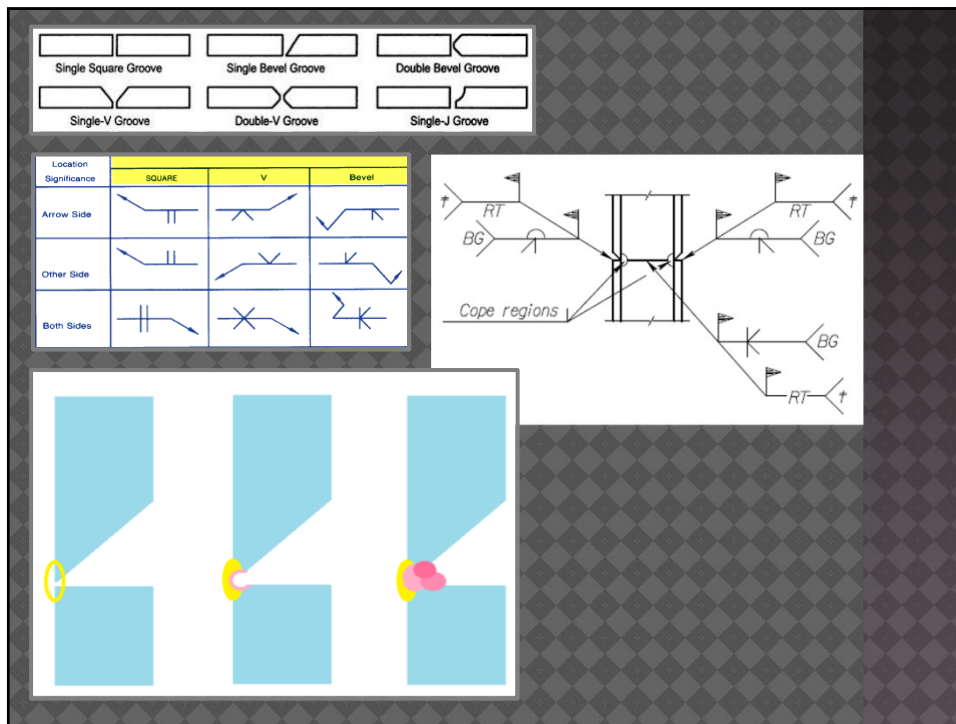
Location	SQUARE	V	Bevel
Significance			
Arrow Side			
Other Side			
Both Sides			

Single Square Groove      Single Bevel Groove      Double Bevel Groove

Single-V Groove      Double-V Groove      Single-J Groove

Location	SQUARE	V	Bevel
Significance			
Arrow Side			
Other Side			
Both Sides			



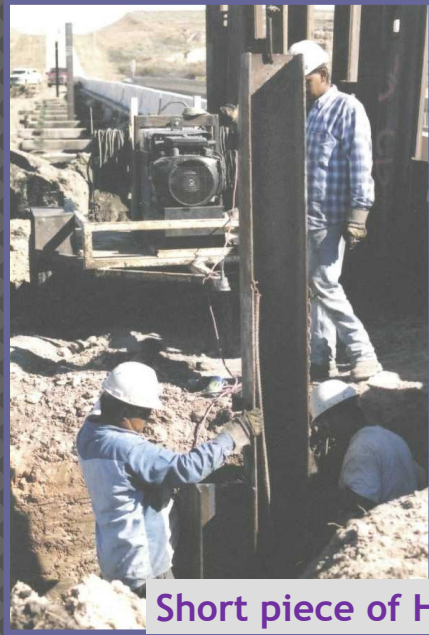




## C-CLAMPS AND BOARDS



## ALIGNMENT METHODS



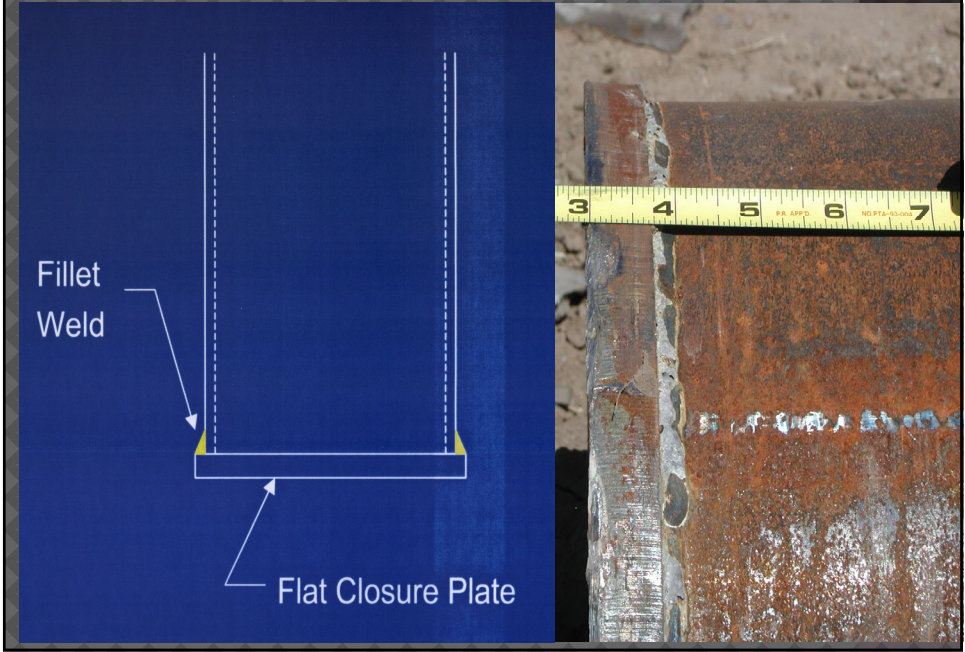
Short piece of H-pile clamped on

## CLOSED END PIPE PILE





# TYPICAL KDOT PIPE PILE PLATE



## WHAT NOT TO DO



QUESTIONS?



## Test Piles and Test Piles (Special)



# Test Piles

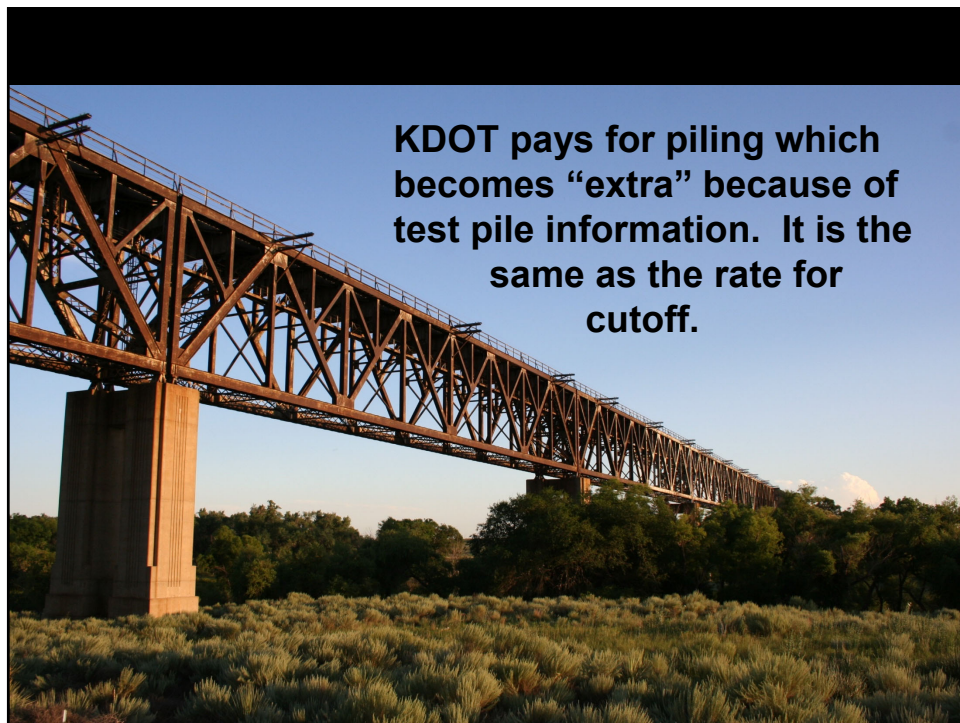
**Driven before main production piles  
to get an idea of how piles will  
behave.**







**We use the information to come up with an efficient way of driving the production piles and to plan any splice locations.**



**KDOT pays for piling which becomes “extra” because of test pile information. It is the same as the rate for cutoff.**

## What You Have To Do For a Regular Test Pile

Make sure the contractor has a certified welder  
on site in case a test pile has to be spliced

Keep a continuous log of driving

## What You Have To Do For a Regular Test Pile

Avoid delays once driving has  
started

- Finish driving the test pile in one  
day **unless you need to do a  
restrike**

*Uh-Oh....*

**If pile doesn't get resistance within roughly  
2 feet of plan elevation, try a restrike**

*Call the Regional Geology Office for help*

**Pile Restrike Procedure *from 704.4 (e)***

Wait overnight

Warm up hammer far from test pile

Immediately restrike test pile for 30 blows or until it  
moves 4 inches, whichever comes first

## Pile Restrike Procedure

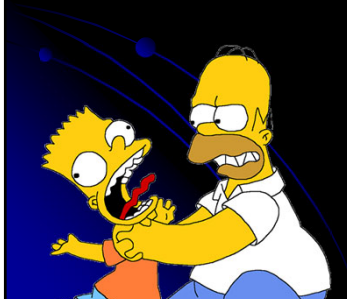
Record penetration for every 5 blows

If pile moves less than  $\frac{1}{2}$  inch, stop  
restrike after 20 blows

Calculate resistance based on average penetration  
for **first** 5 blows

## Pile Restrike Procedure

If calculated resistance is still too low, splice  
and resume driving



Why, you little....!!

## Pile Restrike Procedure

If you get enough resistance with the restrike, then we will use that elevation (plan pile tip elevation) for the production piles

## What You Have To Do

Tell your boss how the test pile went





# Test Pile (Special)

**A fancy name for a test pile that is monitored by the Pile Driving Analyzer**

# Test Pile (Special)

**Contact the Topeka Geology Office when the project gets going, just to warn John.**

**(785) 291-3861**

**Forward him the hammer data when you get it from the contractor.**

# Test Pile (Special)

You are **required** to contact the Topeka Geology Office (John) a minimum of 5 working days before the Test Pile Special.

(785) 291-3861



What to Expect  
When You're  
Expecting  
John...

# Test Pile (Special)

We Will Need Beforehand:

Hammer type and size

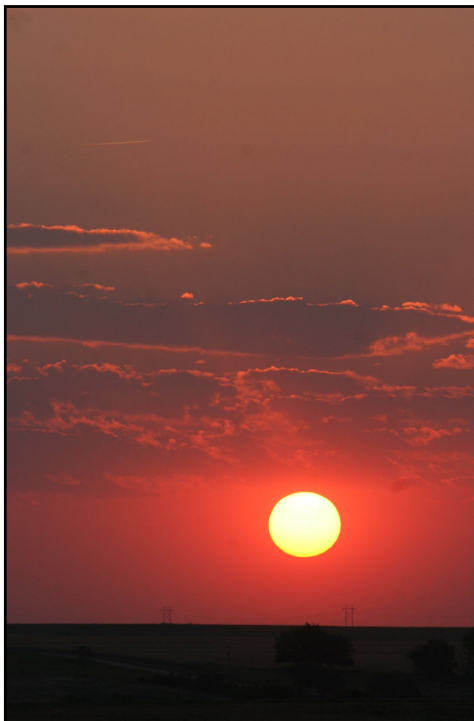
Pile type, size, and grade

Test pile locations

Cut-off elevations

Plan design pile tip elevations

If pile bents, the bottom of web wall elevation



**Remind the contractor that a restrike is required with the PDA. This may be an overnight restrike.**

# Test Piles (Special)

On the day of the test pile we'll need:

Ground elevation at each test pile location

Maybe whiskey and beer,  
depending on how it goes



# Test Piles (Special)

**Keep a continuous log of driving**

**PDA crew will tell you what  
elevation to drive to, or what  
resistance you need using the  
Pile Drive Formula**

Because of the high loads we are putting on piles now, expect to see more test pile *specials* (the PDA). And you probably won't see any regular test piles for the foreseeable future.

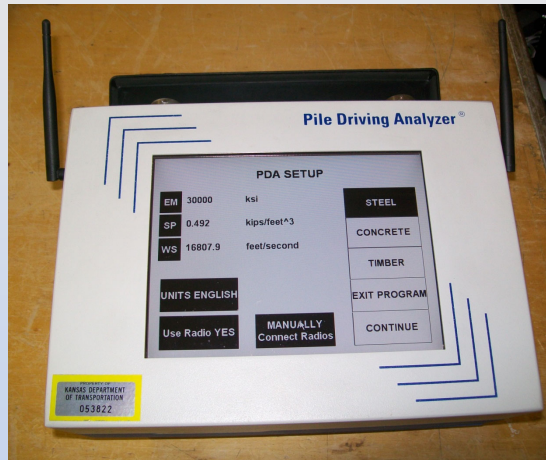


Any questions?





## The Pile Driving Analyzer and Restrike Testing



## Dynamic Testing

- A ram impacts the pile top
- The pile top is compressed at the instant of impact
- A stress wave travels through the pile
- The wave is partially reflected back up the pile due to
  - soil resistance---representing capacity
  - pile property change
  - or at the pile toe
- From the reflected waves PDA calculates capacity

## Measures

- Evaluation of the Drive System Performance
- Calculation of the Driving Stresses During Installation
- Assessment of Pile Integrity



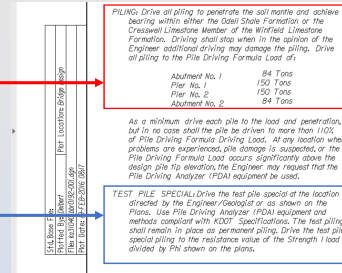
## Measurements Cont.

- Assessment of the Pile Capacity and Soil Conditions
- Allows You to Discount any Bearing Capacity in the Scour Zone
- Allows You to See Shaft Versus Toe Capacity on the Pile



## Before the PDA

- Your target pile load
- PDA target
- PDA target = Strength I load/ Phi factor
- PDA Measures in kips
  - Kip = ½ ton



**DESIGN DATA**

**DESIGN SPECIFICATIONS:**  
 AASHTO Specifications, 2007 Edition and latest Interim Specifications, Load and Resistance Factor Design.

**DESIGN LOADING:**  
 HL-93  
 Design Dead Load includes an allowance of 25 psf for a future wearing surface.

**UNIT STRESSES:**

Concrete (Grade 4,000AE)	$f'_c$	=	4 ksi
Concrete (Grade 4,000AE/3W)	$f'_c$	=	4 ksi
Reinforcing Steel (Grade 60)	$f_y$	=	60 ksi
Steel Piles	$f_y$	=	50 ksi

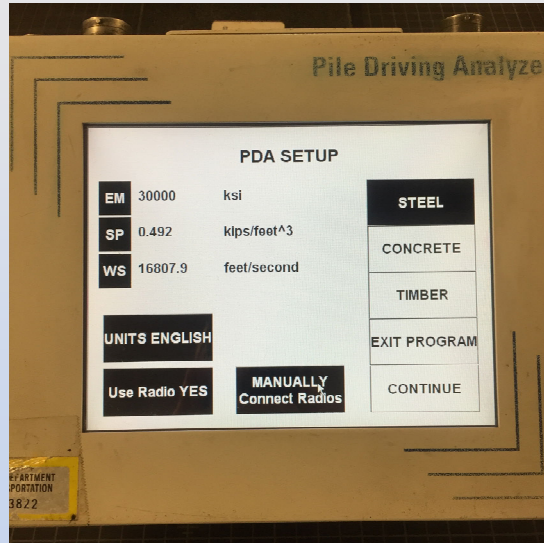
**LRFD DESIGN PILE LOADS:**

Design Loading (Tons/Pile)	Strength I	Service I	Phi
Abutments 1 & 2	84	56	0.65
Piers 1 & 2	150	106	0.65

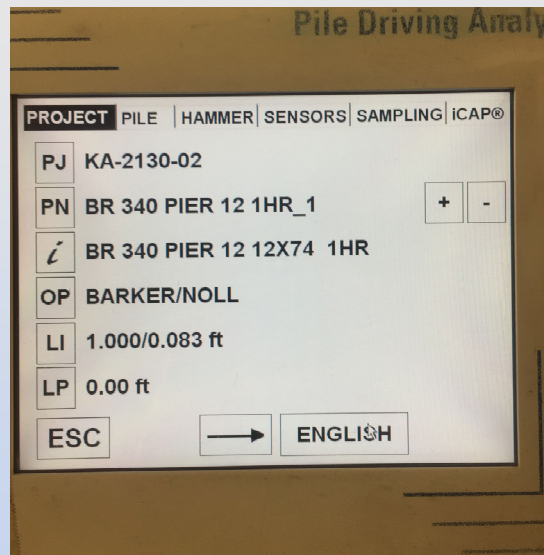
## Before the PDA

- Determine plan tip depth
- Determine depth to bedrock
- Test pile has been clearly marked by the foot
- Communication between Geology, inspectors, and foreman
  - Inspectors keeps track of the blows/foot and stroke of hammer
  - Foreman will be marking the pile every 10 blows

## Before the PDA



## Before the PDA



## Before the PDA

Pile Driving Analy

MONO | SHEET | TAPER

SQUARE | PIPE | **H-PILE** | OCT | TRI | HEX

Section	Area (in.^2)
HP 8 x 36	10.6
HP 10 x 57	16.7
HP 10 x 42	12.4
HP 12 x 63	18.4
HP 12 x 74	21.8
HP 12 x 84	24.6
HP 12 x 53	15.5
HP 14 x 73	21.4
HP 14 x 89	26.1
HP 14 x 102	30.1
HP 14 x 117	34.4
HP 16 x 162	47.7
HP 16 x 101	29.9

North American Options  
 World Wide Options  
 Metric Wide Flange Options

**AREA**  
21.8 inches^2

**BOTTOM AREA**  
148.168 inches^2

**PERIMETER**  
4.0575 feet

ESC OK

## Before the PDA

Pile Driving Analy

PROJECT | PILE | **HAMMER** | SENSORS | SAMPLING | iCAP®

ID	Name	Maker	Type	Weight	Energy
850	D8-22	PILECO	OED	2	18.656
851	D12-42	PILECO	OED	3	29.892
852	D19-42	PILECO	OED	4	42.506
853	D25-32	PILECO	OED	6	58.406
854	D30-32	PILECO	OED	7	70.066
855	D36-32	PILECO	OED	8	84.164
856	D46-32	PILECO	OED	10	107.484
857	D62-22	PILECO	OED	14	161.306
858	D80-23	PILECO	OED	18	197.568
859	D100-13	PILECO	OED	22	246.848
860	D125-32	PILECO	OED	28	308.672

MAX BPM 90.0  
MAX BPM will be suggested based on Sample Size and Frequency.

ESC OK

CUSTOM HAMMER  
SELECT MAKER



# Strain & Acceleration Measurements



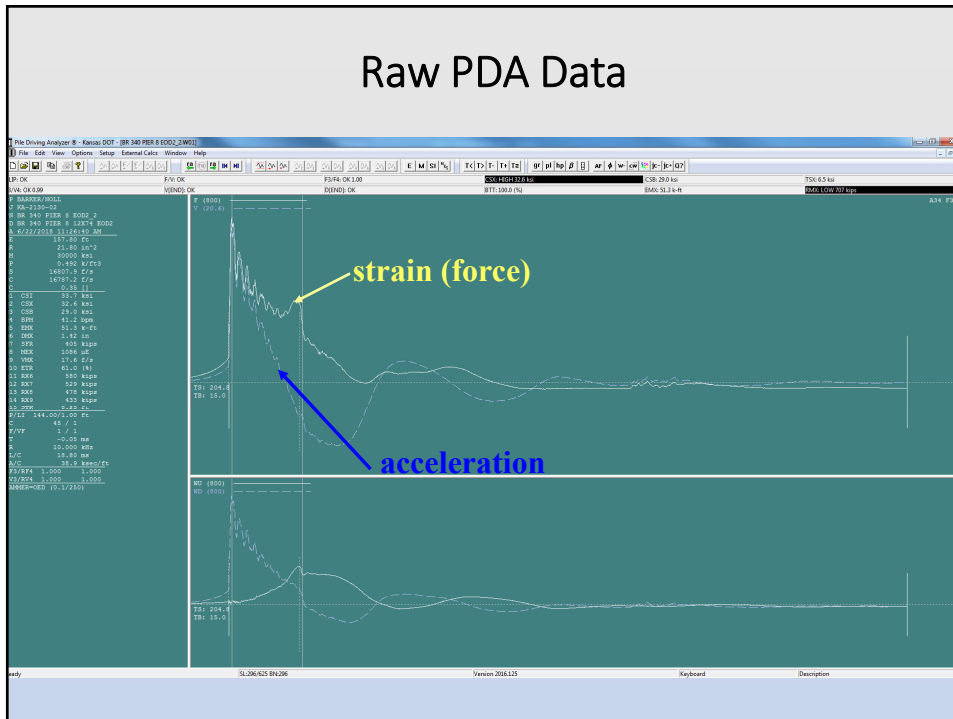
## Strain Transducers measure force

Two Strain Transducers Required to Reduce Bending Effects.

## Accelerometers measure velocity

Two Accelerometers Used for Redundancy

# Raw PDA Data



## Typical Gage Arrangement



## Gage Attachment



## Hammer Placement



## Test Pile Special Length

- Recommended 10 ft longer than production
  - Allows room for PDA equipment
  - Able to drive deeper if necessary
  - Additional length has a mild effect the ENR calculation



## PDA Testing Process

- Foreman marks the pile every 10 blows until end of drive
  - Usually beginning above a depth where capacity is expected to change (bedrock)
- The last 20 blows from the initial drive is used for:
  - PDA Analysis
  - ENR Calculation



## PDA Restrikes

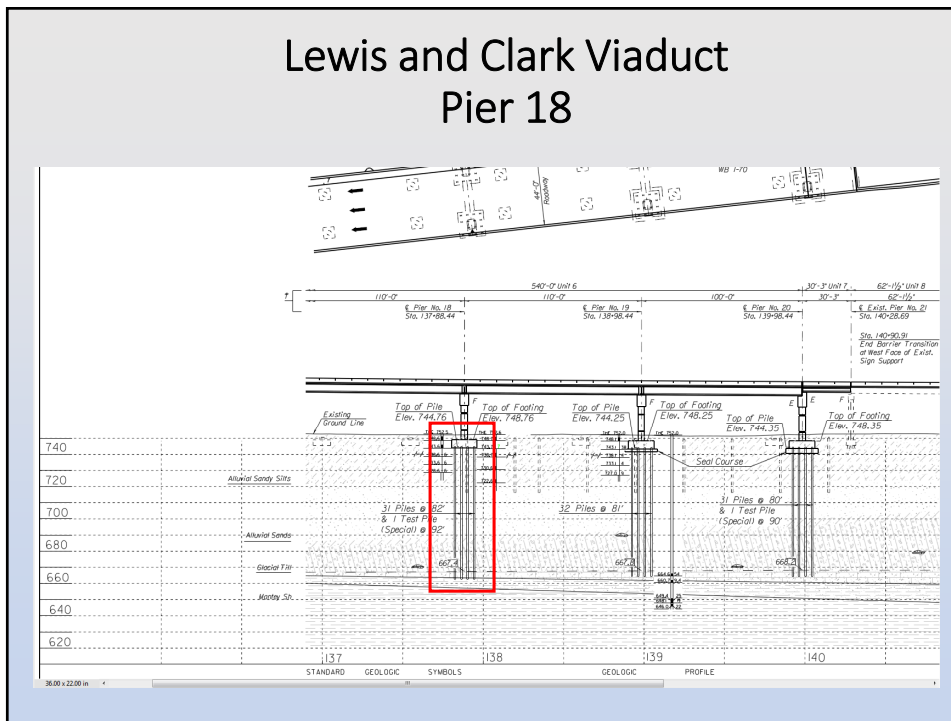
- Standard PDA series of restrikes (15 min, 1 hour, 4 hour, 24 hour) per KDOT
- Foreman marks every 5 blows



## Projects with PDA

- Lewis and Clark Viaduct - Pier 18
  - 1 Test Pile Special
  - Results will be applied to 2 pier (Pier 18 and Pier 17)
  - Pile Design Load = 110 tons
  - PDA Target Load  $(110 / .65) = 169$  tons (338 kips)
  - Plan length 82 ft
  - 12 x 74 H-Pile
  - Pileco D30-32

## Lewis and Clark Viaduct Pier 18





## Lewis and Clark Pier 18

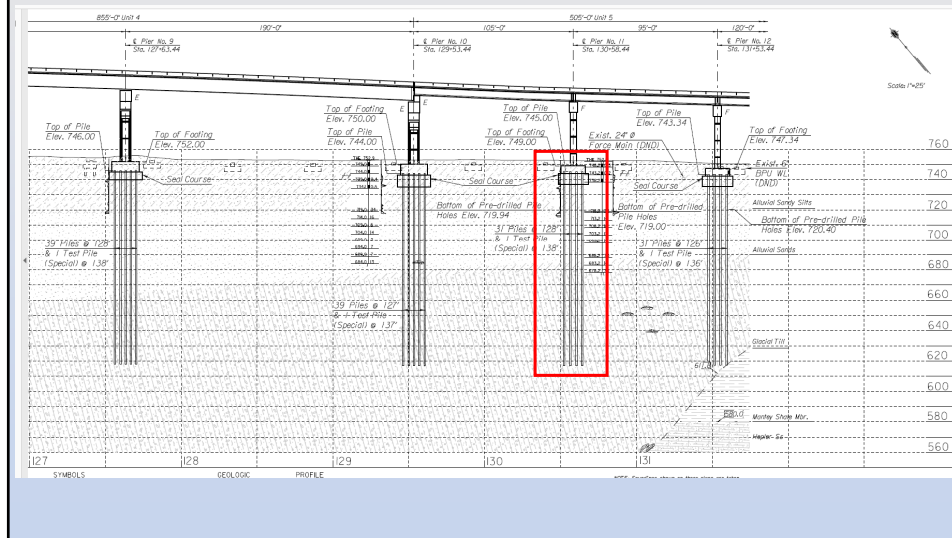
- **End of drive** – Stop 5 feet above plan tip
  - PDA recording **243.5** tons (we needed **169** tons)
  - Bearing Formula recording **80** tons (needed **110** tons)
    - 80 tons is the new target.
- Important to understand
  - We are **NOT** changing the design load of the pile.
  - 80 tons (from the bearing formula) = 243.5 tons (from the PDA)

## Lewis and Clark Viaduct

- Pier 11
  - 1 Test Pile Special
  - Results will be applied to Pier 11 only
  - Pile Design Load = 120 tons
  - PDA Target Load = 184.6 tons (369 kips)
  - Plan Length 128 ft
  - 12 x 74 H-Pile
  - Pileco D36-32



## Lewis and Clark Viaduct Pier 11



## Lewis and Clark Pier 11

- End of drive – Stopped at plan tip
  - PDA recording **131** tons (we needed **185** tons)
  - Bearing Formula recording **45.2** tons (needed **120** tons)
- 15 minute restrrike
  - PDA recording **170** tons
  - Bearing Formula recording **65.9** tons
- 1 hour restrrike
  - PDA recording **193** tons
  - Bearing Formula recording **79.6** tons



## Lewis and Clark Pier 11

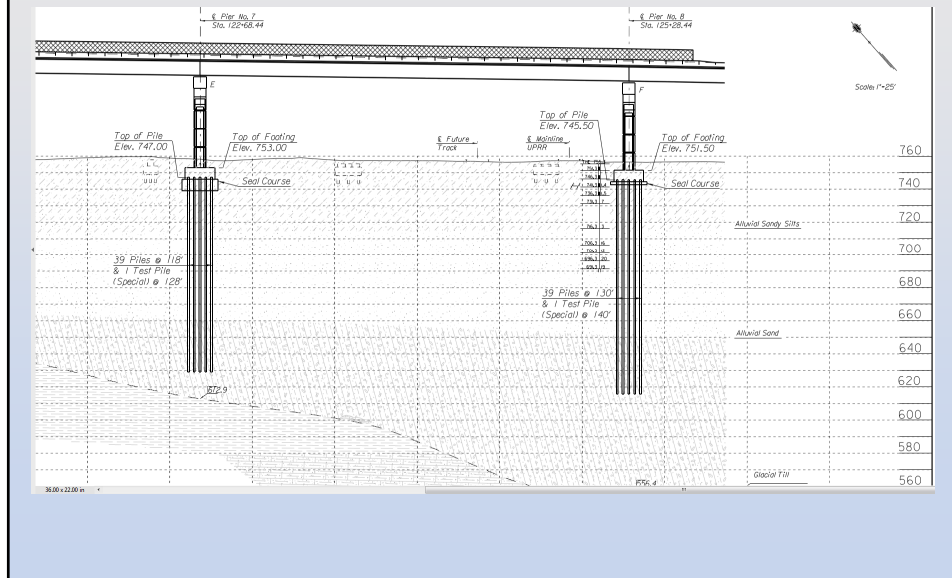
- Results
  - Sufficient capacity achieved after 1 hour.
  - Strictly using the ENR Bearing Formula, driving would have continued well past plan tip elevation.
  - New target Bearing Formula Load is less than plan.
- Important to understand following a PDA with restrikes
  - Follow the initial driving criteria (movement and stroke)
    - **45 tons** will be the new target.
  - If capacity is questionable after initial, conduct a 24 hour restrike.
    - Use the ENR values from the PDA restrikes to guide you.

## Lewis and Clark Viaduct

- Pier 8
  - 1 Test Pile Special
  - Results will be applied to Pier 8 only
  - Pile Design Load = 164 tons
  - PDA Target Load  $164 / .65 = 252$  tons (504 kips)
  - Plan Length 130 ft.
  - 12 x 74 H-Pile
  - Pileco D36-32



## Lewis and Clark Viaduct Pier 8

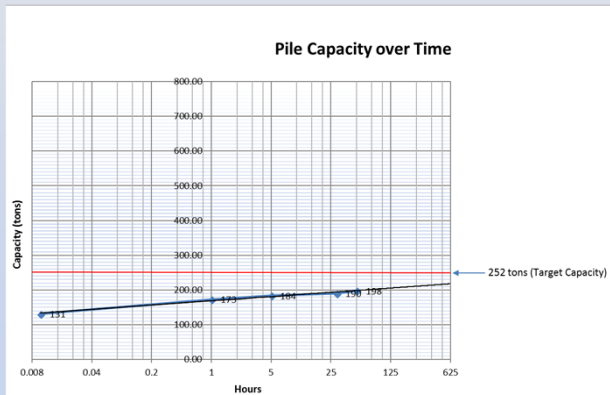


## Lewis and Clark Pier 8

- End of drive – Stopped at plan tip
  - PDA recording **131** tons (we needed **252** tons)
  - Bearing Formula recording **43** tons (needed **165** tons)
- 1 hour restrike
  - PDA recording **173** tons
  - Bearing Formula recording **55.1** tons
- 5 hour restrike
  - PDA recording **184** tons
  - Bearing Formula recording **71** tons
- 29 hour restrike
  - PDA recording **190** tons
  - Bearing Formula recording **85** tons

## Lewis and Clark Pier 8

- 50 hour restrike
  - PDA recording **198** tons (we needed **252** tons)
  - Bearing Formula recording **113** tons (needed **164** tons)
- Summary up to this point
  - 26 days, and still not achieving sufficient capacity near plan tip
  - Within a 2 days
  - Keep driving



## Lewis and Clark Pier 8

- End of drive # 2
  - Spliced on an additional 25 ft.
  - Drove pile until the PDA started showing capacity was being gained
    - Ended up drove an additional 21.5 ft.
  - Decided to let it set over the weekend, would restrike on Monday
  - PDA recording **207** tons (needed **252** tons)
  - Bearing Formula recording **100** tons (needed **165** tons)
- 66 hour restrike
  - PDA recording **306** tons
  - Bearing Formula recording **167.6** tons



# Why use the PDA?

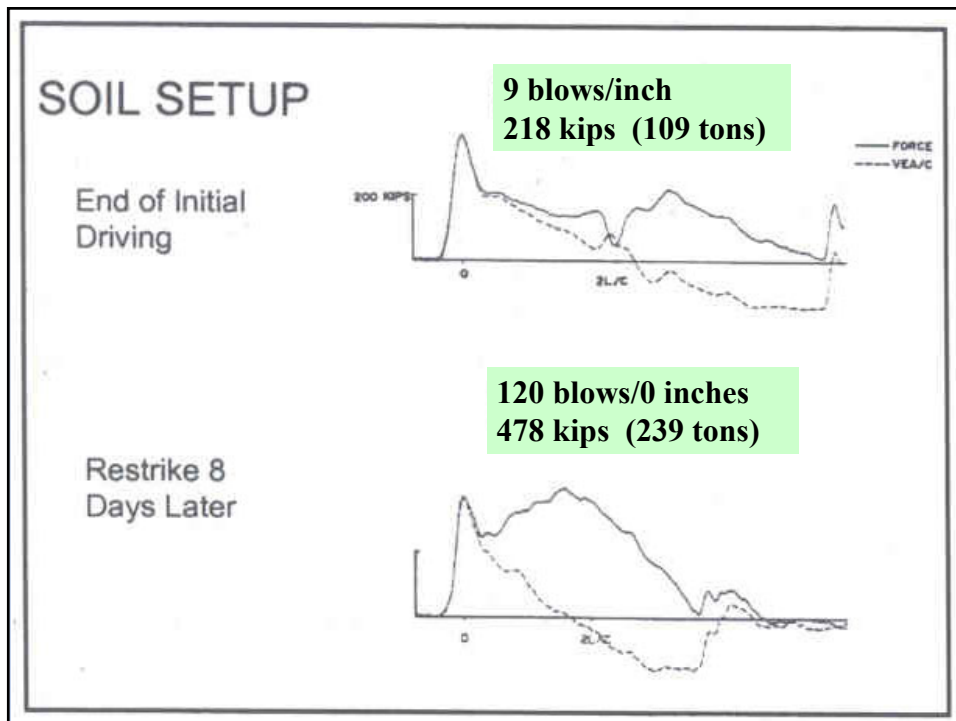
- PDA and Restrike Testing Better Quantifies Bearing Capacity
- PDA Monitors (Bearing Formula cannot do these)
  - Driving Stresses
  - Checks Hammer Performance
  - Evaluates Soil Performance
  - Checks Pile Integrity (damage)
  - Can discount capacity in potential scour areas
- In Most Cases by Utilizing the PDA and/or Restrike Testing a Savings Resulting From Fewer Splices or Shorter Pile Lengths
- Piles Driven Easier and Faster

- PDA monitors driving stresses
  - May allow piles to be driven harder to reach a minimum pile tip elevation
    - Using bearing formula, driving must stop once 110% of pile driving load is achieved because stresses are not known using the formula
    - Hopefully well before as to not damage the pile, especially in end bearing situations

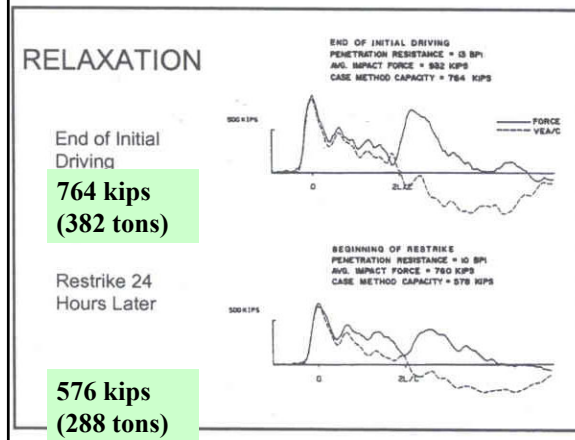
## PDA Restrike Testing

## Restrike Testing

- Long term pile capacity
- Estimating static pile capacity using dynamic method calculations
- Accounts for possible changes in soil conditions
- Restrike testing can record these capacity changes over time
- Only true way to evaluate the pile performance over time



## Soil Relaxation



- Piles driven into weathered shale
- Displacement piles driven into dense saturated silts or fine sands due to a negative pore pressure effect at the pile toe

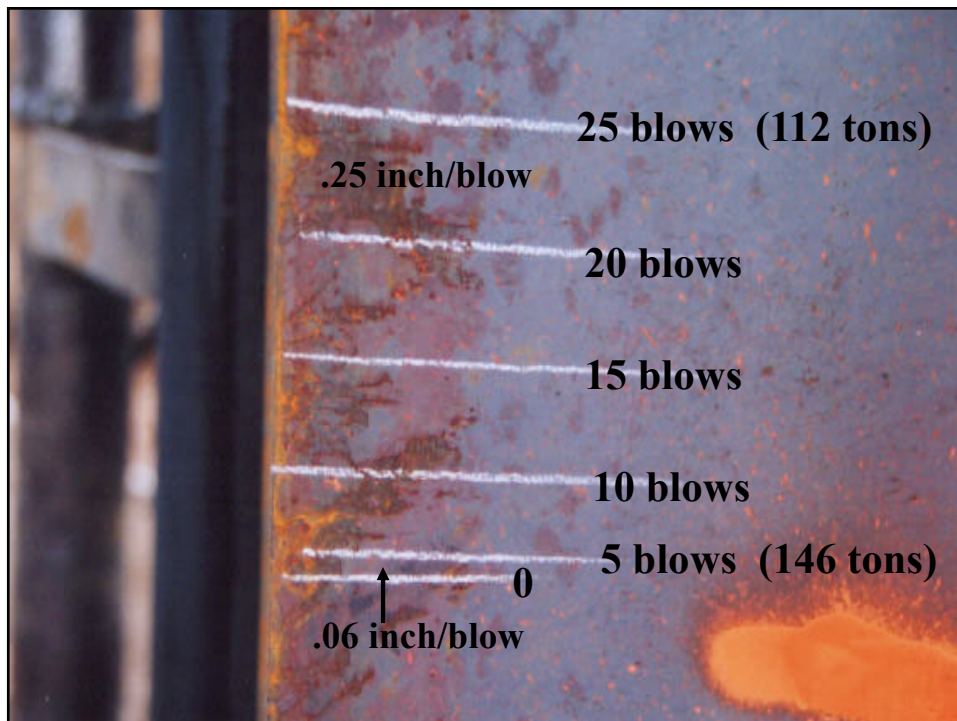
Note:  
Bearing capacity loss at toe  
Some capacity gain on shaft

## PDA Restrike Testing Procedure

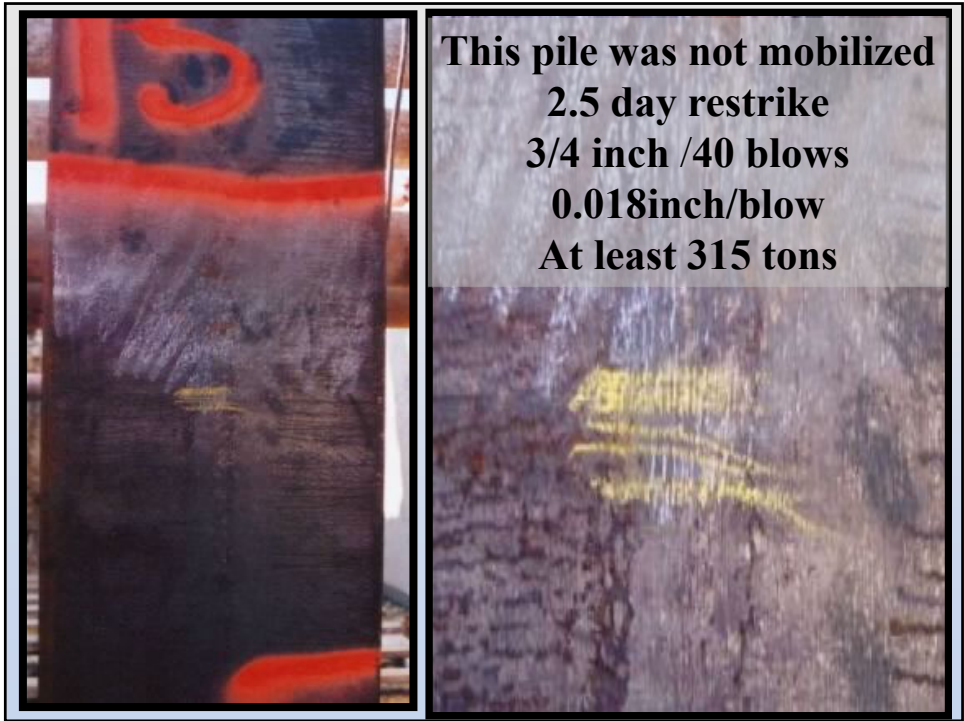
- No driving activity near test site for at least 24 hours prior to testing
- Conduct the restrike a minimum of 24 hours later, unless otherwise specified
- Warm-up hammer—operating correctly
- Hammer should be warmed up at a location as far from the test pile as possible
- Restrike pile for 20 blows or a movement of 4 inches whichever comes first

## PDA Restrike Testing Procedure

- Record the first blows
- Mark every 5 blows
  - Can compare the first blows of the restrike to the last blows of the restrike.
- In most cases by doing a restrike you will see an increase in bearing capacity due to soil setup.
- If pile is mobilized, you should see a difference between beginning and end of restrike in bearing capacity and in set per blow







## THE INSPECTOR'S ROLE



## Before Construction Starts...



## # 1 Study the Plans

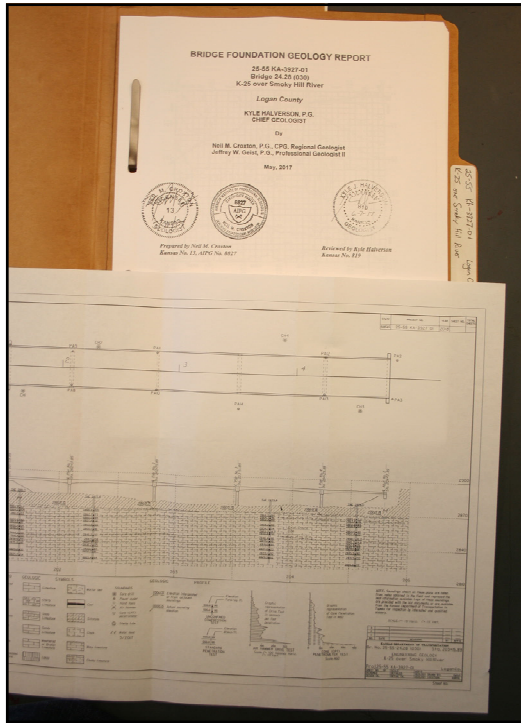


## Study the Plans

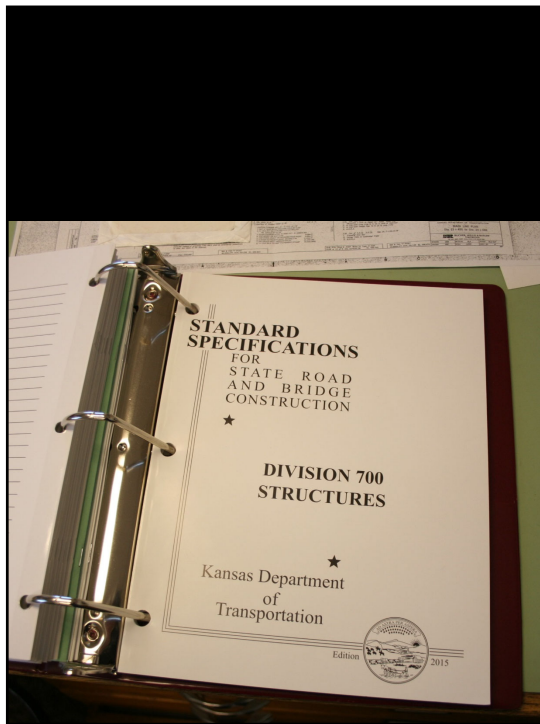
For piling, see the “General Notes and Quantities” page

and the “Engineering Geology” page





**# 2 Read the Bridge Foundation Geology Report**



**# 3 Read Section 704 of the Standard Specifications and check for new Special Provisions**

## # 4 Get all the hammer info from the Contractor

To use the driving equation, you need:

Weight of the hammer piston (ram)

Weight of the pile cap (helmet) and the anvil

## # 4 Get all of the hammer info from the Contractor

To check the hammer size, you also need:

Maximum stroke of piston

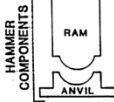


This is Form 217 AA,  
in the Forms  
Warehouse

**NOTICE TO CONTRACTORS**  
**PILE AND DRIVING EQUIPMENT DATA**  
[Test Pile (Special), Section 704, Standard Specifications]

Project No. \_\_\_\_\_ County \_\_\_\_\_  
Contract No. \_\_\_\_\_ Structure Name/No. \_\_\_\_\_  
File Driven By (Contr. or Subcontr.) \_\_\_\_\_

HAMMER: Manufacturer \_\_\_\_\_ Model \_\_\_\_\_  
Type \_\_\_\_\_ Serial No. \_\_\_\_\_  
Rated Energy \_\_\_\_\_ @ \_\_\_\_\_ Length of Stroke  
Modifications \_\_\_\_\_ (ft-lb\J) (ft\m)



CAPBLOCK: Material \_\_\_\_\_  
Thickness \_\_\_\_\_ (in\mm) Area \_\_\_\_\_ (in<sup>2</sup>\mm<sup>2</sup>)  
Modulus of Elasticity - E \_\_\_\_\_ (psi\MPa)  
Coefficient of Restitution - e \_\_\_\_\_

PILE CAP: \_\_\_\_\_ Weight \_\_\_\_\_ (lb\kg)  
Helmet  
Bonnet  
Anvil Block  
Drivehead

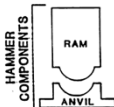
CUSHION: Material \_\_\_\_\_ Area \_\_\_\_\_ (in<sup>2</sup>\mm<sup>2</sup>)  
Modulus of Elasticity - E \_\_\_\_\_ (psi\MPa)  
Coefficient of Restitution - e \_\_\_\_\_

Here is the maximum  
stroke and weight of  
pile cap.

**NOTICE TO CONTRACTORS**  
**PILE AND DRIVING EQUIPMENT DATA**  
[Test Pile (Special), Section 704, Standard Specifications]

Project No. \_\_\_\_\_ County \_\_\_\_\_  
Contract No. \_\_\_\_\_ Structure Name/No. \_\_\_\_\_  
File Driven By (Contr. or Subcontr.) \_\_\_\_\_

HAMMER: Manufacturer \_\_\_\_\_ Model \_\_\_\_\_  
Type \_\_\_\_\_ Serial No. \_\_\_\_\_  
Rated Energy \_\_\_\_\_ @ \_\_\_\_\_ Length of Stroke  
Modifications \_\_\_\_\_ (ft-lb\J) (ft\m)



CAPBLOCK: Material \_\_\_\_\_  
Thickness \_\_\_\_\_ (in\mm) Area \_\_\_\_\_ (in<sup>2</sup>\mm<sup>2</sup>)  
Modulus of Elasticity - E \_\_\_\_\_ (psi\MPa)  
Coefficient of Restitution - e \_\_\_\_\_

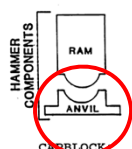
PILE CAP: \_\_\_\_\_ Weight \_\_\_\_\_ (lb\kg)  
Helmet  
Bonnet  
Anvil Block  
Drivehead


CUSHION: Material \_\_\_\_\_ Area \_\_\_\_\_ (in<sup>2</sup>\mm<sup>2</sup>)  
Modulus of Elasticity - E \_\_\_\_\_ (psi\MPa)  
Coefficient of Restitution - e \_\_\_\_\_


Notice that the anvil weight is not here.

**NOTICE TO CONTRACTORS**  
**PILE AND DRIVING EQUIPMENT DATA**  
[Test Pile (Special), Section 704, Standard Specifications]

Project No. \_\_\_\_\_ County \_\_\_\_\_  
Contract No. \_\_\_\_\_ Structure Name/No. \_\_\_\_\_  
File Driven By (Contr. or Subcontr.) \_\_\_\_\_

HAMMER: Manufacturer \_\_\_\_\_ Model \_\_\_\_\_  
Type \_\_\_\_\_ Serial No. \_\_\_\_\_  
Rated Energy \_\_\_\_\_ @ \_\_\_\_\_ Length of Stroke  
Modifications \_\_\_\_\_  
  
CABBLOCK: Material \_\_\_\_\_  
Thickness \_\_\_\_\_ (in\mm) Area \_\_\_\_\_ (in<sup>2</sup>\mm<sup>2</sup>)  
Modulus of Elasticity - E \_\_\_\_\_ (psi\MPa)  
Coefficient of Restitution - e \_\_\_\_\_

PILE CAP:  Weight \_\_\_\_\_ (lb\kg)  
Helmet  
Bonnet  
Anvil Block  
Drivehead

CUSHION: Material \_\_\_\_\_ Area \_\_\_\_\_ (in<sup>2</sup>\mm<sup>2</sup>)  
 Modulus of Elasticity - E \_\_\_\_\_ (psi\MPa)  
Coefficient of Restitution - e \_\_\_\_\_

*Most of the time, a contractor will send you their company's form and not KDOT's*

This is off the internet—  
American Pile Equipment

Anvil: 749 lbs

Striker plate: 628 lbs

Helmet: 1076 lbs

Adapter: 948 lbs

**APE Model D19-52 Single Acting Diesel Impact Hammer**

*D19-52 driving H-beam.*

**MODEL D19-52 (1.9 metric ton ram)**

**SPECIFICATIONS**

Stroke at maximum rated energy	135 in (343 cm)
Maximum rated energy (Setting 4)	47,132 ft-lbs (63.63 kNm)
Setting 3	39,119 ft-lbs (52.81 kNm)
Setting 2	31,107 ft-lbs (41.99 kNm)
Minimum rated energy (Setting 1)	23,566 ft-lbs (31.81 kNm)

*(Variable throttle allows for infinite fuel settings)*

Maximum obtainable stroke: 150 in (381 cm)  
 Maximum obtainable energy: 52,362 ft-lbs (71 kNm)  
 Speed (blows per minute): 34-52

**WEIGHTS (approximate)**

Piston	4,189 lbs (1,900 kg)
Anvil	749 lbs (340 kg)
Striker cross sectional area	124.42 sq in (8,027.71 cm <sup>2</sup> )
Helmet weight (includes trip device)	1,076 lbs (476.3 kg)
Typical operating (weight with cross and reverse insert)	13,152 lbs (5,966 kg)

**CAPACITIES**

Fuel tank (runs on diesel or bio-diesel)	8.3 gal (31.41 liters)
Oil tank	2.3 gal (8.7 liters)

**CONSUMPTION**

Diesel or Bio-diesel fuel	1.3 gal/hr (6.6 liters/hr)
Lubrication	0.13 gal/hr (.49 liters/hr)

*Grease: 6 to 10 pumps every 30 minutes of operation time.*

**OPTIONAL VARIABLE THROTTLE**

**STRIKER PLATE FOR DB 26**

Weight	628 lbs (284 kg)
Diameter	20.4 in (519.15 cm)
Area	328 in <sup>2</sup> (2,107.74 cm <sup>2</sup> )
Thickness	6 in (15.24 cm)

**STRIKER PLATE FOR DB 20**

Weight	440 lbs (199 kg)
Diameter	17.75 in (45.08 cm)
Area	247 in <sup>2</sup> (1,593.55 cm <sup>2</sup> )
Thickness	6 in (15.24 cm)

**CUSHION MATERIAL**

Type	Monocast MC 904
Diameter-DB26	22.5 in (57.15 cm)
Diameter-DB20	17.75 in (45.08 cm)
Thickness	2 in (5.08 cm)
Elastic modulus	285 ksi (1,965 mpa)
Coefficient of restitution	0.8

**DRIVE CAP**

DB 26	1,076 lbs (488 kg)
DB 20	750 lbs (340 kg)

**PISTON WEIGHT**

H-Beam insert for 12" (305 mm) and 14" (355 mm)	948 lbs (430 kg)
Reverse insert for sizes 12" to 24" diameter:	1,830 lbs (830 kg)

Anvil: 749 lbs

Striker plate: 628 lbs

Helmet: 1076 lbs

Adapter: 948 lbs

**Total: 3401 lbs**

This is the weight of  
everything below the piston

Add the weight of the pile, and  
you have "X" for the equation.

**#5 Make sure that the energy rating of the hammer is high enough to drive the piles**

Use the driving equation with 0.1 inch per blow and the maximum stroke for that hammer. Refer to the *Bearing Formula* section in your book.

**Forward the hammer info to Geology when you get it if:**

There is a test pile (special)

You would like one of us on site during the start of driving

# # 6 Get the Type-A Certificate from CMS

Go To "Materials"

...then "Materials Report"

...then "Contract Finals"

## Non Acceptance Tests Report

DTMT112  
RUNDATE: 07 10 06  
RUNTIME: 10:14 AM  
CONTRACT: 503032043 M  
PROJECT ID: K023 090 K 7333 01  
CONTRACTOR ID: 00725

KANSAS DEPARTMENT OF TRANSPORTATION  
NON ACCEPTANCE TESTS REPORT - FINAL

WORK TYPE: BRRPL  
AREA OFFICE: 04  
CONTRACTOR NAME: L & M CONTRACTORS, INC.

STATUS: FINAL  
DISTRICT: 03

PAGE: 4

LINE #	ITEM CODE	ITEM NAME	UNIT	UNIT	ORIGINAL QTY	CURRENT QTY	TEST PERFORMED
	MATL CODE	MATERIAL NAME		SAMPLE ID	SAMPLE QTY	INSP TYPE	
998	099999	TESTED MATERIALS	LNFT			0.000	0.000
	067010000	STEEL BEARING PILE		00456078	M 609.600	CPLY	CTA FREE FORM TEXT
				00468576	M 1 524.000	CPLY	CTA FREE FORM TEXT
				00470725	M 121.920	CPLY	CTA FREE FORM TEXT
				00471472	M 23.384	CPLY	CTA FREE FORM TEXT
				00473445	M 259.080	CPLY	CTA FREE FORM TEXT
		MATERIAL TOTAL :			2 537.984		
998	099999	TESTED MATERIALS	TONS			0.000	0.000
	161060100	CEMENT TY 1/2 BL/BAG		00487436	M 0.000	CPLY	VER FREE FORM TEXT
				00497591	M 0.000	CPLY	VER FREE FORM TEXT
		MATERIAL TOTAL :			0.000		
998	099999	TESTED MATERIALS	TONS			0.000	0.000
	999900312	CRUSHED GRAVEL (OFQ)		00497599	M 0.000	CPLY	VER AGGREGATE QUALITY TEST
		MATERIAL TOTAL :			0.000		
998	099999	TESTED MATERIALS	TONS			0.000	0.000
	999900319	SAND/SAND GRAVEL(OFQ)		00497578	M 0.000	CPLY	VER AGGREGATE QUALITY TEST
		MATERIAL TOTAL :			0.000		



DTMT130 Kansas Department Of Transportation PAGE - 1  
 Run Date: 07 10 06 Maintain Sample ID Record  
 Run Time: 10:03 AM

Sample Id: 00473445 SI: M  
 Inspector Id: 000905012 KELLY MARSHALL Resp Loc: MR Total Samples: 1  
 Type Insp: CTA Date Sampled: 09 29 03 Related Sample Id:  
 Type Test: 900 FREE FORM TEXT  
 Proj Id: K023 090 K 7333 01 Contract #: 503032043 M Line #: 998 Quantity: 259.080  
 Producer: 00035001 Name: NUCOR-YAMATO STEEL Loc: BLYTHEVILLE St: AR  
 Legal Desc: Mix Plant: Name:  
 Matrl Cd: 067010000 STEEL BEARING PILE Desc: A03-5201 Unit: m  
 Qty Represented: 259.080 Nbr of Items: 0 Qty Assigned: 0.000  
 Sampled From: PRODUCTION Ledge: Lot/Heat Nbr:  
 Lab: SER Name: SERVICE Dates::Shipped: 10 01 03 Received: 10 01 03  
 Test Start: 10 01 03 Est Compl: Act Compl: 10 02 03  
 Test Result: CPLY Authorized By: NAT VELASQUEZ BY KDM  
 Remarks:  
 L&M 1600-11 FINAL DISPOSITION SUBJECT TO CONDITION OF  
 MATERIAL WHEN USED AT PROJECT.  
 HEAT(QINM), 218107(60.96), 218103(91.44) 219625(106.68)

There is no prequalified list for piling  
 All piling must go thru testing



# # 7 Make Your Driving Equation Spreadsheet

It's form 217b in Forms Warehouse

Delmag McKierman Terry (Diesel Hammer)													
Summary			Formula		Entry Data								
Hammer Wt.	3528	lbs	$P = 1.6 \cdot W \cdot H$ $S + 0.1 \cdot \left( \frac{X^{**}}{W} \right)$	Weight per foot of piling (lbs/ft):	53	lbs/ft.	Maximum Hammer Drop	11	ft.				
Cap/Anvil Wt.	2403	lbs		Length of Pile:	43	feet	Minimum Hammer Drop	6	ft.				
Pile Type	HP12x53			X:	4682	lbs							
Min. Res.	60	tons		Minimum "S":	0.100	inches/blow							
Max. Res.	66	tons		Maximum "S":	0.300	inches/blow							
Field Blow count:	20												
Penetration per 20 blows (in.)	2.000	2.400	2.800	3.200	3.600	4.000	4.400	4.800	5.200	5.600	6.000		
Average Penetration per blow (in.) "S"	0.100	0.120	0.140	0.160	0.180	0.200	0.220	0.240	0.260	0.280	0.300		
Drop of Hammer (Stroke) (ft.)			Computed Resistance (tons)										
		6.0	73	67	62	58	54	51	48	45	43	41	39
		6.5	79	73	67	63	59	55	52	49	47	44	42
Calculated Bearing is HIGH		7.0	85	78	72	67	63	59	56	53	50	48	46
		7.5	91	84	78	72	68	64	60	57	54	51	49
		8.0	97	89	83	77	72	68	64	61	57	55	52
Calculated Bearing is GOOD		8.5	103	95	88	82	77	72	68	64	61	58	55
		9.0	109	101	93	87	81	76	72	68	65	62	59
		9.5	115	106	98	92	86	81	76	72	68	65	62
Calculated Bearing is LOW		10.0	121	112	103	96	90	85	80	76	72	68	65
		10.5	127	117	109	101	95	89	84	80	75	72	68
		11.0	133	123	114	106	99	93	88	83	79	75	72
Drop of Hammer "H" in feet.		6.0	2.991		2.477								
		6.5	3.461		2.905								
		7.0	3.931		3.333								
		7.5	4.402		3.760								
		8.0	4.872		4.188								
		8.5	5.343		4.616								
		9.0	5.813		5.043								
		9.5	6.283		5.471								
		10.0	6.754		5.899								
		10.5	7.224		6.326								
		11.0	7.695		6.754								

Drop of Hammer "H" in feet.	Penetration required per 20 blows to reach Minimum Resistance (in.)	Penetration required per 20 blows to reach Maximum Resistance (in.)
6.0	2.991	2.477
6.5	3.461	2.905
7.0	3.931	3.333
7.5	4.402	3.760
8.0	4.872	4.188
8.5	5.343	4.616
9.0	5.813	5.043
9.5	6.283	5.471
10.0	6.754	5.899
10.5	7.224	6.326
11.0	7.695	6.754

Drop of Hammer (ft.)	Min. Bearing (inches)	Max. Bearing (inches)
6.0	2.991	2.477
6.5	3.461	2.905
7.0	3.931	3.333
7.5	4.402	3.760
8.0	4.872	4.188
8.5	5.343	4.616
9.0	5.813	5.043
9.5	6.283	5.471
10.0	6.754	5.899
10.5	7.224	6.326
11.0	7.695	6.754

Penetration per	20	blows (in.)										
Average Penetration per blow (in.) "S"	0.100	0.120	0.140	0.160	0.180	0.200	0.220	0.240	0.260	0.280	0.300	
Drop of Hammer (Stroke) (ft.)	Computed Resistance (tons)											
	6.0	73	67	62	58	54	51	48	45	43	41	39
	6.5	79	73	67	63	59	55	52	49	47	44	42
Calculated Bearing is HIGH	7.0	85	78	72	67	63	59	56	53	50	48	46
	7.5	91	84	78	72	68	64	60	57	54	51	49
	8.0	97	89	83	77	72	68	64	61	57	55	52
Calculated Bearing is GOOD	8.5	103	95	88	82	77	72	68	64	61	58	55
	9.0	109	101	93	87	81	76	72	68	65	62	59
	9.5	115	106	98	92	86	81	76	72	68	65	62
Calculated Bearing is LOW	10.0	121	112	103	96	90	85	80	76	72	68	65
	10.5	127	117	109	101	95	89	84	80	75	72	68
	11.0	133	123	114	106	99	93	88	83	79	75	72



## Do a Sample Calculation

Find the appropriate equation such as:

$$P = \frac{1.6 W H}{S + 0.1 (X / W)}$$

Do a calculation by hand to get comfortable with the different variables and how they change things

## # 8 Check Minimum Pile Length

Talk to someone in your office about what to do if you achieve the required resistance before plan length is reached. It will probably be OK, but there may be concerns about scour or minimum pile length.

**Wake Up!**









**NYS-USA** **Sticker on Pile**

521407095

Size: HP10X42 250X62  
Length: 55 FT 16.8 m  
Grade: A572-50  
Heat: 251019 RID: 521407095

Seq # 1847

Test pile  
About 2

W - NYS1 - 04/11/05

521407095



## Check the Piling Itself

Inspect the piles to make sure they are the type called for in the contract



**NYS-USA**

**Sticker  
on Pile**

521407095

Size: HP10X42 250X62

Length: 55 Ft 16.8 m

Grade: A572-50

Heat: 251019 RID: 521407095

Seq # 1847

Test pile  
About 2

NYS1- 04/11/05  
521407095

**NYS-USA** **Sticker on Pile**

521407095

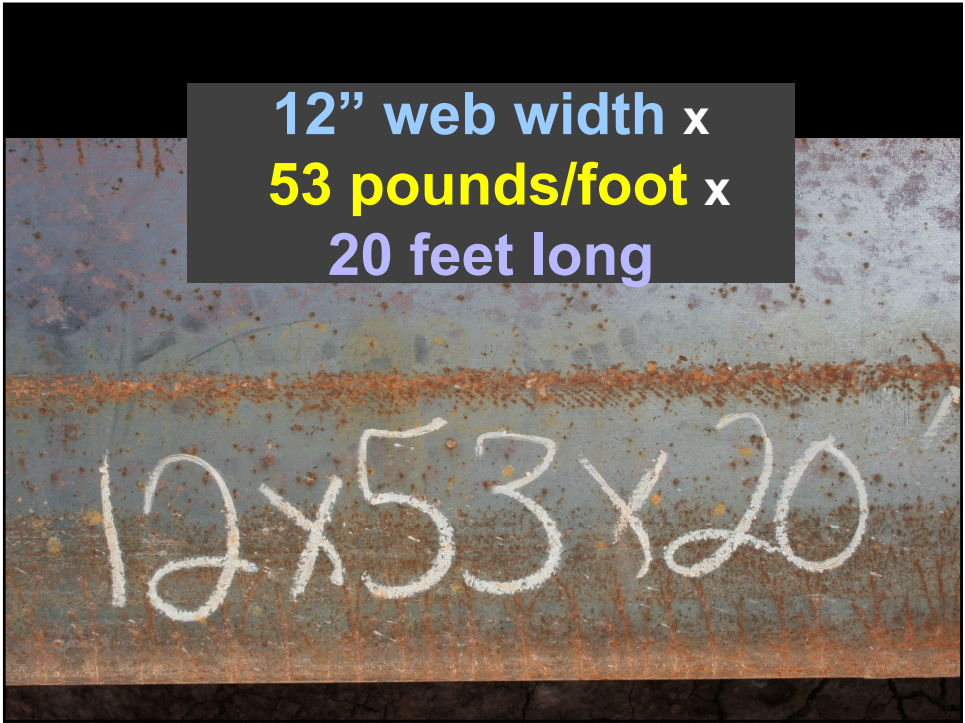
Size: HP10X42 250X62  
Length: 55 FT 16.8 m  
Grade: A572-50  
Heat: 251019

**All H-pile now used in KDOT bridges is Grade 50**

Test pi  
Abut 2

W - NYS1 - 04/11/05

521407095





## Check the Piling Itself

Inspect the piles for damage that might have occurred during shipment, or defects that were overlooked earlier

Pipe piles can get bent; concrete piles can get broken

H-piles can have bent flanges

## # 10 Measure and Mark the Piling







**# 10**

**Measure and  
Mark the  
Piling**



**# 11 Make  
Sure the  
Contractor  
Brought the  
Hammer He  
Told Us He  
Was Bringing**

## # 12 Check the Hammer Cushion



## Check the Hammer Cushion

Cushion has to be made of a material approved to use on KDOT projects

What else?

## **Check the Hammer Cushion**

Cushion has to be made of a material approved to use on KDOT projects

Has to be intact and at least 75% of its original thickness

## **Check the Hammer Cushion**

**Original thickness of cushion should be listed on the hammer data sheet**

**Ask contractor when cushion was last changed**

**Check to see if it looks OK**

**Pry it out of helmet if you think you need to measure its thickness**

**# 13 Line up some help from the office**



**# 13 Line up some help from the office**



# # 14 Help the Contractor Verify that Piles are in the Correct Location



**Make sure.....**

**Oh, never mind.**



## # 15 Make Sure the Piles are Plumb



## # 16 Keep track of where your pile tip is.

*Know the depth you should hit bedrock.*

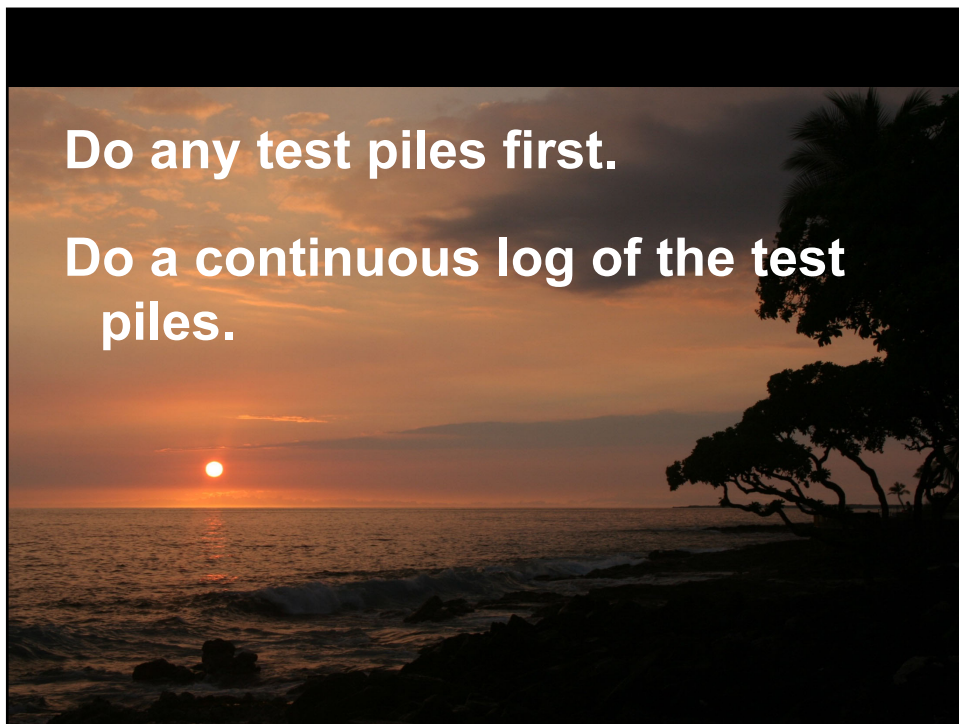


**# 17 Drive  
Pile to Plan  
Length or  
Required  
Resistance**



**Do any test piles first.**

**Do a continuous log of the test  
piles.**



**If you drive to the required resistance before plan length is reached, check with Area Office for scour concerns or minimum pile length**

**If plan length is reached before the required resistance, call Area Office about a possible restrike**

## **# 18 Mark the Cut-off on the Pile**

**Help Contractor mark plan cut-off elevation on the pile after driving.**

**Mark the piece that was cut off, so that you know where it came from. You may need to use it to splice later.**



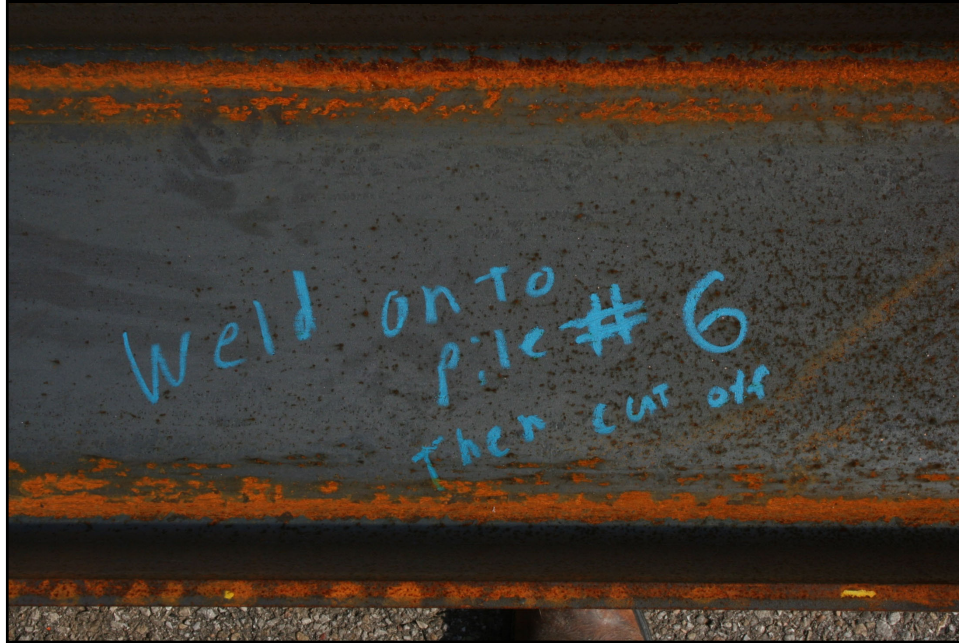
**Use a number or letter—just some way to keep track of it.**



**Some inspectors give them an ID before they are even driven.**



## Whatever works



## # 19 Have Someone Check Your Calculations

Before the contractor places any concrete around the piling, have a second person go over your resistance calculations.





## # 19 Have Someone Check Your Calculations

If you see something on site you don't understand, or aren't sure if what the Contractor is doing is acceptable, make him stop and get it resolved.

Yeah, he'll probably get mad.

He might even put a snake in your car. But he'll get glad in the same clothes he got mad in.



## **You Aren't Alone!**

If you have a question and can't reach your bosses, there are other people in KDOT who will help you:

**Your Regional Geologist**

**the Bridge Designer in Topeka**

**(Bureau of Structures and Geotech Services)**

**your District Construction Engineer**



**Never text and  
drive pile**



**...and stay away  
from these guys**



Then go celebrate!





# Field Problems

**If a problem occurs,  
what do you do?**





**STOP  
DRIVING AND  
EVALUATE THE  
SITUATION**

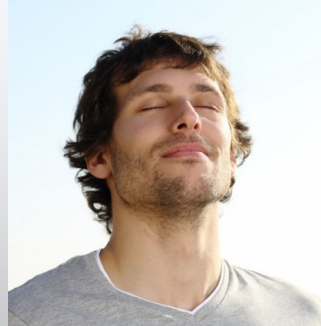
**Some Problem Scenarios**

- Overdriving – encountering hard rock
- Target bearing not achieved
- Misalignment of hammer
- Hammer performance



## Take a Deep Breath

- Take time to problem solve
  - What is happening
- Check calculations
- Check any level runs
- Check the hammer
- Check alignment; pile and hammer
- Check length of pile
- Review the Geology Bridge Sheet



## Problem Solving Continued

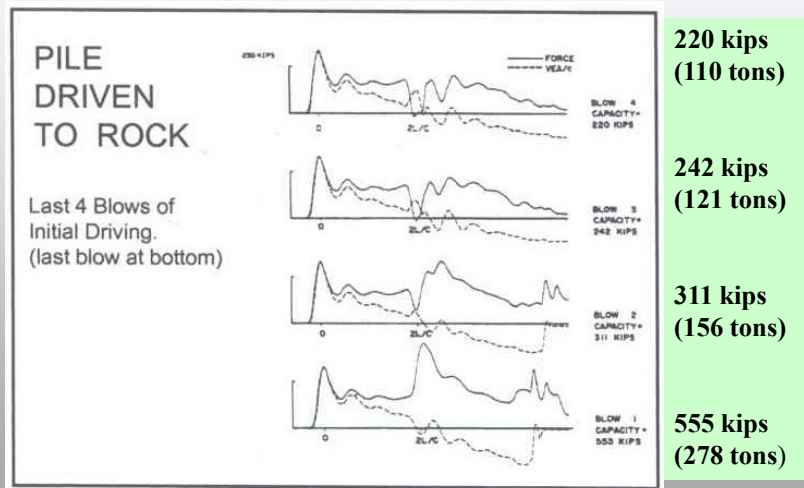
- Are you using the correct formula
- Correct hammer specifications input
- Using the Strength I load
- Wrong size pile
- Wrong length pile



## Solution Found!!

- Can you make the decision to correct it?
- Contact
  - Your Boss
  - Construction Engineer
  - Design Engineer
- Adjust and proceed with driving.
- Always document.

## Driving to Hard Bedrock



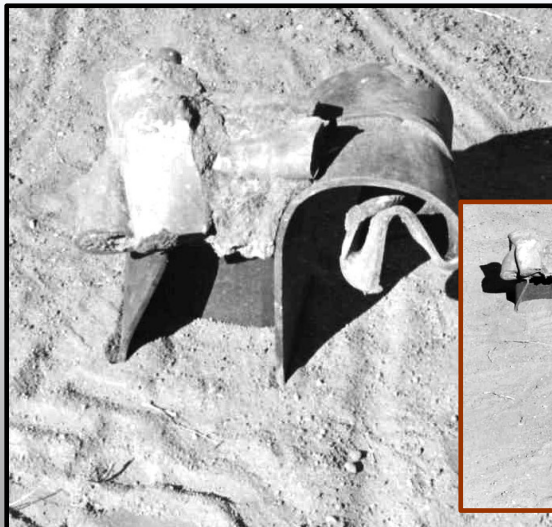
Hamilton County, KS

**The lower 7 feet of  
Pile #5 at Pier 1.**



**1 mile east, 5.5 miles north  
of Syracuse**

Hamilton County, KS



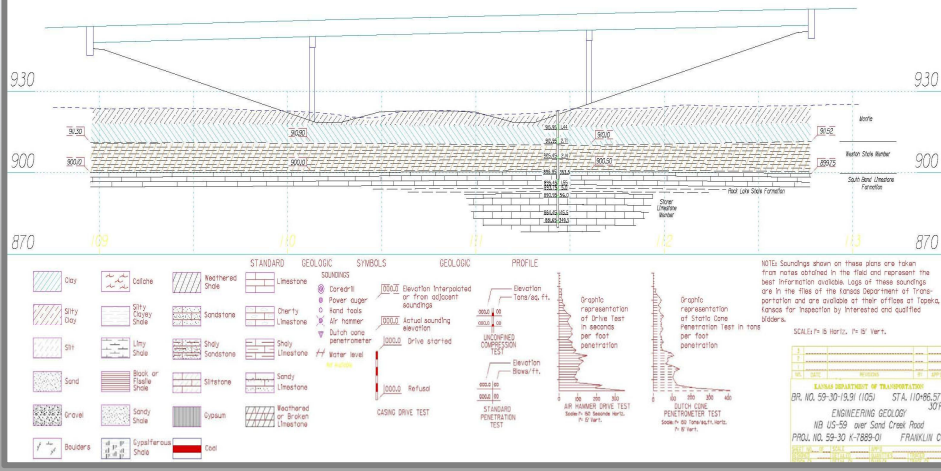
**Bottom 2.5 feet rolled  
Pile #6, Pier 4**

**1 mile east, 5.5 miles north  
of Syracuse**

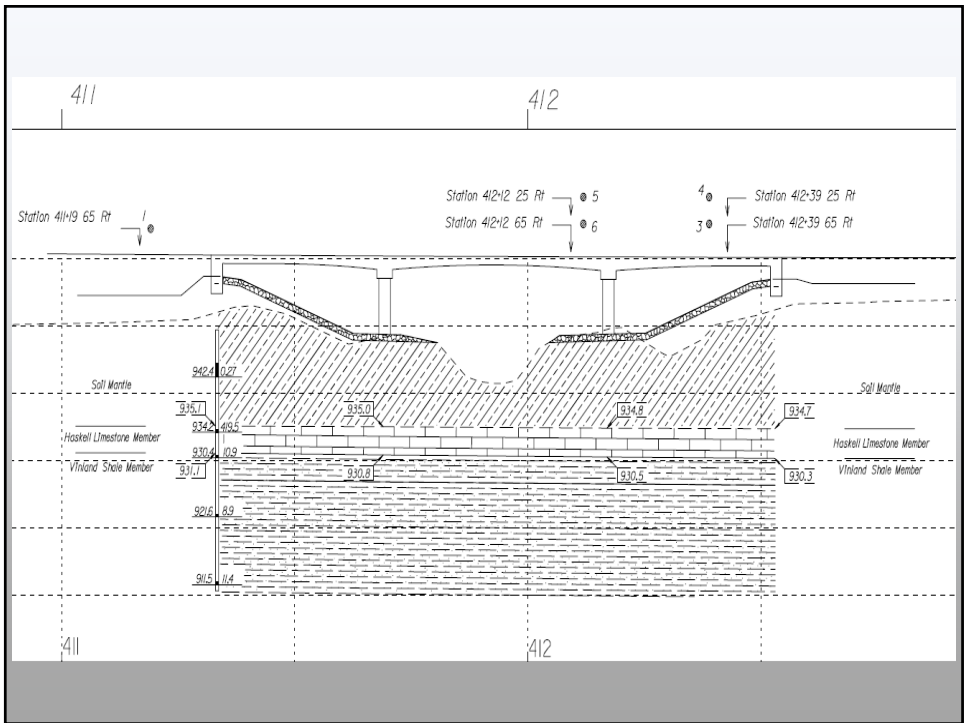


**Top of pile damaged too**

# US-59 Franklin County







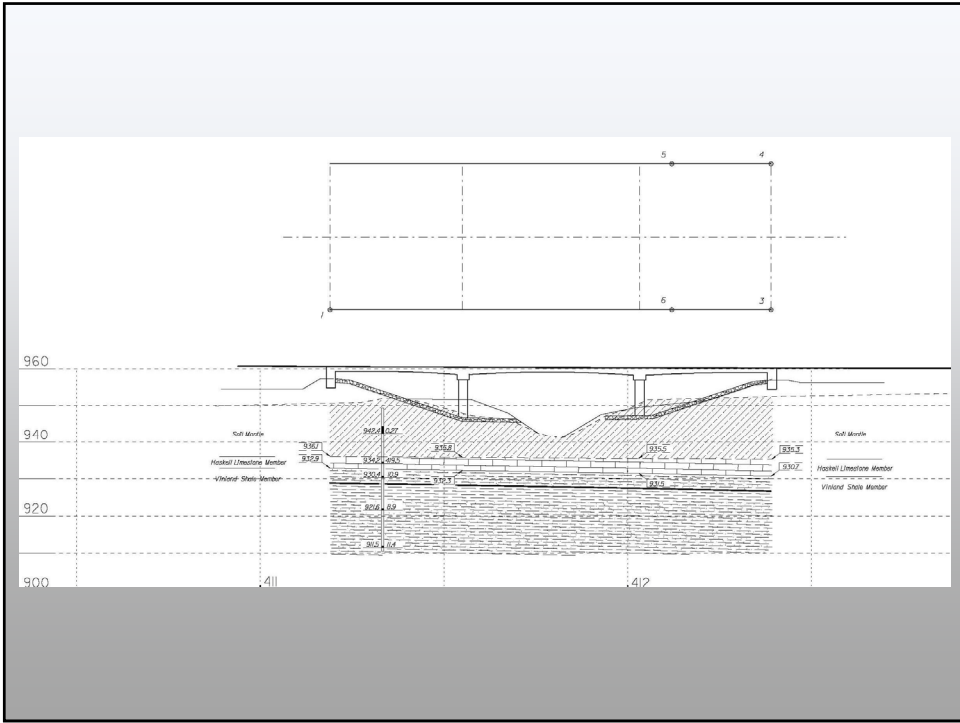






















*Western  
Kansas*



## Alignment

- Can reduce the transferred energy.
- Can damage pile top
- Can give false blow count
- Pipe pile vulnerable

## Barton County

Mushrooming Caused by:

- Misalignment
- Hard driving
- Both?

Could Result in:

- Reduction of transferred energy
- Exaggerated blow count
- Exaggerated bearing capacity



## Pile damage suspected

- Is the damage bad enough to be of concern?
- Is the damage far enough down that the remaining good pile will carry the load?
- Can the pile be pulled and a new one driven?
- Do more piles need to be added to compensate for the damaged pile?

## Minor Damage to Pile Top

- Target bearing not achieved and above plan tip
  - Stop Driving and cut off the damaged portion of the pile.
  - Check alignment of the hammer on the pile
  - Resume driving.
- Target bearing and minimum plan tip achieved.
  - Stop and cut pile off at cut off elevation
- If a restrike test is to be conducted on this pile, the top should be undamaged.



## Pile damage suspected cont.

- Contact the Engineer
- Contact the Geology Section to conduct PDA.



## Trouble Achieving Target Bearing

- Check all calculations
- Check input parameters for bearing formula
- Check hammer
- Contact Engineer or supervisor
- Can a restrike test be conducted to evaluate soil set up?
  - If so, restrike pile in at least 24 hours
- May have to splice on more pile and continue the drive

## Target Bearing Achieved Early

- Check all calculations
- Check input parameters
- Check pile length
- Contact Engineer or supervisor



## Target Bearing Achieved Early

- If pile tip is close to plan tip elevation and **110%** of the **pile driving formula load** has not been reached, the pile can be driven to **110%** (if plan tip must be achieved)
- Is pile hitting an obstruction (boulder, hard layer, old footing, another pile)
  - If so, what concerns will it cause.
- Is there enough pile length in place below cut off to satisfy lateral load and scour requirements and, if required, uplift requirements
  - If so pile can be cut off (**always consult the Engineer**)

## Hammer Performance

- If the hammer is not performing properly the bearing capacity can not be computed accurately
- Improperly functioning hammer:
  - May exaggerate the blow count
  - May give false set per blow information
  - May reduce pile driving ability
  - May simulate hard driving and high capacity at low capacity conditions



## Hammer Performance

- Preignition in diesel hammer
  - Fuel starts to combust or fully combust before impact
  - Reduces ram impact velocity
  - Cushions the impact
  - Reduces transfer of energy to the pile, energy returned to the ram causing a high but false stroke
  - Low energy transfer results in high blow counts
- Can simulate hard driving and high capacity condition at a potentially low soil resistance

## Preignition in Diesel Hammer

- **Preignition in diesel hammer**
  - Caused by overheated hammers
    - Lubrication oils start to burn
    - Fuel vaporizes prematurely due to excess heat
- **Signs of Preignition**
  - Black smoke while stroke is high
  - Flames in exhaust ports
  - Blistering paint
  - Oils and grease on outside smoking or burning
  - No obvious metal to metal impact ringing sound

## Preignition in Diesel Hammer

- **If preignition is suspected:**
  - Stop driving and let hammer cool down for at least 1 hour
  - Recommend the hammer be lubricated to replace any burnt off lubrication
  - Resume driving and monitor stroke and blow count
  - If stroke and blow counts are lower in the first few minutes of driving, preignition was probably occurring

## Hammer Performance

- Some things to look for
  - If you are getting a low set per blow yet a very small stroke, could be problems with hammer.
    - A low set per blow should indicate hard driving and you should have a large stroke.
  - Different looking exhaust
    - Fuel could be contaminated (water in fuel)
      - May not get the best fire on each stroke
  - Maybe the hammer just sounds much different than on the previous drive
    - Question the contractor if you feel something is wrong or different

## Hammer Performance

- Some performance problems and what to look for
  - May be hard to recognize but should be familiar with
- Water or dirt in fuel
  - White exhaust smoke and hollow sounding impacts
- Clogged fuel line (lack of fuel)
  - Little or no exhaust smoke
  - Low strokes
- Malfunctioning fuel pump or fuel injector
  - Inconsistent ram stroke and gray or black exhaust smoke



## Hammer Performance

- Some performance problems and what to look for
- Low lubricating oil or malfunctioning oil pump
  - Lower than normal blows per minute
  - Reduced stroke
  - A quick check
    - see if ram is wet and shiny during drive when upper ram is visible
- Poor Compression-Worn piston or impact block rings
  - Short strokes even in hard driving
  - Easily checked by way of a “cold blow”

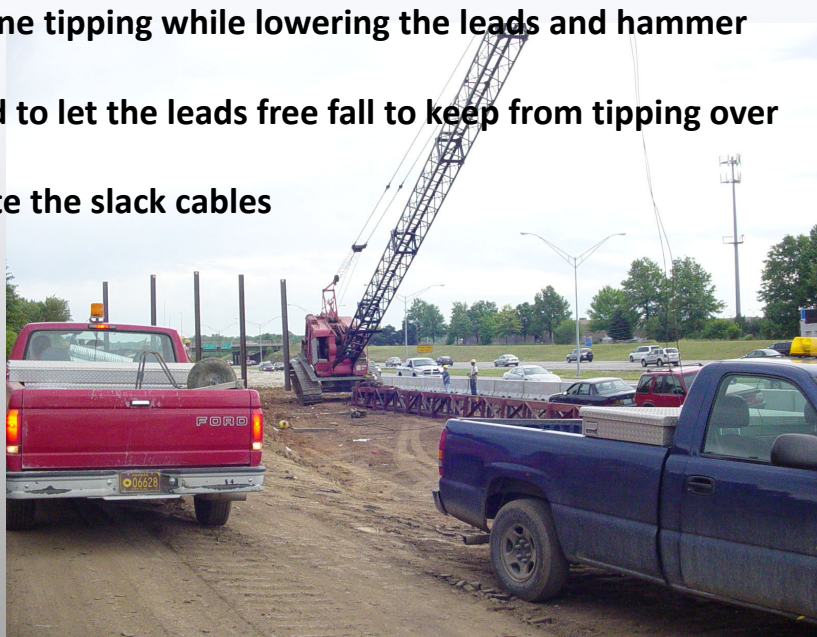
## Hammer Performance

- Some performance problems and what to look for
- “Cold Blow” Procedure
  - Ram is picked up as if to start the hammer but the fuel line rope is kept stretched such that no fuel is pumped.
  - The ram is released and after impact the ram should bounce on the air trapped in the chamber. Each bounce can be heard.
  - Should get 5 to 10 good bounces.

**Crane tipping while lowering the leads and hammer**

**Had to let the leads free fall to keep from tipping over**

**Note the slack cables**



**With all problems you should contact**

**Your supervisor  
Engineer in charge  
Design Engineer**

**If needed you can contact the Geology Section for  
guidance or to have the PDA brought out**

**Neil Croxton Salina Regional Geologist  
785-827-3964**

**Art Peterson El Dorado Regional Geologist  
316-320-1721**

**Denny Martin Chanute Regional Geologist  
620-431-1000**

**John Barker Topeka Regional Geologist  
785-291-3861**

# Questions!



**KDOT**  
Specifications for  
Piles and Pile  
Driving



Where to find information?

**KDOT Standard Specifications Book**

**2015 Edition**

Division 700—Structures

Section 704 Piling

pages 700-15 to 700-21

## Where to find information?

### **KDOT Standard Specifications Book**

#### **2015 Edition**

Division 1600—Ferrous and Non-Ferrous  
Metals

Section 1609    Steel Piling and Pile Points  
page 1600-18

## How to get to the 2015 Edition from the KDOT Intranet

Go to <http://kdotweb>

Click on “Documents & Manuals” on the top banner

Scroll down a while and find “Specifications”



# How to get to the 2015 Edition

Top right side of screen, click on  
"2015 Edition"

The screenshot shows the Kansas Department of Transportation website. The header includes the Kansas logo and navigation links: HOME | NEWS | POPULAR LINKS | CONTACT KDOT. A search bar is located on the right. The main navigation bar contains: HOME, TRAVELER INFORMATION, DOING BUSINESS, INSIDE KDOT, PROJECTS/PUBLICATIONS, and PUBLIC INFORMATION. The page title is "SPECIFICATIONS" with a date "Updated 6/23/2015".

Under the "2015" heading, there are two main sections:

- 2015 - Effective July 2015 Letting**
  - [2015 Edition - Standard Specifications for State Road and Bridge Construction](#) (circled in red)
  - NOTE:** The 2015 Standard Specifications can be ordered by using the [Standard Specifications and Construction Manual Order Form](#)
  - [2015 Special Provisions](#)
  - NOTE:** Project Special Provisions are NOT posted individually online. They can be found in the Contract Bidding Proposal, either the electronic file or paper copy.
  - [Accounting and Cross Reference](#) of the 2007 Special Provisions with the 2015 Standard Specifications for State Road and Bridge Construction **\*\*Updated 6-23-15\*\***
- 2007**
  - [2007 Edition - Standard Specifications for State Road and Bridge Construction](#)
  - NOTE:** The 2007 Standard Specifications can be ordered by using the [Standard Specifications and Construction Manual Order Form](#)
  - [2007 Special Provisions](#)
  - NOTE:** Project Special Provisions are NOT posted individually online. They can be found in the Contract Bidding Proposal, either the electronic file or paper copy.
  - [Guidelines for Development, Review and Approval of Specifications](#)
  - [Commentary](#) on the 2007 Standard Specifications for State Road and Bridge Construction **\*\*Updated 7-26-07\*\***
  - [Accounting and Cross Reference](#) of the 1990 Special Provisions with the 2007 Standard Specifications for State Road and Bridge Construction **\*\*Updated 7-26-07\*\***

At the bottom, there is a "Contact Information" section with the following details:

Contact Information  
If you have any questions or comments, please contact:  
**Ordering:**  
Lee Alvarado  
Bureau of Construction & Materials, 7th Floor  
700 SW Harrison St.  
Topeka, KS 66603-3754  
785-296-7181  
[Lee Alvarado](#)

On the right side, there is a "Checklists/Manuals" section with links to:

- [Construction Checklists](#)
- [Construction Manual](#)
- [Documentation Manual](#)

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**STANDARD SPECIFICATIONS FOR STATE ROAD & BRIDGE CONSTRUCTION - 2015** Last Updated 9/01/15

NOTE: The 2015 Standard Specifications can be ordered by using the [Standard Specifications and Construction Manual Order Form](#)

If you have any questions or comments, please contact:

**Construction:**  
 Lee Ann Legge  
 Bureau of Construction & Materials, 7th Floor  
 700 SW Harrison St.  
 Topeka, KS 66603-3754  
 785-296-3576  
[LeeAnnL@ksdot.org](mailto:LeeAnnL@ksdot.org)

**Materials:**  
 Stacey Lowe  
 Materials and Research Center  
 2300 SW Van Buren  
 Topeka, KS 66611-1195  
 785-296-3899  
[staceyL@ksdot.org](mailto:staceyL@ksdot.org)

[100](#) | [150](#) | [200](#) | [300](#) | [400](#) | [500](#) | [600](#) | [700](#) | [800](#) | [900](#) | [1100](#) | [1200](#) | [1300](#) | [1400](#) | [1500](#) | [1600](#) | [1700](#) | [1800](#) | [1900](#) | [2000](#) | [2100](#) | [2200](#) | [2300](#) | [2400](#) | [2500](#) | [2550](#)

2015 Special Provisions

Section Number	Title
<a href="#">TABLE OF CONTENTS AND INDEX</a>	
<a href="#">15-ER-1.R01</a>	ERRATA SHEET FOR STANDARD SPECIFICATION BOOK FOR STATE ROAD AND BRIDGE CONSTRUCTION, EDITION 2015

## How to get to the 2015 Edition from an outside computer

Go to [www.ksdot.org](http://www.ksdot.org)

Go to “*Letting Information for Highway Contractors*” (yellow hard hat), then “*Specifications*”

Kansas Department of Transportation

HOME | NEWS | POPULAR LINKS | CONTACT KDOT

Enter Search Terms:

HOME TRAVELER INFORMATION DOING BUSINESS INSIDE KDOT PROJECTS/PUBLICATIONS PUBLIC INFORMATION

### KDOT'S CURRENT LETTING INFORMATION

\* To submit letting/project related questions to KDOT and view the answers, please either visit [bids.com](#) or select [Proposal Information](#).

[Highway Contractors' Help/Terms](#)

[Proposal Information](#) (View Plans, Bid Holders List, Non-Bid Holders List, View Proposal Forms, Addendum, Early & Late Start Dates)

[Summary of Quantities](#)

[Exploratory and Project Reports](#)

 [Bid Express](#) (non-KDOT site)

[Earliest/Latest Start Date Archive](#)

[Audio Broadcast of Bid Letting](#)

[As Read Bidders List](#)

[Bid Terms \(Awarded Contracts\)](#)

[Specifications](#)

[Kansas Highway Wage Determinations](#)

[Fuel Adjustment Price Index](#)

[Asphalt Adjustment Price Index](#)

[Bid Item List](#)

[Pre-Qualified Materials \(PQL\)](#)

[Disadvantaged Business Enterprises](#)

[Pre-Qualified Contractors Questionnaire](#)

[Pre-Qualified Contractors List](#)

[Information for Highway Contractors](#)

TRAVELER INFORMATION DOING BUSINESS INSIDE KDOT PROJECTS/PUBLICATIONS PUBLIC INFORMATION CONNECT WITH KDOT

KANSAS 511 SAFETY INFORMATION STATE MAPS CONSULT INFORMATION KANSAS STAYS KANSAS CITY METRO TOPEKA LAWRENCE METRO WICHITA METRO

PERMITS BIDDING & LETTING COMMERCIAL VEHICLES DESIGN CONSULTANTS HIGHWAY CONTRACTORS LOCAL GOVERNMENTS OFFICE OF CONTRACT COMPLIANCE REGIONAL INSPECTION PORTAL LOCAL PROJECTS

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# How to get to the 2015 Edition

Choose "2015 Edition" and you're home free.



## 2015 Special Provisions

Below the 2015 Specifications is the link to Special Provisions.

There is currently one piling Special Provision.

That will change, so always check for more.

## 2015 Special Provisions

15-07017

Adds a line about sheet pile to the bid items

We don't worry about sheet pile in this class

# The Bridge Construction Manual

## Chapter 5.3 Driven Pile

Contains some practical information about bridge piling construction and inspection.

# The Bridge Construction Manual

## Chapter 5.3 Driven Pile

General terminology and definitions, pile and hammer types, and the mechanics of pile driving, including formula examples



# The Bridge Construction Manual

## Chapter 5.3 Driven Pile

We cover all this material in class.

# The Bridge Construction Manual

## Chapter 5.3 Driven Pile

This section is included in the back of your book

# The Bridge Design Manual

## Bridge Design Manual

### Chapter 10.6 Foundation—Piling

Good summary of pile information

# The Bridge Design Manual

## Bridge Design Manual

### Chapter 11.5.7 Abutments, Piers and Walls—Pier Details

Has drawings of bridge foundation types

To get to these Manuals from the Intranet

<http://kdotweb>

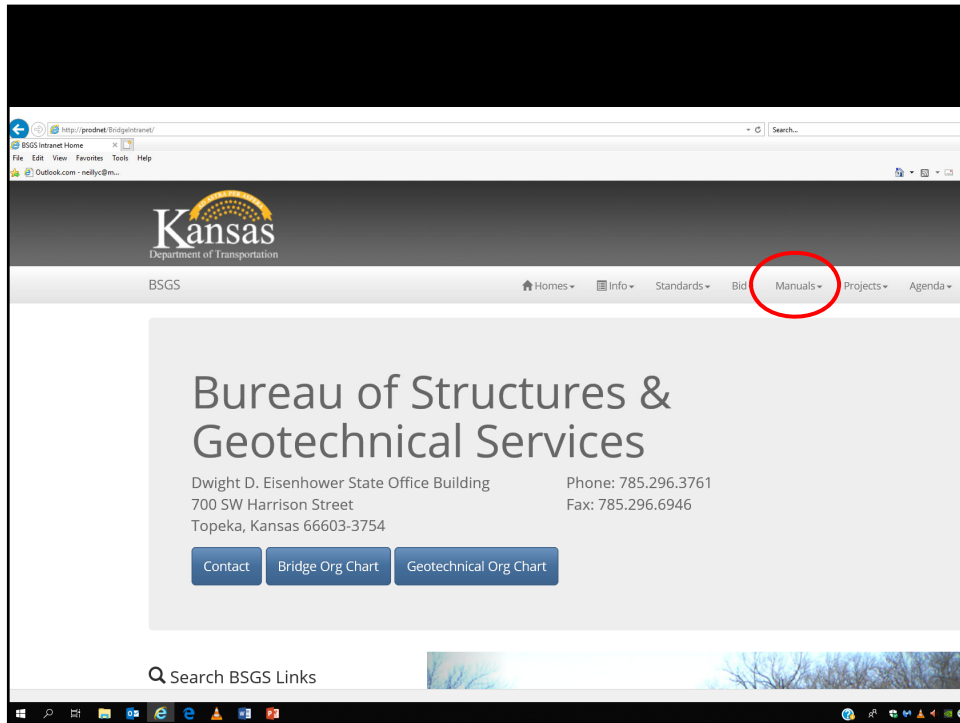
Click on “Organizational Pages”

Click on “Structures & Geotechnical Services”

To get to these Manuals from the Intranet

At the top is a drop-down menu for  
“Manuals”

Choose “Bridge Construction Manual”, or “Bridge LRFD Design Manual”



# The Direct Links Are:

<http://www.ksdot.org/burStructGeotech/constructionmanual/bcm.asp>

<http://kart.ksdot.org>

02) Overture Phantom of the o... Kansas Dept. of Transportat... X

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HOME TRAVELER INFORMATION DOING BUSINESS INSIDE KDOT PROJECTS/PUBLICATIONS PUBLIC INFORMATION

**Service Accounts** Kansas Department of Transportation  
 KDOT Authentication & Resource Tracking

The links below list downloads and other services available.  
 You will need to have a KART service account and be logged in to access downloads.  
[Create a Service Account \(No Charge\)](#)

**KART Service Account Login**

Username is your email address.

Username   
 Password   
 Remember me.

Web applications using a KART service account  
[KDOT Standard Drawings](#)  
[RCB Request Form \(LRFD Design\)](#)  
[KART Web Forms](#)  
[RCSHPT Slab Details Request](#)

General KART Resource Downloads

Category	Title	Version	File Size	Last Modified
Publication	<a href="#">1995 Graphics Standard Manual</a>	1995	19.39 MB	1/1/1995

03) Think of me Phantom of th... Kansas Dept. of Transportat... X

General KART Resource Downloads

Category	Title	Version	File Size	Last Modified
Publication	<a href="#">1995 Graphics Standard Manual</a>	1995	19.39 MB	1/1/1995
Publication	<a href="#">AASHTOWare Bridge Design and Rating Help Resources</a>	2015.1	772 KB	1/7/2015
Publication	<a href="#">Bridge Restriction Map</a>	2015.06.04	2.42 MB	6/4/2015
Publication	<a href="#">Current Graphic Standards Manual</a>	May 2011	3.38 MB	5/5/2011
Publication	<a href="#">Drainage Design Manual</a>	May 2011 Edition	3.97 MB	5/10/2011
Publication	<a href="#">Examples for Rd. Memo. KDOT Policy on Pipe Use</a>	July 11, 2008	3.59 MB	6/11/2008
Publication	<a href="#">Geotechnical Manual</a>	2007	114.14 MB	1/1/2007
Publication	<a href="#">Hydraulic Assessment Checklist</a>	2012.1	440 KB	1/17/2012
Publication	<a href="#">Landscape Info Form</a>	Jan 2 2015	68 KB	1/2/2015
Publication	<a href="#">Local Projects ARRA Information</a>	May 2009	768 KB	4/29/2009
Publication	<a href="#">Local Projects Bridge Inspection Docs and Forms</a>	February 2015	1.14 MB	2/2/2015
Publication	<a href="#">Local Projects Bridge Inspection Manual</a>	February 2015	26.04 MB	2/2/2015
Publication	<a href="#">Local Projects Bridge Inspection Scope of Services</a>	February 2015	792 KB	2/2/2015
Publication	<a href="#">Local Projects LPA Project Development Manual</a>	February 2015	6.49 MB	2/15/2015
Publication	<a href="#">LRFD Bridge Design Manual</a>	4/21/15, Vol III	51.71 MB	4/21/2015
Publication	<a href="#">Metric Bridge Design Manual</a>	6/2006, Vol III	21.27 MB	7/6/2006
Publication	<a href="#">Practical Improvements Guide</a>	August 2009	1.38 MB	8/4/2009
Publication	<a href="#">Road Design Manual</a>	May 2014 Edition	33.21 MB	6/3/2013
Publication	<a href="#">Seed/Native Wildflower Mixes</a>	July 2014	43 KB	7/21/2014
Publication	<a href="#">Survey Manual - Design</a>	2014	2.15 MB	12/16/2013
Software Applications	<a href="#">eBar (English Rebar) Software</a>	0.1.83	4.81 MB	6/15/2015
Software Applications	<a href="#">EvaporATE Software</a>	1.0.21	5.3 MB	6/1/2009
Software Applications	<a href="#">KDOT Column Expert</a>	4.2	791 KB	5/2/2013
Software Applications	<a href="#">KDOT Column Expert</a>	6	1.13 MB	7/9/2015
Software Applications	<a href="#">KDOT Structure Log</a>	October 2014	6.02 MB	11/4/2014
Software Applications	<a href="#">KU-BSP Bridge Scout Program</a>	1.0.0	8.16 MB	6/17/2004
Software Applications	<a href="#">QPlot - Software</a>	1.1	7.79 MB	3/25/2014
Software Applications	<a href="#">Screen Error Software</a>	1.2.18	2.66 MB	5/25/2007
Software Applications	<a href="#">TAEG 2.1</a>	2.1.29	4.84 MB	5/16/2005
Software Support	<a href="#">AASHTOWare Bridge Design and Rating Agency Library</a>	6.6.0	248 KB	1/7/2015





Quick—name the town

## Division 700—Structures

### Section 704.3 Pile Driving Equipment

#### (a) General

Size needed to develop the energy necessary to drive piles at least 0.1" per blow at the required resistance on the plans (the Pile Drive Formula Load)

**Division 700—Structures**  
**Section 704.3 Pile Driving Equipment**

**(a) General**

(1) Open-end Diesel Hammer

Equip with a device extending above ram cylinder to permit visually determining hammer stroke at all times.

**Division 700—Structures**  
**Section 704.3 Pile Driving Equipment**

**(a) General**

(3) Weight of the striking part of air hammers used shall be a minimum of  $\frac{1}{3}$  the weight of the pile and drive cap

Minimum weight of striking part is 2,750 pounds

**Division 700—Structures**  
**Section 704.3 Pile Driving Equipment**

**b. Hammers for Steel Piles, Steel Sheet Piles and Shells for Cast-in-Place Concrete Piles.**

Gravity hammer—minimum weight 3500 pounds

Gravity hammer—maximum drop 12 feet

**Division 700—Structures**  
**Section 704.3 Pile Driving Equipment**

**b. Hammers for Steel Piles, Steel Sheet Piles and Shells for Cast-in-Place Concrete Piles.**

Diesel or air—maximum fall 90% of the maximum fall recommended by manufacturer

Minimum 6000 foot-pounds energy per blow



**Division 700—Structures**  
**Section 704.3 Pile Driving Equipment**

**c. Hammers for prestressed  
concrete pile**

Only driven with diesel or air hammer unless  
otherwise noted

Hammer must develop 1 foot-pound of energy  
for each pound of weight driven

Minimum energy of hammer is 6,000 foot-  
pounds per blow

**Division 700—Structures**  
**Section 704.3 Pile Driving Equipment**

d. Vibratory hammers

Used only when specified in Contract document

If used, 1 of 10 piles must be load tested using an impact hammer (diesel or air) with suitable energy

**Division 700—Structures**  
**Section 704.3 Pile Driving Equipment**

e. Additional Equipment

The plant and equipment provided for air hammers shall have capacity to maintain the pressure at the hammer specified by the manufacturer.



**Division 700—Structures**  
**Section 704.3 Pile Driving Equipment**

e. Additional Equipment

If Contractor cannot drive pile to the required penetration and/or bearing capacity, he must bring a bigger hammer. If the Engineer approves, he may resort to jetting or pre-drilling at his own expense.

**Division 700—Structures**  
**Section 704.3 Pile Driving Equipment**

e. Additional Equipment

Use of the pile driving analyzer may be required when minimum requirements are not met

**Division 700—Structures**  
**Section 704.3 Pile Driving Equipment**

f. Leads

Constructed to allow freedom of movement of the hammer

Except where piles are driven through water, the leads shall be long enough so that followers are not needed

Remember what a follower is?



Followers are used as an extension of the pile between the hammer and the pile head



**Division 700—Structures**  
**Section 704.3 Pile Driving Equipment**

f. Leads

*Long enough to permit them to be spiked into the ground before driving starts*

**Division 700—Structures**  
**Section 704.3 Pile Driving Equipment**

**g. Hammer Cushion**

Required on all impact pile driving hammers  
except gravity hammers

Inspect before driving at each bridge or after  
driving for 100 hours

Replace cushion when thickness is reduced by  
25% or it appears to be deteriorating.

**Division 700—Structures**  
**Section 704.3 Pile Driving Equipment**

**g. Hammer Cushion**

A striking plate is placed on the  
cushion to insure uniform  
compression of the cushion material

**Division 700—Structures**  
**Section 704.3 Pile Driving Equipment**

**g. Hammer Cushion**

Made of “durable manufactured material”

Micarta (Conbest)—fabric and phenol

Nylon—2” blocks

Hamortex- metallized paper reels

Force 10, Forbon, Fosterlon

Aluminum

**Division 700—Structures**  
**Section 704.3 Pile Driving Equipment**

**(h) Pile Driving Head**

Use driving head adequate for distributing the hammer blow to the pile

Guided by the leads and not free-swinging

Should fit the pile head adequately



# *PILE DRIVING HEAD*

Another name  
for the Pile  
Helmet



## **Division 700—Structures** **Section 704.3 Pile Driving Equipment**

### **i. Water Jets**

Only used with permission from the  
Engineer

If used:

Number of jets and volume and  
pressure of water sufficient to erode  
material

Power enough to deliver at least 100 psi  
pressure from  $\frac{3}{4}$ " jet nozzles

**Division 700—Structures**  
**Section 704.3 Pile Driving Equipment**

**i. Water Jets**

Jets shall be withdrawn at least 5 feet from the desired final penetration depth and the pile driven the last 5 feet with an approved hammer

**Section 704.4**  
**Construction Requirements**

**a. Order Lists, Piles, and Test Piles**

Order list is the same as the estimated quantity (number and length of piles) shown in the Contract Documents.

## Section 704.4 Construction Requirements

### a. Order Lists, Piles, and Test Piles

For piles and test piles, submit the completed "Pile and Driving Equipment Data" sheet a minimum of 3 weeks before the scheduled date of driving piling. The Engineer (*that's you*) will forward this information for a Test Pile (Special) to the Chief Geologist.

## Section 704.4 Construction Requirements

### a. Order Lists, Piles, and Test Piles

When Engineer requires a restrike, follow **subsection 704.4e.** for restrike procedures

## Section 704.4 Construction Requirements

### a. Order Lists, Piles, and Test Piles

- Drive test piles at specified locations

Engineer will use test pile information to determine pile tip elevation

## Section 704.4 Construction Requirements

### a. Order Lists, Piles, and Test Piles

If multiple hammers are used on a project with test piles, drive a test pile with each hammer

## Section 704.4 Construction Requirements

### b. Test Pile (Special)

Pile Driving Analyzer  
used to monitor  
test pile



## Section 704.4 Construction Requirements

### b. Test Pile (Special)

Notify Engineer (John) minimum 5 working days prior to test.

Allow 1½ hours for pile to be prepared for test

Allow safe and reasonable access to pile

a personnel lift is **very** handy for this, if the contractor has one

The Engineer will use the PDA results to provide the Contractor with a blow count for production driving.



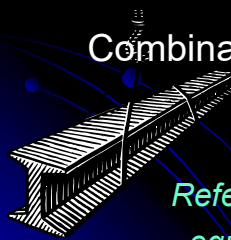
## Section 704.4 Construction Requirements

### c. Driving piles

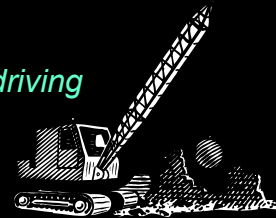
Piles can be driven with a gravity, diesel or air hammer

*or*

Combination of pre-drilled holes or water jetting  
**and** a hammer



*Refer to Subsection 704.3 for pile driving equipment*



## Section 704.4 Construction Requirements

### c. Driving piles

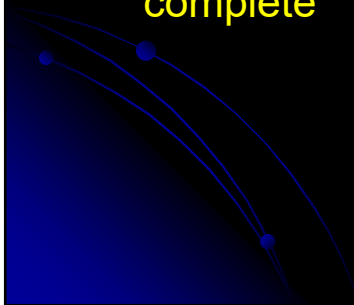
Drive piles at the locations and to lines shown on plans

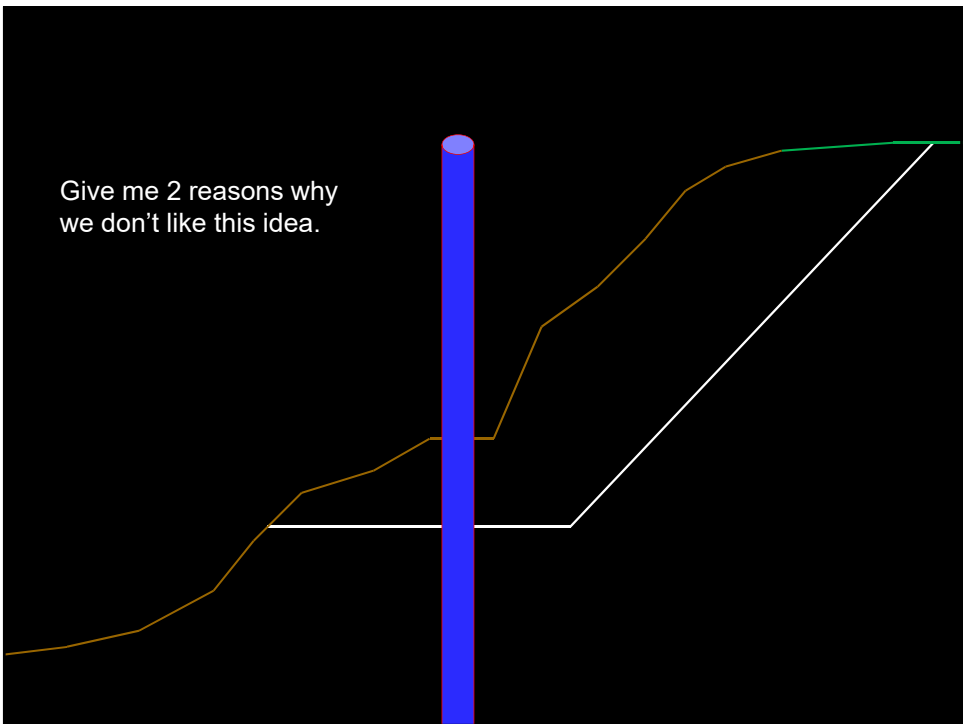
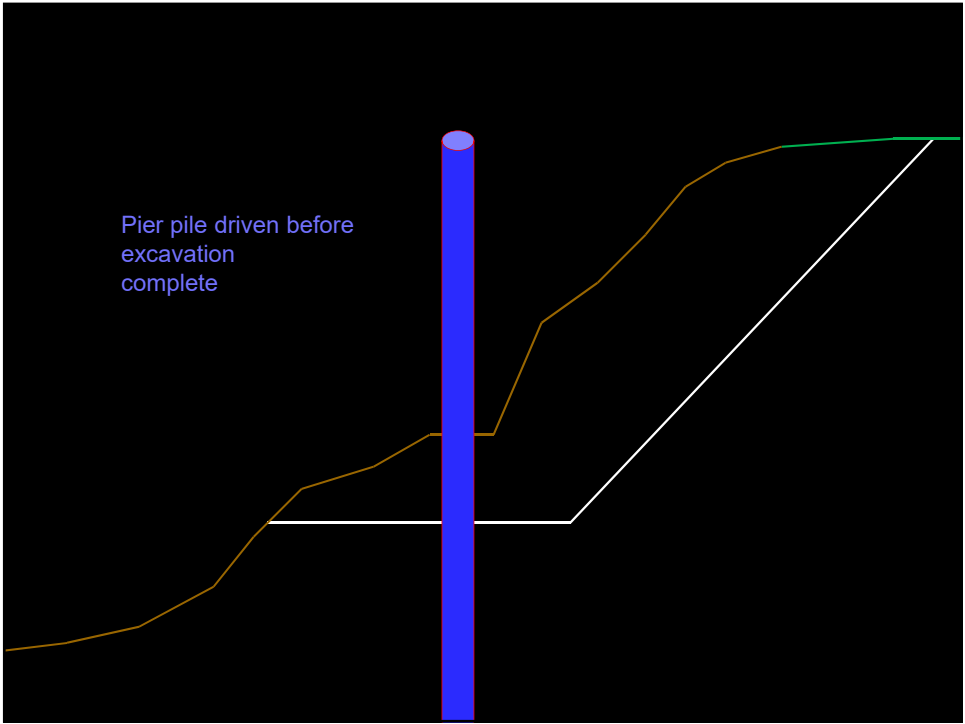
Use leads long enough to be spiked into ground

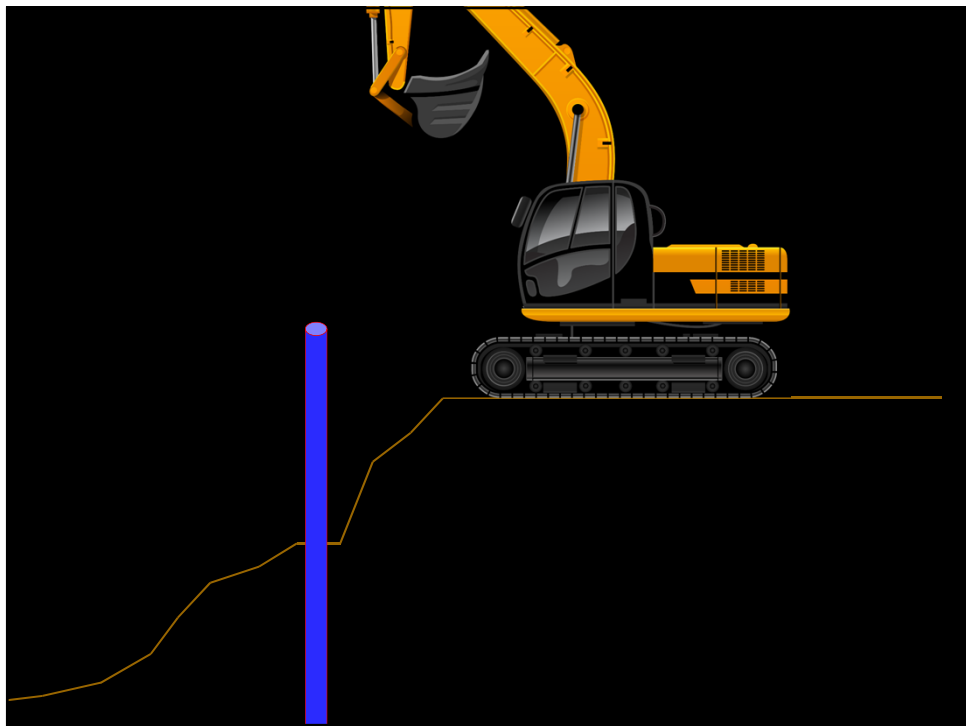
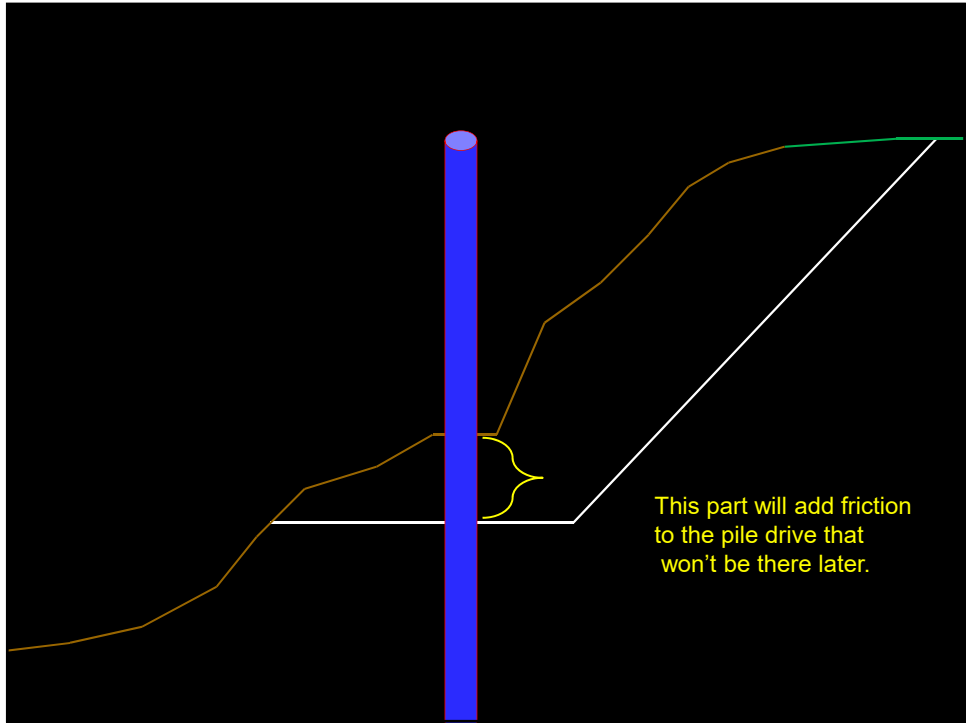
## Section 704.4 Construction Requirements

### c. Driving piles

Do not drive piles until excavation for footing, webwall, or abutment is complete







## Section 704.4 Construction Requirements

Don't allow a contractor to ignore this spec.

Release  
the hounds....



## Section 704.4 Construction Requirements

### c. Driving piles

Drive all piles for a footing or abutment before placing any concrete in the footing or abutment unless pile is over 20 feet from concrete, or unless concrete has cured 24 hours



## Section 704.4 Construction Requirements

### (c) Driving piles

Drill pile holes as shown on the plans

Maximum allowed diameter of predrill holes is 3" greater than pile diameter

If predrilling not specified, Contractor may predrill if Engineer approves

## Section 704 Piling 704.4 Construction Requirements

### (c) Driving piles

After pile is driven, backfill with loose sand or material specified on plans

If concrete is specified for backfill, use adequate slump and vibration to eliminate voids around pile

## Section 704.4 Construction Requirements

### c. Driving piles

Drive all piling perpendicular to long axis of pile

Use pile caps (**helmets**) on all piles

## Section 704.4 Construction Requirements

### c. Driving piles

For pile caps of concrete piles and prestressed concrete piles, use a suitable cushion next to the pile

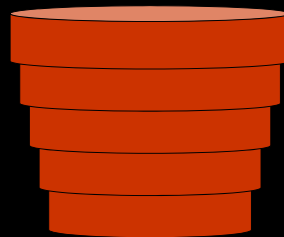
Pile helmets for steel piles must have grooves to accommodate the shape of the pile

## Section 704.4 Construction Requirements

### c. Driving piles

On pipe piles, the helmet must have an **interior guide (mandrel)** that sticks into the pile at least 6 inches.

## Section 704.4 Construction Requirements



**Most of the time**, each step on a guide is 3".  
So we need 2 steps inside a pipe pile.

## Section 704.4 Construction Requirements

### c. Driving piles

It is **not** necessary to have 6 inches of the interior guide up against the pile itself.

Just a **total** of 6 inches.





No reason, I just think this painting is cool

## Section 704.4 Construction Requirements

### c. Driving piles

Use full-length pile where practical

Splice steel pile where shown on plans or with permission of Engineer

Provide experienced welder, **qualified under Section 713** to make the welded splices for steel pile

(Section 713 is Qualification of Field Welders)



## Section 704.4 Construction Requirements

### c. Driving piles

Contractor must  
correct any failed  
splices at his  
own expense



## Section 704.4 Construction Requirements

### c. Driving piles

Avoid extensions, splices, or build-ups of  
prestressed concrete piles

Plans will show method for splicing  
concrete piles

There are no instructions for splicing  
concrete piles in the Specs

## Section 704.4 Construction Requirements

### c. Driving piles

Replace any damaged pile with new,  
longer pile

--crushing or spalling of concrete pile

--deformation of steel pile

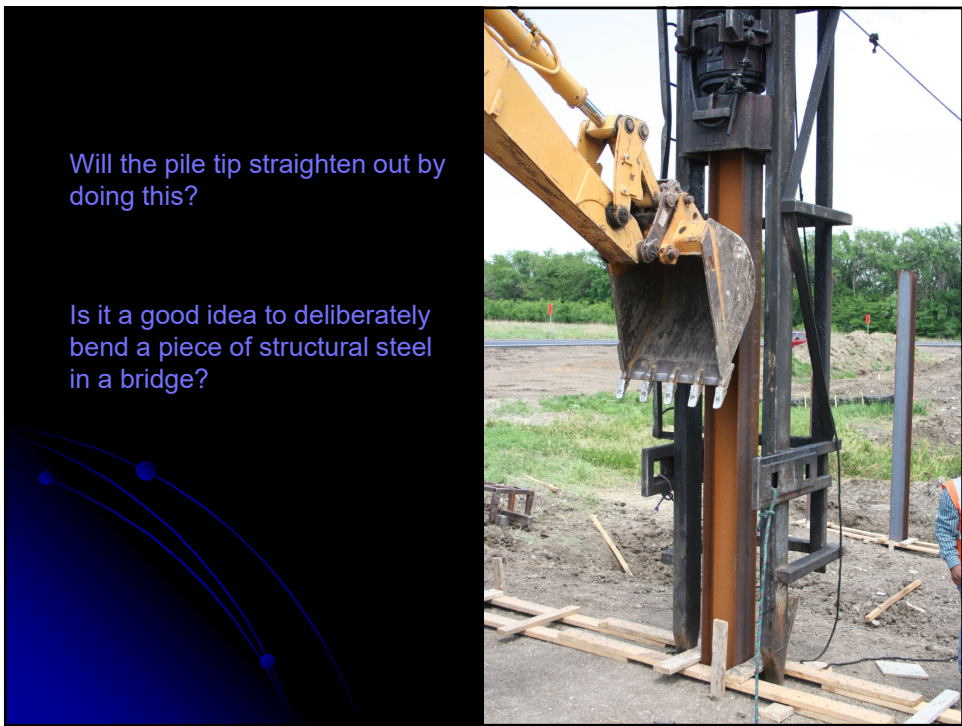
An additional pile may be driven next to  
damaged pile, if approved by Engineer

## Section 704.4 Construction Requirements

### c. Driving piles

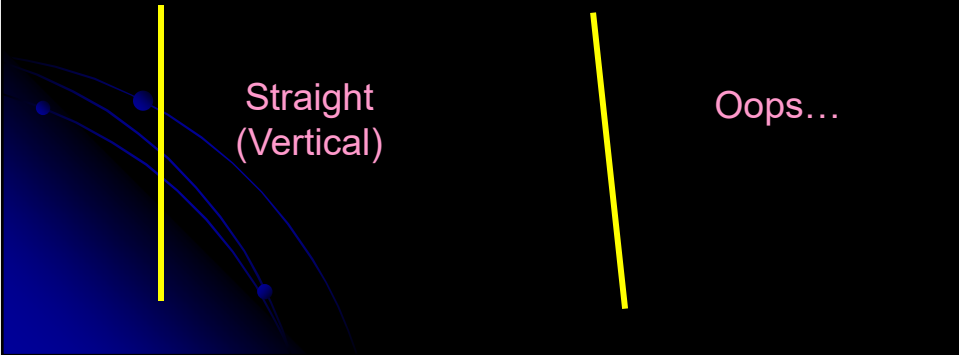
**Do not force misaligned piles into position**

Remove and replace any pile not in its  
proper location with new, longer pile



# Section 704.4 Construction Requirements

Tolerance to Vertical



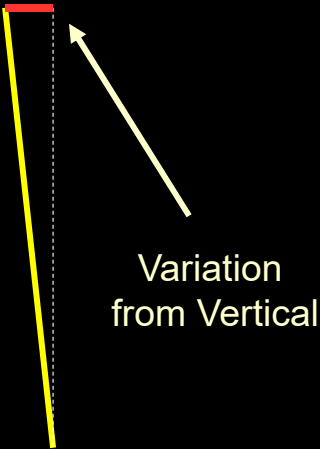
# Section 704.4 Construction Requirements

Tolerance to Vertical



# Section 704.4 Construction Requirements

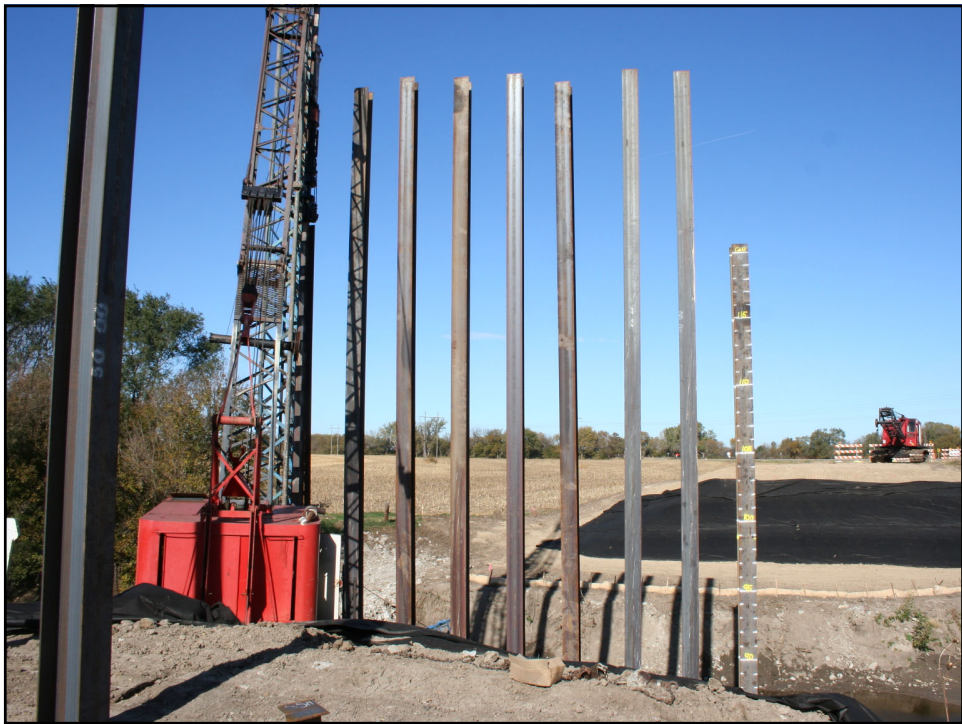
Tolerance to Vertical













**If you have enough pile sticking out of the ground, just measure it directly**

## Section 704.4 Construction Requirements

### c. Driving piles

#### Tolerances to Vertical or Battered Lines

Piles 35 feet or shorter:  $\frac{1}{4}$ " per foot of length

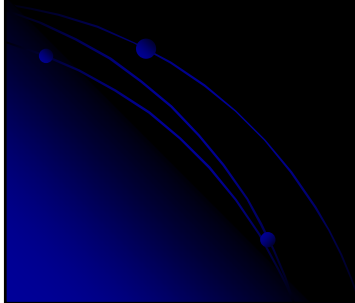
Piles longer than 35 feet:  $\frac{1}{8}$ " per foot

### Driving Tolerances to Vertical—Example

You are driving H-piles into chalky limestone for a 3-pier bridge over Big Possum Creek in southern Gove County. The piers are supported by small pile groups. The order length for piling in Pier 3 is 28 feet. You stop driving when you notice one of the piles seems to be crooked. How can you check to see if it's in spec?

## Driving Tolerances to Vertical—Example

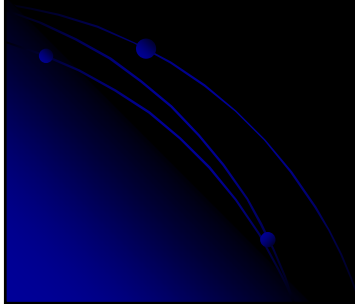
Pile Length—28 feet



## Driving Tolerances to Vertical—Example

Pile Length—28 feet

Tolerance for piles shorter than 35 feet is  $\frac{1}{4}$  inch per foot of pile





## Driving Tolerances to Vertical—Example

Pile Length—28 feet

Tolerance for piles shorter than 35 feet is  $\frac{1}{4}$  inch per foot of pile

You have a 4-foot long level.

$$4 \text{ feet} \times \frac{1}{4} \text{ inch / foot} = ?$$

## Driving Tolerances to Vertical—Example

$$4 \text{ feet} \times \frac{1}{4} \text{ inch / foot} = 1 \text{ inch}$$

You would measure the distance it is out of plumb, and contact the Bridge Office if it exceeds one inch.

When using a 4-foot level to check, you either have  $\frac{1}{2}$ " or 1" leeway, depending on the pile length.

## Section 704.4 Construction Requirements

### c. Driving piles

#### Tolerances to Vertical or Battered Lines

If you don't have enough pile sticking out to measure it directly, have the location surveyed and measure how far off it is. Then back-calculate.

## Section 704.4 Construction Requirements

### c. Driving piles

#### Tolerances to Position of Pile Head (Elevation of Top of Pile)

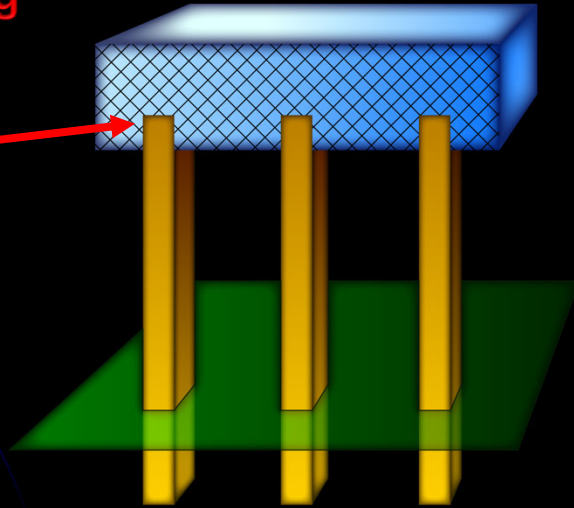
Piles in bents: 2"

Foundation piles (pile groups): 6"

## Maximum Variation from Pile Cutoff Elevation at the Top of the Pile After Driving

Piles in Pile Bents

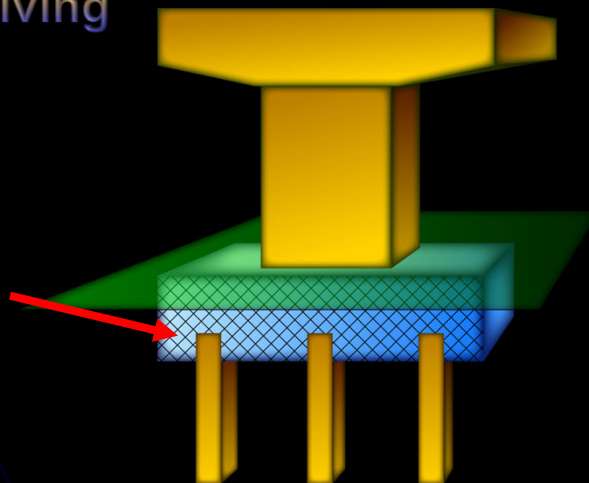
2 inches variation up or down



## Maximum Variation from Pile Cutoff Elevation at the Top of the Pile After Driving

Piles in Pile Groups

6 inches variation up or down



## Section 704.4 Construction Requirements

### c. Driving piles

Drive all piles in the orientation shown on the Plans. If the axial orientation of the pile rotates or twists by more than  $10^{\circ}$ , the Field Engineer (**that's you**) will contact the bridge designer in Topeka.

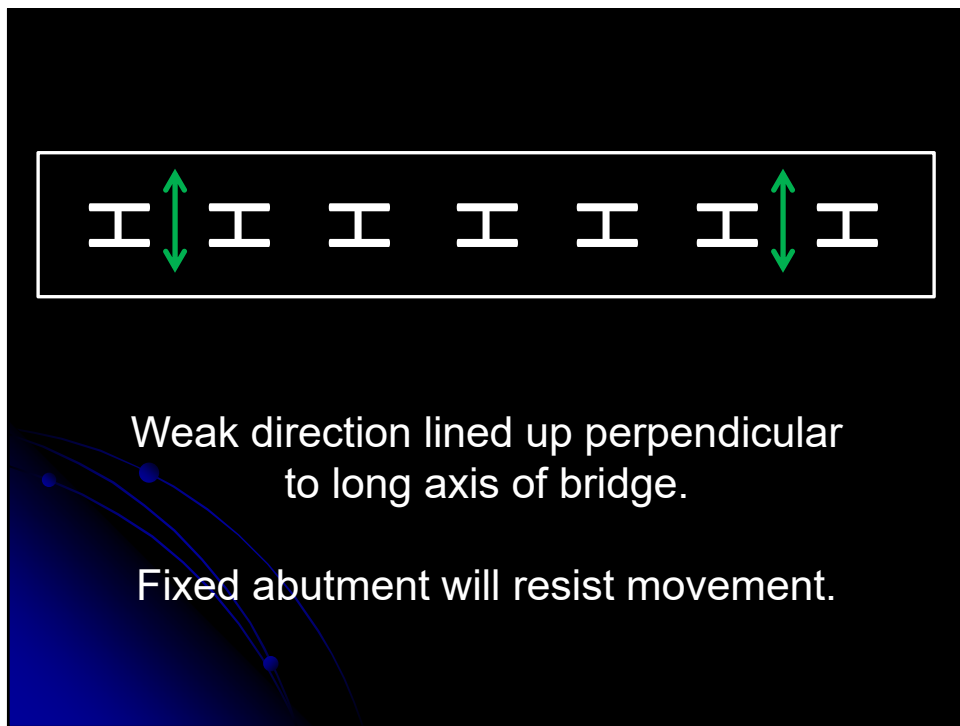
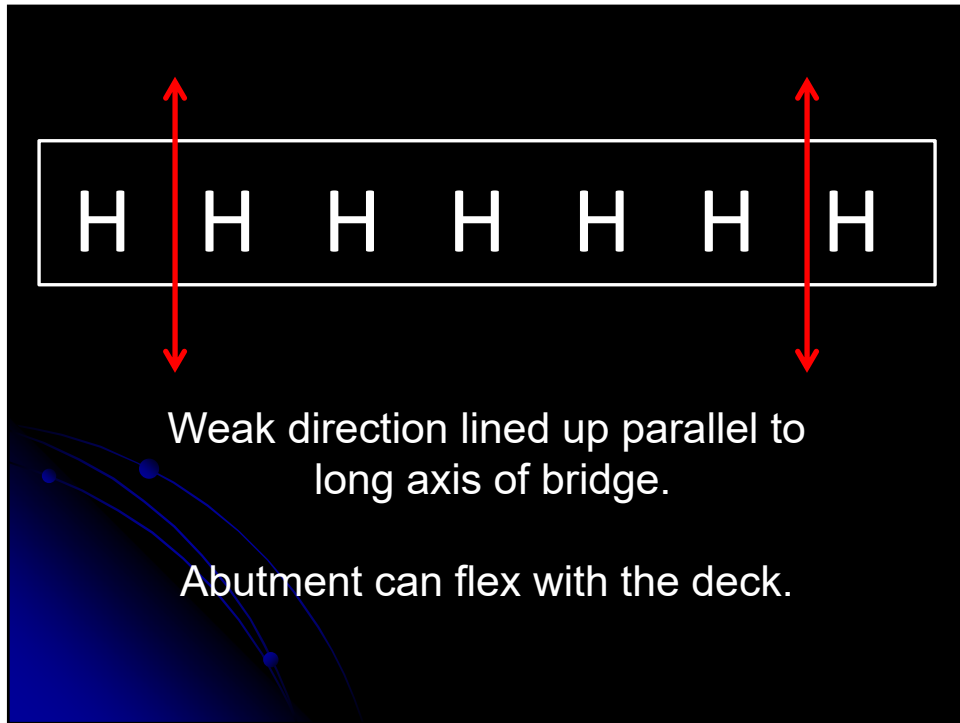




H H H H H H H

Typical Pile Bent Abutment





## Section 704.4 Construction Requirements

### c. Driving piles

Re-drive all piles pushed up by adjacent pile driving or any other cause

## Section 704.4 Construction Requirements

### d. Bearing Values and Required Penetration

Drive piling to the specified bearing value, penetration, and pile tip elevation

Stop driving if 1.1 times the minimum resistance (pile drive formula load) is attained

## **Section 704.4**

### **Construction Requirements**

#### d. Bearing Values and Required Penetration

Stop driving if the pile will be damaged before the minimum requirements are met

## **Section 704.4**

### **Construction Requirements**

#### d. Bearing Values and Required Penetration

If required bearing can't be obtained, the number of piling may be increased with the approval of the Engineer (bridge engineer in Topeka)

## Section 704.4 Construction Requirements

### d. Bearing Values and Required Penetration

This would only be done after splicing and restriking have been tried.

Adding piling is rarely needed.

## Section 704.4 Construction Requirements

TABLE 704-1: PILE FORMULAS

Hammer	Pile Type	Formula
Gravity	Timber	$P = \frac{2}{S+1.0} \frac{W}{H}$
Gravity	Steel Steel Shell Steel Sheet	$P = \frac{3}{S+0.35} \frac{W}{H} \left( \frac{W}{W+X} \right)$
Air/Steam (Single Acting)	All Types	$P = \frac{2}{S+0.1} \frac{W}{H}$
Air/Steam (Double Acting)	All Types	$P = \frac{2}{S+0.1} \frac{E}{H}$
Delmag and McKierman-Terry*	All Types	$P = \frac{1.6}{S+0.1} \frac{W}{H} \left( \frac{X^{**}}{W} \right)$
Link-Belt*	All Types	$P = \frac{1.6}{S+0.1} \frac{E}{H} \left( \frac{X^{**}}{W} \right)$

\*diesel hammers

\*\* For diesel hammers, the quantity X/W shall not be less than 1.

P = safe bearing power in pounds

## **Section 704.4**

### **Construction Requirements**

#### d. Bearing Values and Required Penetration

Formulas only apply when:

- Hammer falls freely

- Penetration is quick and uniform

- No significant bounce after the strike

## **Section 704.4**

### **Construction Requirements**

#### d. Bearing Values and Required Penetration

If water jets used, determine bearing capacity after jets have been removed



## Section 704.4 Construction Requirements

### d. Bearing Values and Required Penetration

If a different brand of **diesel** hammer is used besides the 3 listed in the Formula Table, use **80 % ( 0.80 )** of the manufacturer's listed energy rating in the formula to determine bearing capacity.

## Section 704.4 Construction Requirements

### d. Bearing Values and Required Penetration

For an **air** hammer, use **100 %** of the manufacturer's listed energy rating in the formula to determine bearing capacity and to check if the hammer is large enough.

We're almost done...I promise



## Section 704.4 Construction Requirements

### e. Pile Restrike Procedure

If pile doesn't get resistance within a few feet of plan elevation, a restrike may be used

Call the Regional Geology Office for help

## Section 704.4 Construction Requirements

### e. Pile Restrike Procedure

(1) No test piles called for on bridge and  
PDA not available

- Drive all piles in group to within 2 feet of plan  
Leave them alone for at least 24 hours

## Section 704.4 Construction Requirements

### e. Pile Restrike Procedure

Warm up hammer far from piles to restrike

Immediately restrike 20% of piles in group, minimum  
of 2 piles per group

Restrike piles farthest from each other

When possible, restrike those with lowest resistance  
during driving

## Section 704.4 Construction Requirements

### e. Pile Restrike Procedure

Strike a pile with warm hammer for 20 blows or until it moves 4 inches, whichever comes first

Record penetration for every 5 blows

If pile moves less than  $\frac{1}{2}$  inch, stop restrike after 10 blows

## Section 704.4 Construction Requirements

### e. Pile Restrike Procedure

(1) No test piles called for on bridge and PDA not available

Calculate resistance based on average penetration for first 5 blows

Resistance for all piling in group is the resistance calculated for that one pile. Pretty sweet, huh?

## Section 704.4 Construction Requirements

### e. Pile Restrike Procedure

If calculated resistance is too low, splice and resume driving

*Look sad and say "doh"....*

## Section 704.4 Construction Requirements

### e. Pile Restrike Procedure

(2) Test pile called for on bridge and PDA not available

Treat the test pile as you would a common restrike, using the above rules.



## Section 704.4 Construction Requirements

### e. Pile Restrike Procedure

( 3 ) Test Pile (Special) called for on bridge or PDA is available

Follow recommendations of the Regional Geologist

## Section 704.4 Construction Requirements

### f. Pile Cut-off and Pile Painting

( 1 ) After piles are driven, cut them off at the designated elevation

If capping is required, make the connection as shown in the Contract

## Section 704.4 Construction Requirements

### f. Pile Cut-off and Pile Painting

Pieces cut off become property of  
KDOT, if the Engineer wants them.



## Section 704.4 Construction Requirements

### ( f ) Pile Cut-off and Pile Painting

Some Area Engineers or Area Construction  
Engineers automatically salvage pieces  
longer than 5 or 6 feet.

Others try to decide whether their KDOT area  
will need piling pieces in the near future.



This is one way of cutting off a pile...



## Section 704.4 Construction Requirements

### f. Pile Cut-off and Pile Painting

- ( 1 ) Pile pieces not wanted by the Engineer become the property of the Contractor

## Section 704.4 Construction Requirements

### f. Pile Cut-off and Pile Painting

- ( 2 ) Paint the exposed steel of piling using the same kind of paint and number of coats as used for structural steel of bridge

Paint the piling in the field

## Section 704.4 Construction Requirements

### f. Pile Cut-off and Pile Painting

( 2 ) If no painting specified in plans:

Use prime coat of inorganic zinc

- Use acrylic or polyurethane finish coat

See Division 700



## Section 704.4 Construction Requirements

### f. Pile Cut-off and Pile Painting

( 2 ) Paint the piling for a distance of one  
foot below :

Bottom of channel

Top of embankment

Natural ground

Normal low-water elevation



## Section 704.4 Construction Requirements

### g. Cast-In-Place Concrete Piles

(also called “Shell Piles” and “Closed-end Pipe Piles”)

After steel shells are driven, remove all loose material from inside shells

Fill the shells with Grade 3.5 concrete unless the plans say otherwise

## Section 704.4 Construction Requirements

### g. Cast-In-Place Concrete Piles

Don't place concrete in shells until all driving within 15 feet is finished

*or*

Until all piles for that bent are driven

## Section 704.4 Construction Requirements

### g. Cast-In-Place Concrete Piles

If that isn't possible, stop driving until concrete in all piles for that bent has cured at least 7 days

Remove water from inside the shells before placing concrete

### g. Cast-In-Place Concrete Piles

Vibrate the concrete in the upper 15 feet of the shell



## Section 704 Piling

### 704.5 Measurement and Payment

The Engineer (*that's you*) will measure:

Length of steel piling left in bridge, by linear foot

Length of concrete pile from the tip to the place where it is cut to connect with the cap or footing

*Do not include the length of reinforcing steel at the top of prestressed concrete piles*

## Section 704 Piling

### 704.5 Measurement and Payment

The Engineer (*that's you*) will measure:

Actual length of ordered and accepted test piles by the linear foot

Each cast steel pile point used



## Section 704 Piling

### 704.5 Measurement and Payment

The Engineer (*that's you*) will measure:

Each pile splice needed that wasn't called for in the plans

In other words, when we had to splice because the geology didn't behave

## Section 704 Piling

### 704.5 Measurement and Payment

For all types of steel and concrete pile, if a splice is needed and not shown on the plans, the cost of the splice is :

**4 times** the contract unit price per foot of the pile type

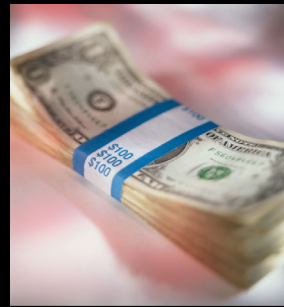
## Example of Pile Splice Cost

Contract unit cost of steel H-pile =  
\$32.00 per foot

The cost of a splice for this type of pile  
is **4 times** the contract unit price per  
foot

The splice would cost

$$\$36.00 \times 4 = \mathbf{\$144.00}$$



## Section 704 Piling

### 704.5 Measurement and Payment

Do **not** measure for payment :

Splices shown on the plans

Splices the contractor did for his own  
convenience



**Section 704 Piling**  
704.5 Measurement and Payment

The Engineer (*that's you*) will measure:

Predrilled holes by the linear foot

Measure from bottom of hole to the bottom of footing (*pile cap*) or abutment

**Section 704 Piling**  
704.5 Measurement and Payment

If the Contractor drills deeper than the plans call for, do not measure the extra depth

If Contractor uses predrilling for his convenience, do not measure for payment

## Section 704 Piling

### 704.5 Measurement and Payment

The Engineer (*that's you*) will measure:

Pile cut-off by the linear foot

- Pile cut-off is the difference between the length of pile ordered and accepted and the actual length of pile remaining in the bridge

## Section 704 Piling

### 704.5 Measurement and Payment

Length Ordered and Accepted

---- Length left in bridge

\_\_\_\_\_

= Length of pile cut-off

**Section 704 Piling**  
**704.5 Measurement and Payment**

<b>Pile Type</b>	<b>% of Contract Unit Price Paid</b>
Cast-in-place (Shell)	60
Pre-stressed concrete	75
Steel	75
Steel Sheet	75

**Section 704 Piling**  
**704.5 Measurement and Payment**

Steel Pile = 75% of the Contract unit price for steel piles

• Prestressed Concrete Pile = 75% of the Contract unit price for prestressed concrete piles

## Section 704 Piling

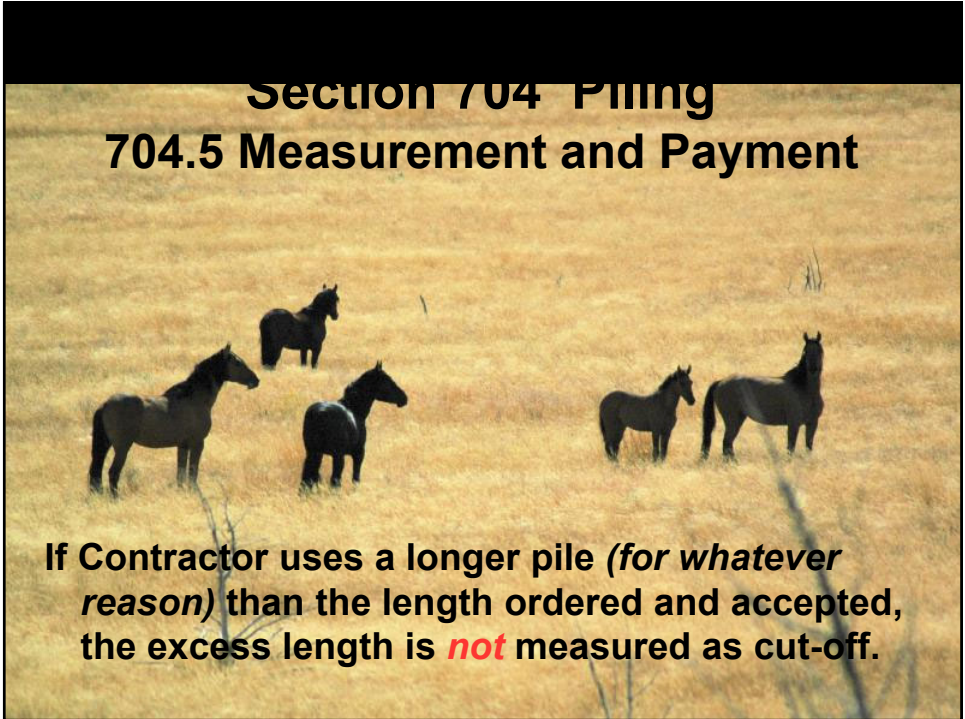
### 704.5 Measurement and Payment

Cast-in-place concrete piles = 60% of the contract unit price for concrete piles

Steel Sheet Pile = 75% of the contract unit price for steel sheet piles

## Section 704 Piling

### 704.5 Measurement and Payment



If Contractor uses a longer pile (*for whatever reason*) than the length ordered and accepted, the excess length is **not** measured as cut-off.

## Materials Section 1609 Steel Piling and Pile Points

Page 1600-18

### Steel Pile:

Explains type of steel accepted (ASTM)

Discusses types of welds on pipe pile

Lists the diameter tolerances on pipe pile

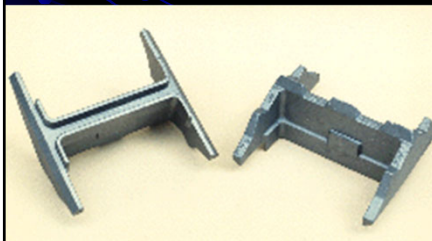
## Materials Section 1609 Steel Piling and Pile Points

Page 1600-18

### Pile Points:

Fabricated or cast from steel

References ASTM Standards







We're finally done  
You'll be back at the  
house in no time



704 - PILING

SECTION 704

PILING

704.1 DESCRIPTION

Drive the specified types of piles to the penetration and bearing values shown in the Contract Documents.

**BID ITEMS**

**UNITS**

Piles (*) (**)	Linear Foot
Test Piles (*) (**)	Linear Foot
Test Piles (Special) (*) (**)	Linear Foot
Cast Steel Pile Points	Each
Pre-Drilled Pile Holes	Linear Foot
*Type: Cast-In-Place Concrete, Prestressed Concrete, Steel or Steel Sheet, Corrugated Metal Sheet <sup>+</sup>	
**Size	
<sup>+</sup> Black or Galvanized	

704.2 MATERIALS

Provide materials that comply with the applicable requirements.

Concrete .....	<b>SECTIONS 401 &amp; 402</b>
Aggregates for Concrete Not On Grade .....	<b>SECTIONS 1102</b>
Prestressed Concrete Piles .....	<b>DIVISION 700</b>
Steel Bars for Concrete Reinforcement .....	<b>DIVISION 1600</b>
Steel Piling and Steel Pile Points .....	<b>DIVISION 1600</b>
Type B Preformed Expansion Joint Filler .....	<b>DIVISION 1500</b>
Paint Materials .....	<b>DIVISION 1800</b>

704.3 PILE DRIVING EQUIPMENT

**a. General.** Pile driving hammers other than drop hammers shall be of the size needed to develop the energy required to drive piles at a penetration rate of not less than 0.10 inches per blow at the minimum driving resistance according to the appropriate pile driving formula in **TABLE 704-1**.

In addition to all other requirements, single and double acting diesel hammers and air/steam hammers require the following.

(1) Open-End (Single Acting) Diesel Hammer. Equip open-end (single acting) diesel hammers with a device such as rings on the ram or a scale (jump stick) extending above the ram cylinder, to permit the Engineer to visually determine hammer stroke at all times during pile driving operation. Also, provide the Engineer a chart from the hammer manufacturer equating stroke and blows per minute for the open-end diesel hammer to be used.

(2) Closed-End (Double Acting) Diesel Hammer. Equip closed-end (double acting) diesel hammers with a bounce chamber pressure gauge, mounted near ground level so as to be easily read by the Engineer. Also, provide the Engineer a chart, calibrated to actual hammer performance, equating bounce chamber pressure to either equivalent energy or stroke for the closed-end diesel hammer to be used.

(3) The weight of the striking part of air/steam hammers used shall be a minimum of 1/3 the weight of the pile and drive cap, and in no case shall the striking part have a weight less than 2,750 pounds.

**b. Hammers for Steel Piles, Steel Sheet Piles and Shells for Cast-in-Place Concrete Piles.** If a gravity hammer is used for driving steel piles, steel sheet and shells for cast-in-place concrete piles, use one with a minimum weight of 3,500 pounds. In no case may the weight of the gravity hammer be less than the pile being driven plus the weight of the driving cap. In lieu of weighing the hammer, a certification may be provided by the Contractor. Equip all gravity hammers with hammer guides to maintain concentric impact on the drive head or pile cushion. Regulate the fall to avoid injury to the piles. The fall shall be a maximum of 12 feet. If diesel or air/steam hammers are used, the maximum fall shall be 90% of the maximum fall recommended by the hammer manufacturer.

## 704 - PILING

If steam or diesel hammers are used, its rated gross energy in foot-pounds shall be a minimum of 2 ½ times the weight of the pile in pounds. The hammer shall develop a minimum of 6,000 foot-pounds of energy per blow.

**c. Hammers for Pre-stressed Concrete Piles.** Unless otherwise provided, drive pre-stressed concrete piles with a diesel or air/steam hammer that can develop an energy per blow at each full stroke of the piston of a minimum of 1 foot-pound for each pound of weight driven. The hammer shall develop a minimum of 6,000 foot-pounds of energy per blow.

**d. Vibratory Hammers.** Vibratory hammers may only be used when specifically allowed by the Contract Documents or in writing by the Engineer. If approved, vibratory hammers shall be used in combination with pile load testing and re-tapping with an impact hammer. In addition, 1 of every 10 piles driven with a vibratory hammer shall be re-tapped with an impact hammer of suitable energy to verify that acceptable load capacity was achieved.

**e. Additional Equipment.** The plant and equipment provided for air/steam hammers shall have sufficient capacity to maintain, under working conditions, the pressure at the hammer specified by the manufacturer. In case the required penetration or bearing is not obtained by the use of a hammer complying with the above minimum requirements, provide a hammer of greater energy or when permitted, resort to jetting or pre-drilling at Contractor expense. Use of the pile driving analyzer may be required when minimum requirements are not obtained or results are doubtful.

**f. Leads.** Construct pile-driving leads to afford freedom of movement for the hammer. Hold them in position with guys or stiff braces to support the pile during driving. Except where piles are driven through water, use leads of sufficient length that the use of a follower shall not be necessary. Leads shall be of sufficient length to allow them to be spiked into the ground at the onset of driving.

**g. Hammer Cushion.** Equip all impact pile driving equipment except gravity hammers with a suitable thickness of hammer cushion material to prevent damage to the hammer or pile and to maintain uniform driving behavior. Use hammer cushions made of durable, manufactured material that shall retain uniform properties during driving. Wire rope and asbestos hammer cushions are prohibited. Place a striking plate on the hammer cushion to maintain uniform compression of the cushion material. Inspect the hammer cushion in the presence of the Engineer when beginning pile driving at each structure or after each 100 hours of pile driving, whichever is more frequent. Replace the hammer cushion whenever there is a reduction of hammer cushion thickness exceeding 25% of the original thickness, or when the cushion begins deteriorating, tearing, etc., before continuing driving.

The following are acceptable types of pile cap material. Other materials may be used with approval of the Bureau of Construction and Materials.

(1) Micarta (Conbest) - This is an electrical insulating material composed of fabric and phenol. Replace when it starts to powderize or when it disintegrates into various layers.

(2) Nylon (2-inch thick blocks) - Occasional vertical cracking is not detrimental. However, replace after the cushion develops horizontal cracks.

(3) Hamortex (metallized paper reels) - Pay attention as it may compress or disintegrate.

(4) Force 10, Forbon, and Fosterlon - These materials are provided by manufacturers of pile driving equipment.

(5) Aluminum - Aluminum is often used to separate layers of softer cushioning material. Replace once the aluminum is deformed or broken.

(6) Wood (plywood or hardwood) should only be used with gravity hammers.

**h. Pile Driving Head.** Fit piles driven with impact hammers with an adequate driving head to distribute the hammer blow to the pile head. Axially align the driving head with the hammer and the pile. The driving head is guided by the leads and shall not be free swinging. The driving head shall fit around the pile head in a manner that prevents transfer of torsional force during driving while maintaining proper alignment of hammer and pile.

**i. Water Jets.** When jets are permitted, the number of jets and the volume and pressure of water at the jet nozzle shall be sufficient to freely erode the material adjacent to the pile. Use a plant with sufficient capacity to deliver a minimum of 100 pounds per square inch pressure at ¾-inch jet nozzles at all times. At a minimum of 5 feet before the desired penetration is reached, withdraw the jets and drive the piles to secure the final penetration with an approved hammer.

**704.4 CONSTRUCTION REQUIREMENTS**

**a. Order Lists, Piles and Test Piles.** The order list is the same as the estimated quantity (number and length of piles) shown in the Contract Documents.

For piles and test piles, provide the Engineer with the completed "Pile and Driving Equipment Data" sheet a minimum of 3 weeks before the scheduled date of driving piling. The Engineer will forward this information for Test Pile (Special) to the Chief Geologist.

When a restrike is required by the Engineer, follow **subsection 704.4e.** for restrike procedures. Provide piles for the structure according to the order list (number and length of piles) prepared by the Engineer.

Drive the specified test piles at the locations shown in the Contract Documents. The Engineer will use the test pile information to determine the pile tip elevation.

If multiple hammers are used on a project requiring test pile or test pile (special), drive a test pile or test pile (special), whichever is specified, with each hammer.

**b. Test Pile (Special).** Pile Driving Analyzer (PDA). The Engineer will use the PDA to monitor the driving of the test piles (special). Provide the Engineer with the completed "Pile and Driving Equipment Data" sheet a minimum of 3 weeks before the scheduled date of driving piling. The Engineer will forward this information to the Chief Geologist.

In order to mobilize the PDA, notify the Engineer a minimum of 5 working days before driving the test piles (special). Prior to driving the test pile (special), the Engineer will require approximately 1½ hours to prepare the test piling (special) and install the dynamic measuring equipment. If with prior approval, the piles are to be welded prior to the Engineer attaching the testing equipment, provide the Engineer with safe and reasonable means of access to the pile for preparing the pile and attaching the instruments.

When a restrike is required by the Engineer, follow **subsection 704.4e.(3).** for restrike procedures.

To obtain the estimated ultimate loads, the Engineer will use the PDA to take dynamic measurements as the test pile (special) is driven to the required driving resistance. If non-axial driving is indicated by dynamic test equipment measurements, immediately realign the driving system. The Engineer will use the PDA results to provide the Contractor with a blow count for production driving.

**c. Driving Piles.** Drive the piles with a gravity hammer, a diesel hammer, an air/steam hammer or a combination of pre-drilled holes or water jetting and a hammer. Use equipment that complies with **subsection 704.3.**

Drive the piles at the locations and to the vertical or battered lines shown in the Contract Documents. Use leads of sufficient length to allow them to be spiked into the ground at the onset of driving the pile.

Do not drive piles until the footing, webwall or abutment excavation is completed. Drive all of the piles required for the footing or abutment before placing any concrete in the footing or abutment, unless the foundation is a minimum of 20 feet away or has cured a minimum of 24 hours.

When specified, drill pile holes before driving the piles. Drill the holes accurately so that the piles are set as shown in the Contract Documents. The maximum size of the pre-drilled holes is equal to the diameter of the pile plus 3 inches. The depth of pre-drilled pile holes is shown in the Contract Documents. If pre-drilled pile holes are not specified, the Contractor may choose to pre-drill pile holes, provided the Engineer approves the Contractor's method and limits. After the piles are driven to their final positions in the pre-drilled holes, fill the holes with loose sand or material specified in the Contract Documents. If concrete is specified, allow sufficient concrete slump and provide vibration to fill all voids around the pile.

Drive all pile heads perpendicular to the longitudinal axis of the piles to prevent eccentric impacts from the drive head of the hammer. Use pile caps on all piles during the pile driving operations. For pile caps of concrete piles and prestressed concrete piles, use a suitable cushion next to the pile head that fits into a casting that supports a timber shock block. On pile caps for steel piles and steel sheet piles, provide grooves in the bottom of the cap to accommodate the shape of the piles to hold the axis of piles in line with the axis of the hammer. On pipe pile, use a helmet with a minimum interior guide of 6 inches.

If specified, use the type of cast steel pile points shown in the Contract Documents. Use pile points that provide full bearing for the piles. Provide an experienced welder to attach the cast steel pile points to the piles.

Use full-length piles where practicable. It is preferred that steel piling is not spliced. Splices may be made with the permission of the Engineer, or when shown in the Contract Documents. Make splices as shown in the Contract Documents. Use an approved welding process as provided in **DIVISION 700** to make the splices. Provide an experienced welder qualified under **SECTION 713** to make the welded splices for structural steel piling and shell piling. Correct or replace any failure in the splice at own expense.

## 704 - PILING

Avoid extensions, splices or build-ups on prestressed concrete piles whenever possible. When splicing is necessary, make them as shown in the Contract Documents.

If the pile driving procedure causes crushing or spalling of the prestressed concrete piles, or deformation of the steel piles, remove and replace the damaged piles with new, longer piles. A second pile may be driven adjacent to the damaged pile, when approved by the Engineer and can be accomplished without detriment to the structure.

Do not force misaligned piles into proper position. Remove and replace piles driven out of their proper location with new, longer piles.

- If the driven pile is 35 feet or less in length, the maximum allowable variation from the vertical or battered lines shown in the Contract Documents is  $\frac{1}{4}$  inch per foot of length.
- If the driven pile is greater than 35 feet in length, the maximum allowable variation from the vertical or battered lines shown in the Contract Documents is  $\frac{1}{8}$  inch per foot of length.
- The maximum allowable variation on the head of the driven pile from the position shown on the Contract Documents is 2 inches for piles used in bents, and 6 inches for foundation piles.
- Drive all piles in the orientation shown on the Plans. If the axial orientation of the pile rotates or twists by more than  $10^\circ$ , the Field Engineer will contact the Bureau of Structures and Geotechnical Services.

Re-drive all piles pushed up by the driving of adjacent piles, or by any other cause.

**d. Bearing Values and Required Penetration.** Drive the piling to attain, as a minimum, the specified bearing value, penetration and pile tip elevation. Stop driving the piling (regardless of the penetration) if  $1\frac{1}{2}$  times the specified minimum driving resistance is attained. Stop driving the piling if, in the opinion of the Engineer, the specified minimum driving resistance, penetration and pile tip elevation can not be attained without damage to the piling. If the specified minimum driving resistance is not attained with the specified number and length of piling, the Engineer may allow additional piling be driven so that the maximum load on any pile does not exceed its safe carrying capacity.

In the absence of loading tests, determine the safe bearing values of piles by the formulas in **TABLE 704-1**.



704 - PILING

TABLE 704-1: PILE FORMULAS		
Hammer	Pile Type	Formula
Gravity	Timber	$P = \frac{2 W H}{S + 1.0}$
Gravity	Steel Steel Shell Steel Sheet	$P = \frac{3 W H}{S + 0.35} \left( \frac{W}{W + X} \right)$
Air/Steam (Single Acting)	All Types	$P = \frac{2 W H}{S + 0.1}$
Air/Steam (Double Acting)	All Types	$P = \frac{2 E}{S + 0.1}$
Delmag and McKierman-Terry*	All Types	$P = \frac{1.6 W H}{S + 0.1} \left( \frac{X^{**}}{W} \right)$
Link-Belt*	All Types	$P = \frac{1.6 E}{S + 0.1} \left( \frac{X^{**}}{W} \right)$

\*diesel hammers

\*\* For diesel hammers, the quantity X/W shall not be less than 1.

P = safe bearing power in pounds

W = weight in pounds, of striking part of hammer

H = height of fall in feet

E = energy of ram in foot-pounds per blow

S = the average penetration in inches per blow for the last 5 blows for gravity hammers and the last 20 blows for air/steam or diesel hammers

X = weight in pounds of the pile plus the weight of any cap and/or anvil used on the pile during driving

The above formulas are applicable only when:

- The hammer has a free fall;
- The penetration is reasonably quick and uniform; and
- There is no appreciable bounce after the blow.

If water jets are used in connection with the driving, determine the bearing capacity by the formulas above from the results of driving after the jets have been withdrawn, or a load test may be applied.

The energy rating used to determine if any type or brand of diesel hammer is of adequate size other than those shown in **TABLE 704-1**, is 80% of the energy rating as listed by the manufacturer.

Use an energy rating of 100% of the energy rating listed by the manufacturer for computing bearing values and to determine if an air/steam is of adequate size. If the number of blows per minute for an air/steam hammer deviates significantly from the number designated by the manufacturer, take corrective action as directed by the manufacturer.

**e. Piling Restrike Procedure.**

If a pile does not attain the minimum driving resistance within a few feet of the plan elevation, the pile restrike procedure may be used. Contact the Regional Geology Office for guidance before using the restrike procedure. Restrike procedures differ depending on whether a Test Pile, Test Pile (Special) or neither is called for in the Contract Documents. When a PDA is used, the restrike procedure will be as directed by the Regional Geologist.

(1) Use the following procedure when neither a Test Pile nor a Test Pile (Special) is called for in the Contract Documents, and the PDA is not available. The following procedure shall be used.

- Drive all of the piling in a group to within 2 feet of plan elevation;
- A group of piling is defined as all piles contained within a single footing.
- All of the piling in the pile group shall sit undisturbed for a minimum of 24 hours;
- Prior to starting the restrike procedure, warm the hammer up at a location as far away from the pile group as practical, preferably in another substructure member or pile group;

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- Using the warmed up hammer, immediately restrike 20% of the piles in a group, with a minimum of 2 in a group restruck. Of these, restrike the piles in a single group with the furthest spacing away from each other. When possible, restrike those with the lowest resistance during driving.
- Restrike for 30 blows or until the pile penetrates an additional 4 inches, whichever comes first. Record the penetration for every 5 blows. In the event the pile movement is less than ½ inch during the restrike, the restrike may be terminated after 20 blows.
- Restrike additional (the 20% or 2 minimum specified above) pile in the group as directed by the Engineer.

The driving resistance of the piling is computed based on the average penetration, if any, for the first 5 blows. The driving resistance of each piling is the driving resistance computed for the pile that was restruck. If the computed driving resistance is less than the design pile load, splice additional length onto each piling in the group and resume driving each piling until the required driving resistance is achieved.

(2) Use the following procedure when a Test Pile is called for in the Contract Documents, and the PDA is not available. The following procedure must be used.

- Drive the Test Pile to within 2 feet of plan elevation;
- The Test Pile shall sit undisturbed for a minimum of 24 hours;
- Prior to starting the restrike procedure, warm the hammer up at a location as far away from the Test Pile as practical, preferably in another substructure member or pile group;
- The Test Pile is then immediately restruck with the warmed-up hammer for 30 blows or until the pile penetrates an additional 4 inches, whichever comes first. Record the penetration for every 5 blows. In the event the pile movement is less than ½ inch during the restrike, the restrike may be terminated after 20 blows.

The driving resistance of the Test Pile is computed based on the average penetration, if any, for the first 5 blows. If the computed driving resistance is less than the design pile load, splice additional length and resume driving until the minimum driving resistance is achieved.

(3) When a Test Pile (Special) is called for on the plans, or a PDA is available, follow the recommendations of the Regional Geologist for the Restrike Procedure.

### **f. Pile Cut-Off and Pile Painting.**

(1) After the piles are driven as specified, cut the piles off at the designated elevation. If capping is required, make the connection as shown in the Contract Documents.

Pile cut-off material becomes the property of KDOT, if the Engineer determines the pile cut-off material is worth salvaging. Store the salvageable material at the site selected by the Engineer. Pile cut-off material determined to not be salvageable becomes the property of the Contractor.

(2) Paint the exposed portion of steel piles, steel sheet piles, or the shells or castings of cast-in-place concrete piles. Unless otherwise noted in the Contract Documents, apply the paint in the field. Use the same kind of paint and total number of coats as specified for the structural steel on the structure. If a paint system is not specified for the structure, use a prime coat of inorganic zinc as required for the shop coat and an acrylic or polyurethane finish coat, as specified in **DIVISION 700** for the final coat. Apply the paint to the pile for a distance of 1 foot below the bottom of the channel, top of the embankment, natural ground or normal low water elevation.

**g. Cast-In-Place Concrete Piles.** After the steel shells are driven as specified, remove all loose material from inside the steel shell. Unless specified otherwise in the Contract Documents, use Grade 3.5 concrete to fill the steel shells. Do not place concrete in the steel shell until the driving of all steel shells within a radius of 15 feet from the pile is completed, or until all the piles for any one bent are driven. If this can not be done, discontinue all driving within the above limits until the concrete in the last pile cast is a minimum of 7 days old. Remove accumulations of water from inside the steel shells before concrete is placed. Consolidate the concrete in the upper 15 feet of the steel shell by internal vibration.

**h. Sheet Pile.** Use a fabricated or cast driving head with corrugations to match the top of the sheeting while driving the sheet piling.

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704.5 MEASUREMENT AND PAYMENT

The Engineer will measure the length of steel pile, steel sheet pile, cast-in-place concrete pile and prestressed concrete pile remaining in the structure, by the linear foot.

The Engineer will measure the length of prestressed concrete from the tip of the pile to the point that concrete is removed to provide the connection with the cap or footing. This measurement does not include the length of reinforcing steel extending beyond the pile and into the cap or footing.

The Engineer will measure the actual length of ordered and accepted test pile and test pile (special) by the linear foot.

The Engineer will measure each cast steel pile point used.

If after driving the ordered and accepted length of pile, plan bearing is not achieved and additional pile is required, the Engineer will measure for payment each pile splice needed to lengthen the pile to achieve bearing. The Engineer will not measure for payment pile splices shown in the Contract Documents or pile splices approved for the Contractor's convenience.

The Engineer will measure pre-drilled pile holes by the linear foot. The Engineer will measure pre-drilled pile holes from the elevation at the bottom of the hole to the bottom of the footing or abutment elevation shown in the Contract Documents. If the Contractor drills the pile holes to an elevation below that shown in the Contract Documents for bottom of hole, the additional drilling below the elevation shown in the Contract Documents is not measured for payment. Pre-drilled pile holes not specified, but drilled for the Contractor's convenience are not measured for payment.

The Engineer will measure pile cut-off by the linear foot for Pile (\*) (\*\*). Pile cut-off is the difference between the length of pile ordered and accepted and the actual length of pile remaining in the structure. If the Contractor (for convenience or method of operation) uses a length of pile that exceeds the length of pile ordered and accepted, the excess length is not measured as pile cut-off.

The Engineer will not measure pile cut-off of Test Pile (\*) (\*\*) and Test Pile (Special) (\*) (\*\*) for payment. If the pile for these items is cutoff and used/spliced on the project, the pile will not be measured for separate payment. Splices will be paid for according to this subsection.

The Pile Restrike procedure shall not be paid for separately, but shall be subsidiary to the bid item "Piling", "Test Pile" and "Test Pile (Special)".

Payment for the various types of "Piles" and "Test Piles", "Cast Steel Pile Points" and "Pre-Drilled Pile Holes" at the contract unit prices is full compensation for the specified work.

Payment for pile splices at 4 times the contract unit price of the type of pile spliced is full compensation for the specified work.

Payment for pile cut-off per linear foot as shown in TABLE 704-2 is full compensation for the specified work.

TABLE 704-2: PILE CUT-OFF PAYMENT	
Pile Type	% of Contract Unit Price Paid
Cast-in-place (Shell)	60
Pre-stressed concrete	75
Steel	75
Steel Sheet	75

The costs of all load tests ordered by the Engineer will be paid for as Extra Work as shown in SECTION 104.

## 5.3 DRIVEN PILE

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## 5.3 DRIVEN PILE

### 5.3.1 General

Driven piles are used as the foundation for almost all abutments in Kansas bridges. Likewise they are used as the foundation for many piers in Kansas bridges. Proper pile driving inspection is critical to a successful bridge project.

#### **What is a driven pile?**

There are two types of driven piles: sheet pile and foundation pile. Sheet piles are long, interlocking, rolled steel plates used in retaining structures, such as walls and cofferdams. Foundation piles are long slender columns designed to be driven into the ground. Foundation piles will be discussed here.

Foundation piles are simply columns, designed to transmit surface loads to low lying soil or bedrock. These loads are transmitted by friction between the pile and ground and by point bearing through the end of the pile. The actual amount of frictional resistance or end bearing is dependent on the particular site conditions.

Foundation piles are made of steel, concrete, or timber. Of these materials, steel H-pile and cast-in-place pipe pile are most commonly used in Kansas. The material and size of pile to be used on a particular project are designated in the plans on the General Notes and Summary of Quantities Sheet.

Piles are used when a deep foundation is necessary. This is the case when the soil near the surface is unsuitable to carry the loads imposed by the structure. Piles are also used when the possibility exists that the soil under the foundation may be washed away.

### 5.3.2 Bid Items

The following is an abbreviated list and brief description of the bid items related to pile foundations. The entire list can be found in the Standard Specifications.

#### **Test Pile:**

There are some instances in which the length of pile cannot be determined accurately by means of a soils boring or sounding. This is usually the case when friction pile or bearing pile is used where the geologic formation is weathered. In these instances a test pile will be required. A test pile is a single pile driven to determine the required length of the remaining pile for that foundation element. The test pile location will be shown on the plans. Usually there will be one test pile per bent location. These are ultimately used as production piles so the location tolerance is the same as a production pile. If the production piles are to be pre-drilled then the test pile is pre-drilled to the same depth.

With all the hammer information known, use the appropriate dynamic pile driving equation to compute the blow count (average) for the specified driving load and 110% of this value. The value for over driving the pile was 150% when Allowable Stress Design was used to determine the soil and pile resistance. As the Geology Section has moved into the realm of Load and

Resistance Factor Design, the limits have been reduced on overdriving the pile. The hammer selected for the particular job should be rated to yield at least this value at the required resistance. Required resistance is 1/4" per 5 blows as the average of the last 20 blows for power driven hammers and the last 5 blows for gravity hammers.

**After the pile penetrates the soft upper layers (about 6 feet) the blow count will be taken for each twelve inches of penetration.** Mark the pile in twelve inch intervals prior to placing the pile in the leads and count the blows as the marks pass a fixed point. Record the average penetration in decimal inches by dividing twelve inches by the number of blows between the marks.

**Test Pile (Special):**

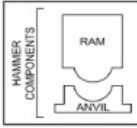
The Test Pile (Special) bid item is used when the geology within an area has unpredictable material properties. In such case the plans will direct the Contractor to notify the Engineer five days prior to driving the test piles. The Engineer will contact the regional Geologist and the State Bridge Office. They will mobilize the Pile Driving Analyzer (PDA) to be used on the project. This equipment attaches to the pile as it is driven and measures the energy being supplied by the driving equipment and the stress in the pile. The bearing capacity can be computed from this information.

**When the plans show the bid item Test Pile (Special), the information found in Form 217AA (pictured below), located in the Forms Warehouse, must be supplied by the Contractor. The Engineer will use this information in the Wave Equation Analysis Program (WEAP).**

**Notice to Contractors**  
Pile and Driving Equipment Data  
Test Pile (Special), Section 704, Division 700, 2007 Standard Specifications

Project No. \_\_\_\_\_ County \_\_\_\_\_  
Contract No. \_\_\_\_\_ Structure Name/No. \_\_\_\_\_  
Pile Contractor or Subcontractor \_\_\_\_\_

**HAMMER COMPONENTS**




Manufacturer \_\_\_\_\_ Model \_\_\_\_\_  
Type \_\_\_\_\_ Serial No. \_\_\_\_\_  
Rated Energy \_\_\_\_\_ @ \_\_\_\_\_ Length of Stroke \_\_\_\_\_  
Fuel Setting \_\_\_\_\_ (ft) \_\_\_\_\_ (ft)  
Modifications \_\_\_\_\_

Material \_\_\_\_\_

**CAPBLOCK**

Thickness \_\_\_\_\_ (inches) Area \_\_\_\_\_ (in<sup>2</sup>)  
Modulus of Elasticity (E) \_\_\_\_\_ (psi)  
Coefficient of Restitution (c) \_\_\_\_\_

**PILECAP**



Helix  
Bornt  
Anvil Block  
Drivehead

Weight \_\_\_\_\_ (lb)

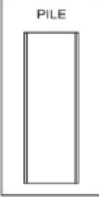
**CUSHION**

Material \_\_\_\_\_ Area \_\_\_\_\_ (in<sup>2</sup>)  
Modulus of Elasticity (E) \_\_\_\_\_ (psi)  
Coefficient of Restitution (c) \_\_\_\_\_

Revision 10/2008 DOT Form 217AA

**Pile and Driving Equipment Data**  
Test Pile (Special), Section 704, Division 700, 2007 Standard Specifications

**PILE**



Pile Type \_\_\_\_\_  
Length (in leads) \_\_\_\_\_ (ft)  
Weight (per foot) \_\_\_\_\_ (lb)  
Wall Thickness \_\_\_\_\_ (in) Taper \_\_\_\_\_  
Cross Sectional Area \_\_\_\_\_ (in<sup>2</sup>)  
Design Pile Capacity \_\_\_\_\_ (ton)  
Description of Splice \_\_\_\_\_  
Tip Treatment Description \_\_\_\_\_

**NOTE:** If a mandrel is used to drive the pile, attach the manufacturer's detail sheets including the weight and dimensions.

Submitted by \_\_\_\_\_ Date \_\_\_\_\_

One Copy Each Sent To:

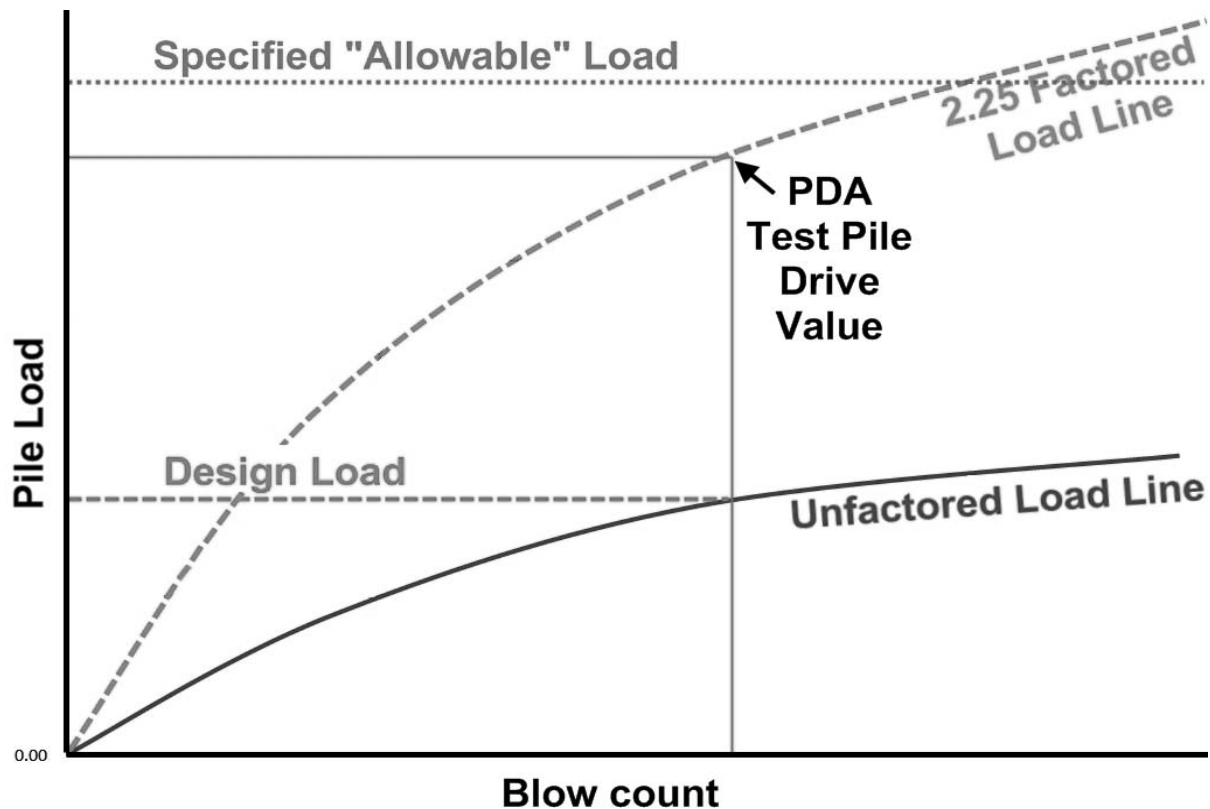
- \_\_\_\_\_ Bureau of Construction and Maintenance
- \_\_\_\_\_ Bureau of Design, State Bridge Office
- \_\_\_\_\_ Bureau of Materials and Research, Geology Section
- \_\_\_\_\_ Project Engineer

Revision 10/2008 DOT Form 217AA

**Friction Pile PDA Procedures:**

Currently plan specified pile driving values include Design Load, Allowable Load, and the General Note that specifies what “allowable” load to drive the pile to at each substructure element. Friction Pile are typically driven in western Kansas since there are no thick bedrock layers to seat a bearing pile into. From a practical standpoint it can be difficult to determine a required pile length with current technology. This is why a PDA is used on these projects to determine the length of pile required, the pile tip elevations, and various other values to allow inspectors to complete the rest of the pile using the equations in the specifications.

The PDA equipment measures the exact value of resistance the pile is building during driving. Current practice gives the geologist running the PDA equipment the authority to modify the values specified in the contract documents to more accurately reflect the subterranean site conditions. The chart below is a representation of what can happen on site during a PDA test pile drive. The values for everything below the green line are only applicable to the geologist running the PDA equipment. The inspector in the field is only given the specified load as stated in the plans. After the PDA test drive is completed, the operator will often have new values for the inspector to achieve for the remaining pile.



The specified load located in the “Piling” General Note the inspector is instructed to drive to can be over-riden by the geologist running the PDA equipment. The PDA operator will drive to 2.25 times the Design Load stated in the plans. Once the PDA operator achieves that value, the operator will back-calculate the equivalent pile load the inspector will need to calculate using the pile driving equations. Other information the PDA operator will give to the inspector is the approximate pile tip elevation, the blow count, average penetration, and the stroke height of the



hammer. The pile driving will proceed using the new values the PDA equipment has determined. **Cut-Off and Splice:**

Pile cut-off and pile splicing are paid for as a function of the bid price for piling per linear foot.

### ***Cut-Off***

The Contractor will have enough of the pile sticking out of the ground for the proper cut off leaving a fresh heading and squared end. The penetration of the pile within an abutment or footing is shown on the plans and is critical to the structural continuity. As a minimum, piling will be encased in 2'-0" of concrete.

The cut off elevation (top of pile) will be called out in the plans and is a surveyed elevation. Do not use the top of a piling as a reference elevation for other structural elements in the bridge. Set elevations from a true vertical control element, i.e. a benchmark.

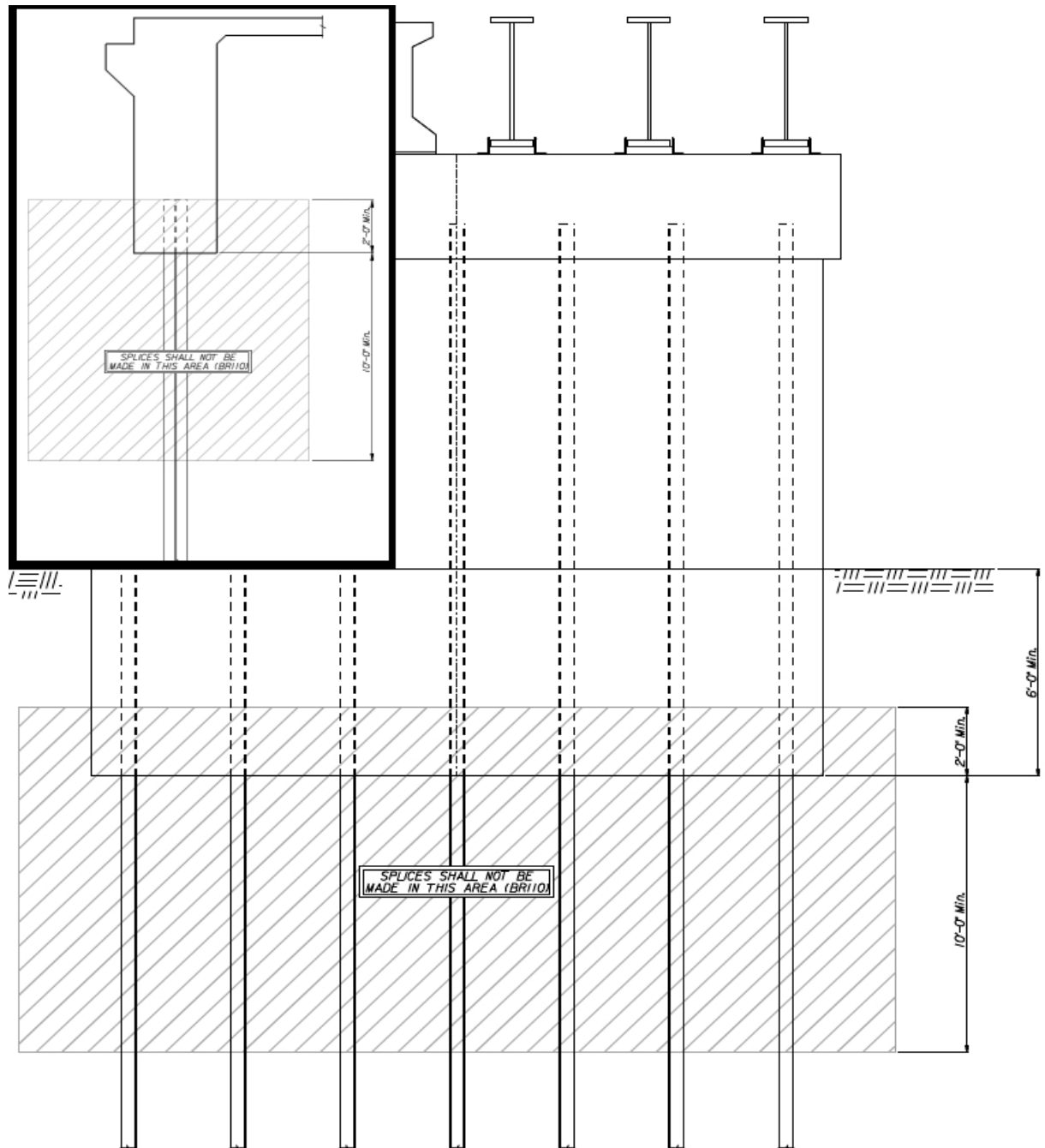
Using the correct pile driving formula, found in Section 704, to calculate the resistance of the pile, and once sufficient resistance is achieved, driving should stop. Continuing to drive the pile to use the ordered length, or the length in the leads may damage the pile. Any excess pile should be cut off at the plan top of pile elevation. It is common to have 3'-0" of cut-off at each pile location.

### ***Pick and Place***

If the contractor chooses a method of securing the pile during the pick and place operations which damages the pile, the contractor must remove the damaged portion of the pile at the contractor's cost before driving. For example, if the contractor burns a hole in the pile as a more secure method to lift the pile into place, the contractor must remove the portion of the pile containing the hole before driving the pile begins. The contractor is required to remove the compromise section of pile to at least one inch below the hole. This cutoff is at the contractor's cost and is considered to be non-pay cutoff. As such, if the total cutoff made for the contractor's convenience reduces the supplied pile to less than the Ordered and Accepted pile length and an additional length of pile is needed to achieve cutoff elevation, the necessary splice is a non-pay splice.

### ***Splice***

Splicing pile becomes necessary when the founding material is deeper than the designer expected, when the founding material is beyond the reach of a single length of pile, or in the case of friction pile, required resistance is not achieved with the length of pile driven. For long steel bridges with integral abutments or for rigid frame structures (integral pile bent piers), it is desirable to have spliced material at the bottom of the pile rather than have a splice near the bottom of the concrete element supported by the pile. If it becomes apparent that several of the piles in an individual structure (pile cap, abutment, etc.) are going to need to be spliced, it is best if the splices are made before driving begins. The spliced end is then driven first. This way, the strength of the welded section is only tested, axially, by driving and not tested in repeated bending by structure loading, because the splice is located away from the end that will go through the most severe bending. Standard details require locating the splice a minimum of ten feet below the bottom of abutments, integral pile bent piers. Rare special cases may exist for some pile caps which will be determined by the design engineer and designated by a general note in the design plans.



**Figure 1 Pile Splice Location Limits**

The “Standard Pile Details” (BR110) sheet states splices will be located a minimum of ten feet below the web wall concrete on piling for integral pile substructure elements. This requirement keeps the splice away from the area of maximum bending. In general, the bottom of a concrete web wall will be located two to six feet below the streambed. This note is not meant to exclude splices from being located within the concrete web wall. If the splice is located within the wall, it should be at least two feet above the bottom of concrete, as shown in Figure 1. In general, the above figure shows where the contractor is not allowed to splice piling; the inspector needs to verify this has not been overridden in the plan notes and/or substructure details for each project.

SPLICES: Splices for steel piles and shell piling shall be in accordance with details shown on this sheet and the Standard Specifications.

For integral pile bent abutments and piers, if a pile splice is required, do not locate the pile splice within a region extending 2'-0" above and 10'-0" below the bottom of the concrete web wall. For abutments, locate the pile splice at least 10'-0" below the bottom of concrete.

With the approval of the Engineer, one splice per bent may be allowed in the region described above without testing. If additional splices are anticipated, based on the geology, the Contractor will add a sufficient amount to the bottom of pile, prior to driving, so that the splice is below the regions described above in the completed pile.

† For integral pile bent abutments and piers, if a splice is located within the regions described above, then the Contractor will test the welds by Radiograph (RT) test methods. Repair and retest any welds not passing the test(s). Each weld tested will have written confirmation of results. Report these results to the Engineer. This work is not paid for directly, but is subsidiary to "Piles".

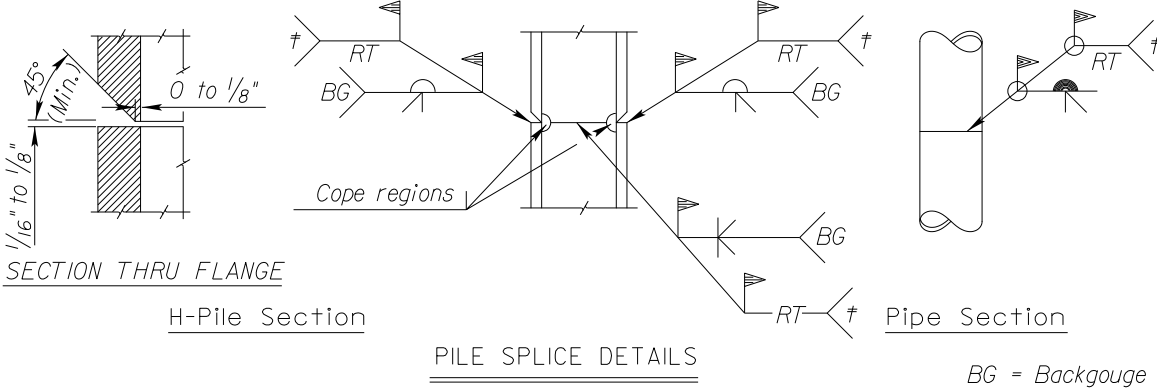
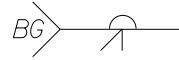


Figure 2 Bridge Standard BR110 Pile Splice Details

The Standard Pile Details (BR110) detail shown in Figure 2 specifies requirements for pile splice welds. One splice is allowed in the restricted region shown in Figure 1, or described in Figure 2, to allow for inconsistencies in the geology across each substructure element. The first splice made within the restricted region should indicate to the contractor the remaining pile should be spliced before they are driven. Standard pile splices that will not fall within the restricted region will only require the standard pile splice weld. However, the second splice, and any additional splices falling within the restricted region in the same substructure element will require more verifiable welding procedures and UT testing. The contractor may elect to excavate below the restricted region, cutoff the pile in order to weld a section below the restricted region that will only require a standard field splice.



Black Flag: Field operation.



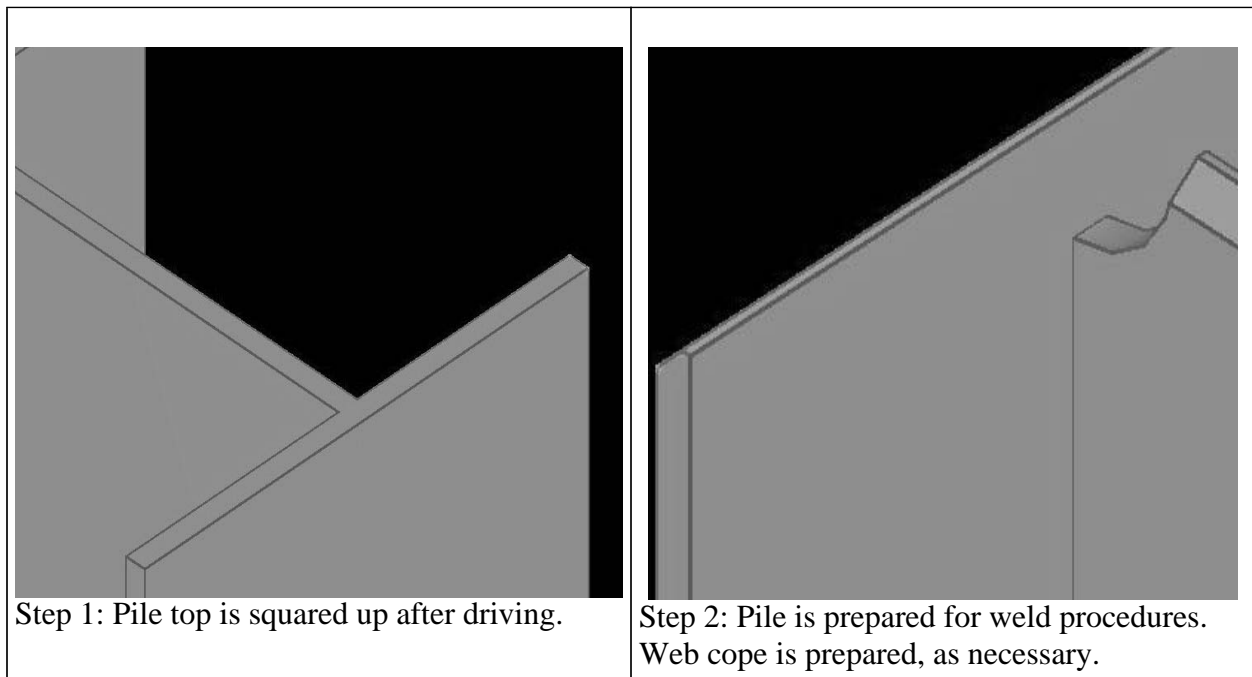
Begin with a backer weld; back gouge (BG) opposite side; finish with groove weld.



Cope required on additional splices within restricted region for testing purposes.

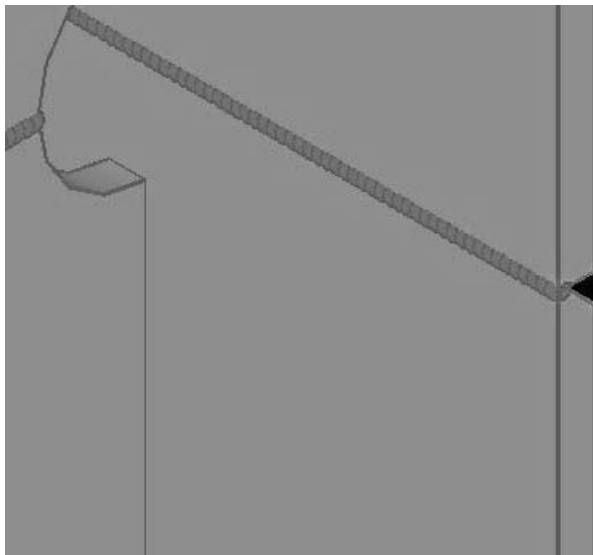
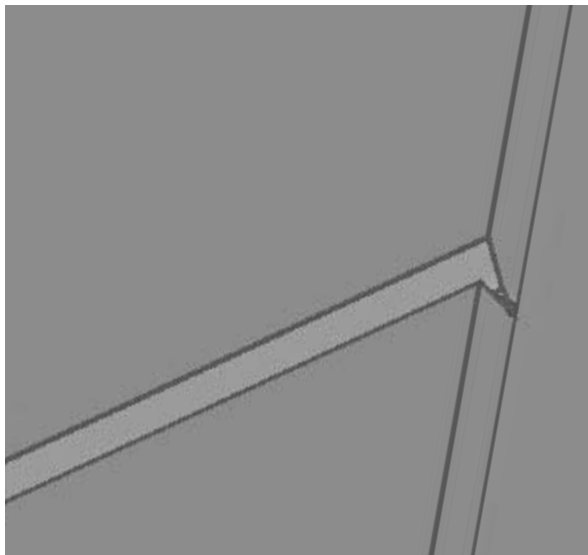
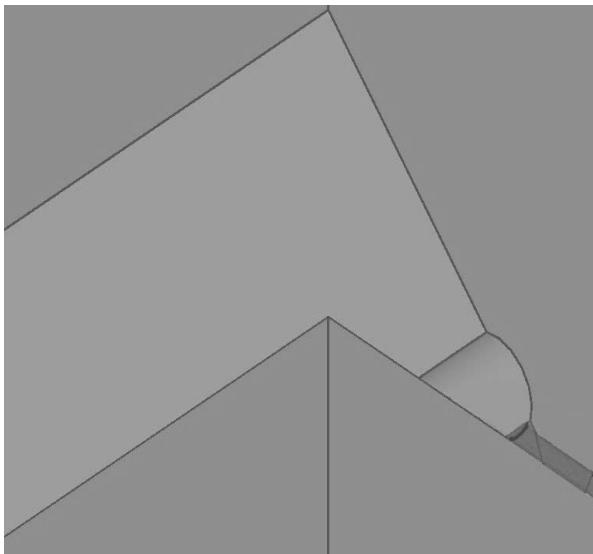
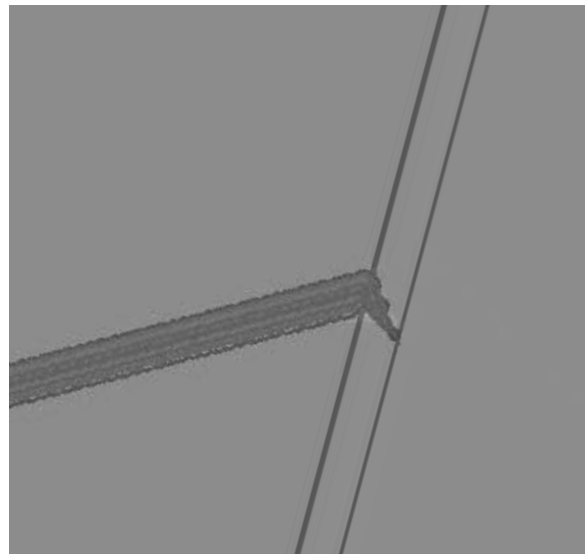


Radiograph Weld testing required on additional splices within restricted region.



Step 1: Pile top is squared up after driving.

Step 2: Pile is prepared for weld procedures. Web cope is prepared, as necessary.

	
<p>Step 3: First backer welds are made on each flange and on the web.</p>	<p>Step 4: Back gouge backer welds to remove weld impurities.</p>
	
<p>Close up image of back gouge of backer weld. Also shows plate prep for pile splices.</p>	<p>Step 5: Place remaining welds (multiple pass) and remove slag/impurities between passes.</p>

### 5.3.3. Types of Piles



**Figure 3 Pile Points**

**Steel Piles:** Steel piles are generally rolled H-pile used in point bearing. H-pile are available in many sizes, and are designated by the depth of the member and the weight per unit length. For example, an HP 12X74 is an H-pile which is 12" deep and weighs 74 pounds per foot. H-piles are well adapted to deep penetration and close spacing due to their relatively small point area and small volume displacement. They can also be driven into dense soils, coarse gravel and soft rock without damage. In some foundation materials, it may be necessary to provide pile points (Figure 2) to avoid damage to the pile. In some instances it may become necessary to increase the length of H-Pile by welding two pieces together. If this is the case, splicing must be done in accordance with KDOT specifications.

KDOT primarily utilizes Steel H-Pile. However, the following types of pile may be used on bridges in Kansas.

**Cast-in-place pipe pile:** Cast-in-place pipe pile are considered as displacement (friction) type pile. Closed-end pipe piles are formed by welding a watertight plate on the end to close the tip end of the pile. The shell is driven into the foundation material to the required depth and then filled with concrete. Thus both concrete and steel share in supporting the load. After the shell is driven and before filling with concrete, the shell is inspected internally its full length to assure that damage has not occurred during the driving operation. Pipe pile may be either spiral or longitudinally welded or seamless steel. Pipe piles are normally used in foundation footings. Their use for above ground pile bents is not recommended. Pipe pile are considered concrete pile for bidding and on the Standard Pile sheet.

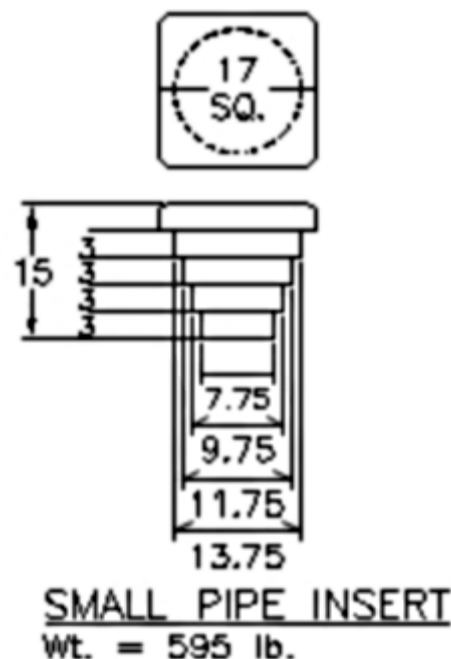
**Timber Piles:** Timber piles are used for comparatively light axial and lateral loads and where conditions indicate they will not be damaged by driving. Timber piles are rarely used on permanent bridge structures today, but they are used for temporary structures such as falsework construction. Care shall be taken when driving falsework piling to avoid underground utilities. For permanent installations, untreated timber pile is used below water line (pile will be continually wet) and treated timber at all other locations. Untreated pile may be used on temporary structures. Pile points for timber pile are unnecessary unless hard driving is anticipated.

**Concrete Piles:** Concrete piles come in precast, prestressed, cast-in-place, or composite construction form. Composite concrete piles are very rarely used in KDOT construction and therefore are not discussed in this manual.

- **Precast piles:** Precast piles are cast at a production site and shipped to the project site. The Contractor should take special care when moving these piles as not to create tension cracks. The pickup points on these piles should be as shown on the shop drawings.

- **Prestressed Piles:** Prestressed piles are produced in the same manner as a prestressed concrete beam. The advantage of prestressed piles is their ability to handle large loads while maintaining a relatively small cross section. Also, a prestressed pile is less likely to develop tension cracks during handling.

- **Cast-In-Place-Piles:** Cast-in-place pressure grouted piles are constructed by drilling with a continuous-flight, hollow-shaft auger to the required depth. A non-shrinking mortar is then injected, under pressure, through the hollow shaft as the rotating auger is slowly withdrawn. A reinforcing steel cage is placed in the shaft immediately after the auger is withdrawn. When a shell or casing is used the contractor must make sure that the inside of the casing is free of soil and debris before placing the concrete. This system is used when hammer noise or vibration could be detrimental to adjacent footings or structures.



**Figure 4 Pipe**

### 5.3.3.1 Basis of Acceptance (Materials)

Material for H-Pile and Steel Shells for Cast-in-Place Concrete Piles are covered by a Type A certification. With approved certification, the field Engineer may accept the piling provided a visual inspection shows that it meets dimensional requirements and that it can be identified with the mill test report by means of heat lot numbers painted or stamped on each piece.

### 5.3.3.2 Pile Order Lengths

The length and type of pile required by plan is given in a box under the Summary of Quantities on the General Notes and Quantities Sheet. The location and plan length for each pile is given on the elevation view of the geology sheet. The Contractor will most likely provide slightly more pile than required by the plans. This additional length is to account for any pile which is damaged during driving.

KDOT's geology section may require the ideal length of pile to be determined in the field by driving one or more test piles. This will occur when the founding material is fractured, less competent than anticipated or otherwise variable. The Field Engineer may require additional test piles to be driven if sufficient information is not provided from the plan quantity and location for test pile. Typically one test pile per bent is all that is needed. The Contractor will no longer be required to wait to order pile until after the required test pile(s) are driven. The primary use of the test pile is now to verify the subterranean geology (Log of Continuous Pile form), elevations and soil types, which has been provided by the Geology section.

### 5.3.4 Pile Driving Equipment

This section is governed by **Section 151.30** of the **Standard Specifications**

Pile hammers are unique pieces of equipment. They serve two functions. One, they are tools used by the Contractor to drive pile; two, they are measuring instruments used by the Engineer to determine the bearing provided by the piles.

#### 5.3.4.1 Pile Leads:

Pile leads are required for use with all hammer types except the vibratory and sonic power hammers. The leads serve to contain the pile hammer and to direct its alignment, thus ensuring the pile receives a concentric impact with each blow. They also provide a means for bracing long, slender piles until they have been driven to sufficient penetration to develop their own support. It is essential the leads be well constructed to provide free movement of the hammer. For drop hammers, it is essential the leads be straight and true to prevent restrictions to free fall which would reduce the energy delivered.

There are several types of leads: underhung leads (pinned to the tip of the crane boom); extended 4-way leads (like the underhung lead, but extending vertically above the top of the boom); and swinging. Swinging leads are the most commonly found on Kansas bridge projects. There are usually two stabilization points which provide stability to the bottom of the leads. The leads are then held plumb or to the proper batter by a crane line. The leads are required to be long enough to accommodate, at a minimum, the pile length plus the length of the hammer. It is generally good practice to use a somewhat longer length as a contingency.

#### 5.3.4.2 Pile Cap (Helmet):

Driving different types and shapes of pile requires different types and shapes of pile caps. For standard H-pile or sheet pile, the specifications require grooves, or extended tabs, at the bottom of the cap to hold the pile in alignment with the axis of the hammer. The grooves or tabs for driving H-pile, or sheet pile, must be a minimum dimension of three inches. The cap required for driving pipe pile must have an insert into the top of the pipe a minimum of six inches. The depths are different because pipe pile are only manufactured using 36ksi steel, much weaker than the 50ksi H-pile, and the six inch requirement offers additional alignment accuracy while driving. If a pipe pile were misaligned and struck with the hammer causing damage at the top of the pipe, the Contractor would have a very difficult time squaring the top of the pipe in the field.

Pipe pile inserts typically have several stepped cylinders to allow one cap to be used to drive several sizes of pipe. The Pipe Pile detail in Figure 4, the insert would be acceptable to drive pipe pile varying in size from a 14" diameter down to a 10" diameter pipe. In accordance with the current specifications a minimum of 6" (2 stepped 3" cylinders) must be inside the pipe pile during driving operations.

The weight of the helmet is not included in the weight of the striking part of the hammer (W). The helmet weight is included in the cap or anvil weight calculation (X) in the appropriate pile driving equation.

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### 5.3.4.3 Types of Hammers:

**Drop hammer / Gravity hammer** – This is the original pile driving hammer. It consists of a steel ram that is guided within a set of leads. The hammer is raised to a certain height and allowed to drop on top of the pile, thus producing the driving reaction. This type of hammer is most often used for driving falsework pile, but sometimes it is used for driving production pile, especially shorter piling. It has the disadvantage of slow operation and ram velocity. If a drop hammer is used for production pile, it is generally necessary to provide a steel cap and shock block over the pile during the driving.

For timber piles the hammer weight shall not be less than 2000 lbs, and preferably not less than 3500 lbs, and the drop will not exceed 12'. When the contractor wants to use a gravity hammer on steel and concrete piling, the hammer must weigh at least 3500 lbs and the drop still must not exceed 12'. In no case will the hammer weigh less than the pile plus the cap. In addition, the falling weight must move within a guide.

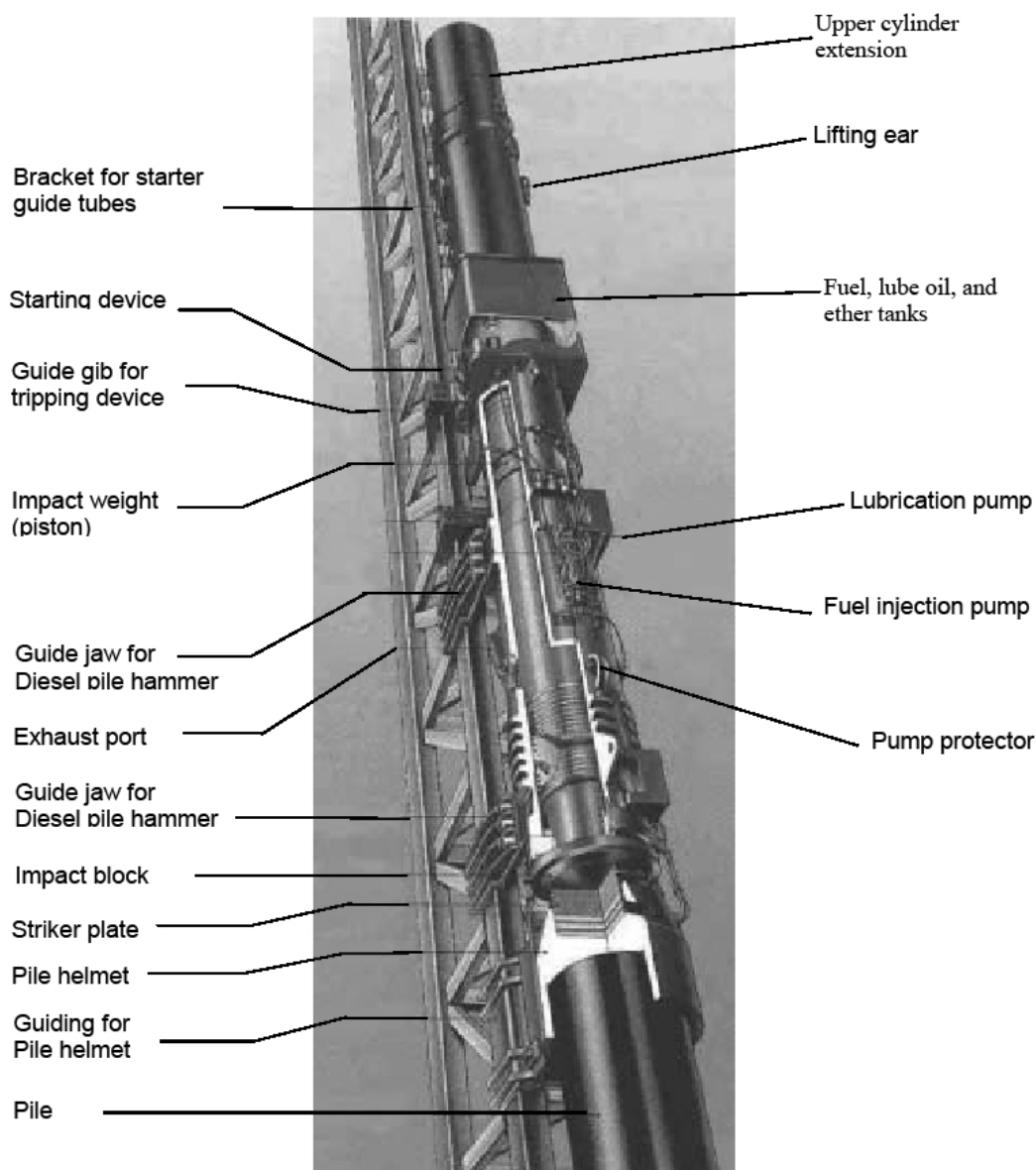
The energy provided by a drop hammer is simply calculated by multiplying the weight of the ram by its vertical drop.

**Single acting power driven hammer** – Hammers of this type are basically power gravity hammers. The difference between a gravity hammer and a single acting power hammer is that the ram (striking part) is encased in a steel frame work and is raised by steam or compressed air rather than by the crane load lines. The frequency of the blows is also considerably higher than a drop hammer. The ram mass is usually greater than a drop hammer and the vertical travel is usually less than that of a drop hammer. Any type of power hammer is usually more efficient than a drop hammer because there is less time between blows for the soil to set up around the pile. A typical hammer of this type utilizes a ram weight of 5000 lbs with a 3 ft drop. It is adequate for most pile less than 70 feet in length. The energy of this type of hammer is calculated exactly like the drop hammer.

**Double Acting Power Driven Hammer** – The ram is raised by steam or compressed air, as in the case of the single acting power hammer. When the ram approaches the top of its stroke a valve is opened into a chamber at the top of the cylinder allowing high pressure air or steam into the cylinder forcing the ram downward. Some double acting hammers utilize a light ram, operating at a high frequency, to develop the energy blows comparable to those developed by heavier, slower acting hammers. The advantage of the lighter ram hammer is that there is less time between blows for soil to re-settle against the pile, thus increasing the driving efficiency and decreasing the drive time. The energy is generally related to frequency and is obtained by referring to the manufacturer's specifications. The manufacturer's rating is a maximum rating and is probably never obtained in the field. Therefore, KDOT specifications require a 20 percent reduction in rated energy for bearing computation.

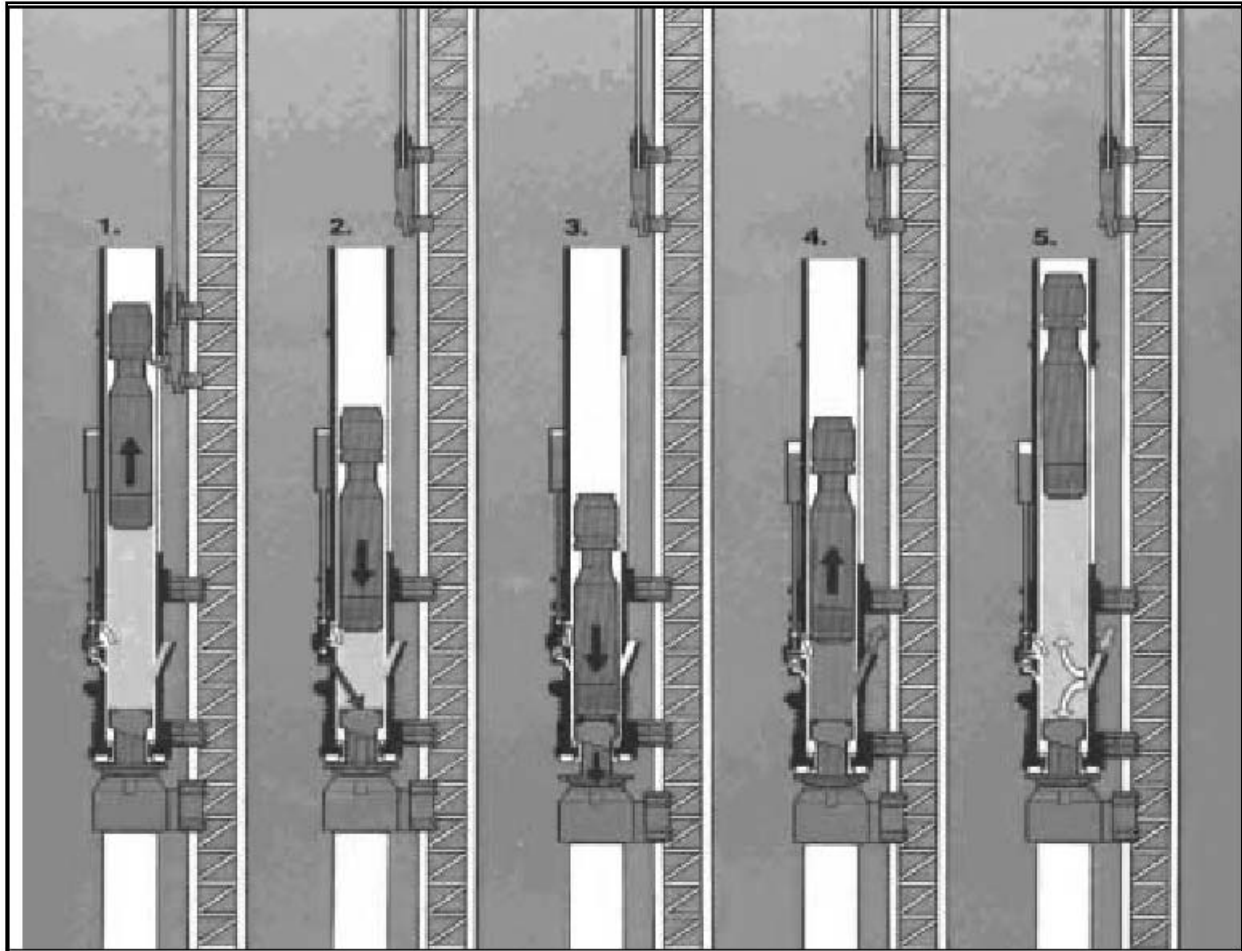
**Diesel Power Driven Hammers** – Single acting diesel hammers are probably the most common type found on bridge projects in Kansas. They are simply a one cylinder diesel engine consisting of a steel cylinder containing a ram and an anvil. The ram is raised initially by an outside power source (crane) and dropped. As the ram drops, it activates a fuel pump, which injects fuel into a

cup in the top of the anvil. The ram continues down blocking the exhaust ports and compressing the air in the combustion chamber. A ball on the end of the ram, mating closely with the cup in the anvil, forces the fuel into the hot compressed air between the ram and the anvil. The fuel then explodes forcing the ram up and forcing the anvil, and in turn, the pile down. Three common diesel hammers are: Delmag, M.K.T. and Link Belt. The Delmag and M.K.T. are single acting hammers, operating as described above. Link Belt hammers are double acting. Double acting hammers operate in the same way as a single acting hammer except that there is a chamber at the top of the cylinder which provides a cushion of air which is compressed as the ram moves upward. As the ram reaches the top of its stroke the pressure in the chamber provides force in addition to gravity to the ram for the downward stroke. The most noticeable difference between a single acting hammer and a double acting hammer is the frequency of the blows. The double acting hammer will operate at about twice the frequency of the single acting.





**Vibratory and Sonic Power Driven Hammers** – These are the most recent developments in pile hammer technology. They are comparatively heavy, requiring handling equipment of greater capacity than required for conventional pile hammers. The Vibratory Hammer vibrates the pile at frequencies and amplitudes which tend to break the bond between the pile surface and the adjacent soils, thus delivering more of the developed energy to the tip of the pile. The Sonic Hammer operates at a higher frequency than the vibratory hammer, usually 80 to 150 cycles per second. At this frequency, the pile changes minutely in cross sectional dimension and length with each cycle, thus enlarging the cavity then elongating the pile. The matter of determining the pile bearing values for these hammers is a problem. Often the vibratory hammer is used to position the pile to plan tip elevation, then a diesel hammer is used to drive the pile to plan bearing.



**1. Raising the piston (starting).** For starting the diesel hammer, the piston (ram) is raised by means of a mechanical tripping device and is automatically released at a given height.

**2. Injection of diesel fuel and compression.** As the piston falls through the cylinders, it activates a lever on the back of the fuel pump, which injects a measured amount of diesel fuel on to the top of the impact block. Shortly after this, the exhaust ports are closed.

**3. Impact and atomization.** Compressing all the air /fuel between the exhaust ports and the top of the impact block, the piston continues falling until it strikes the top of the impact block. The

heat generated by the compression of air, in the presence of atomized fuel, causes the explosion of the fuel, throwing the piston upward and forcing the impact block downward against the pile.

**4. Exhaust.** While moving upwards, the piston will pass and open the exhaust ports. Exhaust gases will escape and the pressure in the cylinder will equalize.

**5. Scavenging.** The piston continues its upward momentum, which draws in fresh air for the next cycle, cools the cylinders, and releases the pump lever. The pump lever returns to its starting position, so that the pump will again be charged with fuel. Gravity stops the upward motion of the piston and it starts falling through the cylinders once again.

#### **5.3.4.4 Power for Hammers:**

Except for self-contained power source hammers, such as diesels, vibratory and sonic hammers, an outside power source is required for power-driven hammers. Years ago, steam was the primary outside power source, but currently air compressors are the most common source of power. Regardless of source, adequate power must be supplied if hammers are to function properly. Insufficient power will result in a hammer that operates at something less than specified stroke or frequency.

#### **5.3.4.5 Diesel Hammer Terminology:**

##### **Energy Range:**

The potential energy for single acting hammer is the product of ram weight and stroke; whereas, for double acting hammers, the force resulting from "bounce chamber pressure" is added to the gravitational component. Some manufacturers may include the effects of the explosive force to the hammer potential energy.

For inclined pile driving, only the vertical component of the stroke should be used in computing hammer potential energy.

Example: Energy is 75,230 ft-lbs, batter is 3:12.

Energy Vertical Component =  $75,230 * \frac{12}{13} = 70,073$

##### **Model:**

This is the model name designation given by the manufacturer to each hammer. Usually, it provides some description of the hammer (e.g., Delmag D30 hammer has a ram weight of 6600 lbs).

##### **Manufacturer:**

The name of the manufacturing company.

##### **Type:**

Single acting hammers are open ended at the top while double acting hammers are closed ended. Single acting hammers allow the ram to travel outside the cylinder which makes it visible for inspection of the stroke. Double acting hammers utilize a bounce chamber for increasing the hammer rate of operation. The ram is not visible in a double acting hammer.

**Blows per Minute:**

Number of strokes per minute. For single acting hammers, the rate can be empirically correlated to the stroke. The hammer rate depends on many factors including but not limited to, the hammer, the type and length of pile, as well as soil conditions. The height of the stroke of a **single acting** diesel hammer can be computed from the following equation:  $H = 0.04 * t^2$ . Where H is the height of the stroke in ft., and t is the length of time in seconds to record 10 strokes.

**Weight of Striking Part:**

This is the weight of the part of the hammer that actually impacts the pile. This is commonly known as the “ram or piston”. Hammer rated energy and general effectiveness is a direct function of the weight of its striking part. In some cases, this weight is indicated as part of the hammer model designation.

**Total Weight:**

This is the total weight of the hammer. This value is important in sizing the crane, transportation requirements and other aspects involving the hammer.

**Hammer Length:**

This is the total length of the hammer in its normal operating configuration. This excludes any accessories which may be present between the hammer and the pile head.

**Maximum Stroke:**

Maximum attainable stroke. Values obtained under favorable controlled conditions. Strokes under common field conditions vary depending on hammer mechanical condition, cushion and pile elastic effects, soil resistance and general hammer-cushion-pile-soil dynamic compatibility.

**Jaw Dimensions:**

Dimensions of the hammer guides which interface with the leads. All diesel hammers have “female” type jaws and most have provisions for changeable guides.

**Fuel Consumption:**

This is the amount of fuel (diesel) per hour that a hammer might consume. Actual amount is subject to operating variations. For proper hammer function, the appropriate type of fuel must be used.

**Ram (Piston):**

This is the internal mass that moves up and down in the cylinder. The ram masses for different hammers are given in the appendix at the end of this chapter.

**Helmets (driving caps or anvil blocks) for steel piling:**

These are provided for use with standard bases when driving sheet pile or H-pile. The upper ring is filled with a cushion material.

**Cushion Material:**

Cushions soften the sharp blow of the hammer and distribute the load evenly.

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**Follower:**

Followers are placed between the top of the pile and the hammer when it is necessary to drive the head of pile below the reach of the hammer. Using followers introduces an additional uncertainty to the dynamic pile equations. Followers should not be used without permission from the District Engineer.

**5.3.5 KDOT Specifications for Hammer Sizes:****Section 151.30****(a) Hammers for Timber Piles.**

Gravity hammers for driving timber piles shall have a mass not less than 2,000 lbs and preferably not less than 3,500 lbs. The fall shall be so regulated as to avoid injury to the piles, and in no case shall exceed 12 feet. When a steam or diesel hammer is used the total energy developed by the hammer shall be not less than 6,000 foot-pounds per blow.

**(b) Hammers for Steel Piles, Steel Sheet Piles, and Shells for Cast-in-Place Concrete Piles.**

Gravity hammers for driving steel piles, steel sheet piles and shell piles shall have a mass not less than 3,500 lbs. In no case shall the gravity hammer weigh less than the pile being driven plus the weight of the driving cap. All gravity hammers shall be equipped with hammer guides to ensure concentric impact on the drive head or pile cushion. The fall shall be so regulated as to avoid injury to the piles and in no case shall exceed 12 feet. Steam hammers or diesel hammers for driving steel piles, steel sheet piles, and shells for cast-in-place concrete piles shall be of such size that the rated gross energy of the hammer in foot-pounds shall be not less than 2½ times the weight of the pile in pounds. In no case shall the hammer develop less than 6,000 foot-pounds per blow.

*Contractor certified weights may be used for the weight of gravity hammers.*

**(c) Hammers for Prestressed Concrete Piles.**

Unless otherwise provided, prestressed concrete piles shall be driven with a diesel, steam or air hammer which shall develop an energy per blow at each full stroke of the piston of not less than one foot-pound for each pound of weight driven. In no case shall the energy developed by the hammer be less than 6,000 foot-pounds per blow.

**(d) Vibratory Hammers.**

Vibratory hammers may be used only when specifically allowed by the Contract documents or in writing by the Engineer. Vibratory hammers, if permitted, should preferably be used in combination with pile load testing and re-tapping with an impact hammer. In addition, one of every ten piles driven with a vibratory hammer shall be re-tapped with an impact hammer of suitable energy to verify that acceptable load capacity was achieved.

**(e) Hammer Cushion.**

All impact pile driving equipment except gravity hammers shall be equipped with a suitable thickness of hammer cushion material to prevent damage to the hammer or pile and to insure uniform driving behavior. Hammer cushions shall be made of durable, manufactured material, which will retain uniform properties during driving. *Except for use with a gravity hammer, all*

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*wood, wire rope, and asbestos hammer cushions are specifically disallowed and shall not be used.* A striking plate shall be placed on the hammer cushion to insure uniform compression of the cushion material. The hammer cushion shall be inspected in the presence of the Engineer when beginning pile driving at each substructure element or after each 100 hours of pile driving, whichever is less. Whenever there is a reduction of hammer cushion thickness exceeding 25 percent of the original thickness, the hammer cushion shall be replaced by the Contractor before driving is permitted to continue.

The following are acceptable types of hammer cushion material. If the contractor proposes a material type that is not included in this list, contact the Bureau of Materials and Research.

**Micarta (Conbest)** – This is an electrical insulating material composed of fabric and phenol. It must be replaced when it begins to disintegrate or when it delaminates into various layers.

**Nylon (Blue or other colors)** – This material comes in 2" thick blocks. Occasional vertical cracking is not detrimental. However, after the cushion develops horizontal cracks, it should be replaced.

**Hamortex** – This material consists of metallized paper reels. It has good engineering properties but needs attention as it may compress or disintegrate.

**Force 10, Forbon, and Fosterlon** – These materials are provided by manufacturers of pile driving equipment.

**Aluminum** – Aluminum is often used to separate layers of softer cushioning material. The aluminum does no cushioning itself; however, it is thought to extract the heat from the cushion stack. Once the aluminum is deformed or broken, it should be replaced.

**NOTE:** Wood (plywood or hardwood) will probably remain the most common type of material used as a pile cushion for gravity hammers.

### 5.3.6 Pile Driving Mechanics:

The length of stroke or fall of the hammer ram is a factor that influences the energy delivered by the hammer. As mentioned above, for a single-acting hammer,

Energy = (weight of ram) X (height of fall)

The weight of the ram is an important factor, since a heavy-ram impact hammer working on a short stroke is more effective in driving a pile than a light-ram long-stroke hammer. The weight of the ram, the length and speed of the stroke, and their relation to the weight of the pile is important to the proper driving of the pile. In theory, a pile can be of such a length that all the energy, which it receives from a hammer blow, is absorbed into its mass. Under these circumstances, a blow of the hammer will not advance the point of the pile. To appreciate this statement, it is necessary to understand what happens when the hammer hits the pile.



A hammer blow causes the pile to compress and rebound. This compression and rebound travels through the pile from the head down to the tip in the form of a wave, thus driving the pile into the ground. As the wave travels through the pile, energy is lost. In a short pile, this effect is negligible and can be disregarded. In a long pile, the energy losses due to the temporary compression of the pile can be considerable. Using an undersized hammer results in a driving resistance which is higher than the actual resistance, and thus a lower bearing capacity. For this reason, it is absolutely necessary that heavy-ram hammers be used in the driving of long piles.

The size of the ram should be gauged for the work that has to be done. A heavy-ram slow-acting hammer is more effective than a light-ram fast-acting hammer in driving a pile of a given weight, even though the two hammers may have the same rated energy per blow. The heavier-ram hammer will drive the pile deeper with each blow and will produce a more accurate bearing value than the equally rated lighter-ram hammer. As a general rule, pile driving should employ the heaviest-ram hammer that will not damage the pile. If the ram weight exceeds twice the pile weight, the pile material should be checked for resistance to impact.

### 5.3.6.1 Reviewing the Information on the Plans:

**Type of pile:** Called out on the General Notes Sheet in a box under the Summary of Quantities (example: Use only HP10x42). This designation identifies the pile to be used as an H-Pile, with 10 indicating the long dimension of the web is 10 inches, and the pile has a weight of 42 pounds per linear foot.

**Pile Length:** Called out on the General Notes Sheet, Construction Layout and Geology Sheet (example: 9 @ 40'-0"). This notifies the inspector there should be 9 pile at least 40 feet long used in the substructure element.

**Pile Location:** Geology Sheet Plan View

**Pile Orientation:** This locates the direction of the web (example: strong axis or weak axis)

**Pile Batter:** This is the slope of the pile as driven (example: 3/12 = 3" horizontal per 12" vertical.). Unless shown otherwise on the plans, pile shall be driven plumb.

**Design Pile Load:** This is the load the bridge designer and checker agreed upon based on all combination of live load, dead load, wind, water etc.

**Allowable Pile Load:** Found in the general notes, this is the minimum required driving resistance to be accepted by the Engineer. The maximum driving resistance allowed will also be shown within this note.

**Depth of Pile:** The General Notes Sheet will include a note directing the Contractor to drive the pile to penetrate or bear upon a specified formation. Or, the note will direct the contractor to drive to a specified depth and resistance. The Geology sheets will show the formations and their approximate elevations

The tip elevation is not called out explicitly, but may be estimated from the top of pile elevation and the length of pile specified on the geology sheet.

**Pre-Drill:** The bid item “Pre-Drilled Pile Holes” will appear in the Summary of Quantities and the depth of pre-drill will be in the general notes.

**Cut-off elevation (top of pile):** This elevation is shown on the Construction Layout in the profile view. This locates the top of the pile within the pile cap, abutment or pile bent. Usually, the embedment is between 2 feet to 3 feet in an abutment; one foot (1'-0”) in a footing.

### 5.3.6.2 Preparing to Drive Pile

The inspector should check to see if the Contractor’s choice of hammer will provide enough energy to drive the pile to bearing. To do this the inspector needs the hammer specifications. For steel pile to achieve bearing, assume required resistance to be reached at 10 blows per inch. Use this number when checking the adequacy of the hammer. Here is an example of checking the Contractor’s hammer.

Example:

Given: **Diesel Hammer Delmag D12**  
**1 inch per 10 blows, therefore S = 0.1 in./blow**  
 (Assumption based on previous experience)

**From Pile Hammer Specifications:**  
**Piston weight = W = 2750 lbs**  
**Max Height of fall = H = 8.17 ft**  
**Weight of pile cap and/or anvil = 2690 Lbs.**  
 (Contractor provides this information)

**Weight of Pile (HP10x42, length=40 ft.) = (42 lbs/ft.)(40 ft.) = 1680 lbs.**

**X = Weight of Pile + Weight of pile cap and/or anvil = 4370 lbs.**

**P = bearing load = 112,000 lbs (according to general notes in plans)**

$$\text{Analysis: } P = \frac{1.6 W H}{\left(S + 0.1 \left(\frac{X}{W}\right)\right)} \quad \text{Delmag hammer equation, Division 700, Section 704}$$

**Note: the quantity (X/W) shall not be taken less than 1.0.**

**X/W = 4370/2750 = 1.589**

**P must be at least 112,000 lbs. and not greater than 110% (2009 General Notes Revision) of 112,000 lbs.**

**P = (1.6(2750)(8.17))/(0.1+0.1(1.589)) = 138,849 lbs.**

**112,000 < 123200 < 138,849 Hammer is O.K.**

**Use caution as the hammer is capable of overdriving the pile.**

The Contractor’s hammer has been checked. The Engineer should now calculate the actual average penetration per blow for the last 20 blows of the hammer. Below is an example.

Given: **Solve the equation for S given the previous information.**

$$\text{Analysis: } P = \frac{1.6 W H}{\left(S + 0.1 \left(\frac{X}{W}\right)\right)}$$

$$\text{Rearrange and solve the equation for S: } S = \left(\frac{1.6 W H}{P}\right) - 0.1 \left(\frac{X}{W}\right)$$

**Note: the quantity (X/W) shall not be taken less than 1.0.**

$$X/W = 4370/2750 = 1.589$$

$$S = (1.6(2750)(8.17)/112,000) - 0.1(1.589)$$

$$S = 0.16 \text{ in/blow}$$

**So, for the last 20 blows the pile should move (0.16/blow)(20 blows) = 3.2 in.**

**If the pile is driven further than 3.2 inches for the last 20 blows then the pile is NOT to bearing yet, and driving must continue.**

An important note to remember, the Contractor is not allowed to modify his hammer in the field by making the fall height greater in order to achieve more energy. If the Engineer finds the hammer is inadequate the Contractor must use a **heavier** hammer.

The Engineer should mark the pile which is to be continuously logged every 12 inches. Continuous logging will be discussed later in this section.

### 5.3.6.3 During the Drive



**Figure 5 Plumbing an H-Pile**

After the Contractor has the pile “stabbed” and is preparing to drive the pile, make sure the pile is plumb, or battered as shown on the plans (see the photo above). The Standard Specifications require that piles be driven within 1/4 inch per foot of length to the vertical or battered lines indicated on the plans, except that foundation piles more than 3.5 feet long or any piles used in bents shall be driven to within 1/8 inch per foot of length to the vertical or battered lines indicated on the plans. Orient the pile as shown in the plan sheets. Effective for letting from July 2013, a maximum rotation of 10 degrees from plan orientation of the pile is allowed by specifications. The maximum variation on the head of the pile after driving from the position shown on the plans shall be 2" for piles used in bents and 6" for other foundation piles. Bents are rows of pile, for instance in a pier, or an abutment. Misaligned piles shall not be forced into position. It is for this reason that it is so important to position the pile and leads correctly at the beginning of driving operations.

The rotation of a pile can be measured easily by use of a string line. The string line should be placed over the center line or offset parallel to the center line of the foundation being built. Measure the distance from the string line to the two flange tips of each individual pile; for each individual pile subtract the smaller measured distance from the larger measured distance of the flange tips to the string line. The subtraction of the smaller from the larger distance of the flange tip to string line measurement establishes the difference. Once the difference has been calculated for each pile acceptance or rejection of the pile maybe established by looking in the table below. If the difference you have calculated for any pile in the foundation is greater than the maximum allowable difference in the table, that pile is not acceptable and can be rejected. The contractor will then have to propose a solution that is acceptable to the field engineer and the State Bridge Office. (Figure 6 demonstrates the use of a string line for making measurements in the field.)

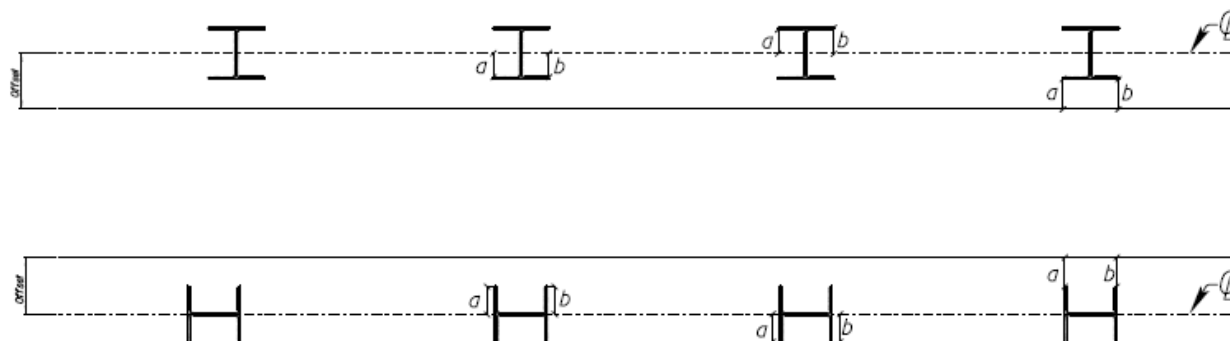



Figure 6 Measuring Rotation of a Pile

Weak Axis Orientation		
Pile Size	Depth (inches)	Maximum Allowable Difference (a-b) (inches)
HP 14x117	14.2	2 7/16
HP 14x102	14	2 7/16
HP 14x89	13.8	2 3/8
HP 14x73	13.6	2 3/8
HP 12x84	12.3	2 1/8
HP 12x74	12.1	2 1/8
HP 12x63	11.9	2 1/16
HP 12x53	11.8	2 1/16
HP 10x57	9.99	1 3/4
HP 10x42	9.7	1 11/16
HP 8x36	8.02	1 3/8



**Table 1 for Rotated Pile**

Strong Axis Orientation 		
Pile Size	Flange Width (inches)	Maximum Allowable Difference (a-b) (inches)
HP 14x117	14.9	2 9/16
HP 14x102	14.8	2 9/16
HP 14x89	14.7	2 9/16
HP 14x73	14.6	2 9/16
HP 12x84	12.3	2 1/8
HP 12x74	12.2	2 1/8
HP 12x63	12.1	2 1/8
HP 12x53	12	2 1/16
HP 10x57	10.2	1 3/4
HP 10x42	10.1	1 3/4
HP 8x36	8.15	1 7/16

**Table 2 for Rotated Pile**

**Plumbing the leads prior to driving:**

If the pile is to be continuously logged the Engineer must log the number of blows per 1 foot of penetration. There are two ways to keep track of the continuous log of driving. The Engineer can observe the 1 foot marks painted on the pile as they are driven below ground, and count how many blows are required to drive the pile from one mark to the next. It is important that the Engineer stand in the same place during the entire drive as to keep the same perspective on the pile marks as they enter the ground.

The second way of keeping track of continuous log of driving is to use a theodolite. The Engineer should set the cross-hairs of the instrument close to the ground level. The Engineer observes through the instrument as driving proceeds and counts the number of blows between the marks on the pile as described above. As the pile nears the plan formation or plan length, the Engineer must monitor the items required to calculate bearing; namely, the average penetration "S" for the last 20 blows (5 for gravity hammers), the length of stroke for single acting hammers and bounce chamber pressure for double acting hammers.

"S" is calculated as follows: A four foot level or straight edge is leaned against the pile during driving, and the pile is marked at the top of the level or straight edge. Then the level is moved away while keeping the bottom end in position. After 20 blows the level is leaned back against the pile and the pile is marked again. The distance between the marks is measured and then divided by the number of blows to give the average penetration per blow.



**Figure 7 Mark pile as Driving Continues**



**Figure 8 Mark After Specified Blows**



**Figure 9 Measure Displacement**



**Figure 10 Continue Driving Until Bearing**

The length of stroke for a single acting hammer can be monitored two different ways. The simplest way is to visually note the top of the hammer at the top of the stroke in relation to some premeasured reference. The reference is usually a 2x4 attached to the hammer and marked in relation to the top of the hammer at rest. Another way is to compute the theoretical stroke length based on the time required for a number of blows. This will only work on a warmed up hammer hitting with a consistent rhythm. The length of stroke can be calculated from the following equation:

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$H = 0.04 \times t^2$  Where H is in feet and t is the length of time in seconds to record 10 blows

When the length of stroke / height of fall is known and an average penetration is known, these values are used to compute a bearing resistance as in the example above.

Some time can be saved by programming a calculator so the average penetration and stroke length are input and the bearing resistance is calculated. Once the required bearing is achieved, the Engineer approves the pile and the Contractor may move on to the next pile in the group.

### 5.3.7 Pile Restrike

Drive end-bearing pile, such as HP10x42, until they reach the penetration and bearing value shown on the plans. During driving, the pile will essentially stop penetrating. Driving will stop when the resistance calculated by the pile driving formula is between 100% and 110% of the allowable pile load shown on the plans. If 110% of the resistance calculated using the correct pile driving formula is reached before the plan penetration occurs by two feet or more, contact the regional geologist

Drive friction piles, such as concrete-filled pipe piles and sometimes H-pile, until they attain the resistance shown on the plans. Resistance is built up gradually as the pile is driven, and the additional depth that each hammer blow drives the pile is fairly uniform. For example, over 10 hammer blows, the pile may be driven 3 inches per blow, 30 inches for those 10 blows. If 110% (2009 General Notes Revision) of the resistance calculated using the correct pile driving formula is reached before the plan tip elevation occurs by two feet or more contact the regional geologist.

There are cases where friction piling will not achieve adequate resistance near the formation or driven length specified in the plans, and splicing would be needed to meet the capacity requirements. Rather than splicing additional pile length in these cases, it is possible to let the soil set-up for at least 24 hours. Striking the piling with a warmed up hammer after this 24 hour period may show improved driving resistance. This procedure is called “restrike”. Using a “restrike” test may save considerable pile length. When planning a restrike procedure, contact the regional geology office to see if a PDA is necessary to monitor the pile during driving.

The restrike procedure cannot be used in all pile driving situations. Depending on soil conditions, performing the restrike procedure may not lead to enough of a gain in driving resistance to prevent the need for splicing and further driving. In some soils, relaxation can occur, which would lead to a loss in driving resistance, although this is rare in Kansas. Using restrike on friction piling in a potential scour area requires weighing many factors. Do not use restrike to reach penetration before the plan length has been driven. The length of pile below a scour line must be sufficient to support the structure if the material above the scour line is lost. Contact the regional geology office and State Bridge Office before using restrike.

The term “test pile” in the following procedure may refer to a production pile or the “Test Pile” and “Test Pile (Special)” bid items discussed in Section 5.3.2. The restrike procedure is as follows:

- All but the test pile are driven to within two feet of the plan elevation. It is recommended that the test pile be an exterior pile. All pile driving on the test pile bent should cease a minimum of 24 hours prior to the test or as directed by the regional geologist.
- If a PDA is used, drive the test pile to within 6' to 7' of the plan elevation in order to allow room for the PDA attachments.
- All of the piling should be allowed to sit undisturbed for at least 24 hours.
- Prior to starting the restrike procedure, warm the hammer up to operating temperature at a location as far away from the pile group as practical, such as on a dummy block, a different pile bent, or an opposing exterior pile. Do not warm-up the hammer on a pile in the bent to be tested, without the approval of the regional geologist.
- The test pile is then immediately restruck with the warmed-up hammer for 30 blows or until the piles penetrate an additional 4", whichever comes first.

The bearing capacity is computed based on the penetration of the first 5 to 10 blows. The penetration used in the bearing formula is the penetration for 5 blows multiplied by 4, or the penetration for 10 blows multiplied by 2. It is important that the first 5 to 10 blows are used to calculate the bearing capacity; because, by the time 20-30 blows are reached, the soil has been disturbed and set-up is negated. The resistance is then essentially the same as before the restrike.

If the first 5 to 10 blows indicate that the bearing resistance has been reached, no further driving is necessary for the test pile and the remaining pile in the bent can be driven to the pile tip elevation determined from the test results or as directed by the regional geologist. If the bearing resistance has not been reached, driving should resume, which may require additional pile length. If the calculated bearing capacity is within 5% of the required bearing capacity, the piling must again be left undisturbed for an additional 24 hours before the restrike procedure can be performed again.

It is important that all pile restrikes be performed with a hammer that is warmed-up and operating efficiently before being used to restrike the test pile. Equally important is that no driving is done near the test pile during the set-up period, which would disturb the surrounding soil and negate the test results.

Payment for the piling installed will depend on the bid items. The restrike procedure may be initiated by the Contractor or by the Engineer. The regional geology office's recommendation to proceed is required. The restrike procedure is an option to meet the design intent and no additional payment is made for the procedure. Payment is for in-place piling as per specification.

If the "Test Pile (Special)" item is on the plans, the piling recommendations must come from the PDA results.

### **Hammer Performance**

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Hammer performance is important in determining bearing resistance in that, if the hammer is not performing properly the bearing resistance can not be computed accurately. Following are some possible problems and indicators of those problems.

Pre-ignition means that the fuel combusts before impact occurs. Thus, pre-ignition reduces the ram impact velocity and cushions the impact. When a hammer pre-ignites, the full ram energy is not transmitted to the pile, but rather returned to the ram, causing the stroke to be very high. The low energy in the pile results in a high blow count. Pre-ignition, therefore, has all the symptoms of a hard driving condition at a potentially low soil resistance. Overheated hammers often pre-ignites after long periods of hard driving when lubrication oil starts to burn or fuel vaporizes prematurely due to heat.

The following are signs of pre-ignition in hard driving:

- Black smoke while strokes are high.
- Flames in exhaust ports.
- Blistering paint (due to excessive heat).
- No obvious metal to metal impact sound.

If pre-ignition is suspected, then the hammer should be stopped, allowed to cool down for an hour, and then restarted. Stroke and blow count should then be accurately monitored. If both stroke and blow counts are lower during the first two minutes after the resumption of driving, then proof exists of a pre-ignition condition before the cooling period was established.

Most atomized fuel injection hammers have some design pre-ignition. The fuel usually starts to burn when the ram is a small distance above the impact block. If the ram descends slowly, the pressure has more time to act on the ram than in the case of a high stroke, when the ram reaches the impact block within a short time. Thus, in hard driving, with high strokes and, therefore, high ram velocities, “design pre-ignition” is of little consequence.

*Water in the fuel* will cause the exhaust to be white and the impact of the hammer will sound hollow.

*Clogged fuel lines* will cause little or no exhaust smoke.

*A malfunctioning fuel pump* is indicated by inconsistent ram strokes and gray or black exhaust smoke.

*A malfunctioning fuel injector* is indicated by inconsistent ram strokes and gray or black exhaust smoke.

*Low lubricating oil* is indicated by lower than normal blows per minute.

*A malfunctioning oil pump* is indicated by lower than normal blows per minute.

*Water in the combustion chamber* is indicated by white exhaust smoke and hollow sounding impacts.

*Worn piston rings* are indicated by short strokes. When the pile is near the required resistance the hammer stroke should be near the maximum published height.

*Overheating* is indicated as above in the pre-ignition section.

### 5.3.8 Log of Pile Driving

#### **Log of Continuous Pile Driving:**

A Continuous Pile Driving Record should be recorded for a representative pile on each abutment and pier footing on a structure. The record should be inclusive from the beginning of the drive to the final bearing of the pile. For structures under 755 feet in length, the above information will be required on two footings only. One of the piles should be in an abutment footing and the other in a pier footing near the opposite end of the structure. If the structure has no piling in the pier footings, then the record should be made for a pile in each abutment footing.

For structures over 755 feet in length, the continuous record stipulated above will be required on three footings, one on an abutment and two on pier footings. If the piers have no piling then the information will be recorded on one pile from each abutment.

The log of Continuous Pile Driving records are the same as records obtained for structures that have the bid item of test piles, and will, therefore, not need to be recorded in cases where structures include the bid item of test piles.

The State bridge Office plots the pile driving log on the Geology Sheet of the as-built plans for historical purposes.

#### **FORM 217 – LOG OF PILE DRIVING**

The form shown below can be found in the KDOT forms warehouse:

(English Version): <http://www.ksdot.org/burdesign/bridge/constructionmanual/217us.xls>

1.FORM POLICY: Complete and submit this report as soon as all piling is driven in an abutment or pier. Also, complete and submit this report for all test piling immediately after driving each test pile.

#### 2.PREPARING REPORT:

##### A.General Information:

1. “Type of Hammer” – Enter the brand and model of the hammer used.
2. “Hammer Weight” – Enter the weight of the striking part of the hammer (i.e. piston or ram) as denoted on the specification plate on the hammer or in Figure IV-1 of the Construction Manual (4.03.08).



3. “Cap and/or Anvil Weight” - Enter the weight of any cap and/or anvil to be used while driving pile.
4. “Energy Rating (ft-lbs)” - Enter the energy rating as denoted on the specifications plate on the hammer, or in Figure IV-1 of the Construction Manual (4.03.08). Also, note the 80% factor in the Standard Specifications (704.04(e)).
5. “County” and “Project” – Enter the name of the county. Enter the project number, if available.
6. “Br. No. and/or Sta.” - Enter the bridge number of the structure for which the piling was driven. Also, enter the station for the structure, **not** the station for the pier or abutment where the pile was driven. For city or county structures that don’t have a bridge number, the station of the structure is sufficient.
7. “Type of Pile” – Enter the entire bid item name for the type of piling used. Examples: PILE (STEEL) (HP10X42), TEST PILE (STEEL) (HP12X57), PILE (PRESTRESSED CONCRETE) (12 in.) or TEST PILE (SPECIAL) (HP10X42).
8. “Plan Note Overdrive %” – A drop down menu will allow the user to select 110 or 150 to determine the maximum resistance allowed based upon the “Piling” note within the General Notes for the project.
9. “Min. Resistance Required” - Enter minimum required bearing as specified under the “Piling” note on the plans. This is **not** to be confused with the bearings listed under the Design Data.
10. “Max. Resistance Allowed” - The maximum bearing is now calculated based upon the value listed under the “Piling” note on the plans. This value is now based upon This is **not** to be confused with the bearings listed under the Design Data.

After filling out the General Information sheet, select the tab associated with the hammer to be used to drive the pile. “Gravity (Steel),” “Air-Steam (Single),” “Air-Steam (Double),” “Delmag & McKierman – Terry,” “Link-Belt” tabs are the hammer types available. Many comments are available all across the new form, and can be read by placing the cursor over the cell with the red triangle in the upper right corner of the cell.

1. “Abutment” **or** “Pier” - Enter the number, taken directly from the design plans, for the abutment or pier where the pile will be driven.
2. “Number, Individual Length, and Total Length of Pile” – Enter the total number of pile in the substructure unit (abutment beam, pier footing, pier bent, etc.), then enter an “@” symbol, the total length of one pile, and the sum of all pile in the unit. (8 @ 45 = 360 ft.)
3. “Plan Cutoff Elev. (ft.)” – Enter the Top of Pile elevation given on the plans for the substructure unit.
4. “Wt. per foot piling (lbs/ft)” – This data can be found in different locations for different types of pile.
  - a. For H-pile, physical properties are in the name. Such as with HP12X53, the 12 represents the long dimension of the web in inches, and the 53 represents the weight per linear foot.
  - b. For steel shell pile, the weight per meter can be found on mill test/lading ticket from the supplier. If that information is not available, some physical properties for steel shell pile are shown in Table 1 at the back of this document.

- c. For pre-stressed concrete pile, if the weight per foot is not given on the test report, the inspector can use a density of **150lbs/ft<sup>3</sup>** to calculate a theoretical weight per foot:
- i. 12 inches square – 150 lbs/ft<sup>3</sup>
  - ii. 14 inches square – 204 lbs/ft<sup>3</sup>
  - iii. 16 inches octagonal – 220 lbs/ft<sup>3</sup>
5. “Type of Cushion Mat’l” – Plywood, oak, whatever material will be used to protect the top of the pile.
  6. “Footing Sketch” – Draw a sketch of the footing with piles numbered to represent the numbers listed in the “Pile No.” column of this form. The north arrow must be shown.

**B. Driving Information:** Measure and report piling length to the nearest one-hundredth of a foot (i.e. 0.01 ft.). Report all elevations to the nearest one-hundredth of a foot (i.e. 0.01 ft.).

1. “Pile No.” – Represents the as labeled in the footing sketch.
1. “Varied Plan Cutoff Elev.” is used if the substructure element is super-elevated and each pile has a distinct pile cutoff elevation. Enter the elevation listed on the plans for each pile so the “Pile Tip Elev.” field calculates correctly.
2. “Actual Length in Leads” – This is the length of pile the Contractor opts to use. This length is used to calculate the weight of the pile for use in the bearing formula, and the length can change as driving operations progress:
  - When driving operations first start, the “Actual Length Placed in Leads” is equal to length of pile placed in the leads. If bearing is not achieved and a splice is required, the **new** value for “Actual Length Placed in Leads” is equal to the original length placed in the leads, **plus** the length of pile spliced on to it.
  - If bearing is achieved prior to splicing the pile and the splice is made solely to achieve plan cutoff elevation, the “Length Placed in Leads” will increase by the amount spliced onto the pile to achieve plan cutoff elevation, and “Ordered and Accepted” will equal the “Length Placed in Leads.” In no case should the “Actual Length in Leads” be less than the “Length Left in Footing” cell.
3. “Ordered and Accepted” – Typically this is the length of pile the Engineer instructs the Contractor to use (i.e. the length of pile indicated on the plans). However, situations do arise where the “Ordered and Accepted” length will differ from the plans:
  - If the length indicated on the plans is too short and additional length is needed to achieve bearing and “Plan Cutoff Elevation”, the Engineer instructs the Contractor how much additional length is to be spliced onto the pile. In which case, the “Ordered and Accepted” length is now equal to the original length on the plans, plus the additional length that the Engineer authorized being spliced.
  - If the Contractor opts to use a longer pile than the Engineer authorized and the additional length, in part or in whole, is needed to achieve bearing and “Plan Cutoff Elevation”, the “Ordered and Accepted” length is equal to the length of pile

left in place. Thus, the “Ordered and Accepted” length and “Length Left in Foundation” are equal.

- If the contract has test piling, the Engineer will determine the “Ordered and Accepted” length from the test pile data.
4. “Spliced after Drive” is used when the contractor drives a length of pile, then splices a section to the top, but does not drive the additional length. The accurate bearing is calculated on the length placed in leads, so do not change this number. If the length spliced onto the pile brings the total to more than the Ordered and Accepted length, the Ordered and Accepted length will be changed accordingly. Cutoff should not be an issue in this situation. The contractor will likely splice on the exact length needed to bring the pile up to cutoff elevation.
  5. “Actual Cutoff” – The actual length of pile cutoff after achieving bearing and “Plan Cutoff Elevation.”
    - The “Actual Cutoff” is not necessarily equal to “Pay Cutoff.”
      - i.If the Contractor elects to use a longer pile than was specified by the Engineer (“Ordered and Accepted”), the length in excess of the length specified by the Engineer is considered “Non Pay Cutoff.” (Example: The pile are supposed to be 20 foot sticks, but the Contractor uses a 40 foot stick on the first pile. Actual Cutoff is measured at 23 feet. This would equal 3 feet of “Pay Cutoff” and 20 feet of “Non Pay Cutoff” if this was the only pile to be driven.)
      - ii.The “Actual Cutoff” from one pile may be spliced in part, or in whole, to other pile. In which case, it will become part of the “Ordered and Accepted Length” on the pile receiving the splice. This depends on the length of pile the Engineer directs the Contractor to use. (Example: From above, the Contractor turns around and uses the 23 foot cutoff pile for the next pile. It is driven to bearing and Actual Cutoff is 8 feet, so Pay Cutoff for this pile is 5 feet, and the Non Pay Cutoff is equal to 3 feet. In total, for both pile, the Pay Cutoff sum is 8 feet and the Non Pay Cutoff sum is only equal to 3 feet, since all of the Non Pay Cutoff from the first pile has been used for the second pile. This prevents the State from paying for Cutoff for lengths of pile eventually used in the structure.)
  5. “Length Left in Footing” is the **PAY LENGTH**, and is the length of pile left after Actual Cutoff is removed.
    - If no splice is made, or a splice is made to extend the pile to achieve bearing, the “Length Left in Foundation” equals the “Actual Length Placed in Leads”, minus the “Actual Cutoff.”
    - If a splice is made solely to achieve “Plan Cutoff Elevation” (i.e. bearing is achieved prior to splice), the “Length Left in Foundation” equals the “Ordered and Accepted” length equals the “Actual Length in Leads.”

6. “Pay Splices” – Enter the number of Pay Splices occurring for the individual pile. This does not include splices made for the Contractor’s convenience.
7. Length Left in Footing” is the **PAY LENGTH**, and is the length of pile left after Actual Cutoff is removed.
8. “Pile Tip Elev.” **typically** is the “Plan Cutoff Elev.” minus the “Length Left in Footing.” However, if the pile is battered, the batter needs to be taken into account to determine the tip elevation.
9. “Stroke (Drop of Hammer)” is observed by the inspector, and recorded in the appropriate column.
10. “Average Penetration” is equal to the penetration in inches for 20 blows divided by 20 blows.
11. “Computed Bearing Power” – Computed by the inspector immediately upon reaching a predetermined point to establish the actual bearing relationship with plan bearing. Even though laptops are routinely used in the field, an inspector should **thoroughly** understand the bearing formula and how to manually calculate the bearing, before a laptop is used.
12. “Range” – This will indicate where the driving process is for the entered data by displaying “Low,” “OK,” or “High” based on the Min and Max bearing numbers.
13. “Totals” – Automatic totals for each column for “Actual Length Placed in Leads”, “Ordered and Accepted Length”, “Actual Measured Cutoff” and “Length Left in Foundation.”
14. “Accepted Length” – Equals the total from the “Ordered and Accepted” column.
15. “Non Pay Cutoff” – Represents the length of pile in excess of the length specified by the Engineer, and was cutoff. It equals the “Actual Cutoff” column minus “Pay Cutoff” minus the “Non Pay Cutoff used for Splice (Reg)” cell.
16. “Non Pay Cutoff used for Splice” - Is the length of pile that was originally considered as part of the “Non Pay Cutoff”, but was spliced to another pile to achieve “Plan Cutoff Elevation” and/or bearing. A column exists for Reg, for production pile, and Test, for Non Pay Cutoff from a Test Pile. It is important for the inspector to keep track of the amount of Non Pay, or Pay Cutoff used in the structure. KDOT does not want to pay 75% of the contract price for Pay Cutoff, only to have the same pile spliced on and used in the structure to be paid at full contract price.
17. “Pay Cutoff used for Splice” – Is the length of pile that was originally considered as part of the “Pay Cutoff” from one pile, but was spliced to another pile to achieve “Plan Cutoff

Elev.” and/or bearing. Since the cutoff was previously considered “Pay Cutoff”, deduct it from the “Pay Cutoff” total, so it is **not** paid for as “Pay Length” **and** “Pay Cutoff.” Show the deduction on the report for the footing where the cutoff came from. If this report has already been submitted, submit an amended report showing the deduction. (Example: A 6 foot stick of Pay Cutoff pile from Abutment 1 is spliced onto a pile in Pier 2. Go back to the report for Abutment 1 and enter 6 into the “Pay Cutoff used for Splice” cell so the pile does not get paid for as Pay Cutoff on the Abutment 1 report, but all, of a portion of it will get paid for as Pay Length and/or Pay Cutoff on the Pier 2 report.)

18. “Total Cutoff used for Splice” – Equals the “Non Pay Cutoff used for Splice” plus “Pay Cutoff used for Splice.”
19. “No. of Pay Splices” – Equals the total number of splices, ordered by the Engineer, to extend the pile beyond the original “Ordered and Accepted Length”. Splices made for the Contractor’s convenience are not considered pay splices.
20. “Pay Length” – Equals the total from the “Length Left in Footing” column.
21. “Pay Cutoff” – Equals the “Accepted Length” minus the total from the “Length Left in Foundation” column, minus “Pay Cutoff Used for Splice.”
22. “Remarks” – Provide a recap of **all** splicing information, and unique information about the pile driving operations:
  - a. Indicate if a splice was a pay or non-pay splice (i.e. instructed by the Engineer or the contractor’s option.)
  - b. Which pile a splice pile came from.
  - c. Which pile a splice pile was spliced to.
  - d. The length of each splice pile.
  - e. Indicate if a splice was made after bearing was achieved.
22. “LOG OF CONTINUOUS PILE DRIVING AND/OR TEST PILE” – Record a continuous pile driving record for a representative pile on each abutment and pier footing on a structure. The record should be inclusive from the beginning of the drive to the final bearing of the pile. Refer to the example below.
  - a. “Total Pile Length”- Report the length of pile to be driven into the ground. Once the pile has developed enough resistance to require **at least** 1 blow per foot, begin recording in 1.0 foot increments. In the first “To” cell, if the pile drops 6.75 feet with the first three blows, enter 6.75 in the “To” cell, and enter “3” in the “Number of Blows” cell. If the pile drops 1.5 feet in the next two blows, enter “8.25” in the next “To” cell, and “2” in the next “Number of Blows” cell. At the point the pile

requires at least 1 blow per foot, record the one foot increment in the “To” column and record the appropriate number of blows. Also, record the fractional increment just prior to achieving final bearing (i.e. 16.25 – 16.6).

- b. “Number of Blows” is the number of blows that were counted while driving the pile each foot (after it has developed the resistance mentioned in (a.) above).
- c. “Drop of Hammer” is observed by the inspector, and recorded in this column.
- d. “Average Penetration” is the one foot increment divided by the “Number of Blows” for that increment.
- e. “Computed Resistance” is the computed bearing after driving each one foot increment.
- f. Under the last entry (i.e. fractional increment), record the penetration for the last 20 blows and associated bearing.

Pile No.	Total Pile Length	Length Driven		Number of Blows (Blow Count)	Drop of Hammer (Stroke) (ft.)	Average Penetration (in.)	Computed Resistance (tons)	Computed vs. Specified
		From	To					
A1	18.6	0.00	6.75	3	4.00	27.00	0.4	Low
A1	18.6	6.75	8.25	2	5.00	9.00	1.3	Low
A1	18.6	8.25	9.25	1	6.00	12.00	1.2	Low
A1	18.6	9.25	10.25	2	6.00	6.00	2.4	Low
A1	18.6	10.25	11.25	4	8.00	3.00	6.2	Low
A1	18.6	11.25	12.25	7	8.50	1.71	11.2	Low
A1	18.6	12.25	13.25	21	9.50	0.57	34.0	Low
A1	18.6	13.25	14.25	28	10.00	0.43	45.4	Low
A1	18.6	14.25	15.25	32	10.00	0.38	50.5	Low
A1	18.6	15.25	16.25	39	10.00	0.31	58.9	Low
A1	18.6	16.25	16.60	20	10.00	0.21	77.4	Ok
A1	18.6	16.60						

**Figure 11 Continuous Log Example**

For structures under 750 feet in length a continuous pile driving record is required on two footings; create one record for a pile in an abutment footing and the second record for a pile in a pier footing near the opposite end of the structure. If the pier footings have no piling, then create the second record for a pile in the opposite abutment.

For structures over 750 feet in length a continuous pile driving record is required on three footings. Create one record for a pile in an abutment footing and the second and third record for piling in two pier footings. If the pier footings have no piling, then create a second record for a piling in the opposite abutment, and disregard the third record.

23. DISTRIBUTION LIST: Unless extenuating circumstances exist, requiring additional distribution, submit one copy of this form to the District Office and three copies to the Bureau of Construction and Maintenance – Change Order Section. Once all “Log of Pile Driving” forms for a structure have been submitted, the Bureau of Construction and Maintenance – Change Order Section will distribute copies to the Bureau of Materials and Research – Geology Section, Bureau of Design – State Bridge Office and Bureau of Local Projects.



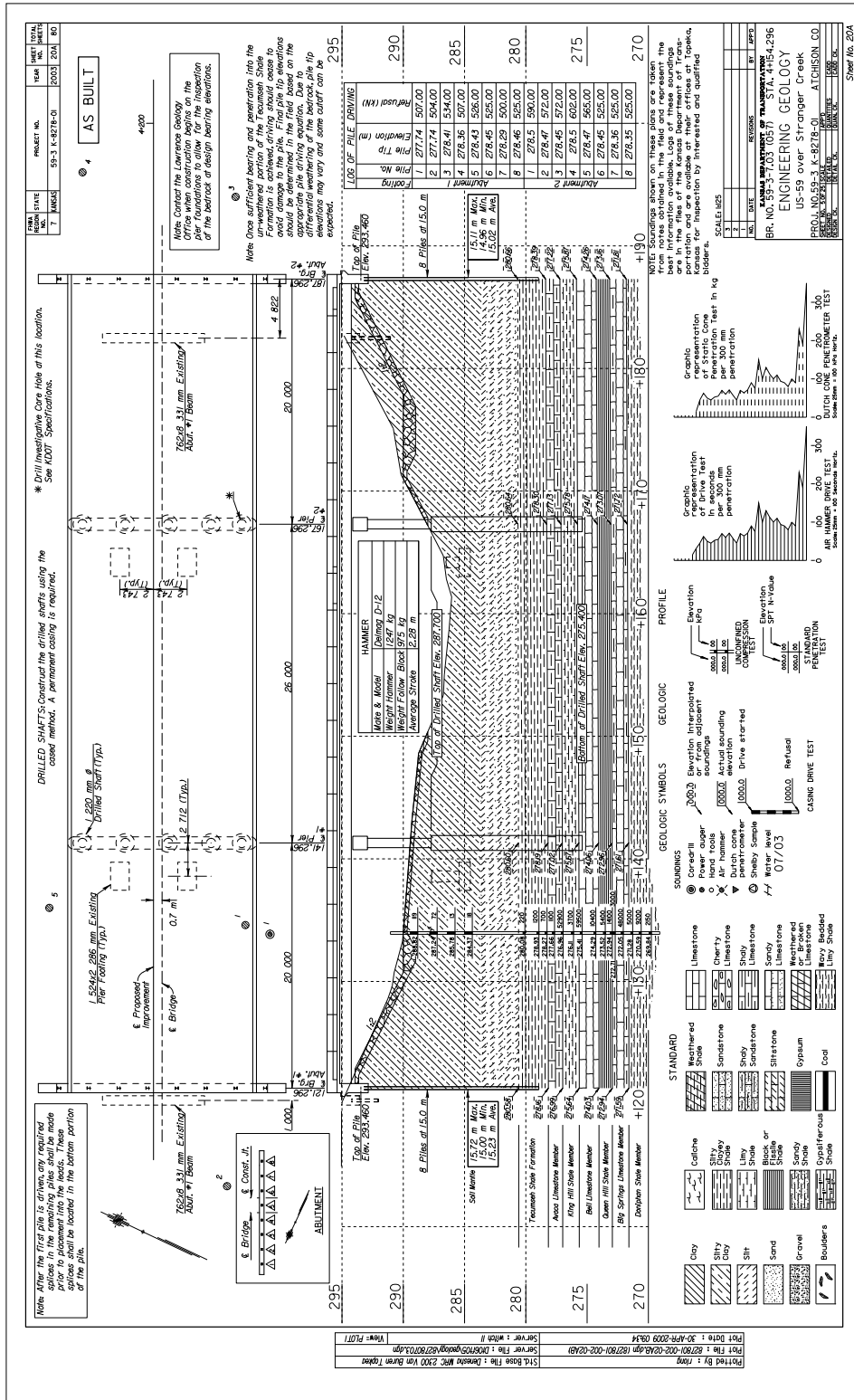
24. SIGNATURES: **Always** include the names of the individuals that inspected the pile driving operations, checked the computations and submitted the form.
25. The following is a completed example of “Remarks” in a “Log of Pile Driving.” Note the “Plan Length” for each pile is 16.7 ft.
- **Pile #1** - Driven to bearing with 0.2 ft. (non-pay cutoff) trimmed off to reach “Plan Cutoff Elevation.”
  - **Pile #2** – Driven to bearing with 1.90 ft trimmed off to reach “Plan Cutoff Elevation” - 1.7 ft (pay cutoff) and 0.2 ft (non-pay cutoff).
  - **Pile #3** – After driving 16.9 ft of piling bearing wasn’t achieved. To provide a fresh head 0.2 ft (non-pay cutoff) was trimmed off and 1.9 ft from #2 was spliced (pay splice) on (1.7 ft of pay cutoff, 0.2 ft of non-pay). The pile was then driven to bearing and 0.7 ft (pay cutoff) and 0.2 ft (non-pay) was cutoff.
  - **Pile #4** – Bearing was achieved after driving the 16.9 ft pile, but it was below cut off elevation. Thus, 0.2 ft (non-pay cutoff) was trimmed off to provide a fresh head, and 0.5 ft was spliced (pay splice) on to reach plan cutoff elevation.
  - **Pile #5** – The Contractor used a longer pile than was specified by the Engineer. Thus, the pile was driven to bearing with 0.5 ft (non-pay cutoff) and 0.20 ft (pay cutoff) cutoff.
  - **Pile #6** - Contractor elected to splice (non-pay splice) together two pieces of cutoff from Pier 1. After the pile was driven to bearing the resultant cutoff was 0.75 ft (non-pay cutoff) and 0.3 ft (pay cutoff). Appropriate amounts of Cutoff used for Splice have been deducted from Pier 1 sheet.

### 5.3.8.1 As-Built Geology

Occasionally the as-built pile lengths, and even pile locations, may vary from those shown on the plans. It is important for any deviation in foundation elements from the plans to be recorded on the as-built geology sheet and submitted to the District Engineer. The District Engineer will in turn submit these sheets the Bridge Office. Someone from the Bridge office will then incorporate those changes into the original geology sheet. This is done so that there is a permanent record for use in the future. An example of an as-built geology sheet is shown below.



As Built Geology



PU=80

### 5.3.8.2 Pile Driving Formulas

Hammer Type	Pile Type	U.S. Customary
Gravity	Steel, Shell, Steel Sheet	$P = \frac{3 \cdot W \cdot H}{S + 0.35} \cdot \left( \frac{W}{(W+X)} \right)$
Steam (Single Acting)	All Types	$P = \frac{2 \cdot W \cdot H}{S + 0.1}$
Steam (Double Acting)	All Types	$P = \frac{2 \cdot E}{S + 0.1}$
Delmag/McKierman-Terry*	All Types	$P = \frac{1.6 \cdot W \cdot H}{S + 0.1 \cdot \left( \frac{X^{**}}{W} \right)}$
Link-Belt* All Types	All Types	$P = \frac{1.6 \cdot E}{S + 0.1 \cdot \left( \frac{X^{**}}{W} \right)}$

\* Diesel Hammers

\*\* For Diesel Hammers if the quantity (X/W) is less than one, (X/W) is set equal to one.

**ENGLISH**

P in Pounds

W in Pounds

X in Pounds

S in Inches

E in Foot-Pounds

H in Feet

### 5.3.8.3 Field Pile Driving Guide

Many methods can be used to calculate resistance in the field. The inspector can program a calculator to compute resistance at the appropriate number of strokes, but this can be difficult because the height of the stroke and the penetration are both changing as the pile advances. The PDA calculates resistance as the pile is driven, but it is not currently specified on all projects. The field may request the PDA through the regional geology office. The State Bridge Office created the “Field Pile Driving Guide” to help the inspector calculate resistance as stroke and penetration change. This form will be available on the Forms Warehouse, or through contacting the Bridge Construction Manual Engineer.

First, the inspector needs to have all the appropriate information from the Contractor. If Form 217AA has been filled out, all of this information can be found there. Next, fill out the project information on the “General Information” sheet 217B. The plans will show the designer’s specified load for each substructure pile and the pile type, which will give the inspector the pile weight in units of pounds per foot. Additional sheets included in the form are related to the hammer that the contractor will use for the project. The inspector will go to the correct hammer sheet and enter data into the light green shaded cells. Enter the Length of Pile near to the length that will be left in the ground. This will provide the inspector with the calculations near the end of the drive as the pile reaches the specified load stated in the “Piling” note on the “General Notes” sheet of the plans. The Hammer, Cap, and Anvil weights will come from the contractor. It is important to make sure that the contractor’s hammer data is within the limits set in Sections 157 and 704 in the Standard Specification. The minimum and maximum penetration, “S”, will depend on the energy of the hammer and the piling that is being driven. Values of  $\frac{1}{8}$ ” and  $\frac{1}{4}$ ” per blow are appropriate for most cases; however, a blue “band” of acceptable values is the goal of Form 217B in order to give the inspector an achievable range in the field. The minimum and maximum hammer fall, “H”, will depend on the energy of the hammer and the piling that is being driven. For gravity hammers, the maximum fall may go up to 15’.

After the data is entered, the spreadsheet highlights the band of acceptable bearing values, and provides a graph based on Drop of Hammer vs. Penetration in 20 blows. The top line on the graph is the Minimum Bearing line; for a given hammer drop, the penetration in 20 blows must be less than the value given at this line. The bottom line on the graph is the Maximum Bearing line; for a given hammer drop, the penetration in 20 blows must be more than the value given by this line. For a small hammer drop, with a large penetration in 20 blows (above and left of the two lines), the pile has not achieved minimum bearing. For a large hammer drop, with a small penetration in 20 blows (below and right of the two lines), the pile has gone beyond the maximum bearing. The highlighted portion of “Computed Resistance” and the “Acceptable Range” in the graph can be adjusted by changing the range of hammer fall and the range of average penetration. While the contractor drives the piling, the inspector regularly checks the value of resistance for the observed fall of the hammer and pile penetration. Instructions are included on the “General Information” sheet within the form, and the [Bridge Construction Manual Engineer](#) should be contacted for further guidance.

Field Pile Driving Guide	
Enter known data in all available cells.	
General Information	
If you can not see colored tabs for different hammers at the bottom of the window, go to "View" tab, "Arrange All", and hit "OK" in the window that pops up.	
(This information is common to all sheets in the Workbook)	
Hammer Information	PROJECT INFORMATION
Type of Hammer <input type="text"/>	County <input type="text"/>
Hammer Weight <input type="text"/> lbs	Project <input type="text"/>
Cap and/or Anvil Weight <input type="text"/> lbs	(Br. No.) and/or Sta <input type="text"/>
Energy Rating <input type="text"/> ft-lbs	Type of Pile <input type="text"/>
	Plan Note Overdrive % <input type="text"/> %
	Min. Resistance Required <input type="text"/> tons
	Max. Resistance Allowed <input type="text"/> tons

Figure 12 Form 217B General Information Sheet



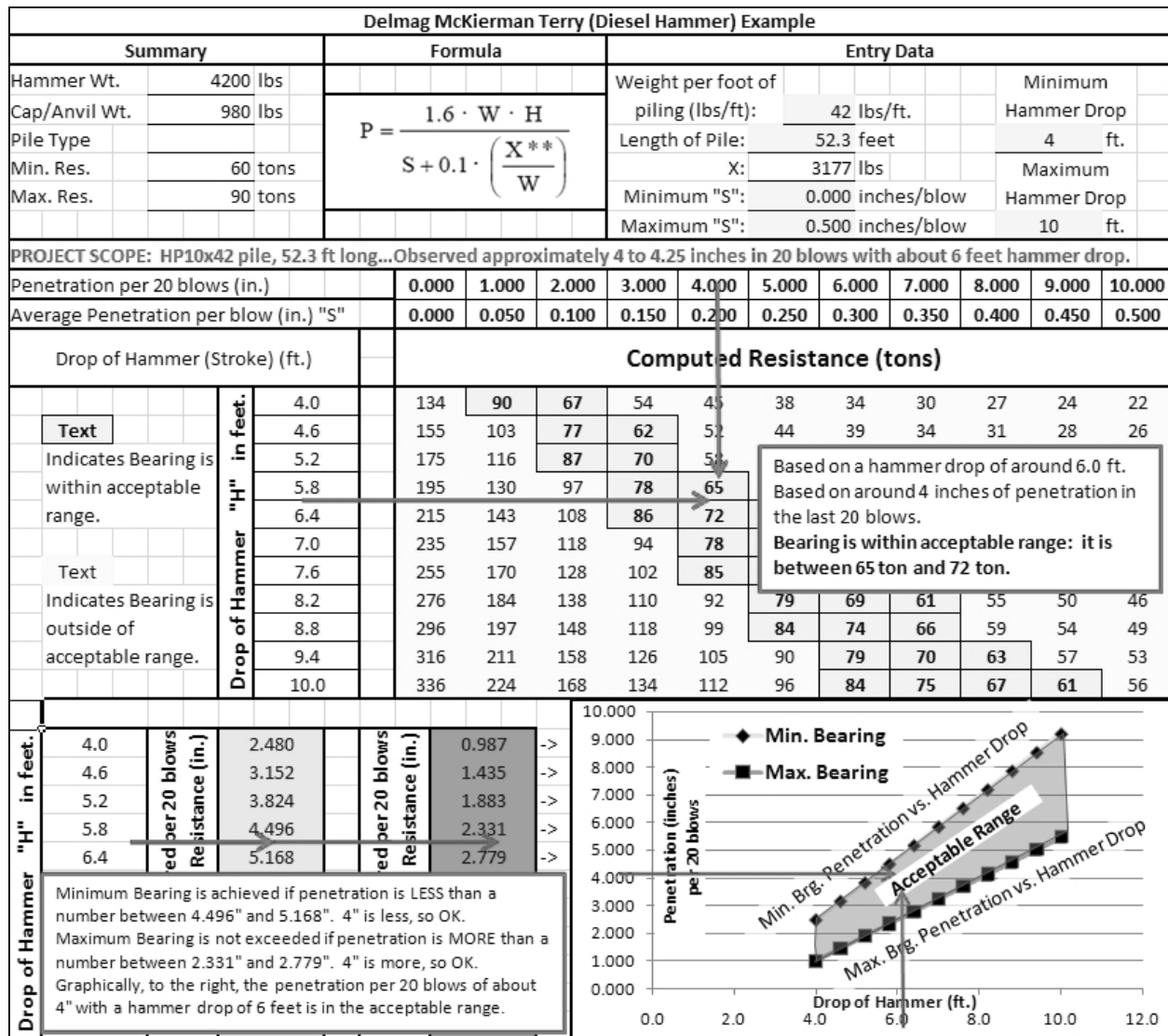


Figure 13 Form 217B Delmag Sheet Example

### 5.3.9 Hammer Data

More information is available online than is included here:

<http://www.conmaco.com/html/new equip.html>

<http://www.apevibro.com/asp/manuals-MKT.asp> M-K and APE data