KANSAS STATE
POLYTECHNIC

DRILLED SHAFT INSPECTION WORKBOOK

2019-2020

CIT Program

Kansas
Department of Transportation

Kansas
Department of Transportation

Day 1

1:00 pm	Announcements, Introductions, Class Expectations, Questions and Comments
1:30 pm	Session 1, Geology Lessons and Geology Report - Kyle
2:15 pm	Session 2, Drilled Shaft Design and Plans, Special Provisions, Mix Designs, - Jake
3:00 pm	Break
3:30 pm	Session 3, Drilled Shaft Equipment - Kyle
5:00 pm	Adjourn

Day 2

8:00 am	Questions from Day one!
8:15 am	Session 4, Excavation of Drilled Shafts, - Kyle
9:15 am	Session 5, Rebar cage, - Kevin
10:00 am	Break
10:30 am	Session 6, Concrete Placement, Volume Curves, Comprehensive Dry and Wet pours, measurements - Jake
12:00 pm	Lunch
1:00 pm	Session 7, Integrity Testing, - Kyle
1:40 pm	Session 8, Measurement and Payment, Safety Issues, - Kevin
2:10 pm	Session 9, Pre-Construction Meeting Drilled Shaft Installation plan and 13 questions - Jake
3:00 pm	Break
3:30 pm	Session 10, Group Scenarios, Homework, Instructors: All
5:00 pm	Adjourn

Day 3

8:00 am	Session 11, Review Homework, When Things Go Bad! And Question and Answer, - Kyle and Kevin
9:30 am	Break
10:00 am	Test Time

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^2) 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^2 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.

Kansas State Polytechnic

www.polytechnic.k-state.edu

Campus Parking Permit Key

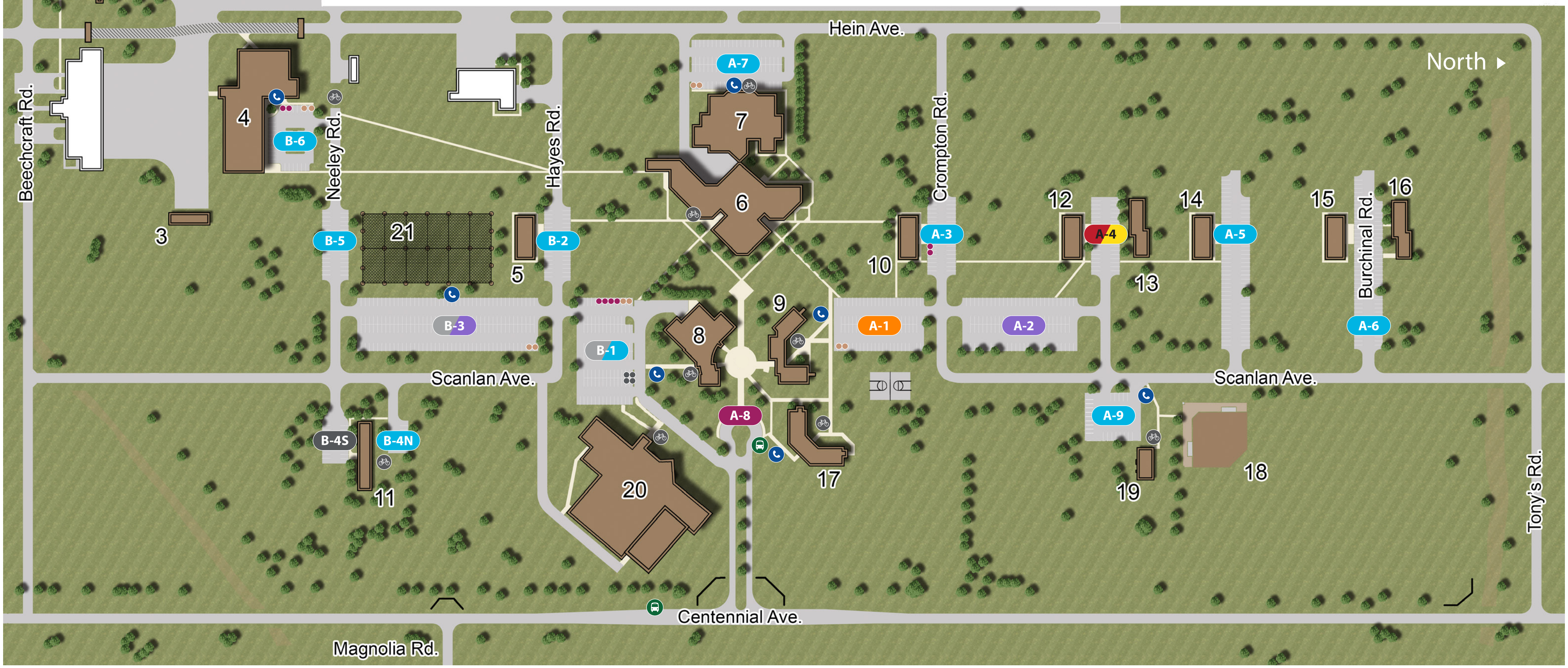
T	O, W, E, K or V
R	R or V
Z	Any K-State Permit
SLC	SLC
M	M
K	K
W	W, E or V
Visitor	No permit required
Metered	No permit required

Lots enforced M-F, 7 a.m. - 5 p.m. (R lots at all times).

Visit **www.k-state.edu/parking** for permit purchasing information & regulations

Other Transportation

- Bicycle Rack
- Salina CityGo® Bus Stop
- **Emergency Phone**



1 Aeronautical West Hangar
2 Aeronautical East Hangar
3 Composite Building
4 Aviation Center/Stevens Flight Center
5 U.A.S. Laboratory
6 Technology Center
7 Technology Center West
8 College Center
9 Schilling Hall
10 Tullis Building
11 Welcome Center
12 Outreach Center
13 Science Center/K-State Research Extension
14 Construction Lab
15 Facilities Maintenance - Shops
16 Facilities Maintenance - Offices
17 Harbin Hall
18 Thaemert Park/Sports Field
19 Sports Support Facility
20 Student Life Center
21 U.A.S. Flight Pavilion

DIRECTIONS TO CAMPUS

If you are traveling east or west on I-70, stay on I-70 until the I-70/I135 interchange. Travel south on I-135 to the Magnolia St. exit (No. 90). Go west on Magnolia to Centennial Rd. Turn right and proceed to Kansas State University Polytechnic Campus.

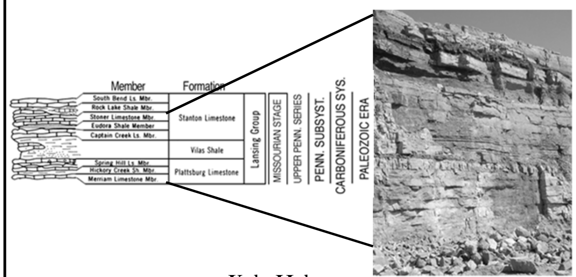
If you are traveling north or south on I-135, take the Magnolia St. exit (No.90). Go west on Magnolia to Centennial Rd. Turn right and proceed to Kansas State University Polytechnic Campus.

08/18

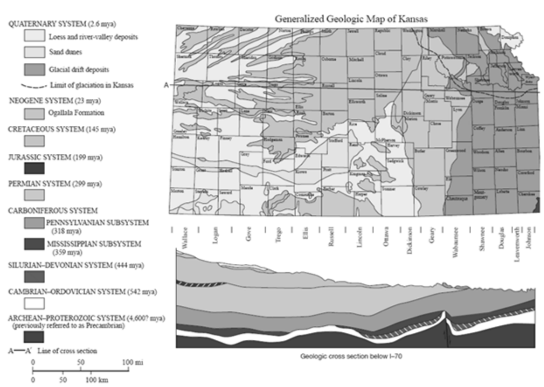
1. **Geology Report**
2. **Design & Other Issues**
3. **Drilled Shaft Equipment**
4. **Excavation & Cleaning**
5. **Reinforcing Cage**
6. **Concrete Placement**
7. **Integrity Testing**
8. **Measurement & Payment**
9. **Pre-Con & Installation Plan**
10. **Group Scenarios and Questions**
11. **When Things Go Bad!**
12. **Misc. Documents, Plans**

Drilled Shaft CIT Class

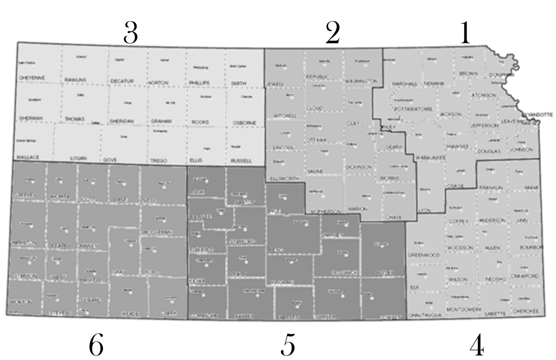
Kansas Geology 101



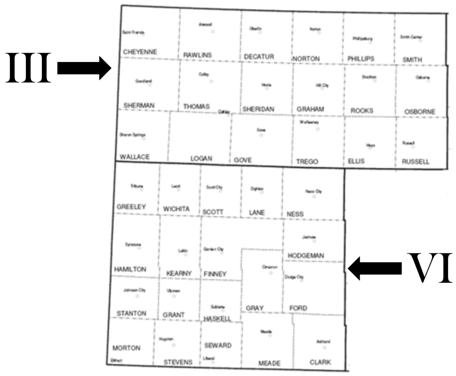
Kyle Halverson
Chief Geologist



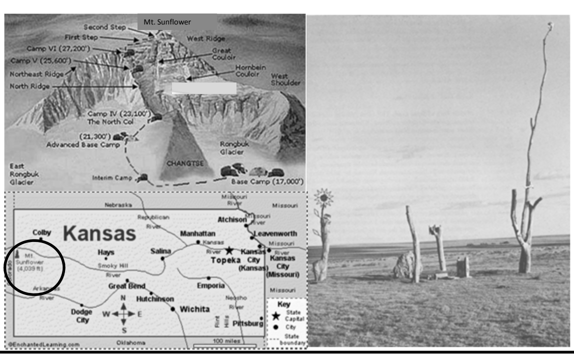
Districts within the State



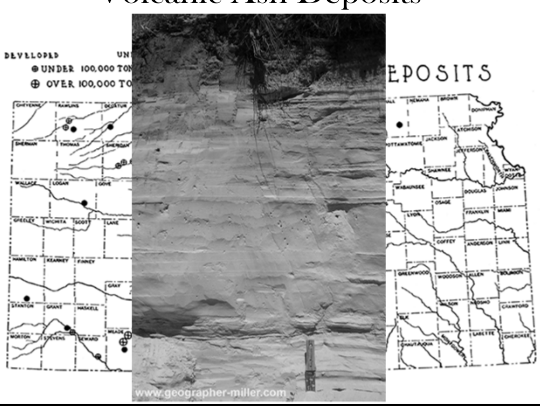
District III and VI



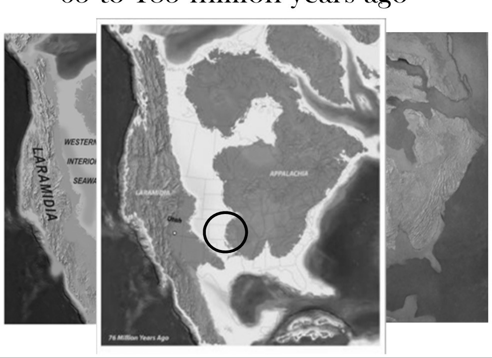
View from Mount Sunflower
Elevation 4039



Volcanic Ash Deposits

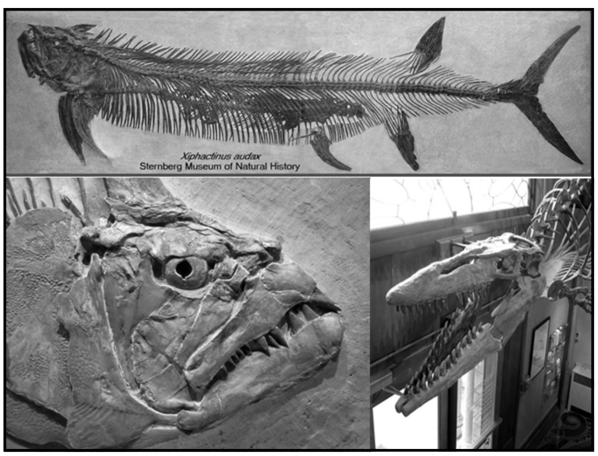


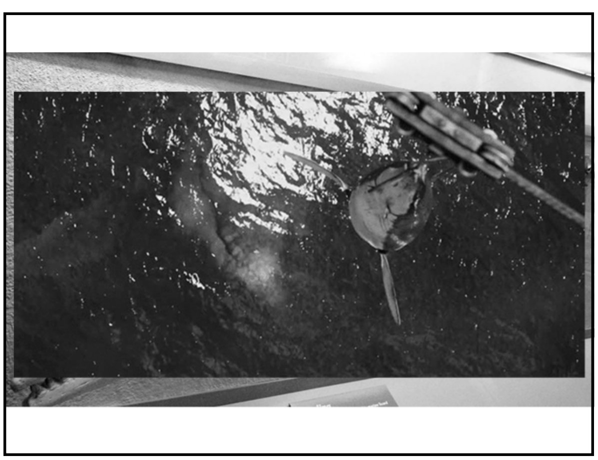
Ancient North American Sea
65 to 135 million years ago



Camel Rock Kiowa County

Arikaree Breaks Cheyenne CO.

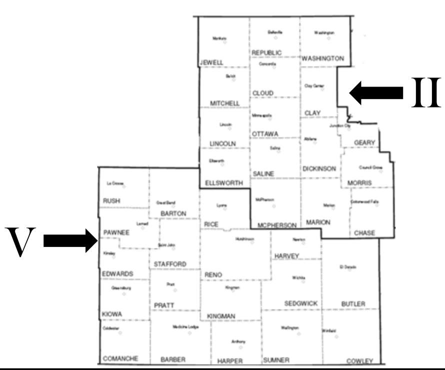

Xiphactinus audax
Sternberg Museum of Natural History

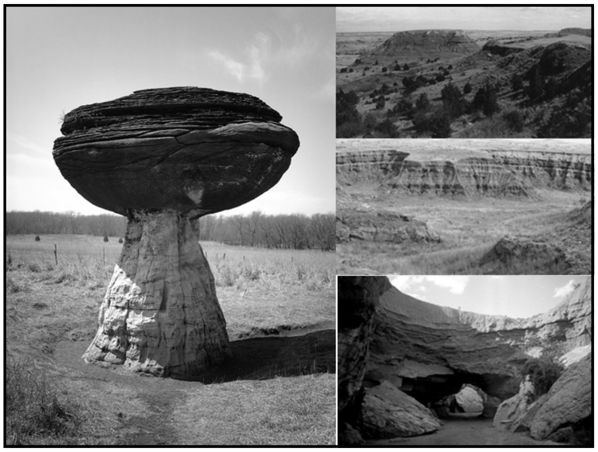


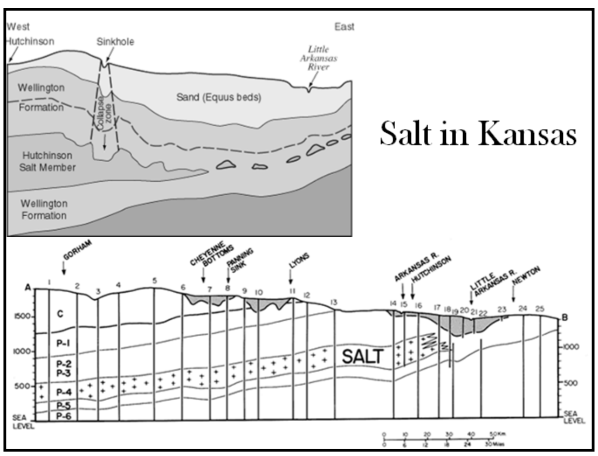
What to expect in your district

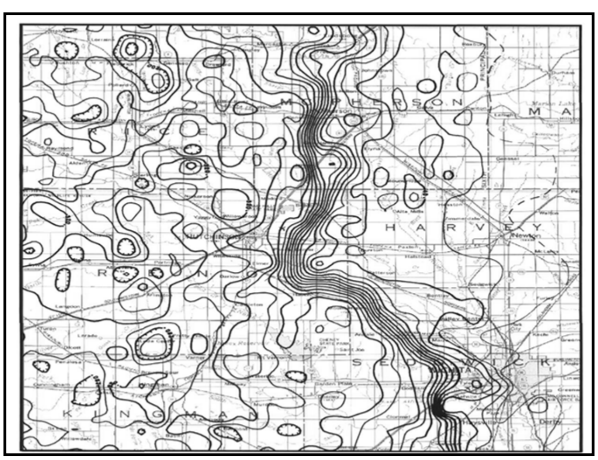
- Districts 3 & 6- Weak limestones and shales, and thick deposits of sand and soil. Drilled shafts have been constructed in these districts when bedrock is close to the surface and of good quality. Most of the time the depth to bedrock and the poor quality of bedrock, limits drilled shaft construction.

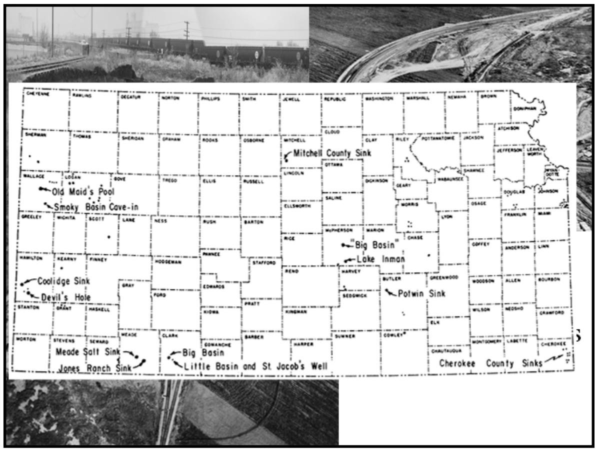
District II and V






West
East
Hutchinson
Sinkhole
Little Arkansas River
Wellington Formation
Sand (Equus beds)
Hutchinson Salt Member
Wellington Formation
Salt in Kansas
GORHAM
CHEYENNE BOTTOMS
LYONS
ARKANSAS R.
HUTCHINSON
LITTLE ARKANSAS R.
NEWTON
SALT
SEA LEVEL


HARVEY

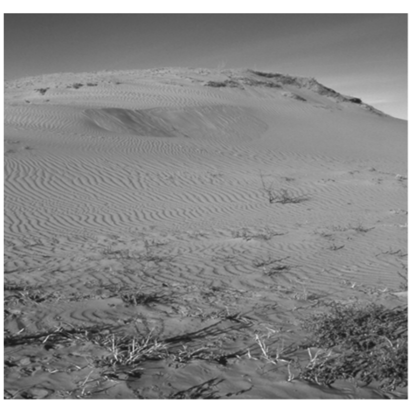


Green Rock?

- District 2 has some unique deposits of Opaline Cemented Sandstone.
- The opal or chert cement is green.
- This material is commonly used for rip-rap on western Kansas lakes and as a concrete aggregate.

Post Rock Quarry

Sand Dunes



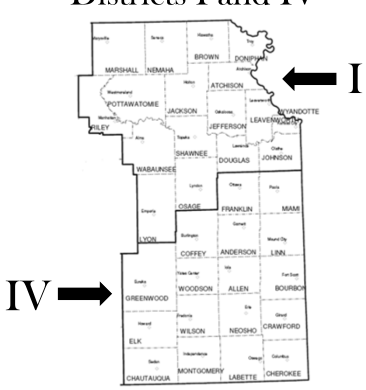
What to expect in your district.

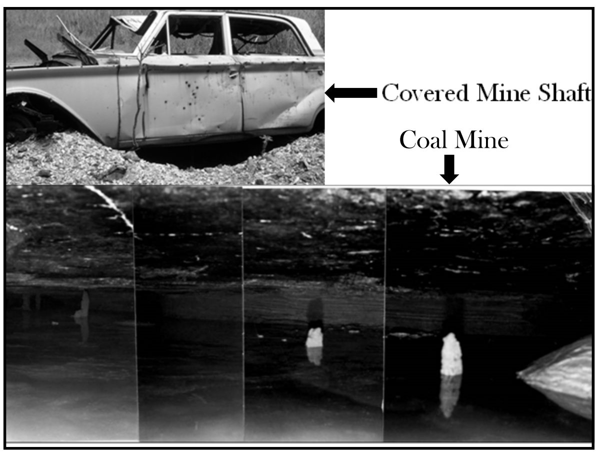
- District 2- Limestones, shales, and sandstones. Eastern half is similar to District 1. Western half rock is of good quality but special considerations must be taken before a drilled shaft is constructed.

What to expect in your district.

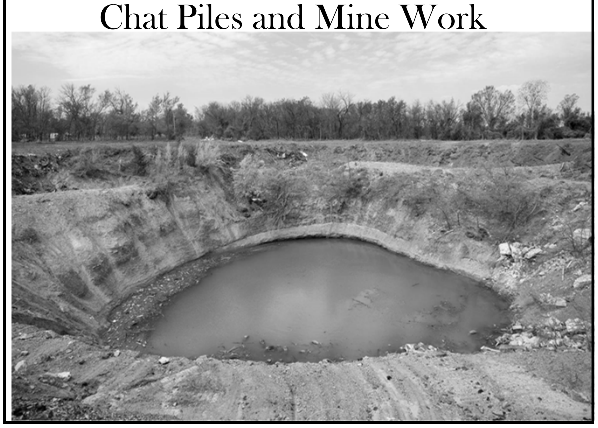
- District 5- Limestone (east), shale, and thick layers of sand. Eastern part (Butler and Cowley Co.) is similar to District 4. Western part has weaker shales and lots of sand that can very deep (100ft +) Drilled shafts can be placed but depth to bedrock and foundation material must be considered.

Districts I and IV

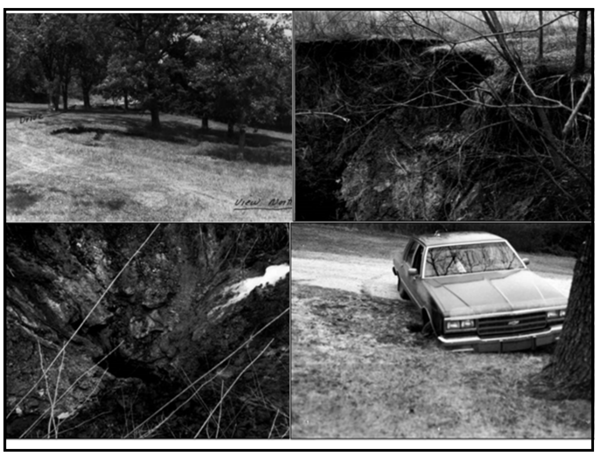


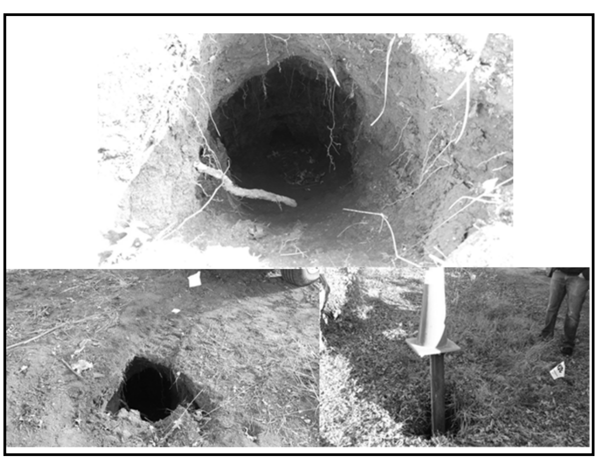


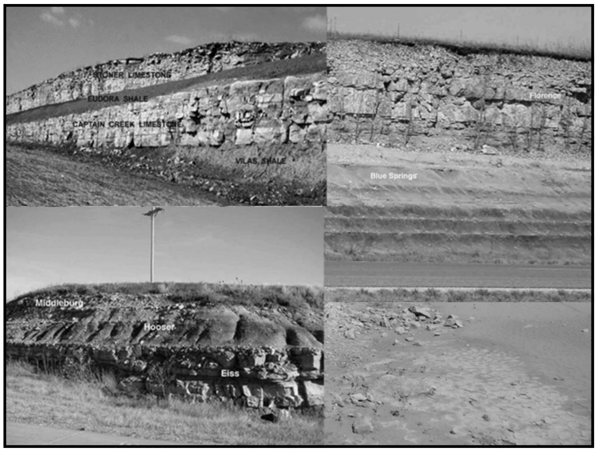
Chat Piles and Mine Work



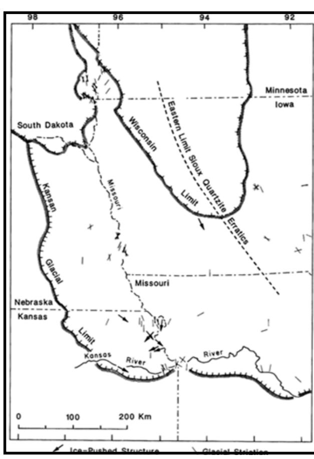

A
B
C







Glacial Erratic's



What to expect in your district.

- Districts 1 & 4- Limestones, shales, and sandstones. Lack of depth to bedrock and hardness of material make it nearly ideal for drilled shafts

Common Rock Types?

- What are the 3 main sedimentary rocks we have in Kansas?
- What variations can we have?

Who you need to Contact

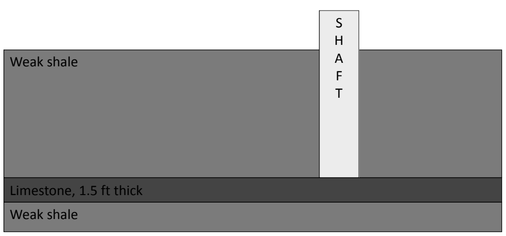
- District 1- John Barker
  - (785)291-3861
- Districts 2 & 3- Neil Croxton
  - (785)-263-4597
- District 4- Denny Martin
  - (620)431-1000
- Districts 5 & 6-Art Peterson
  - (316) 320-1721

Why are tip elevations important?

- Strength of material at this location is best.
- May be supported by a thin unit.
  - At least 2 ft. thick.
  - Less than 2 ft. may cause a punch out

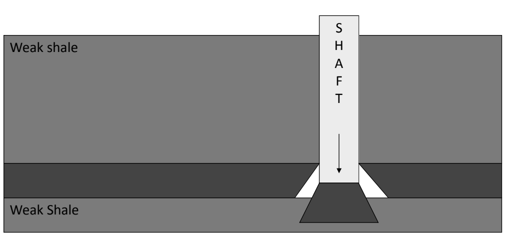
Punch Out

Drilled shaft on too thin of Limestone



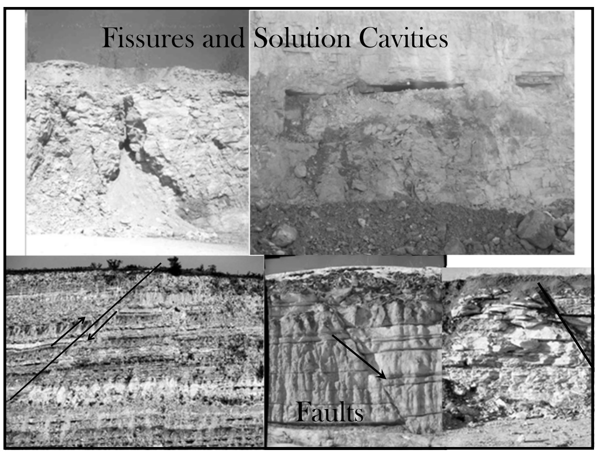
Punch Out

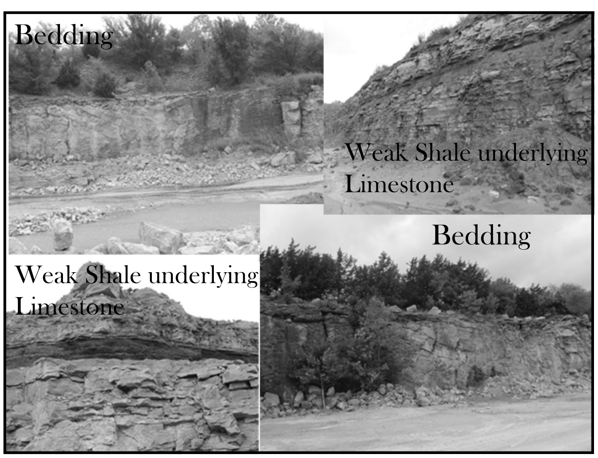
- What can happen



GEOLOGIC PROBLEMS

1. Solution Cavities and Fissures
2. Limestones Underlain by Weak Shales
3. Bedding
4. Faulting





Why a Subsurface Study?

- For design :
  - Must know subsurface materials
  - Must know engineering properties
  - Must know capability to support loads
- For construction:
  - Materials dictate rig and tool choices
  - Materials dictate construction method
  - Identifies potential problems

Geology Investigations

- Once we have a set of Field Check Plans, we begin our foundation investigation.
- The investigation includes the following:
  - 1. Survey in the new structure.
  - 2. Power Auger all foundation element locations, if possible.
  - 3. Drill at least one core hole.

GOALS OF THE SUBSURFACE STUDY

To gather data about the site:

- Geologic formations
- Soil & Rock units
- Material engineering properties
- Groundwater conditions
- Ground surface elevation
- Localized conditions

} THE BORING LOG

THE EXPLORATION

A variety of subsurface exploration methods can be employed.

Most common include:

- Standard Penetration Test Borings (Split-spoon)
- Undisturbed Sampling (Shelby tube)
- Rock Coring

GEOLOGY CORES

- Drilled Shaft Foundations are investigated by obtaining Core Samples.
- Samples of the cores are sent in for testing. An unconfined compression test is conducted.
- The test results and visual inspection of the core, provide guides as to where the bottom of the rock socket should be placed.

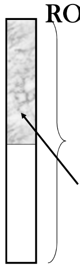
Rock Core Recovery

- Rock Core Recovery (REC)
  - Defined as the length of core recovered divided by the length of core run and is expressed and reported as a percentage.
  - $\% \text{ REC} = \dfrac{\text{Length of Core Recovered}}{\text{Length of Core Run}} \times 100$

Rock Core Recovery

<u>Sample</u>

ROCK CORE RECOVERY (REC)



Length of Run = 5.0’

Recovered 2.6’

REC = 2.6’/5.0’= 52%

Rock Quality Designation

- Rock Quality Designation (RQD)
  - Defined as the sum of all recovered pieces of rock core greater then 4” in length by the length of core run and is expressed as a percentage.
  - % RQD= <u>Sum of Pieces >4”</u> X 100
    Length of Core Run

RQD-Rock Quality

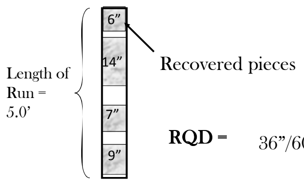
RQD (%)	Description of Rock Quality
0-25	Very Poor
25-50	Poor
50-75	Fair
75-90	Good
90-100	Excellent

Sample Problems

RQD is defined as the sum of all recovered pieces of rock core greater than 4" (100 mm) in length divided by the length of core run and is expressed and reported as a percentage.

$$\% \text{ RQD} = \frac{\text{Sum of Pieces >4" (100 mm)}}{\text{Length of Core Run}} \times 100$$

<u>Sample</u>



RQD = 36"/60"= 0.6 x100= 60%

Sample Problems

Can REC be greater than 100%?
YES

Can RQD be greater than REC?
NO

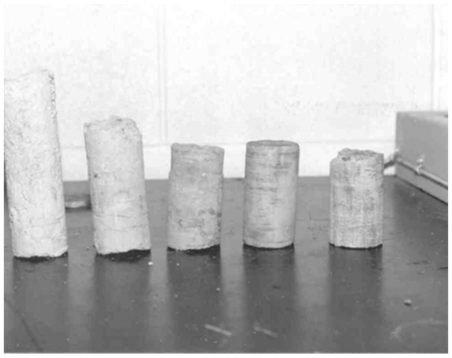
Can RQD be greater that 100%?
NO

How fast will that shale degrade?

- We are often requiring drilled shafts founded in shales to be poured as quickly as possible. In the Geology Report you will find the time limit from completion of the excavation to the placement of concrete. Here is the main reason why!!!
- What other change usually occurs when the shafts are founded in shale?

Shale Samples

- Four Shale Core Samples
- 1. Scranton Shale Formation
- 2. Lane-Bonner Springs Shale
- 3.&4. Two samples of the Cherokee Shale
- 5. Vilas Shale
- Samples covered in water for 24 hours and this is the result:



The Geology Report

When in doubt…………

Sections of the Geology Report

- Introduction
  - Location of bridge
  - Local conditions
- Geology at Bridge Site
  - Soil Mantle
  - Bedrock
- Foundation Recommendations
  - Pile foundations
  - Drilled shaft foundations
  - Investigative Core Holes
- Hydrology

Introduction

- The content of this report provides geologic information pertaining to the design of US77 over Big Blue River. The proposed bridge will be 750 feet in length and 40 feet in width. This new bridge will be located in Marshall County approximately one-half mile east of Blue Rapids near the intersection of US-77 and K-9 and will parallel the existing bridge to the right.

Geology at Bridge Site
-Soil Mantle

- What is the soil mantle composed of?
- How thick is the mantle material?
- Does the composition and thickness change over the length of the bridge?

Geology at Bridge Site

The soil mantle is classified as all unconsolidated material above bedrock. The soils at the site are primarily alluvial material consisting of sands, silts and gravels deposited by the Big Blue River along with minor amounts of residual silty clays. The mantle soils occur in colors of brown, tan and gray. Thickness of the mantle at Abutment 1 is 32 feet and thins to approximately 11 feet in the stream channel. At Abutment 2 the residual materials making up the soil mantle thins to less than one foot thick.

Geology at Bridge Site
-Bedrock

- What is the bedrock composed of?
- How thick is the bedrock material?
- Does the composition and thickness change over the length of the bridge?
- What is the foundation material?
- Any special conditions?

Geology at Bridge Site -Bedrock

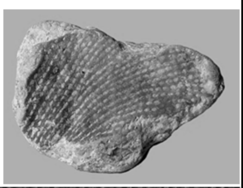
- **<u>BEDROCK</u> Lower Permian Series Gearyan Stage Council Grove Group Easly Creek Shale Formation**
- An erosional remnant of the Easly Creek Shale Formation was found at the mantle/bedrock contact at Abutment 2. This shale was found to be highly weathered, multicolored (tan to light gray) clayey and less than one foot thick.
- **Bader Limestone Formation Middleburg Limestone Member**
- At this location, the Middleburg Limestone Member is 2.6 feet in thick and varies from a hard, dense limestone to a highly weathered limestone. This limestone will be found at Abutment 2 only. The Middleburg Member has a Rock Mass Rating of 27, giving it a Class IV, Poor Rock rating.

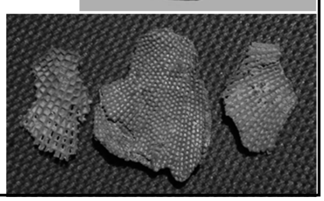
Bedrock Continued

- **Eiss Limestone Member**
- The Eiss Limestone Member is the lowermost member of the Bader Limestone Formation. The upper portion of this member lacks uniformity in that it varies between a hard, dense limestone to a pitted, vuggy limestone. This varied nature is due to differential solutioning of the limestone. The center portion of the Eiss Member contains several thin beds of limy shale up to 1.4 feet thick. These beds are the result of a episodic shallowing of the ocean waters during deposition. The lower limestone of this member consists of a hard, dense limestone just under 3 feet thick. The unconfined compressive strength tests performed yielded results between 111 and 276 TSF. Total thickness of the member was measured at 9.7-9.8 feet and will be found at Abutment 2 only. The Eiss Limestone Member has been assigned an overall Rock Mass Rating of 40, giving it a Class IV, Poor Rock Rating.

Common Fossils

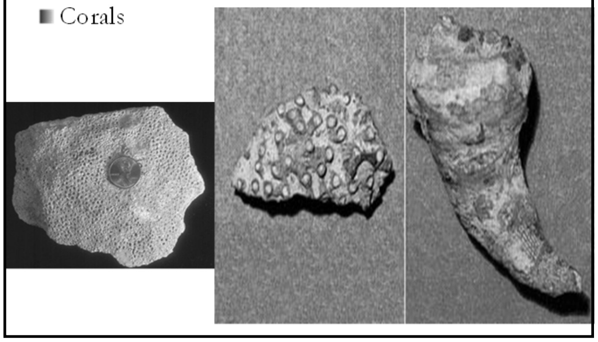
- Fennestralina Fans
- (Ancient Sea lilies)
- Plant Fossils





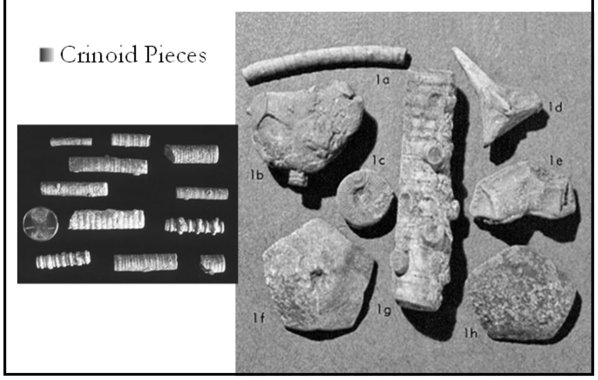
Common Fossils

- Corals



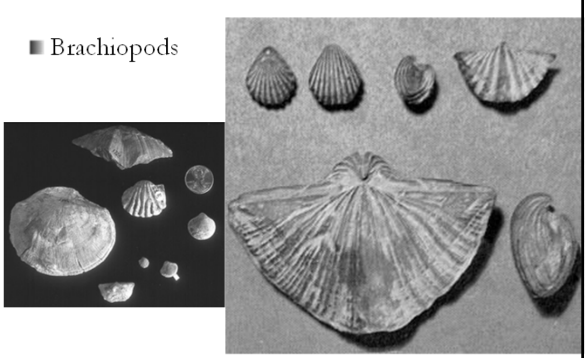
Common Fossils

- Crinoid Pieces



Common Fossils

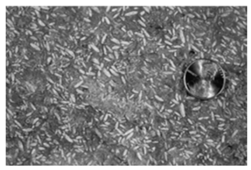
- Brachiopods



Common Fossils

- Fusilinids





Foundation Recommendations -Pile foundations

- What material will the pile be founded in?
- What type of pile will be used?
- What are the pile tip elevations?

Foundation Recommendations -Pile foundations

- Steel H-Pile is recommended for the Abutment 1. The 10 X 42 Pile will likely reach the recommended resistance in the shale of the Eskridge Formation, while the larger pile are expected to penetrate the soil mantle and the Eskridge Formation and achieve capacity on or in the limestone of the Neva Member. The tables below list the recommended pile tip elevations, the nominal geotechnical resistance, the factored resistance and the phi factor for each type of pile below. The resistances are governed by the driving stresses. Some variation in final pile tip elevations across the bridge site should be expected.

Pile Foundations Abutment 1

Location	Centerline Station	Elevation Top of Bedrock	Pile Tip Elevation				
			10 x 42	12 x 53	12 x 74	14x73	14x89
Abut. 1	57+02.00	1077.6	1072.6	1070.4	1070.4	1070.4	1070.4

Foundation Recommendations -Drilled shaft foundations

- What material will the drilled shaft be founded in?
- How deep ?
- What are the Shaft tip elevations?
- Special situations! Shale

PIERS 1-3 DRILLED SHAFT FOOTING**S**

- Drilled Shafts are recommended to support the piers for the new bridge. The drilled shafts for the piers should be set in competent material of the Neva Limestone Member. Permanent casing is required for all piers, with the casing set approximately 3 feet into the weathered top of the Eskridge Shale Formation. (See recommended elevations below.) If
- water is percolating through bedrock material at a high rate, a wet pour may be required. Allow no loose material within the footing when the footing is considered ready to pour.
- It is critical that the bottom socket be clean and relatively flat. The bottom of the rock socket should be placed no higher that the elevations below.
- The table below gives the Nominal Geotechnical Resistance results from Shaft 6 and hand calculations using six foot diameter drilled shafts at the piers. The LRFD Factored Resistance was calculated using a phi factor 0.50 for the end bearing and 0.55 for the side resistance.
- The following Drilled Shaft recommendations have taken into account the preliminary Strength I loads of 1800 kips for the piers along with the weight of the drilled shafts using 4.23/kips/ft for the recommended 6.0 ft. diameter drilled shafts.

Drilled Shaft Table

Location	Station	Dia. of shaft (ft)	Approximate Elevation at Bottom of Casing	Elevation Base of Drilled Shaft	Nominal Geotechnical Resistance kips	LRFD Factored Resistance kips
Pier 1	57+02.00	6.0	1074.1	1064.9	4270.98	2140.16
Pier 2	60+77.00	6.0	1074.7	1063.0	4298.56	2152.00
Pier 3	62+87.00	6.0	1082.0	1062.8	4334.38	2242.16

Foundation Recommendations -Drilled shaft foundations

INVESTIGATIVE CORE HOLE:

Standard Specification 703.3b

Investigative core holes will be required at the far right columns of Pier 1, Pier 2, and Abutment 2, and the center column of Pier 3.

Extract and maintain a core of the foundation material from 4 feet above the top of the plan tip elevation and 6 feet below the plan tip elevation. The contractor will maintain and protect the properly labeled (elevation and location) samples for review by the Regional Geologist. The location of the core hole will be a surveyed location with the same construction tolerance as that of the shaft construction.

Issues with the Investigative Cores

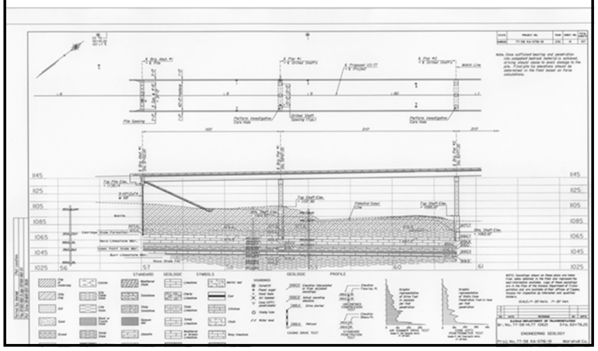
- Location
- Logs
- Recovery
- Not notified

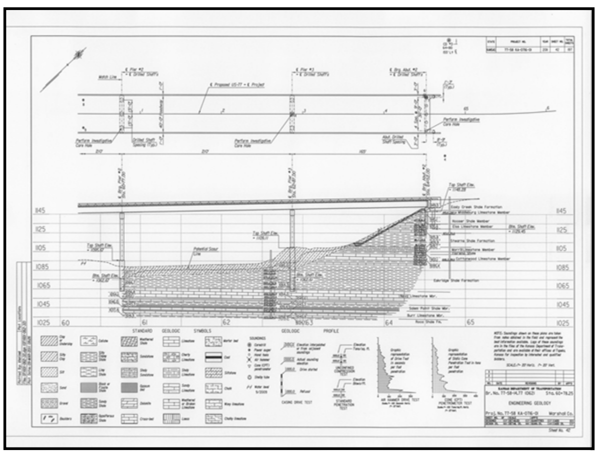
HYDROLOGY

- States if dewatering equipment will be needed
- Gives ground water elevations
- Also can State if casing will be used

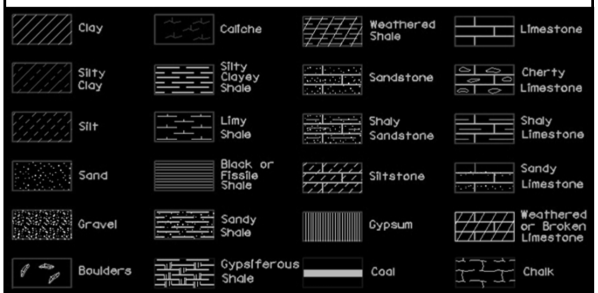
"Groundwater was found at approximate elevation 1093.0 throughout the area. Excavation for pile caps or drilled shafts will require dewatering equipment."

Engineering Geology Sheet-
Some things you might like to know.

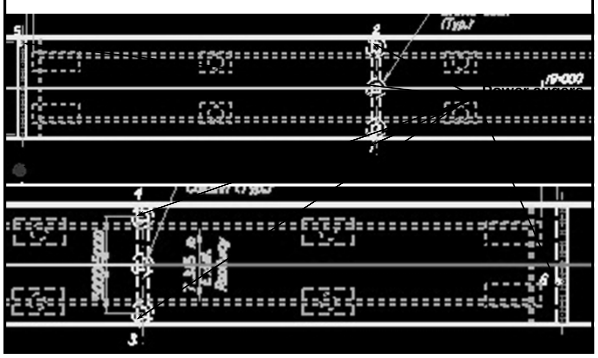




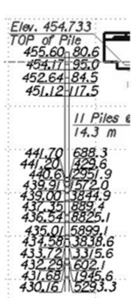
Engineering Geology Sheet- Geology

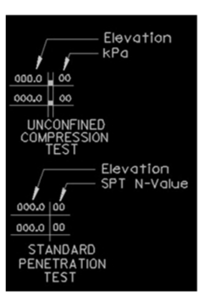


Engineering Geology Sheet- Shows the Geology Investigative holes



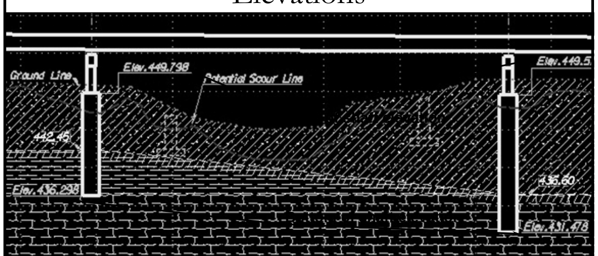
Engineering Geology Sheet- Unconfined compression test





Engineering Geology Sheet- Formations

Engineering Geology Sheet- Elevations



When in doubt………… You can find

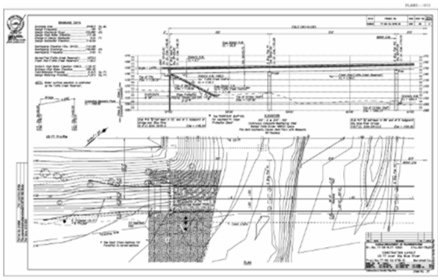
- Site conditions- location, geology, and hydrology
- Foundations- Pile and drilled shaft elevations and locations
- Special instructions- Investigative core hole, construction recommendations

The End

Questions?

Design, Specifications and Plans

Jake Pfannenstiel
Engineering Associate – Bridge Design



- Obtain a brief understanding of drilled shaft design
- Review the specifications covering drilled shaft construction
- Where do I find the Information in the plans to build the drilled shafts as they were designed

PL - 2

Topics

- **Design**
- **Specifications**
  - **Concrete Mix Design**
  - **Casing Requirements**
- **Plans and Details**
- **Osterberg Cell**

PL - 3

Design

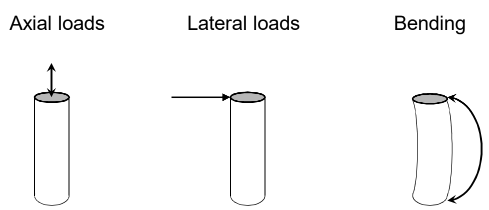
Why do we use drilled shafts?

- **The footing would have short piles**
- **The water table is high**
- **A spread footing would be uneconomical because rock is deep**
- **Concerns about pile driving vibrations, or noise**

DES - 4

Design

What types of loads do we design for?



DES - 5

Design Loads

Axial loads

Self weight of the Bridge and everything the bridge holds up against gravity

End Bearing Limestone 25-30 tsf Shale 10-15 tsf

Skin Friction Limestone up to 27 tsf Shale up to 11 tsf

Lateral & Bending loads

Flowing Water, Wind, Braking Forces, Moment from Structure, and Seismic

Are counteracted by Soil Mantle and Ultimately Fixity at the Rock Socket

DES - 6

Specification

SECTION 703 – Drilled Shafts

- 703.1 Description
- 703.2 Materials
- 703.3 Construction Requirements
- 703.4 Measurement and Payment

PL - 7

Specification

- 703.1 Description

BID ITEMS	UNITS
Drilled Shaft (*) (**)	Linear Foot
Permanent Casing (*) (Set Price)	Linear Foot
Sonic Test (Drilled Shaft) (Set Price)	Each
Core Hole (Investigative)	Linear Foot

*Size
**Cased (If Contract Documents specify the cased method.)

PL - 8

Specification

- 703.2 Materials
  - a. Concrete
  - b. Grout/Flowable Fill
  - c. Granular Backfill Material
  - d. Reinforcing Steel
  - e. Casing
  - f. Pipe for Sonic Testing

PL - 9

Specification

- 703.3 Construction Requirements
  - a. General
  - b. Investigative Core Hole
  - c. Excavating the Drilled Shaft
  - d. Placing Reinforcing Steel and Sonic Testing Pipes
  - e. Final Inspection and Access

PL - 10

Specification

- 703.3 Construction Requirements cont.
  - f. Placing Drilled Shaft Concrete
    - Errata R15
  - g. Raising Temporary Casing
  - h. Curing
  - i. Sonic Testing
  - j. Backfill

PL - 11

ERRATA R15

SECTION 703.3f

- R15 modified 703.3f and can be found on OnBase

PL - 12

ERRATA R15

SECTION 703
DRILLED SHAFTS

Page 700-11, subsection 703.3f., delete from Method C to end of 703.3f. and replace with the following:

Method C (Figure 3): Use a tremie tube, with a sealed gate separating ground water and concrete, to place concrete in the shaft. Fully charge the tremie tube and hopper, then raise the tremie tube by 1 tremie diameter and seal the discharge end of the tremie tube with the fresh concrete.

(3) For both Dry and Wet Pours. When the concrete reaches the top of the shaft, continue placing concrete (over-pump) to expel any excess water, debris or unsound concrete. If the casing extends above the planned shaft elevation the excess material must be expelled by providing an outlet in the casing above the planned elevation if the shaft. Do not bail the excess material out of the shaft. On all wet pours, regardless of the method used, the Engineer will make a set of cylinders (in addition to normal concrete cylinder sampling requirements) from the top of the shaft after completing over-pumping. This set of cylinders will be used to verify a compressive strength of 1800 psi before proceeding with subsequent substructure (i.e. columns, abutments, etc.) construction.

Prior to constructing the portion of the substructure that attaches to the drilled shaft, thoroughly clean the top of the drilled shaft to facilitate the bond at the cold joint.

PL - 13

Specification

- 703.4 Measurement and Payment
  - a. Drilled Shafts
  - b. Permanent Casing
  - c. Sonic Test (Drilled Shaft) (Set Price)
  - d. Payment

PL - 14

Mix Design

- Where does the mix come from?

  The Contractor requests a mix design from Materials and Research, using their choice of pre-qualified materials, or designs one according to Section 401 or Appendix A.

  Ultimately the contractor is responsible for the concrete mix, regardless of who aids in creating it.

DES - 15

Drilled Shaft Mix design

- Optimized Gradation for workability and strength.

1102 - AGGREGATES FOR CONCRETE NOT PLACED ON GRADE

TABLE 1102-3: ALLOWABLE GRADING FOR MIXED AGGREGATES FOR CONCRETE

Type	Usage	Percent Retained - Square Mesh Sieves											
		1 ½"	1"	¾"	½"	⅜"	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
MA-3	Optimized All Concrete		0	2-12	Note[1]	Note[1]	Note[1]	Note[1]	Note[2]	Note[2]	Note[2]	95-100	98-100
MA-4	Optimized All Concrete	0	2-12	Note[1]	Note[1]	Note[1]	Note[1]	Note[1]	Note[2]	Note[2]	Note[2]	95-100	98-100
MA-5	Optimized Drilled Shafts		0	2-12	8 min	22-34		55-65		75 min		95-100	98-100
MA-6	Optimized for Bridge Overlays		0	0	2-12	Note[1]	Note[1]	Note[1]	Note[2]	Note[2]	Note[2]	95-100	98-100
MA-7	Contractor Design KDOT Approved	Proposed Grading that does not correspond to other limits in this table but meet the requirements for concrete in **DIVISION 400**.											98-100

[1]Retain a maximum of 22% (24% for MA-6) and a minimum of 6% of the material on each individual sieve.
[2]Retain a maximum of 15% and a minimum of 6% of the material on each individual sieve.

DES - 16

Mix Design

What are we looking for in a mix?

- 703.2.a Drilled Shafts – Materials – Concrete

Must be in compliance with Section 401 (General Concrete), Section 402 (Structural Concrete) and Section 1102 (Aggregates for Concrete Not Placed On Grade)

- 9” slump is the target (+/- one inch)

f. Slump.

(1) Designate a slump for each concrete mix design that is required for satisfactory placement of the concrete application. Reject concrete with a slump that limits the workability or placement of the concrete.

(2) If the designated slump is 3 inches or less, the tolerance is ±3/4 inch, or limited by the maximum allowable slump for the individual type of construction.

(3) If the designated slump is greater than 3 inches the tolerance is ±25% of the designated slump.

(4) For drilled shafts the target slump just prior to being pumped into the drilled shaft is 9 inches. If the slump is less than 8 inches, redose the concrete with admixtures as permitted in **subsection 401.3i**.

(5) Do not designate a slump in excess of 5 inches for all other structural concrete.

DES - 17

Mix Design

- **Trial mix**

The concrete specification requires that a trial batch be produced and tested, unless a positive history exists. This is the time a **slump loss analysis** should be done. This includes a **slump loss test**.

DES - 18

Slump Loss Test

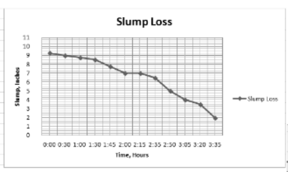
Kansas Dept. of Transportation Slump Loss Test Report

Time	Elapsed Time	Slump from In-Place (In.)	Slump from Mixer Truck (In.)	% Air (if Entrained)	Concrete Temp	Ambient Temp	Date of Test: 5/21/2012
11:15 AM	0:00	9 1/4	-	-	78.1	78.1	
11:45 AM	0:30	9	-	-	80.4	80.0	Time Test Started
12:15 PM	1:00	8 3/4	-	-	83.3	80.2	11:15 AM
12:45 PM	1:30	8 1/2	-	-	86.2	83.8	
1:00 PM	1:45	7 3/4	-	-	87.3	83.8	Contract Number:
1:15 PM	2:00	7	-	-	87.4	85.1	
1:30 PM	2:15	7	-	-	89.1	88.0	
1:50 PM	2:35	6 1/2	-	-	91.2	89.6	Project Number:
2:05 PM	2:50	5	-	-	93.2	90.0	67 C-4270-01
2:20 PM	3:05	4	-	-	94.5	89.2	
2:35 PM	3:20	3 1/2	-	-	95.4	90.3	Ready Mix Plant:
2:50 PM	3:35	2	-	-	95.6	91.5	O'Brien Ready Mix
							Parson's
							Inspector:

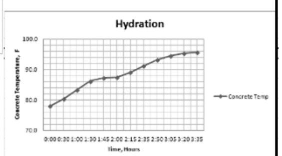
Notes: 3 Yds Concrete Batched at 10:25 AM, simulated drive/delivery time 40 minutes, at 11:10 AM Super Plasticizer was added at a rate of 42.67 oz per Yd and 40 revolutions were applied to the Truck.

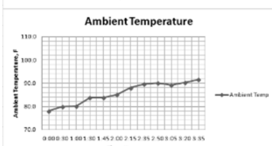
DES - 19

Kansas Dept. of Transportation Slump Loss Test Report



Slump Loss Test





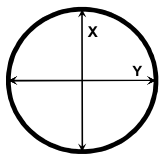
Graphs that are produced by the excel spreadsheet for the inspector's use

Casing

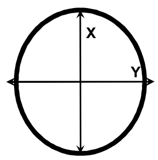
- Permanent, Must be Water Tight
  - Thick walled
  - CMP (14 gage minimum)
- Temporary
  - Immediately after the concrete is placed the Temp. Casing can be raised the depth of embedment plus 6 inches.
  - Temp. Casing cannot be removed for 24 hours AND a Compressive Strength of 1800 psi OR 72 hours have passed.

PL - 21

Casing
703.2.e



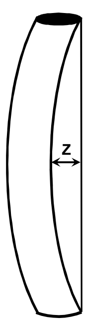
IF X = Y
Casing is "Round"



IF X > Y or Y > X
Casing is **"Out of Round"**

IF the difference (X-Y) is less than or equal to 1", the casing is acceptable.

Casing
703.2.e



String line (chord) – End to end

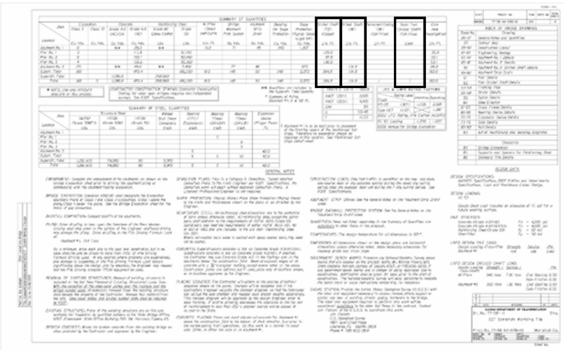
If "Z" is less than or equal to 2":
Casing is **acceptable**

Casing

- Make sure the minimum rock socket length is provided
  - Do not try to make the hole dry by advancing the casing (This is a case were deeper is not better, set the bottom of the casings were the plans show them)
  - It is always better to pour the shaft using wet pour methods than to try to make a wet hole dry

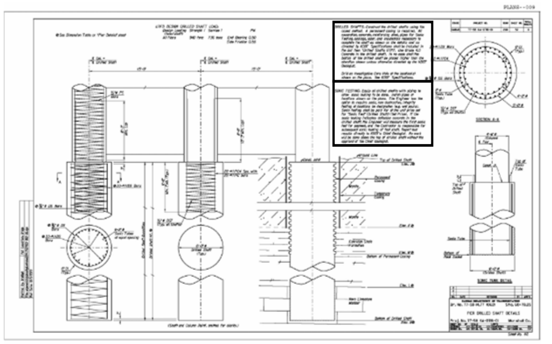
PL - 24

General Notes



PL - 25

General Notes



PL - 26

General Notes

DRILLED SHAFTS: Construct the drilled shafts using the cased method. A permanent casing is required. All excavation, concrete, reinforcing steel, pipes for Sonic Testing, casings, labor, and incidentals necessary to complete the shaft as shown on the details and as directed by KDOT Specifications shall be included in the bid item "Drilled Shafts (72")". Use Grade 4.0 Concrete in the drilled shaft. In no case shall the bottom of the drilled shaft be placed higher than the elevation shown unless otherwise directed by the KDOT Geologist.

Drill an Investigative Core Hole at the location(s) shown on the plans. See KDOT Specifications.

SONIC TESTING: Equip all drilled shafts with piping to allow sonic testing to be done. Install pipes at locations shown on the plans. The Engineer has the option to require sonic, non-destructive, integrity testing at locations he designates (e.g. wet pours). Sonic testing shall be paid for at the unit price set for "Sonic Test" (Drilled Shaft) (Set Price). If the sonic testing indicates defective concrete in the drilled shaft, the Engineer will measure the first sonic test for payment, and the Contractor is responsible for subsequent sonic testing of that shaft. Report test results directly to KDOT's Chief Geologist. No work will be done above the top of drilled shaft without the approval of the Chief Geologist.

Drilled Shaft (72") (Cased) Lin. Ft.	Drilled Shaft (36") Lin. Ft.	Permanent Casing (36") (Set Price) Lin Ft.	Sonic Test (Drilled Shaft) (Set Price) Each	Core Hole (Investigative) Lin. Ft.
129.0				50.0
97.5				32.1
138.0				53.1
	131.8			26.8
364.5	131.8			162.0
364.5	131.8	1	1	162.0

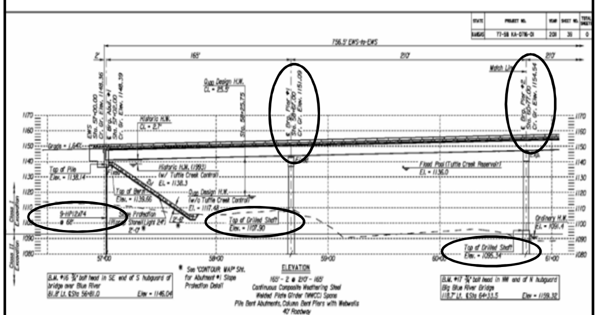
PL - 27

Other Notes

- DRILLED SHAFT BACKFILL: Backfilling the annular space between the temporary casing and the permanent casing, as defined in the KDOT Specifications, is not required at this location.
- FOUNDATION ROCK INVESTIGATION: Drill at least one 1 1/2 - 2 inch diameter hole at each drilled shaft location to penetrate the bedrock a minimum of 4 feet below the base of the shaft. If a cavity or otherwise incompetent zone is detected in the bedrock below the shaft, revise the shaft to ensure a competent shaft. Drill the test holes in the presence of the Engineer. The work required for investigation shall be subsidiary to the excavation. Payment for lowering or repairing the shafts will be in accordance with KDOT Specifications.

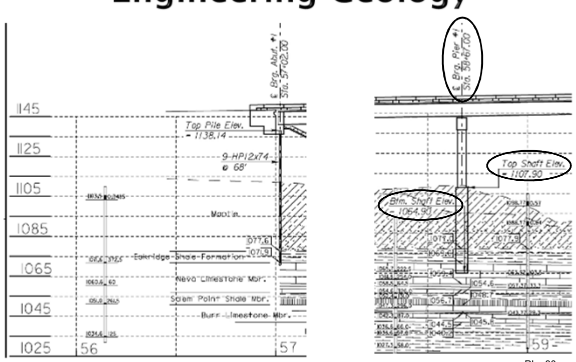
PL - 28

Construction Layout



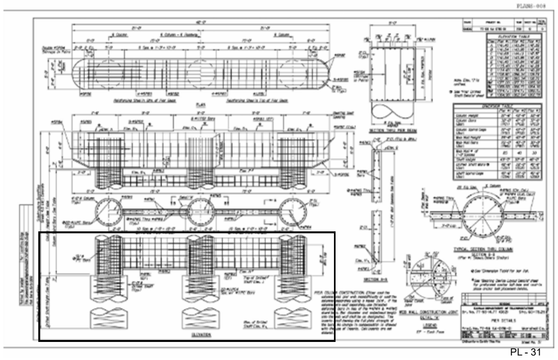
PL - 29

Engineering Geology



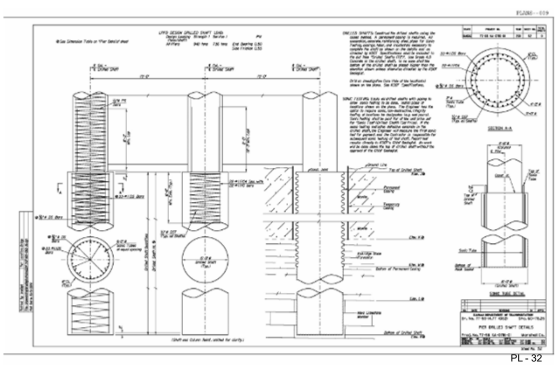
PL - 30

Pier Details



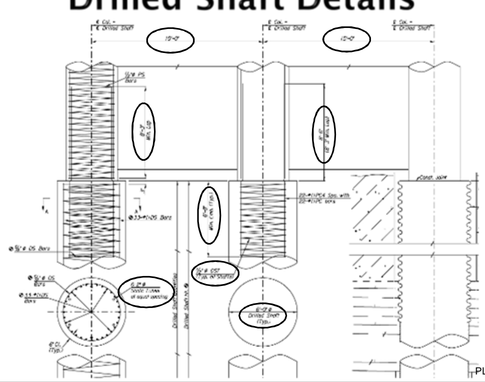
PL - 31

Drilled Shaft Details



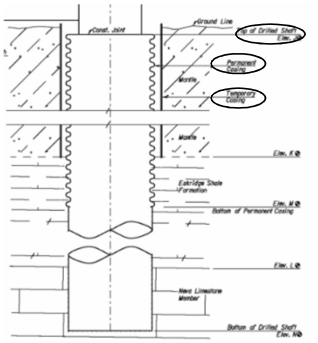
PL - 32

Drilled Shaft Details



PL - 33

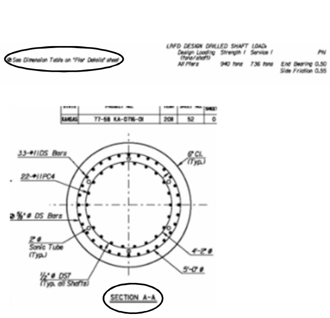
Drilled Shaft Details

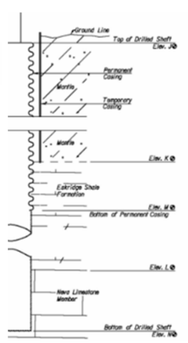


ELEVATION TABLE			
Elev.	Pier #1	Pier #2	Pier #3
A	1141.40	1143.84	1147.28
B	1141.54	1143.98	1147.42
C	1141.68	1144.13	1147.57
D	1141.54	1143.98	1147.42
E	1141.40	1143.84	1147.28
F	1135.40	1137.84	1141.28
G	1134.40	1136.84	1140.28
H	1108.90	1096.34	1109.78
J	1107.90	1095.34	1108.78
K	1077.00	1077.70	1085.00
L	1069.60	1066.70	1064.30
M	1074.1±	1074.7±	1082.0±
N	1064.90	1062.84	1062.78

PL - 34

Drilled Shaft Details

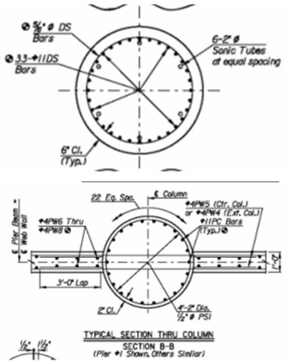


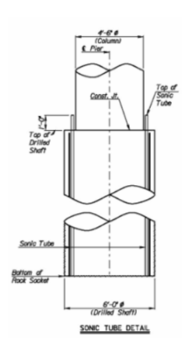


Section Through Shaft @ Shaft/Column Reinforcement steel lap splice

PL - 35

Pier Drilled Shaft Details

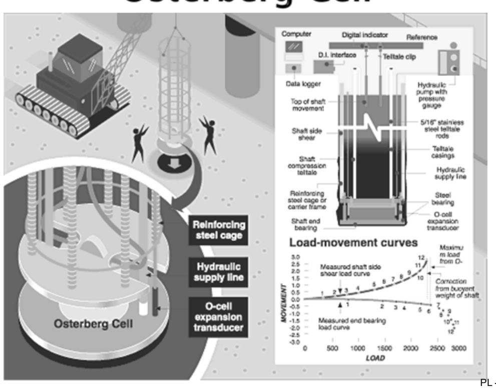




PL - 36

PL-37

Osterberg Cell



PL - 38

Osterberg Cell

PL - 39

Osterberg Cell

PL - 40

What do O-cell tests provide other than Headaches for the contractor?

- Test shafts very similar to the production shafts. Gives the contractor a heads up on the construction practices needed at the site.
- Gives real skin friction and end bearing values
- Hopefully gives you the same capacity data you calculated (or more).
- Lets you have the most economical shaft for the structure.
- Not cheap!

PL - 41

Questions?

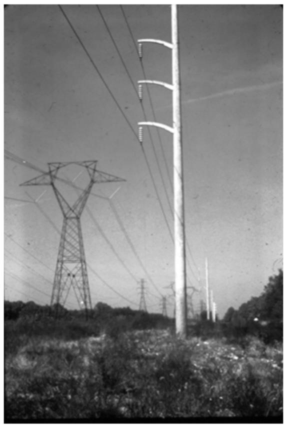
PL - 42

Drilled Shaft Equipment

By
Kyle Halverson
Chief Geologist

Drilled shaft Rigs have been available since the early 1900's and Were powered by horses! This Beck Rig is from Texas in the 1950's. Notice the large gear drive system.

Drilled shafts are foundation of choice for large axial, and lateral loads associated with bridges
Kansas Bridges are founded only in rock! (Shale, Limestone, Sandstone)



Drilled shafts are often used for tower structures to resist uplift loads and for constructability

Light tower Shafts maybe set into bedrock or soil.

Drilled shafts used in an tangent-pile retaining wall for excavation support

Smaller diameter drilled shafts are used for residential structures, landslide repair, and other applications. Many times these small augers are mounted on the back of tractors

Drilled Shafts:
Potential Disadvantages

- Construction may be difficult or more costly in difficult ground (e.g., groundwater problems, squeezing clay, cobbles, and boulders)
- Lack of redundancy compared to pile group
- Not suitable in v. soft - soft clays
- Quality is sensitive to construction procedures
- Requires engineers to be familiar with constructibility issues

Basic elements of a drilled shaft rig

Drilled Shaft Rigs

- Crane Mounted
- Truck Mounted
- Crawler Mounted
- Carrier Mounted

light-medium duty rig
Watson 2000, crawler mounted
capacity: 82 ft. depth, 5 ft. dia

medium-heavy duty rig
Watson 3000, carrier mounted
up to 118 ft. deep, 7.9 ft. diameter
torque: 136 kN-m
crowd: 225 kN

The *Lo-Drill*, a low-clearance rig

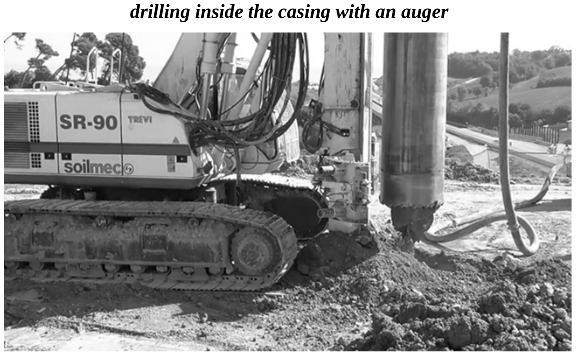
Crane attachment, mounted on a bridge platform that can drill to 328 ft. with torque of 340 kN-m

US VS. European Rigs

- US Rigs tend to be mechanical driven
- European Rigs are mostly Hydraulically driven.
- European Rigs can drill and advance casing at the same time
- European Rigs are becoming much more popular in the last ten years.

SOILMEC SR-90

Can be configured with dual rotary heads to install casing while drilling inside the casing with an auger



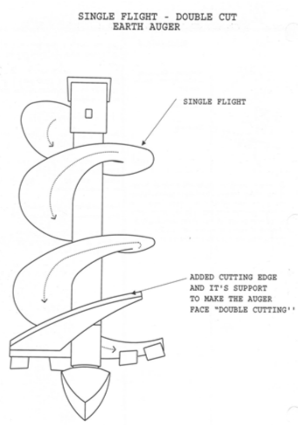
The Leffer Oscillator
installs casing by oscillation
soil is excavated from inside as casing is advanced

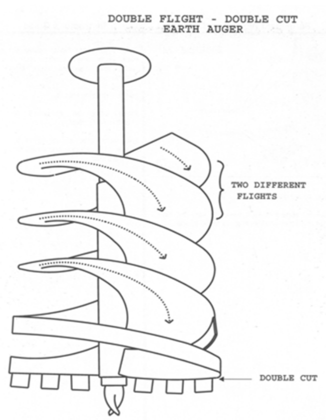
7 ft. diameter shafts, 69-121 ft. deep

Clamshell hammer grab tool

Augers

- Two Main Types: Soil and Rock
- Augers can be single cut or double cut
- Single flighted or double flighted.
- Auger can have adjustable diameters.





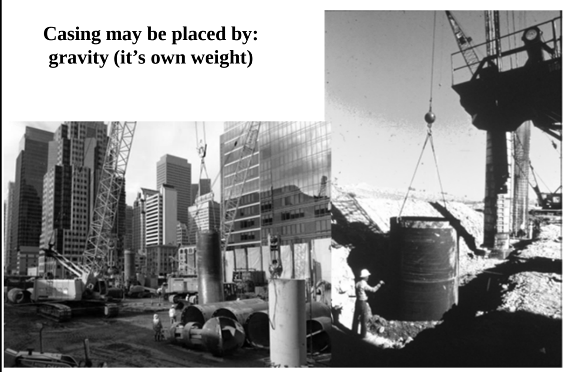
Adjustable Diameter Soil Auger

Single-Flight

Soil Auger

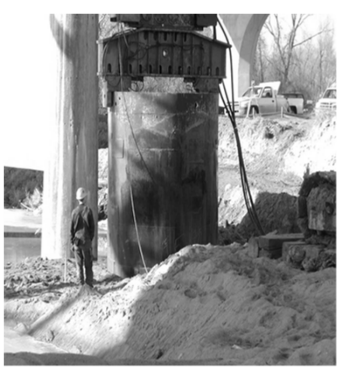
6-33

Casing may be placed by:
gravity (it's own weight)



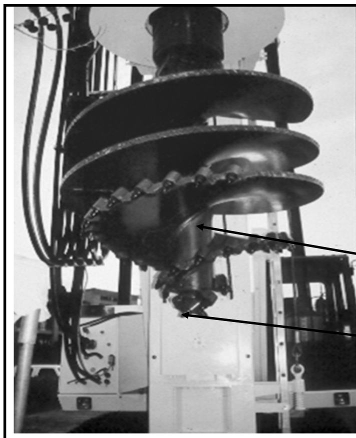
"twister" fits into slots in casing, allowing drill rig to apply torque and crowd

Vibratory Hammer
Make sure hammer has two clamps
One is for sheet pile installation!



ROCK AUGERS

Rock augers are generally used in soft to hard rock formations.

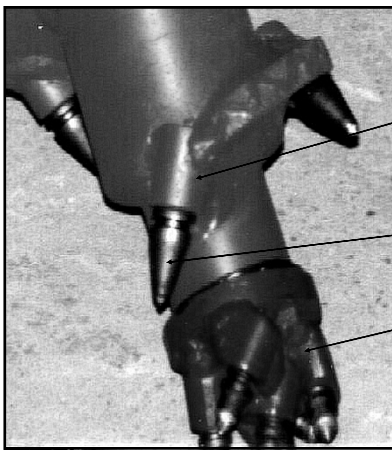


Tapered Geometry

Conical (Bullet) Carbide Teeth

6-36

ROCK AUGERS



Pocket

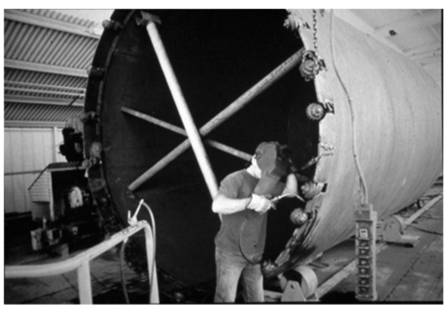
Carbide tip tooth

Carbide tip
Replaceable tooth
Stinger

6-37

Rock Core Barrel

End View of Core Barrel

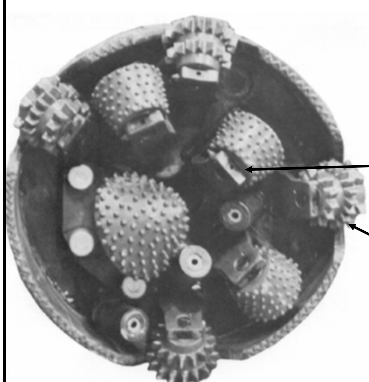


Addition of Rolla Cone Bits for Hard Bedrock

14 foot Diameter Shaft in Very Hard Granodiorite!

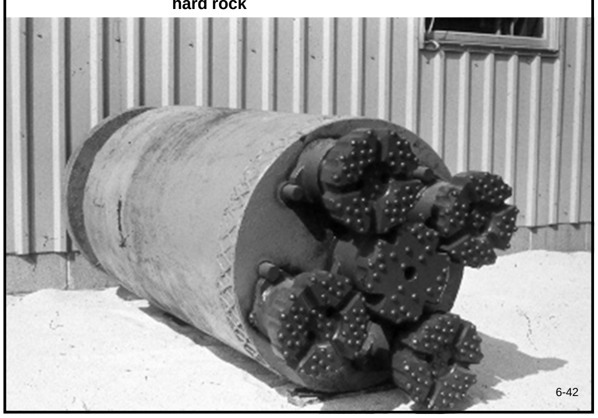
ROCK BITS

This is typical of rock bits designed for drilling in hard to very hard rock.



6-41

Down hole Hammer Bit for very hard rock



6-42

Clean out bucket

Inside View of Clean out bucket

Cleanout bucket in operation

<u>CLEANOUT TOOL</u>

Final cleaning down-the-hole pump

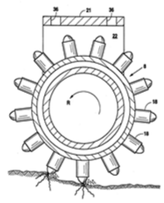
6-52

Air Lift

<u>Overreaming Bucket</u>

To roughen the Sides of the Drillled Shaft

Used when an Increase in Skin Friction is Req.



5-58

What will the Inspector need at this point?

- Weighted Tape
- Field Book
- Bridge Foundation Geology Report

BRIDGE FOUNDATION GEOLOGY REPORT

23-35 KA-3995-01
K-23 over Arkansas River

Gray County

Kyle Halverson, P.G.
Chief Geologist

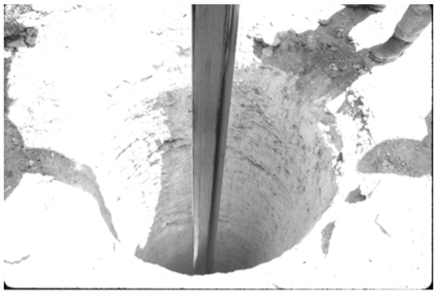
Arthur E. Peterson, P.G., Regional Geologist
Jason Kolb, P.G., Professional Geologist II

February 2017

Kansas
Department of Transportation
Bureau of Structures and Geotechnical Services
Geology Section

What should the Inspector Note about the Contractor's Equipment?

- Tool and Casing Diameters
- Casing Lengths
- Casing Cleanliness



Hopefully all your drilled shafts would be as easy as this one!!!

Questions?

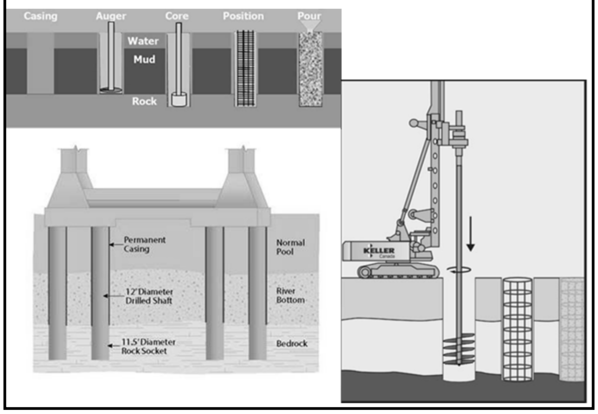
Drilled Shaft Excavation and Cleaning


Drilled Shaft Excavation

- Survey in Location
- Auger Soil Mantle
- Set Temporary Casing or Thick-walled Permanent Casing
- Drill Rock Socket
- Clean Rock Socket
- Install CMP Permanent Casing

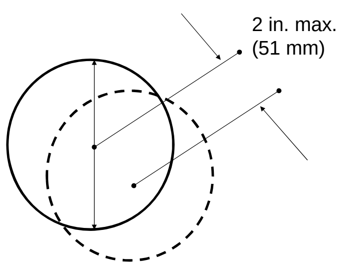
Trial Drilled Shaft

- Trial Shafts are used to test the contractors methods.
- This can include drilling, sealing of groundwater setting of casing, setting rebar cages, and concrete placement.
- The trial shaft should be drilled to the maximum depth of any production shaft shown on the plans.



Is the shaft being constructed in the correct location & within tolerance?

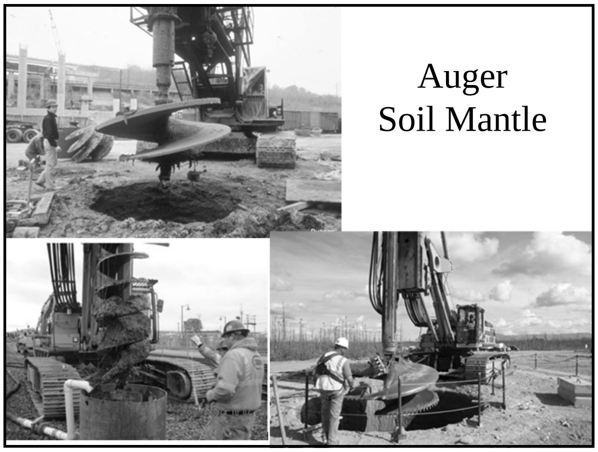
Plan Position



11-15

Auger Soil Mantle

- Excavation of the Soil mantle is done before the casing is set.
- Use a Weighted Tape to check Progress of the Excavation.

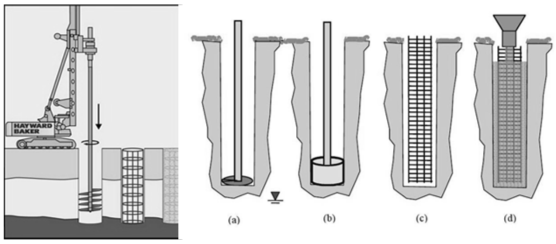


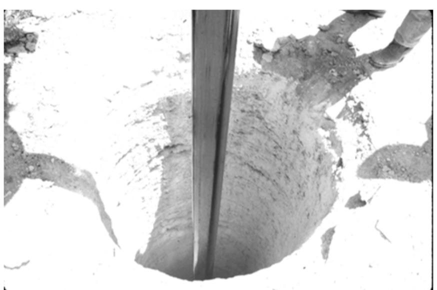
Auger Soil Mantle

Class Exercise

- Soil and its properties

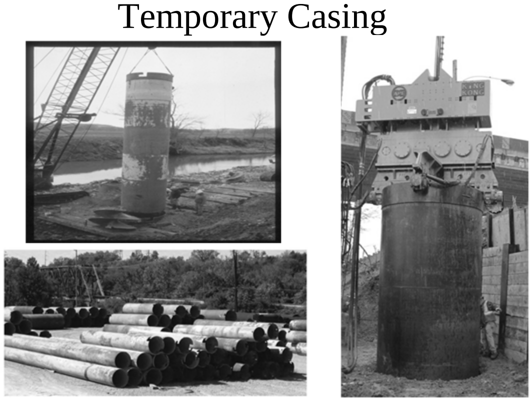
Dry Pour Method





Dry construction in travertine, Thermopolis, WY

Temporary Casing



Vibrating Thick-walled Permanent Casing

Inspector Checklist

- At this point the Inspector should record the following:
- Material Augered from Shaft
- Type of Casing
- Length and Size of Casing
- Elevation of Top of Casing
- Anything out of the ordinary. Excessive time, material not as shown on plans.

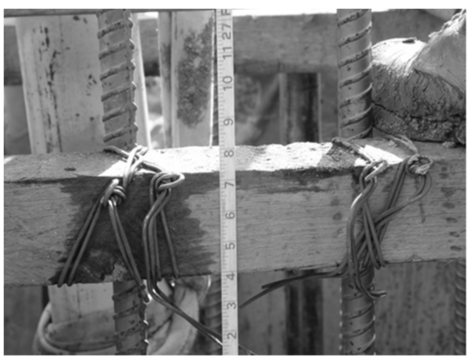
Rock Socket Excavation

- Rock Socket can be augered or cored.
- Rock socket maybe wet or dry
- Pay close attention to what type of material is being excavated. What is the foundation Material supposed to be? Limestone, Shale etc
- Measure elevation from known reference point
- Do Not over excavate the depth of the shaft.

Excavation of the Bedrock

Check Depths with a Weighted Tape

Measure to a Known Reference Point



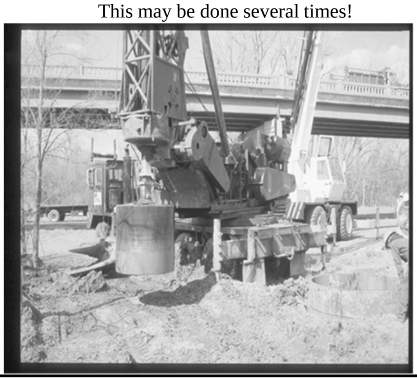
Class Exercise

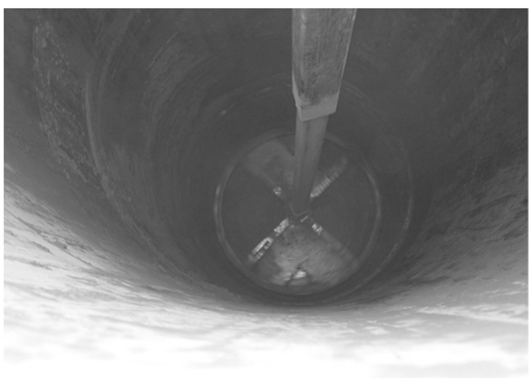
- Rock Properties and Identification
- Wet and Dry Methods!

Check the depths!

Cleaning out the Rock Socket

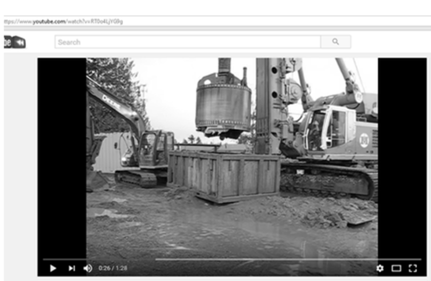
This may be done several times!





Cleaning out rock socket

- https://youtu.be/RT0o4LjYG9g

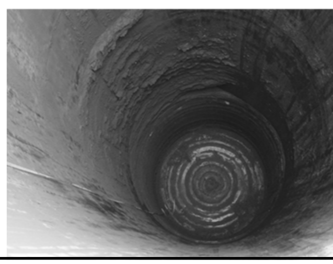


Air Lift Pump

Clean Water indicates a Clean Socket

Cleaned Rock Socket

Rock Socket should be free of debris and relatively flat. The augers or other equipment used to excavate the rock socket should be within 3/8ths of an inch per foot from vertical. (31 mm/m)



PERMANENT CASING

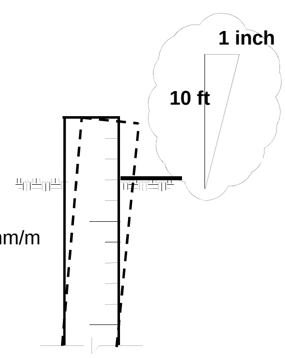
- Permanent Casing is required when you have a wet pour or specified on the plans.
- Permanent Casing must be water-tight and can be a corrugated metal pipe or a thick walled metal pipe.
- Casing can not be more than 1 inch or 25 mm out or round.
- Deviation of a chord must be less than or equal to 2 inches or 51 mm.

Installation of CMP Permanent Casing

Class Exercise

- 3 drilled Shafts
- Drilled Shaft inspection procedure
- What documentation and equipment will you need
- Which of any are acceptable
- If not acceptable, why not and what is your next step?

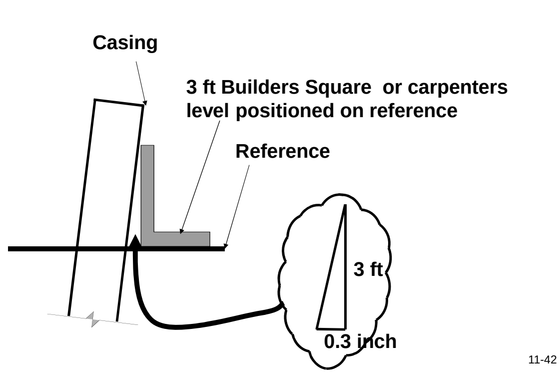
Is the shaft within allowable vertical alignment tolerances
Maximum is 6 inches or 150 mm out of alignment



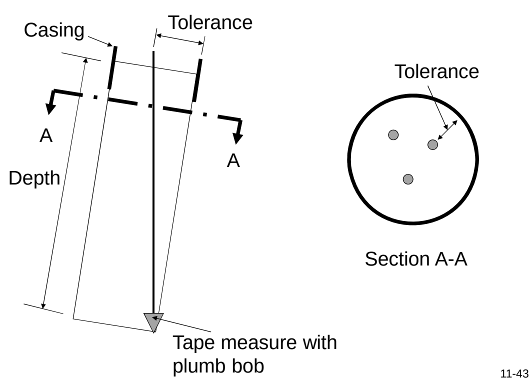
If a Metric Job:
Tolerance is 8.3 mm/m

11-41

TO CHECK FOR VERTICAL ALIGNMENT



TO CHECK FOR VERTICAL ALIGNMENT



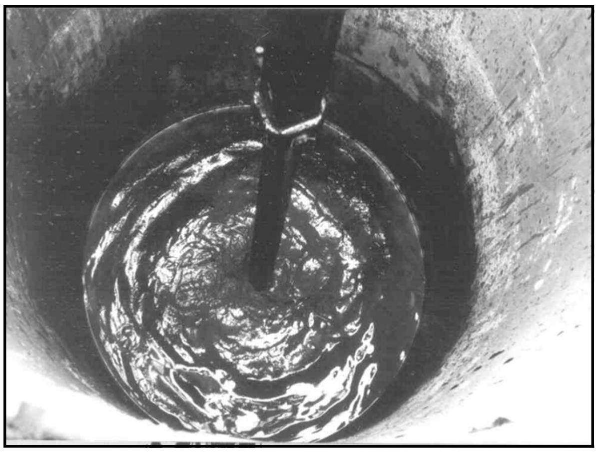
Is the shaft of proper depth? Marks on a Kelly Bar are Very unreliable!

Does the shaft bottom meet the requirements?

ROCK SOCKET EXCAVATION INSPECTION

- **Maximum depth of sediment or debris = ½ inch or 13mm of Sediment over 75% of the shaft bottom.**
- **Dry Shafts no more than 4 inches or 102mm of water in a 5 minute Period and the shaft can be dewatered so only 2 inches or 51 mm of water is left in the shaft.**
- **Inspection of a wet shaft.**

11-56



11-59

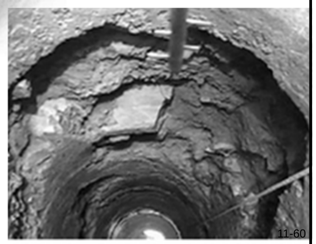
Video Recording

- On any shaft 6 foot in diameter or over a down hole camera must be used.
- The hole can be pumped out then fresh clean water pumped back into the socket
- Or a flocculent can be used to settle out the cuttings and clear up the water.

SHAFT INSPECTION DEVICES

11-58

Inside 36” rock socket



11-60

Clay filled cavity in sidewall of 36" rock socket.

SHAFT CLEANLINESS

Shaft cleanliness is important for:

A) end-bearing shafts

B) side-friction shafts

C) both of the above

D) none of the above

11-62

TYPICAL PROBLEM

Dirty Hole

11-65

Very large defect found by Sonic Echo test. Probably due to dirty hole.

No concrete

11-67

ANY QUESTIONS?

11-70

Reinforcing Cage

Kevin Palic
Field Construction Engineer
Bureau of Construction and Materials

1

Learning Objectives

- Summarize the key points of inspecting the reinforcing steel cage in a drilled shaft foundation
- Determine the circumference of a shaft and rebar cage and calculate the required number of side spacers.
- Explain how to assess the Contractor's compliance with cage construction/placement requirements

2

Inspector Duties

- Responsible for:
  - Verifying proper reinforcing steel diameter, length, spacing and quantity
  - Verifying the steel is properly tied in place
  - Verifying proper spacer installation

3

Reinforcing Steel and Sonic Testing Pipes

- Why do we need these in drilled shafts?
  - Sonic testing pipes are for testing the concrete in the shaft only, there is no structural significance
  - Sonic testing pipes are required in every drilled shaft for bridges.
  - Not required for shafts in noise walls, high mast towers or overhead structures

4

Requirements for Shaft before reinforcing steel placement

- Outlined in Standard Specifications Division 700 section 703.3 c
  - Shaft drilled using a full diameter core barrel
  - Use a full size clean-out bucket a minimum of 95% of the diameter of the rock socket
  - Sound the bottom of shaft using a weighted tape
  - Provide access to the entire perimeter of shaft

5

Requirements for Shaft before reinforcing steel placement

- Section703.3 c
  - Flocculate the finished shaft to increase the visibility in water for underwater video
  - Prior to concrete placement, perform a video inspection to inspect sides and base of rock socket
  - This video needs to be reviewed with the Engineer prior to placement to verify cleanliness of the shaft

6

Placing Reinforcing Steel and Sonic Testing Pipes

- See Standard Specifications Division 700
- Reinforcing Steel section 703.2 d
  - Refers to Division 1600
  - Sections 1601 Steel Bars for Concrete Reinforcement
  - Section 1604 Helical Reinforcement
  - Section 1605 Reinforcing Steel Splices
- Sonic Testing Pipes 703.2 f
  - Provide pipe that complies with Division 1600

7

Placing Reinforcing Steel and Sonic Testing Pipes

- Section 703.3 d
  - This section outlines the requirements for placing reinforcing steel and sonic testing pipes
  - Reinforcing steel
    - Tie all intersections
    - Place reinforcing steel as one unit
    - Place 1 non-corrosive circular spacer per 30 inches of circumference of the reinforcing cage
    - Spacers will be spaced 2 to 4 feet from bottom and top not to exceed intervals 10 feet vertically

8

Placing Reinforcing Steel and Sonic Testing Pipes

- Reinforcing Steel
  - If shaft is lengthened and the length of the cage is required to be increased make sure splice is at the bottom of the reinforcing steel cage
  - ***If the cage is required to be lengthened, contact the state bridge office for guidance on splicing**

9

Placing Reinforcing Steel and Sonic Testing Pipes

- Section 703.3 d
  - Sonic testing pipes
    - Remove any corrosion protection coating on the pipes by sandblasting to bare metal
    - Sonic testing pipes be full length of shaft and a minimum of 12 inches above top of concrete
    - These pipes must extend to the bottom of the shaft

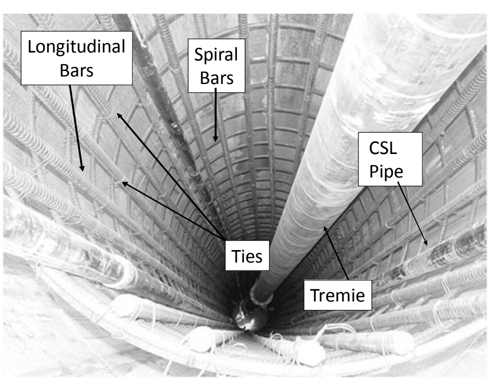
10

Sample drilled shaft inspection checklist

Reinforcing Cage	Yes No	NA
21. Is the rebar the correct size and configured in accordance with the project plans?		
22. Is the rebar properly tied in accordance with 2015 Standard Specifications part 703.3 d?		
23. Does the Contractor have the proper spacers for the steel cage in accordance with 2015 Standard Specifications part 703.3 d?		
24. If the cage is spliced, was it done in accordance with the contract documents and was the State Bridge office consulted?		
25. Is the steel cage secured from settling and from floating (during concrete placement cages sometimes rise with the concrete)?		
26. Is the top of the steel cage at the proper elevation?		

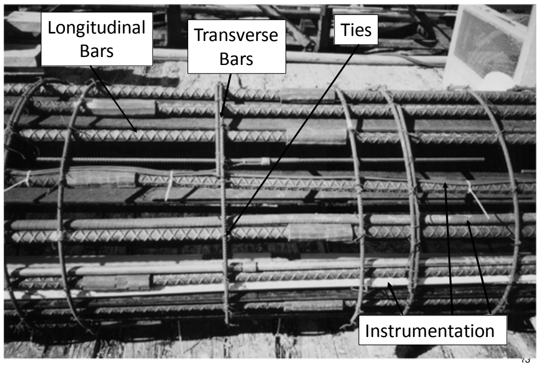
11

REINFORCING CAGE



12

REINFORCING CAGE

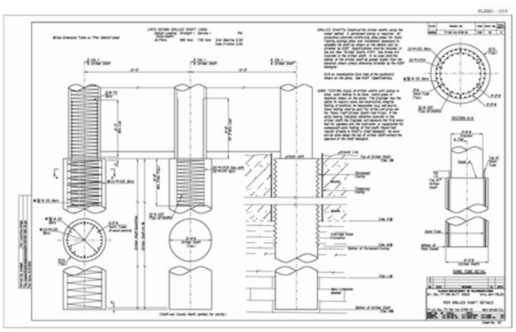


Reinforcing cage construction

- Reinforcing steel cage construction and placement
  - Shall be completely assembled prior to placement
  - Placed immediately after inspection and acceptance of shaft
  - Internal stiffeners removed as cage is placed in the excavation

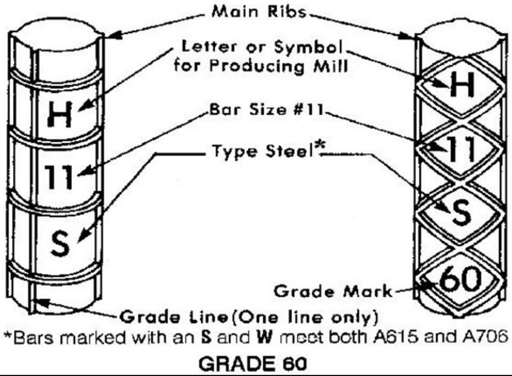
14

Is the rebar the correct size and configured in accordance with the project plans?



15

IDENTIFICATION MARKS
ASTM STANDARD REBARS



ASTM STANDARD REBARS

Bar No.		Weight/Mass		Diameter	
US	SI	Lbs/Ft	KG/M	in	mm
3	10	0.376	0.560	0.375	9.5
4	13	0.668	0.994	0.500	12.7
5	16	1.043	1.552	0.625	15.9
6	19	1.502	2.235	0.750	19.1
7	22	2.044	3.042	0.875	22.2
8	25	2.670	3.973	1.000	25.4
9	29	3.400	5.060	1.125	28.7
10	32	4.303	6.404	1.250	32.3
11	36	5.313	7.907	1.375	35.8
14	43	7.650	11.380	1.750	43.0
18	57	13.600	20.240	2.250	57.3

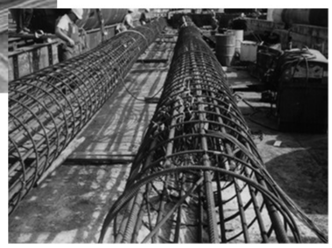
17

Reinforcing steel storage & handling

- Should not be stored in contact with soil
- Keep away from oil or other deleterious materials
- Adequate supports provided during lifting

18

Storage & handling



Properly Tie Reinforcing steel

20

SPACERS & STANDOFFS

What are the spacers used for?

To maintain the minimum required clearance between the cage and the walls of the shaft.

What are the standoffs used for?

To maintain the bottom of the cage a certain distance, generally 6” to 12” off the bottom of the shaft. These are rarely used in Kansas.

21

Spacer placement

- Start spacers 2' to 4' from the bottom and top of cage
- Up the cage at intervals not exceeding 10 ft. intervals

22

Drilled shaft spacers

- PLACING REINFORCING STEEL AND SONIC TESTING PIPES.
  - Must insure minimum clearance between outside of cage and shaft walls shown on the plans (usually 6").
  - Circular Non-corrosive spacers must be used.

23

HOW MANY SPACERS?

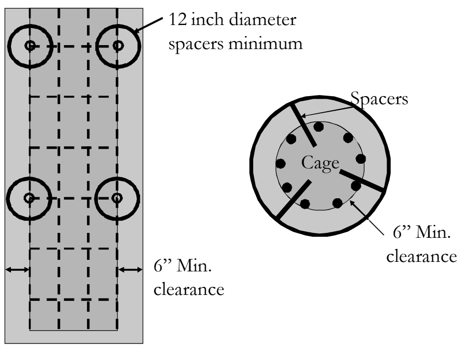
How many spacers are needed around the cage at each 10 ft. or less interval?

The current specification requires the following

....."minimum of one non-corrosive circular spacer per 30 inches of circumference of the reinforcing steel cage."

24

Clearance



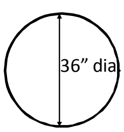
25

CIRCUMFERENCE OF A CIRCLE

Circumference (C) = πD

Where: C = circumference
D = diameter = 2 times radius
π = 3.142

PROBLEM



What is the circumference of the shaft in inches?

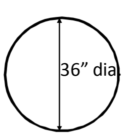
In feet?

CIRCUMFERENCE OF A CIRCLE

Circumference (C) = πD

Where: C = circumference
D = diameter = 2 times radius
π = 3.142

PROBLEM



What is the circumference of the shaft in inches?

C = πD
C = 3.142 (36”)
C = 113.1 inches

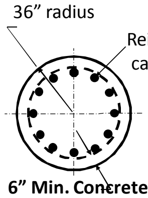
In feet?

C = πD
C = 3.142 (3 ft.)
C = 9.43 ft.

CIRCUMFERENCE OF THE REINFORCING CAGE

Circumference (C) = πD

Where: Diameter of cage = Shaft diameter minus 2 times the Concrete cover
D = diameter = 2 times radius
π = 3.142

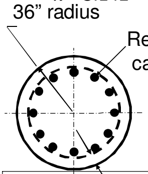


What is the circumference of the reinforcing cage in inches.?

CIRCUMFERENCE OF THE REINFORCING CAGE

Circumference (C) = πD

Where: Diameter of cage = Shaft diameter minus 2 times the Concrete cover
D = diameter = 2 times radius
π = 3.142



What is the circumference of the reinforcing cage in inches.?

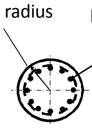
D = 72”– 2 x Req’d Clearance

D = 72” – 12” = 60”

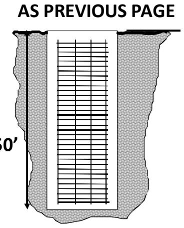
C = πD or 3.142 x 60”

C = 189”

SIDE SPACERS FOR SHAFT ALIGNMENT



SAME CIRCUMFERENCE AS PREVIOUS PAGE



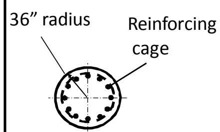
…spacing devices shall be used at sufficient intervals [near the bottom and at intervals not exceeding 10 feet up the shaft] …. Use a minimum of one spacer per 30 inches of circumference of cage with a minimum of three at each level.

How many side spacers are required shaft?

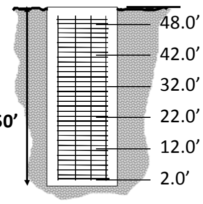
How many levels?

Total number of spacers =

SIDE SPACERS FOR SHAFT ALIGNMENT



SAME CIRCUMFERENCE AS PREVIOUS PAGE



…spacing devices shall be used at sufficient intervals [near the bottom and at intervals not exceeding 10 feet up the shaft] …. Use a minimum of one spacer per 30 inches of circumference of cage with a minimum of three at each level.

How many side spacers are required shaft?

Number of spacers per level = $\frac{189''}{30''}$ = 6.3 ➡ **7**

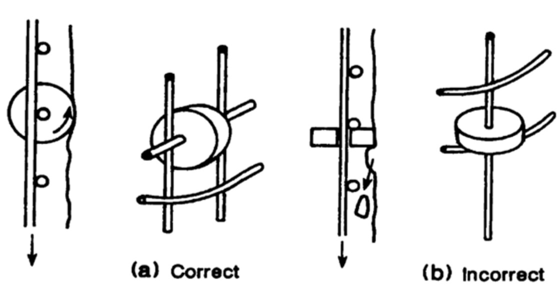
How many levels? 6

Total number of spacers = 7 X 6 = 42

Cage Diameter (in.)	No. of spacers required
30	4
36	4
42	5
48	6
54	6
60	7
66	7
72	8
78	9
84	9

32

Clearance



33

Install proper number of spacers around and up the shaft

Pl
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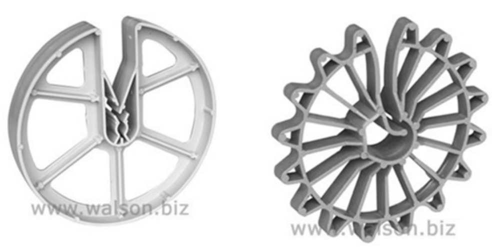
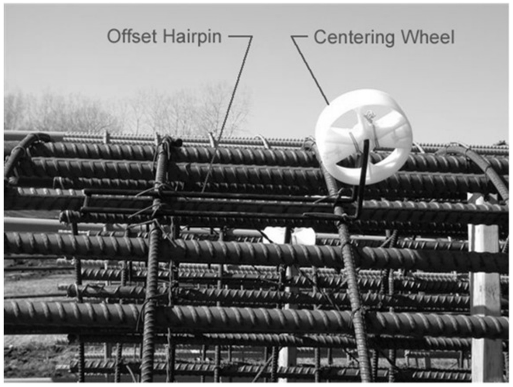
• M ved

34

TYPICAL SPACERS



36



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Spacers

Foundation Technologies, Inc.
Toll-Free Phone:800.773.2368
Fax:770.723.0844
3300 Montreal Ind. Way Suite 8
Tucker, GA 30084

http://www.foundationtechnologies.com/default.asp

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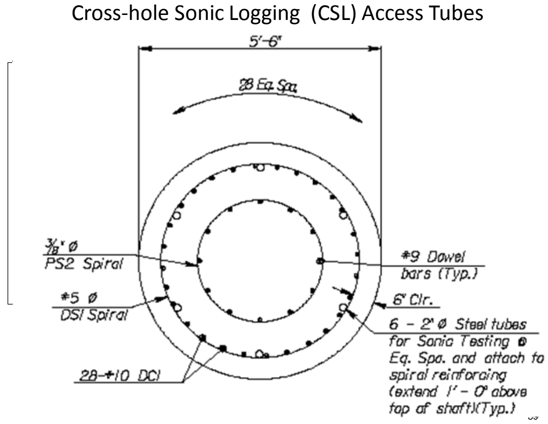
Cross-hole Sonic Logging (CSL) Access Tubes



Cross-hole Sonic Logging (CSL) Access Tubes

- 2015 Standard Specifications Division 700 section 703.2 f. Sonic Testing Pipes:
  - Division 1600 provide 2 inch diameter steel pipe that complies with ASTM A 53 or ASTM A 500, Grade B, Standard Weight.

40

Cross-hole Sonic Logging (CSL) Access Tubes

- 2015 Standard Specifications Division 700 section 703.3 d Placing Reinforcing Steel and Sonic Testing Pipes:
  - Remove corrosion protection coating from sonic testing pipes by sandblasting to bare metal
  - Place number of testing pipes shown in contract documents

41

Cross-hole Sonic Logging (CSL) Access Tubes

- 2015 Standard Specifications Division 700 section 703.3 d Placing Reinforcing Steel and Sonic Testing Pipes:
  - Pressure test each pipe before installation in the reinforcement cage
  - Test all pipes after being placed and tied in reinforcement cage

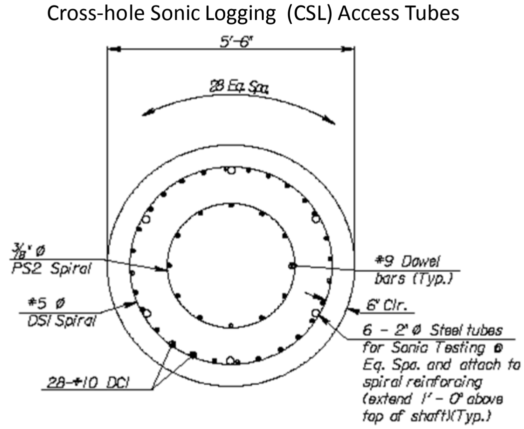
42

Cross-hole Sonic Logging (CSL) Access Tubes

- 2015 Standard Specifications Division 700 section 703.3 d Placing Reinforcing Steel and Sonic Testing Pipes:
  - When the drilled shaft is greater than 30 feet in length, perform a second test after reinforcing steel is installed in shaft
  - Pipe must be pressurized to 100 psi pressure loss can not be greater than 5% in 3 minutes

43

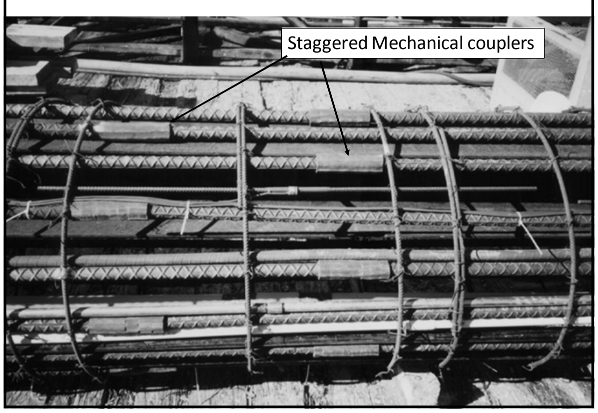
Cross-hole Sonic Logging (CSL) Access Tubes



SPLICING OF CAGE

- If the rebar cage must be extended splices usually will be made at the bottom of the cage
- Remember that the CSL tubes must go to the bottom of the shaft

47



SPLICING OF CAGE

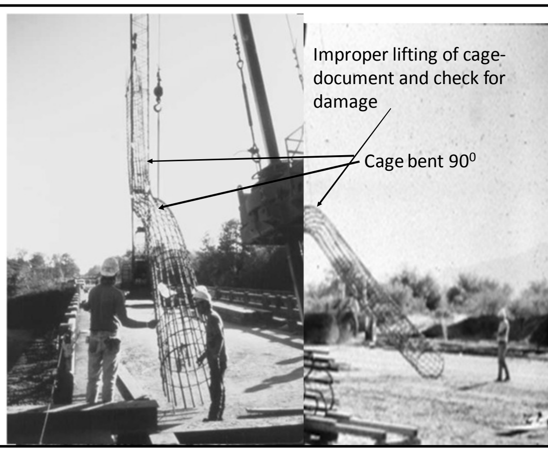
- Typical plan notes might say:
  - Minimum of one-half of longitudinal bars extended on bottom
  - Tie or spiral bars continue for the extra depth
  - Stiffener bars extended to final depth

49

If the cage is spliced, was it done in accordance with the contract documents?

- Occasionally, due to a variety of things, the shaft will be deeper than the length of the cage and a splice will be required
- Typically the specifications or plans will contain the requirements for splicing, remember contact State Bridge Office

50




CAT

TYPICAL INSPECTION FORM

This may be a separate form or part of another form, such as the Shaft Inspection Form, as shown below

Rebar Cage:	Proper # Vert. Bars	yes- 18 #8
	Proper # Horz. Bars	yes- 43 #5
	Side Standoffs	15 – 12" dia. (5 rows/3)
	Bottom Standoffs	6" (18)
	Epoxy Condition	See Remarks
	Ties & Connections	All intersec.

63

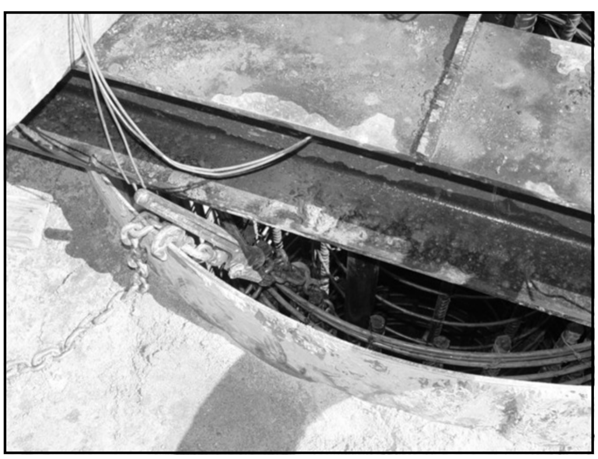
Keeping the cage in place

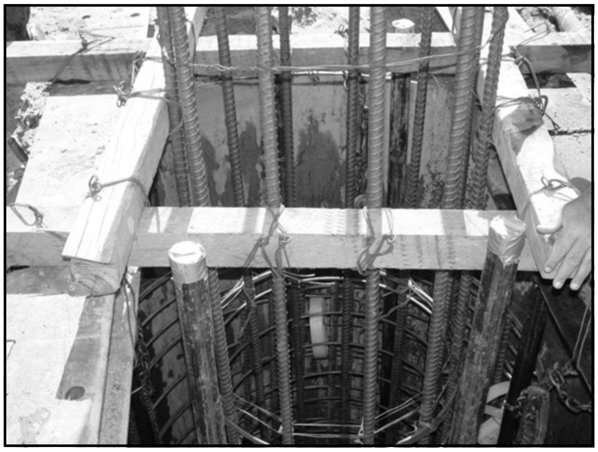
- Once cage is set need to keep it place so it does not move during placement of the concrete
- Cage could lift out of concrete from pressure

64

Good Cage Support

65





Special Provision 15-07007

- This is for noise wall, high mast towers, overhead sign structures and other specified items
- Basically the same requirements for placing steel as section 703

69

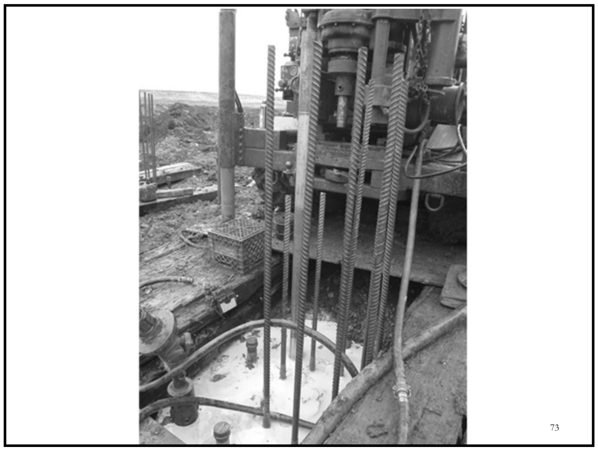
Special Provision 15-07007

- Sonic testing pipes are not required
- Spacer requirements are the same
- Usually smaller shafts than what are required for bridge structures

70

When things go bad

71



Learning Objectives

- Summarize the key points of inspecting the reinforcing steel cage in a drilled shaft foundation
- Determine the circumference of a shaft and rebar cage and calculate the required number of side spacers
- Explain how to assess the Contractor's compliance with cage construction/placement requirements

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ANY QUESTIONS?

79

DRILLED SHAFT CONCRETE PLACEMENT

JAKE PFANNENSTIEL
ENGINEERING ASSOCIATE – BRIDGE DESIGN

CON - 1

Placing Drilled Shaft Concrete

Two Methods for Shaft Pours used by KDOT are:

- Dry Pour Method
  - Cased
  - Uncased
- Wet Pour Method
  - CASED ONLY

CON - 2

Placing Drilled Shaft Concrete

- **Is it a Dry Pour or Wet Pour?**
- **How is the appropriate method determined?**
  - **Is the shaft Dry?**
    - **Dry Pour Method**
  - **Is there water in the Shaft?**
    - **Can the water be pumped down to within 2″ or less of the bottom of the shaft and refill 4″ or less in depth in 5 minutes when the pump is shut off?**
      - **Yes, could use dry pour but remember only 2″ of water is allowed in the bottom of the shaft when concrete placement begins**
      - **No, then it must be a wet pour**

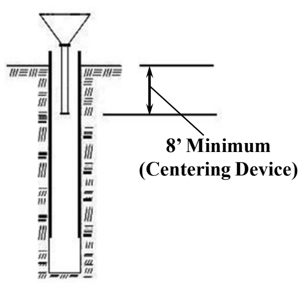
CON - 3

Free Fall Method

CON - 4

Dry Pour Method
Cased Shaft

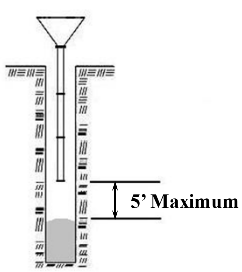
Unlimited Free Fall



CON - 5

Dry Pour Method
Uncased Shaft

Limited Free Fall

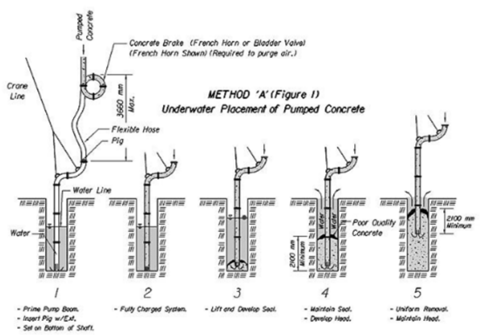


CON - 6

Concrete Placement
Wet Pour Method

- To separate the ground water from plastic concrete these are essential items.
  - Static Water Level
  - Fully Charge
  - Initial Seal
  - Embedment
  - Over Pump

CON - 7



Static Water Level | Fully Charge | Initial Seal | Embedment | Over Pump

CON - 8

Method "A" with a French Horn

The French Horn minimizes air being pumped through the concrete during initial placement

CON - 9

703.3 Construction Requirements
Placing Drilled Shaft Concrete

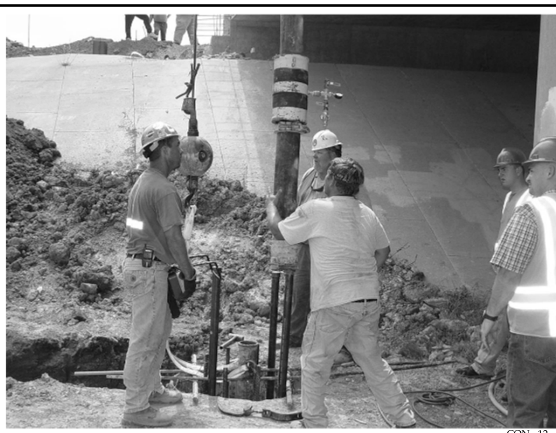
French Horn

Insert Pig here

Using a sealed discharge pipe with a pump

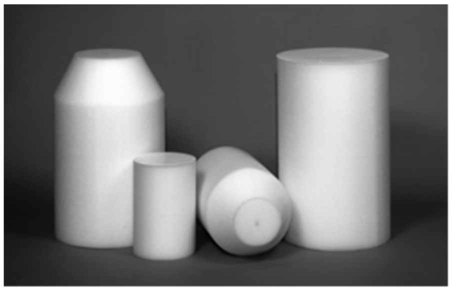
CON - 10

CON - 11



CON - 12

Example Pigs



1 lb./ Ft^3 – 30 IFD

CON - 13

GIRARD INDUSTRIES

6531 North Eldridge Parkway
Houston, Texas 77041-3507, USA

Phone Toll Free: (800) 231-2861

Web Address: www.girardind.com

CON - 14

Pig Manufacturer:
Future Foam

Future Foam
Wes Putnam
Newton, KS
(316) 283-8600

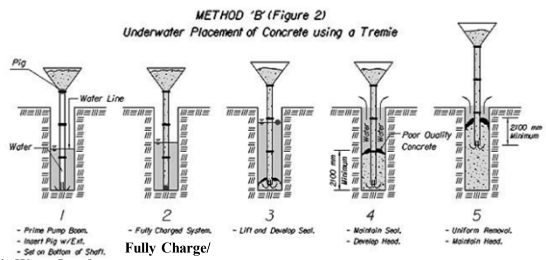
CON - 15

CON - 16

CON - 17

CON - 18

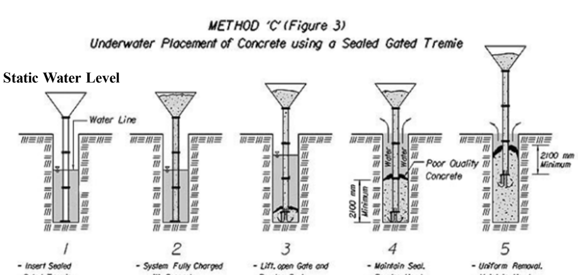
CON - 19



Static Water Level | Fully Charge/ Initial Seal | Embedment | Over Pump

CON - 20

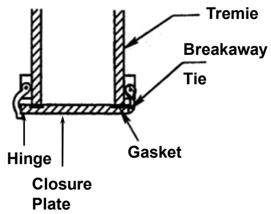
Static Water Level



Fully Charge/ Initial Seal | Embedment | Over Pump

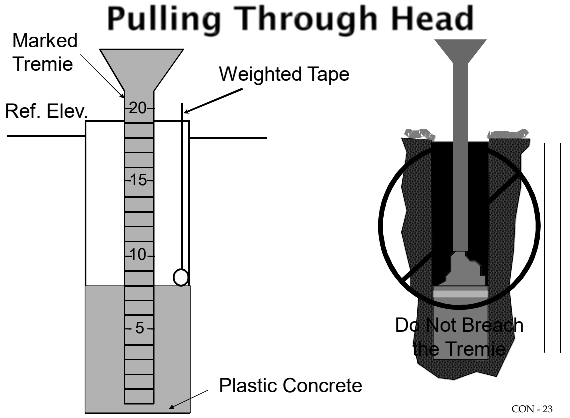
CON - 21

Method "C" Sealed Gated Tremie



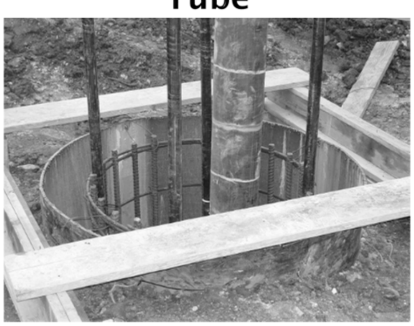
CON - 22

Pulling Through Head



CON - 23

Marked Tremie/Discharge Tube



CON - 24

CON - 25

CON - 26

CON - 27

CON - 28

CON - 29

CON - 30

Raising Temporary Casing

- Sites with temporary casings only.
  - **Not allowed since 2007 specs.**
- Sites with a permanent and temporary casing. (In accordance with 703.3.g)

g. Raising Temporary Casing. Do not remove the temporary casing until the concrete in the shaft has met the following conditions:

- Completed shafts have been allowed to set for a minimum of 24 hours after the concrete placement; and
- Developed a compressive strength of 1800 psi; or
- If compressive strength does not meet 1800 psi, the Engineer may allow the Contractor to proceed when the shaft has cured 5 days after completion of the concrete placement.

However, immediately after completing concrete placement in the permanent casing, it is acceptable to raise and hold the temporary casing at the embedment depth plus 6 inches.

Before raising the temporary casing completely, backfill the space between the 2 casings according to **subsection 703.3j**.

CON - 31

Measurement and Payment

- Completed Shaft
- Casings
- Sonic Tests
- Investigative Core Holes

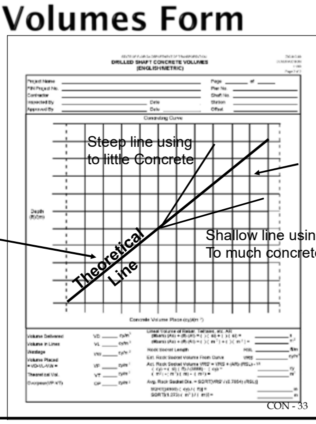
CON - 32

Concrete Volumes Form

Compute Concrete Curve

Fill in before placement starts

During Placement Slope of the line Is key to Detecting trouble



CON - 33

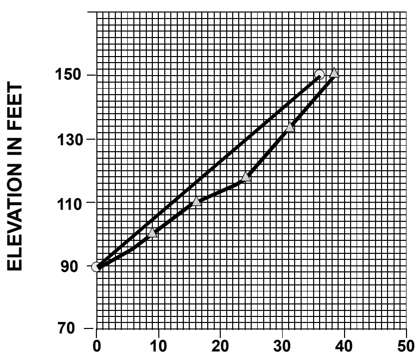
Concrete Volume Curves

❑Concrete Volume Curve can be the first line of defense to recognize this is a deficient shaft.

❑ This is much easier and often much cheaper to address **before** the concrete has set up

CON - 34

Plotting the Concrete Volumes Curves



CON - 35

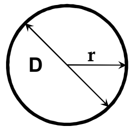
Determining Concrete Volumes

To perform your responsibilities and complete the Concrete Placement and Volume Form, you need to know how to:

- Calculate the theoretical volume of the shaft
- Determine the depth to top of concrete in the shaft
- Plot the actual concrete volume versus the theoretical volume
- Recognize problems based upon the concrete volume plots

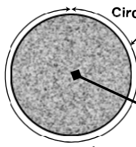
CON - 36

Information Needed



D = Diameter = Full Width of Circle

r = Radius = $\frac{D}{2}$



Circumference = Distance around circle

Circumference = $2 * \pi * r = \pi * D$

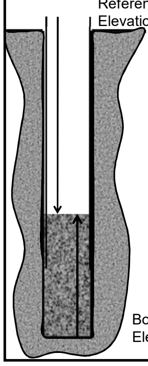
Area = $\pi * r^2 = 0.25 * \pi * D^2$

To convert from feet to inches: feet * 12 = inches

To convert from inches to feet: $\frac{\text{inches}}{12}$ = feet

To convert from cu. ft. to cu. Yd.: cu. ft./27 = cu. Yd.

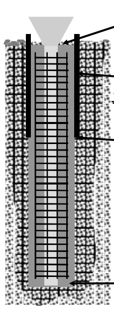
Terminology



"Depth of Hole" or "Filled to an elevation…": Measured from Reference Point down.

"Depth of Concrete" or "To an Elevation Of": Measured from bottom Elevation up.

CONCRETE VOLUMES
PRACTICE PROBLEM #1



1. **Calculate the theoretical volume of the hole**

Volume = Depth X Area / 27

Depth = 158-80 = 78 feet

Area $= 0.25 \times \pi \times D^2$

$D = 3.5$ ft

Area $= .25 \times \pi \times 3.5^2$

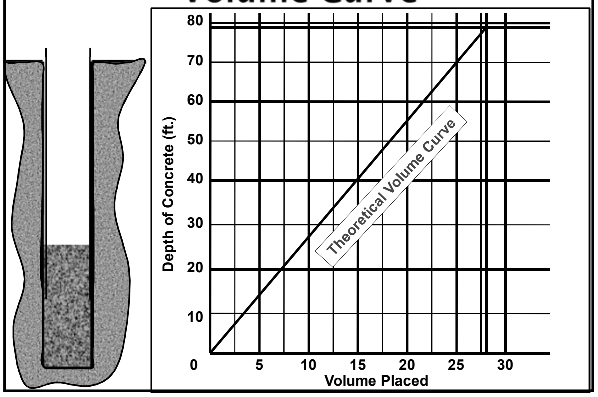
$= 9.62$ ft^2

Volume = 78 X 9.62 /27

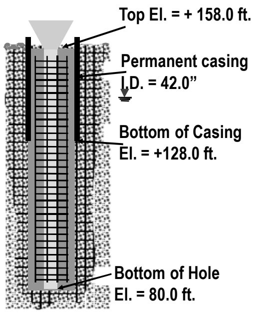
= 27.8 Cu Yds.

CON - 39

Volume Curve



CONCRETE VOLUMES
PRACTICE PROBLEM #1 (CONT.)



2. Concrete volume following each truck

Calculate the rise of the top of concrete per cubic yard

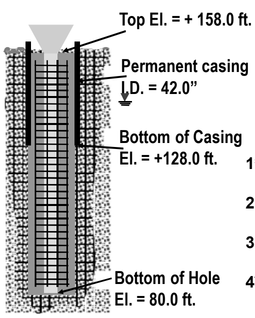
= Shaft Length/Shaft Volume

= (158.0-80.0) ft./ 27.8 cu. Yd.

==>2.8 feet "filled" per cu yd

CON - 41

CONCRETE VOLUMES
PRACTICE PROBLEM #1 (CONT.)



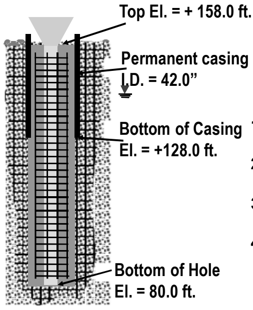
2. Concrete volume following each truck

Assume: 9 cu yds per truck
2 cu yds waste on first truck
--2.8 feet "filled" per cu yd

1st truck	(9-2) X 2.8 = 19.6 ft.	19.6 ft.
2nd truck	9 X 2.8 = 25.2 ft	44.8 ft.
3rd truck	9 X 2.8 = 25.2ft.	70.0 ft.
4th truck	8' + waste	

CON - 42

CONCRETE VOLUMES
PRACTICE PROBLEM #1 (CONT.)

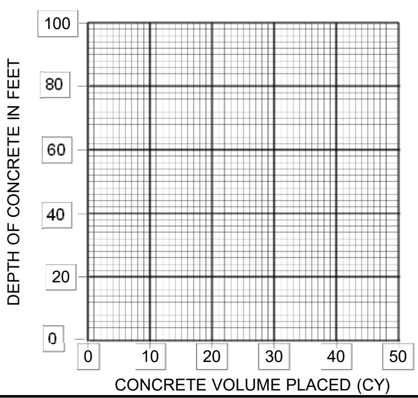


3. Take Tape Measurement and Calculate ACTUAL Concrete Depth

	Tape Length		Concrete Depth
1st truck	59.0 ft.		19.0 ft.
2nd truck	37.0 ft.	Shaft Length minus Tape	41.0 ft.
3rd truck	12.0 ft.		66.0 ft.
4th truck		12' + waste	

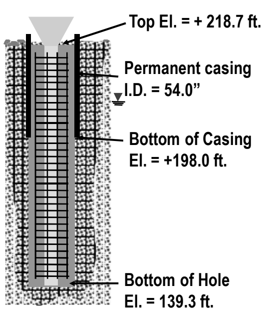
CON - 43

Plot the Concrete Volume Curves for the previous slide



CON - 44

CONCRETE VOLUMES
PRACTICE PROBLEM #2



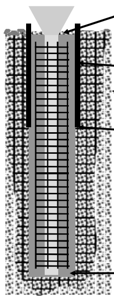
1. Calculate the theoretical volume of the hole

Total Volume = 46.8 cubic yards

CON - 45

CONCRETE VOLUMES
PRACTICE PROBLEM #2

2. Concrete volume following each truck

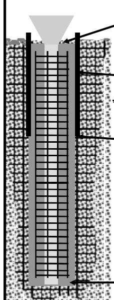


Calculate the rise of the top of concrete per cubic yard

==>1.7 feet "filled" per cubic yard

CON - 46

CONCRETE VOLUMES
PRACTICE PROBLEM #2



Assume: 10 cu yds per truck
2 cu yds waste on first truck

1st truck (10-2) X ___ = ____ ft. ____ ft.

2nd truck 10 X ___ = ____ ft ____ft.

3rd truck 10 X ___ = ____ft. ____ft.

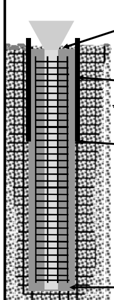
4th truck 10 X ___ = ____ft. ____ft.

5th truck ___' + waste

CON - 47

CONCRETE VOLUMES
PRACTICE PROBLEM #2

3. Take Tape Measurements and Calculate ACTUAL Depth of Concrete

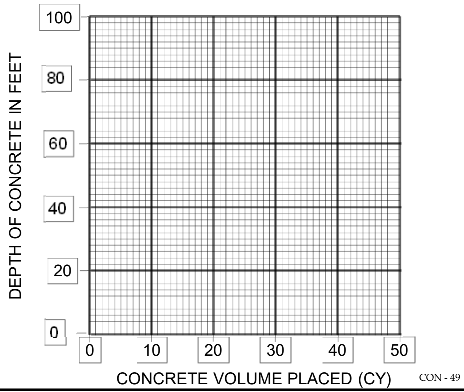


	Tape Length		
1st truck	66.4 ft.		____ ft.
2nd truck	51.4 ft.	Shaft Length minus Tape	____ ft.
3rd truck	36.4 ft.		____ ft.
4th truck	21.4 ft.		____ ft.
5th truck	6.4 ft.		____ ft.

6th truck is needed!

CON - 48

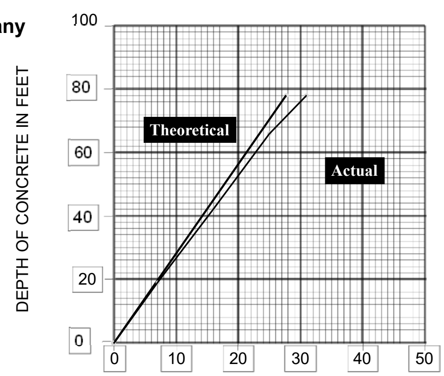
Plot the Concrete Volume Curves for the previous slide



CON - 49

Concrete Curve #1

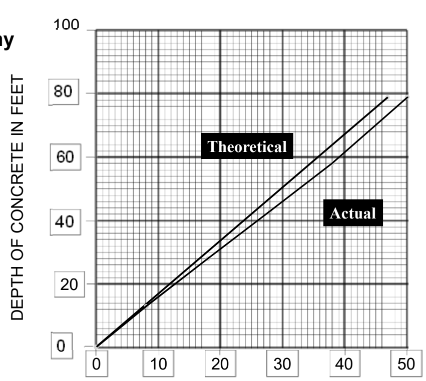
Are there any problems with this curve?



CON - 50

Concrete Curve #2

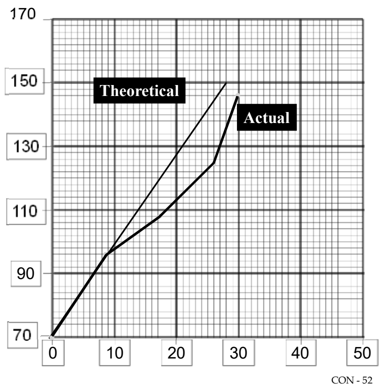
Are there any problems with this curve?



CON - 51

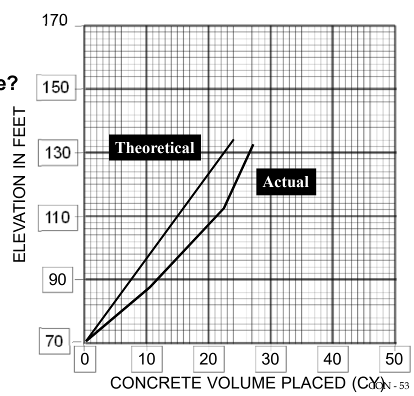
Concrete Curve #3

Are there any problems with this curve?



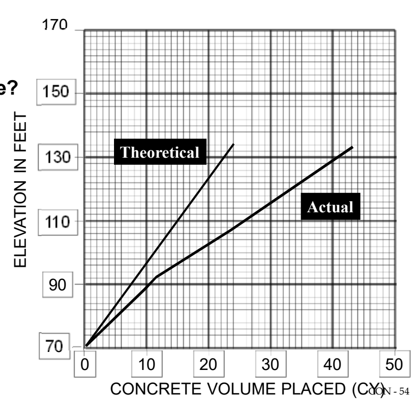
Concrete Curve #4

Are there any problems with this curve?



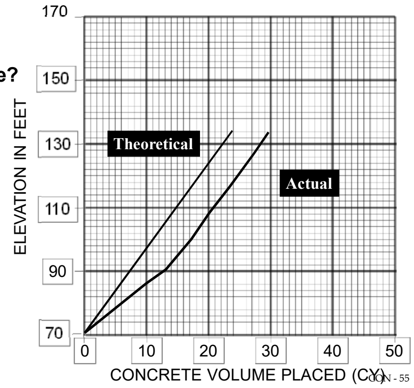
Concrete Curve #5

Are there any problems with this curve?



Concrete Curve #6

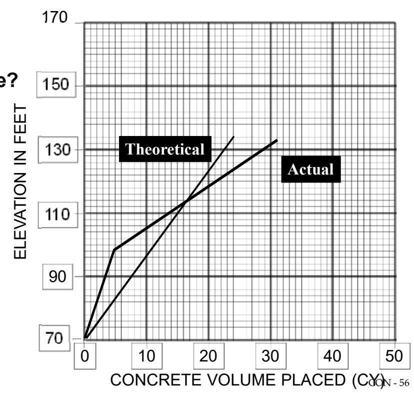
Are there any problems with this curve?



CON - 55

Concrete Curve #7

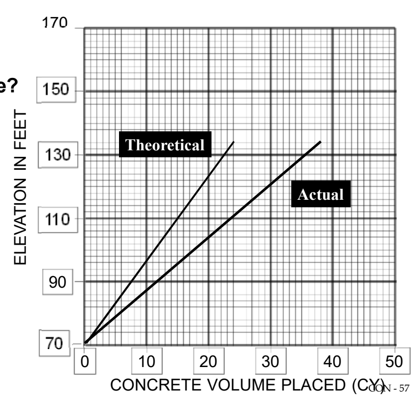
Are there any problems with this curve?



CON - 56

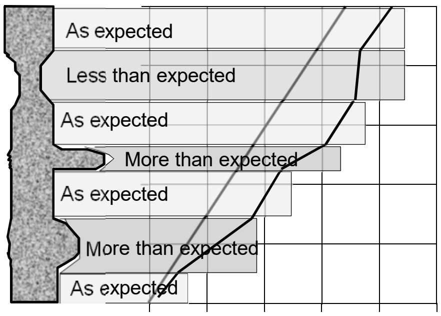
Concrete Curve #8

Are there any problems with this curve?



CON - 57

Possible Causes of Curve Irregularities



CON - 58

Questions?

Call

Jake Pfannenstiel (o) (785) 296-5006

or

Kyle Halverson (o) (785) 291-3860

CON - 59

POST INSTALLATION
&
INTEGRITY TESTING

14-4

POST INSTALLATION TESTS

To determine if the shaft, as constructed, will carry the loads designed for.

To evaluate the soundness or "integrity" of the constructed shaft.

INTEGRITY TESTS

14-7

<u>INTEGRITY TESTS</u>

Cross-hole Acoustic ("CSL")

Thermal Integrity Profiling (TIP)

Gamma-Gamma Logging

Echo Sounding

Coring

Visual Observation

14-19

INTEGRITY TESTS

"Anomalies." unusual patterns: voids or poorly consolidated concrete.

Anomalies are probably structural defects if they correlate to some potentially damaging occurrence during construction recorded by the Inspector.

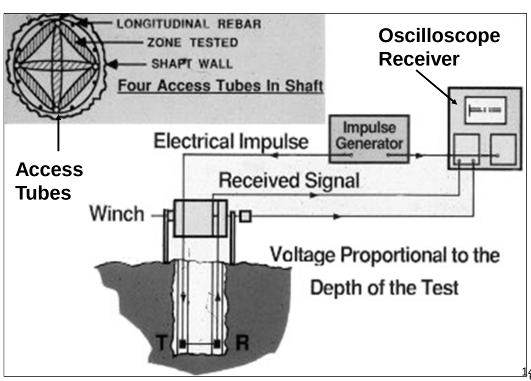
14-20
4

Cross-hole sonic logging (CSL)

- Several steel access tubes are placed regularly around the inside circumference of the cage. One per foot of shaft diameter is a good rule of thumb. Up to 8 but at least 4.
  - **Place inside cage because "shots" can not be received through rebar**
- "Shots" are made from a source that generates acoustic energy to an energy receiver in another tube at the same elevation. Both the time of travel from the source tube to the receiver tube and the amount of energy transferred between tubes are indicators of the presence of either sound concrete or defective concrete.
- In order to help maintain bond between the tubes and concrete and to couple the transmitter and receiver to the concrete, the tubes must be filled with water before the concrete is placed.

5

Cross-hole sonic logging



14-27
6

Source and Receiver Tools for CSL Test

14-30 7

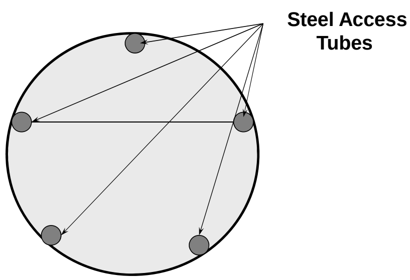
CSL Receiver

8

Pulley

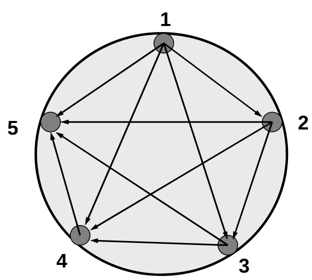
9

Sonic Logging



10

Sonic Logging



10 times

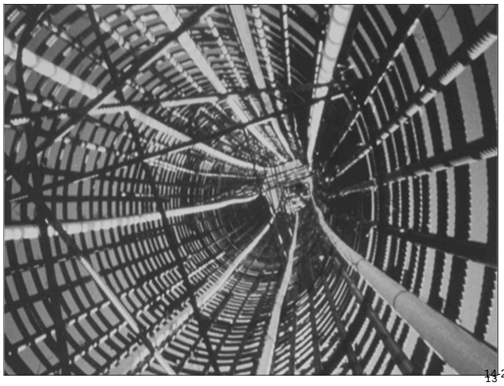
11

Sonic Logging

- What an inspector needs to look for when examining the tubes:
  - Check tubes for inside defects or obstructions
  - Make sure tubes are watertight
  - Check to see if watertight caps are on both ends of the tubes
  - Check for damaged or bent tubing

12

Access Tubes for Down-Shaft Tests



14-28

13

Sonic Logging

- When is test ran?
  - Between 2 and 21 days after shaft is completed.
- Who runs the test?
  - A consultant will run the first test, and provide a report indicating if any anomalies were found.
  - Currently, if anomalies are found a consultant will run more tests after defects have been resolved.
  - KDOT is in the process of getting their own CSL equipment to run the follow up tests, but will continue to have the consultants run the first one.

14

Sonic Logging

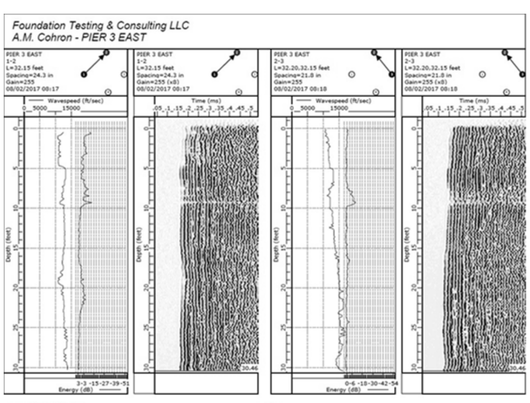
- What not to do:
  - Do not allow the contractor to fill CSL tubes until all tests and remediation procedures have been completed and shaft has been accepted.

15

The velocity drop criteria are as follows

Percent velocity drop	Action taken
0-10%	Acceptable, review by geology
10% - 15%	Questionable, review by geology & design, may core
>15%	A core will be taken, remediation is possible, Review, Remediate andRetest

17



Sonic Logging

- When all testing and remediation procedures have been completed and shaft has been accepted:
  - Fill core holes and CSL tubes by pressure grouting with approved materials (subsection 706.2 (b)).
    - Use a pipe extending to the bottom of the hole to fill it from the bottom to the top.

19

Sonic Logging

- If you have any questions:
  - **See subsection 706.3 (j) of KDOT standard specs**
  - **Call the Chief Geologist. All CSL results are sent through my office for recommendations!!**

20

Gamma Gamma Logging

- Non-destructive test method.
- Uses radioactive gamma rays to detect anomalies in the concrete. It is the same principle as a Nuclear Soil Density meter. The higher the density the fewer radioactive particles make it back to the receiver
- The maximum penetration is within 3 inches of each tube.

21

Gamma-Gamma Results

- Results are very similar to CSL in that the data is processed then printed out for each tube tested.

23

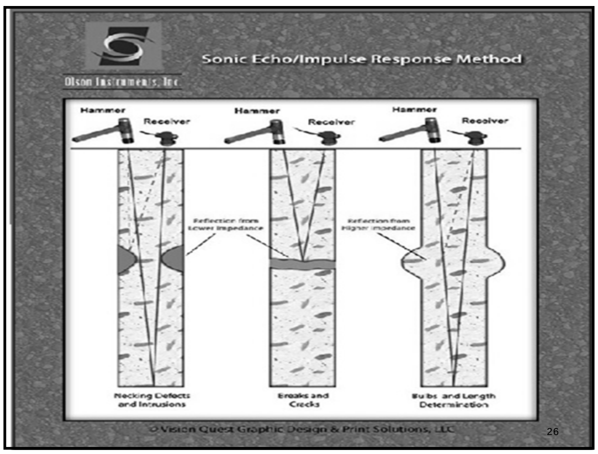
Echo Sounding

- Seismic investigation on a micro-scale.
- Used for shafts but also used for structural concrete testing such as walls etc.
- Hit the concrete with a the instrumented hammer and record the wave returns with the geophones.

24

Echo Sounding Equipment

25



Coring

Core Barrel Bit

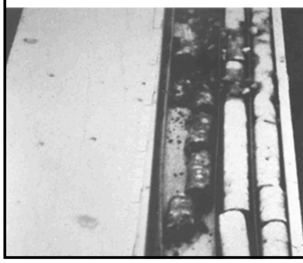
14-25 27

Coring Is Not Always Definitive in Ruling Out Defects —

Defects Can Be Missed by the Coring Tool

KDOT uses coring after a CSL test has been ran and defects have been found.

Not Good



Acceptable

14-26

Bad Cores

29

Bad Cores

30

Remediation

- If a void within the shaft is found
  - Voids might be able to be cleaned out and filled with either
    - Epoxy- for smaller voids
    - Grout- for larger voids

31

A Good Shaft

14-35

32

Backfill

- When temporary and a permanent casing are used, backfill the annular space (between casings) with material specified in the contract documents:
  - Granular material fine enough to fill the entire volume or
  - Grout or flowable fill described in **subsection 706.2 (b) Grout / Flowable Fill**
  - If the plans don't specify a material, use the granular material.

33

Backfill

- Before completely raising temporary casing, fill the annular space with grout/flowable fill to the top of the casing:
  - If the annular space contains water, use a pump with an extension pipe or tremie (extending to the bottom of the annular space) to fill the annular space.
  - If the annular space is dry, the grout/flowable fill can free fall to the bottom of the shaft.
  - After temporary casing has bee removed, filled the rest of the annular space with granular material.

34

Questions?

Measurement and Payment and Safety

Kevin Palic
Field Construction Engineer
Bureau of Construction and Materials

Learning objectives

- Be able to describe the pay items associated with drilled shaft construction
- Be aware of some of the hazards associated with drilled shaft construction

Measurement and Payment

- 2015 Standard Specifications Division 700 section 703.4 and Special Provision 15-07007
- Bid Items section 703
  - Drilled Shaft (*) (**) — Linear Foot
  - Permanent Casing (*) Set Price — Linear Foot
  - Sonic Test (Drilled Shaft)(Set Price) — Each
  - Core Hole (Investigative) — Linear Foot

  *Size

  **Cased (If Contract Documents specify cased method)

Measurement and Payment

- Bid Items Special Provision 15-07007
  - Drilled Shaft (*) (Special) Linear Foot
  - * Size

Measurement and Payment

- Core Hole (Investigative)
  - These cores are taken at locations shown on the construction layout sheet
  - Nominal 2.125 inch core barrel
  - Contractor must maintain, protect and label the sample and provide core cardboard boxes for storage
  - Investigative core hole determines shaft tip elevation

Measurement and Payment

- Core Hole (Investigative)
  - Measured from existing ground surface elevation to 6 feet below drilled shaft tip elevation
  - Measure by the linear foot
  - Pay to the nearest 0.1 linear foot

Measurement and Payment

- Drilled shaft (*) (**)

Drilled Shaft (** in) Cased Lin. Ft.	Drilled Shaft (** in) Lin. Ft.	Permanent Casing (** in) Lin. Ft.

Measurement and Payment

- Payment for Drilled Shaft (*) (**) includes:
  - Excavation
  - Casing if required (outlined in contract documents)
  - Reinforcing steel
  - Concrete
  - All materials and labor required

Measurement and Payment

- Completed Shaft – Measured from the bottom of the rock socket to the top of the completed drilled shaft (not existing ground elevation)
  - Measured by the linear foot
  - Pay to the 0.1 of a foot
- The Engineer will not consider a request to increase the bid prices unless the length of the drilled shaft changes by more than 20%

Measurement and Payment

- Permanent Casing (*) (Set Price)
  - Paid for when required but not specified in the contract documents
- Do not pay for the casing if:
  - Contract documents require a permanent casing
  - Contractor uses the casing for their convenience
  - Casing is a temporary casing

Measurement and Payment

- Permanent Casing (*) (Set Price)
  - Measured by the linear foot
    - Top of the shaft elevation to bottom of casing
  - Pay to the nearest 0.1 linear foot

Measurement and Payment

- Sonic Test (Drilled Shaft) (Set Price)
  - Paid for when required by contract documents
  - Test are required <u>for all wet pours</u>
  - Test required on dry pours required when directed by Engineer
  - Test to be completed between 2 and 21 days after shaft is complete

Measurement and Payment

- Sonic Test (Drilled Shaft) (Set Price)
  - When sonic test are required by contract documents (wet pours)
    - If test shows concrete is defective the test will be measured for payment
    - After the corrections have been made, the shaft will need to be retested, this test will not be measured for payment

Measurement and Payment

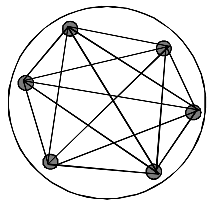
- Sonic Test (Drilled Shaft) (Set Price)
  - Test required by engineer (Dry pours)
    - When not shown on contract documents and sonic test indicate concrete acceptable, the test will be measured for payment
    - When not shown on the contract documents and sonic test indicate concrete is defective, test will not be measured for payment
    - When not shown on the contract documents and sonic test indicate concrete is defective and investigative cores reveal concrete is defective test will not be measured for payment

Measurement and Payment

- Sonic Test (Drilled Shaft) (Set Price)
  - Test required by engineer
    - When not shown on the contract documents and sonic test indicate concrete is defective and investigative cores reveal sound concrete test will be measured for payment

Measurement and Payment

- Sonic Test (Drilled Shaft) (Set Price)



4 tubes	6 combinations	one test
6 tubes	**15 combinations**	**one test**
8 tubes	28 combinations	one test

Measurement and Payment

- Payment for Drilled shafts (*) (**), Permanent casing (*) set price, Sonic Test (Drilled Shaft) (Set Price), and Core hole (Investigative) is made at the Contract unit prices
- Sonic Test (Drilled Shaft) (Set Price) and Permanent Casing (*) are paid for at the Contract set price and is full compensation for the specified work

Measurement and Payment

- Items paid by adding lines to the contract (Extra work)
  - Extending the length of the shaft by more than 20%
  - Extra reinforcing steel due to lengthening a shaft
  - Post installation coring directed by the engineer

Measurement and Payment

- Items paid by adding lines to the contract
  - If the Engineer lengthens the drilled shaft during construction, the Engineer will measure and pay for additional reinforcing steel according to the requirements of Section 104.6.
  - Section 104.6 is the section of the specifications covering extra work.

Measurement and Payment

- If the sonic test indicates bad concrete in the shaft, and the Engineer requires cores, the Engineer will not pay for the cores – IF the cores reveal defective concrete.
  - IF the cores reveal good concrete the engineer will pay for the coring as an Extra Work item according to section 104.6

Safety

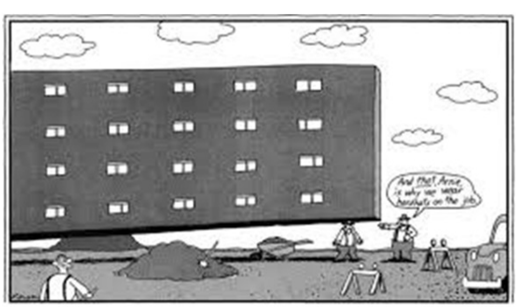
Safety

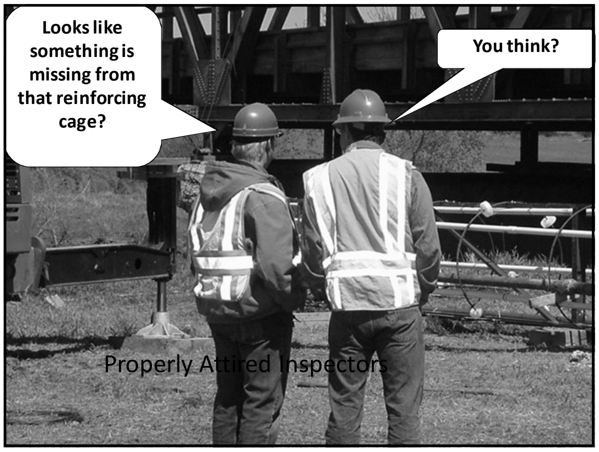
- Safety equipment
- Situational awareness

Safety Equipment

- Safety vest
- Hardhat
- Boots
- Hearing protection
- Eye protection
- Lanyards

Safety



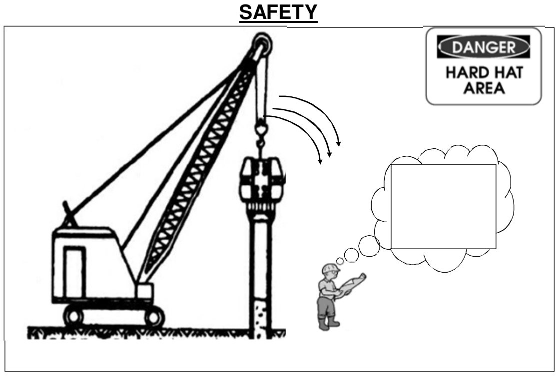


Safety

- Situational awareness
  - Knowing what's going on around you

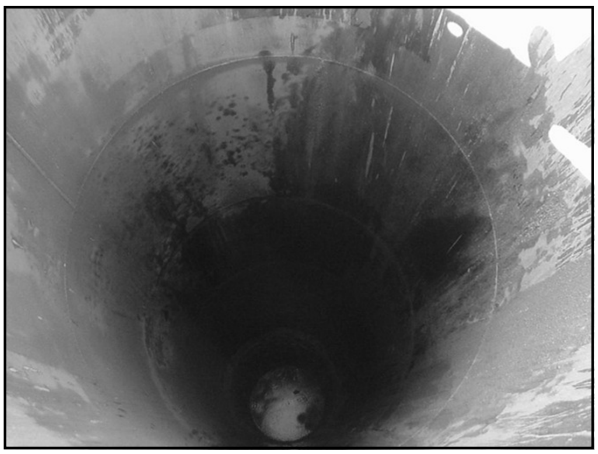
Remember, even a temporary loss of focus can be dangerous

SAFETY



Safety

- ALWAYS BE AWARE OF SURROUNDINGS!!!
  - Unprotected Holes

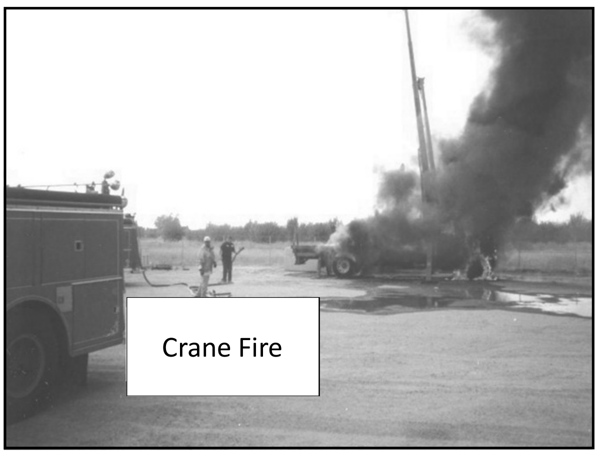


Safety

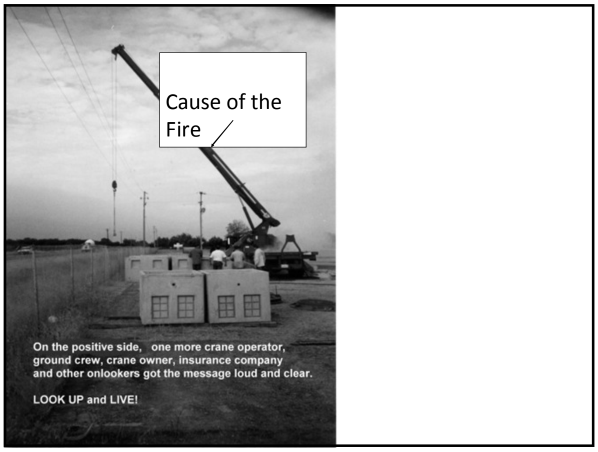
- ALWAYS BE AWARE OF SURROUNDINGS!!!
  - Unprotected Holes
  - Caving Holes

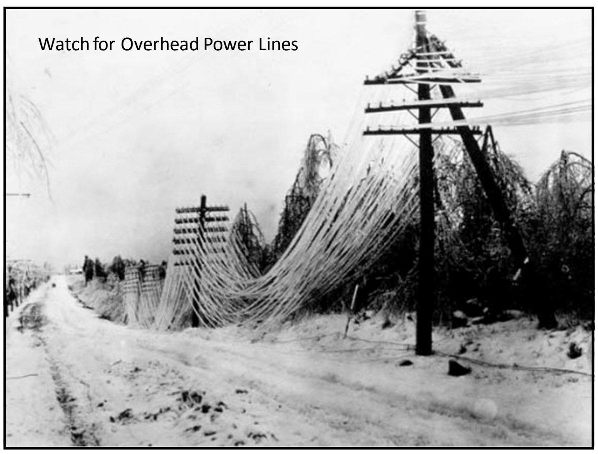
Safety

- ALWAYS BE AWARE OF SURROUNDINGS!!!
  - Unprotected holes
  - Caving holes
  - Overhead equipment

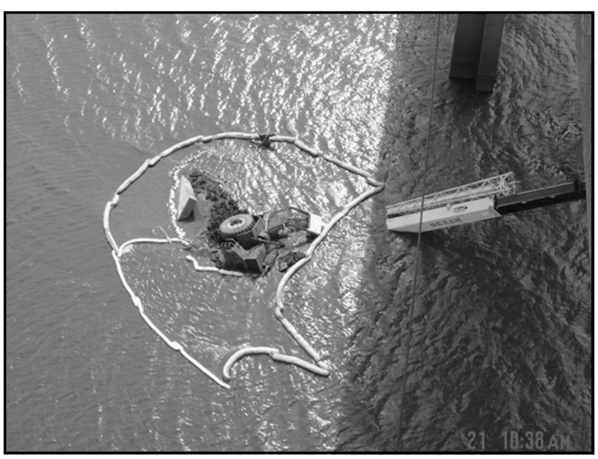

Crane Fire

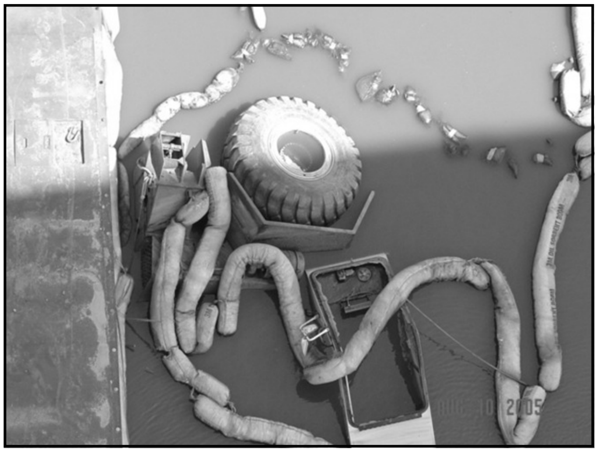

Another Shot
of the Fire


Cause of the
Fire
On the positive side, one more crane operator, ground crew, crane owner, insurance company and other onlookers got the message loud and clear.
LOOK UP and LIVE!


Watch for Overhead Power Lines


PRESTON


21 10:38 AM



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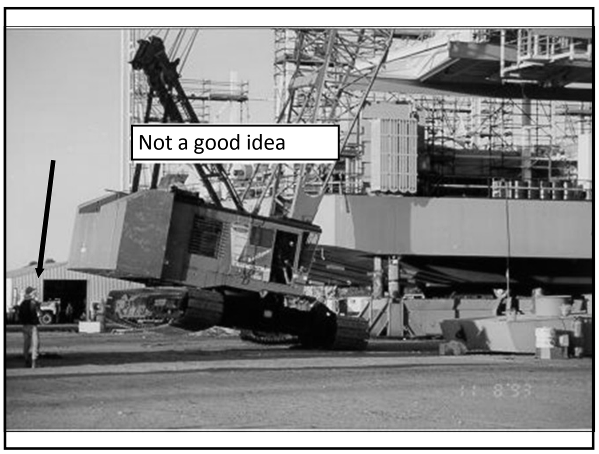


Not a good idea

CraneAccidents.com


Boom Deforms

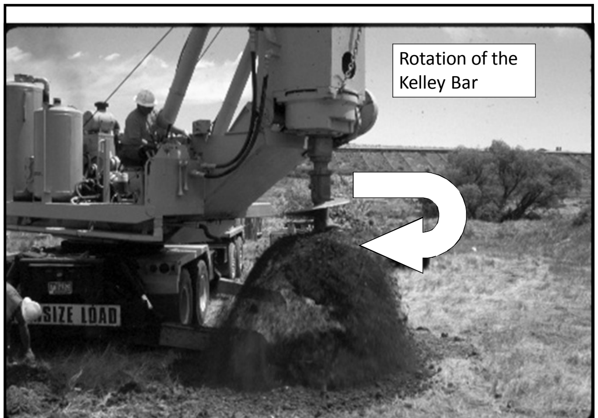

Complete Boom Failure


CraneAccidents.com
Operator

Collapse Kills 2

Safety

- ALWAYS BE AWARE OF SURROUNDINGS!!!
  - Unprotected holes
  - Caving holes
  - Overhead equipment
  - Rotating equipment

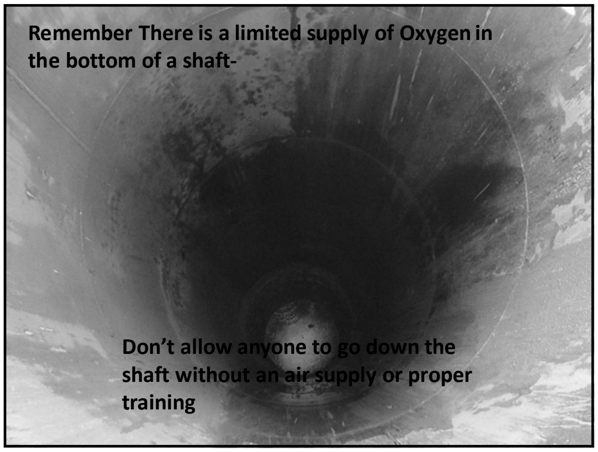


Operator has Limited Visibility

When approaching the drill rig approach from the front and make eye contact with the operator

Safety

- ALWAYS BE AWARE OF SURROUNDINGS!!!
  - Unprotected holes
  - Caving holes
  - Overhead equipment
  - Rotating equipment
  - Confined spaces



Review

- Measurement and payment
  - Bid items
  - Measurement
  - How to pay for changes from plan
- Safety
  - Protective clothing
  - Situational awareness

Questions

PRE-CON
&
INSTALLATION PLAN

Jake Pfannenstiel
Engineering Associate – Bridge Design

Pre Construction - Drilled shaft meeting

- Request for the Bridge Construction Engineer and Geologist be present
- Request for all subs to be present: Driller, Pumper, Concrete Supplier
- Discuss the Plan in detail
  - Excavation methods
  - Rock socket cleaning methods
  - Placement methods

Pre Construction - Drilled shaft meeting

- Request for the Bridge Construction Engineer and Geologist be present
- Request for all subs to be present: Driller, Pumper, Concrete Supplier
- Discuss the Plan in detail
- Discuss possible problems
- Discuss how to address these problems if they develop during the operation
- See the "13 Questions to ask before drilling begins"

Thirteen questions to ask prior to a wet pour

1. How is the Contractor going ensure the bottom of the hole is clean?
2. Is the Contractor going to let the water level in the shaft reach its normal static elevation or pump the shaft full of water?
3. How is the Contractor going to place the concrete, pump it through an extension tube or place through a tremie?
4. Is the tremie/extension tube watertight?

Thirteen questions to ask prior to a wet pour

5. How will the tremie/extension tube be sealed (separate the ground water and concrete), a "pig" or flap gate on the tremie?
6. What material is being used for the pig?
7. Where is the pig going to be placed in the tremie/extension tube or pump?

Thirteen questions to ask prior to a wet pour

8. How is the Contractor going to fully charge the pump tubes or tremie before any concrete is discharged into the shaft?
9. How is the Contractor going to ensure the initial seal (discharge end in fresh concrete) is achieved?
10. How are you going to ensure the discharge end of the tremie/extension tube is sufficiently embedded in the fresh concrete?

Thirteen questions to ask prior to a wet pour

11. Is the tremie/extension tube marked in one foot increments?
12. When and how much are you going to lift the tremie/extension tube?
13. How is the Contractor going to over pump the shaft to displace the questionable (i.e. poor quality or frothy) concrete that has risen to the top of the shaft?

Questions?

Call

Jake Pfannenstiel (o) (785) 296-5006

or

Kyle Halverson (o) (785) 291-3860

Scenarios for Drilled Shaft Group Activity

1. Halfway through the concrete placement in a wet drilled shaft, the contractor raises the end of the discharge tube above the top elevation of fresh concrete. How would you proceed with the concrete placement?

2. Immediately after the concrete placement in a drilled shaft the inspector notices the contractor accidentally moved the reinforcing cage out of alignment, so there is only 3" of clearance on one side. At the same time the contractor is positioning equipment at the next pier to proceed with another concrete placement. At each pier, what actions would you recommend to the contractor and why?

3. During the predrilled shaft construction meeting, the contractor describes his placement procedure for pumping concrete in wet drilled shafts. Since the shafts on this project are deep (approximately 60'), the contractor indicates he'll have to remove sections of the discharge tube (i.e. break pipe) halfway through the placement. What questions/concerns should an inspector address about breaking pipe, and should the inspector have any requirements for the contractor when he breaks pipe?

4. At the drilled shaft preconstruction conference the contractor indicates they'll use a pump truck to place all shafts (wet or dry) and that is all the information offered. During some follow-up questioning, the contractor indicates they'll use a 10' piece of flexible hose at the end of the discharge pipe in the bottom of the shaft. What additional follow-up questions should the inspector ask? Also, what, if any, concerns should the inspector have about the contractor's placement procedure?

5. About halfway through the placement of a deep (approximately 60') drilled shaft by the wet placement method, the reinforcing steel cage rises:
   - Situation 1 – rises about one-half of a foot.
   - Situation 2 – rises about five feet.

   What are some factors that could cause the reinforcing steel cage to rise, and how should the contractor address those factors on subsequent placements? Also, for each situation, what actions would you recommend to the contractor?

Drilled Shaft Class Homework!!!

1. How many Geology units are found on the bridge sheets?
2. What is the type of bedrock the drilled shafts are set in at Abutment 2?
3. What are the shafts set in at Abutment #1?
4. At what elevation is the top of the Temporary Casing to be set at Pier #1?
5. At Pier #2, How many cage spacers are needed at each level?
6. At Pier #2, How many cage spacers are needed on the entire rebar cage?
7. How many CSL tubes are needed on the cages for Pier 2?
8. What is the minimum Length for the CSL Tubes at Pier 2?
9. How much concrete is required to pour 1 foot of the shaft at Pier 2?
10. How much concrete is required to pour the shaft to a depth of 18 feet at Pier 2?
11. How much concrete is required to complete the pour for the shafts at Pier 2?
12. How much concrete should be over pumped at the end of the pour?

Helpful Hints:

Phi = 3.14

Circumference=phi X diameter of the circle, Cir=πD

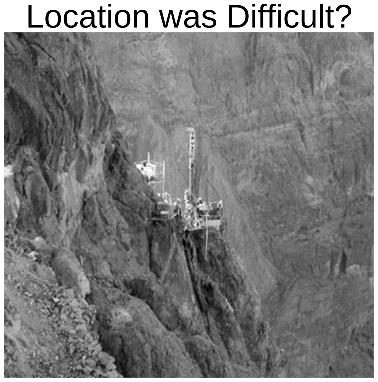
Area of a circle=πr^2

Volume of a Cylinder= πr^2 X height

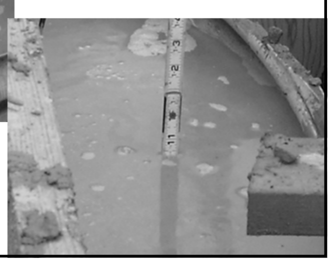
When Things Go Bad!!!

I-25 Bridge South of Kaycee, WY August 02

And You Thought Your Test Hole Location was Difficult?

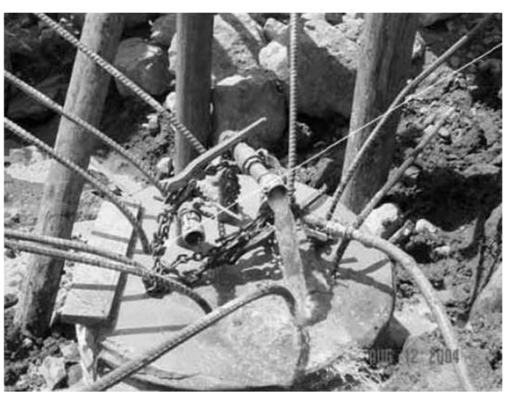


Bad Shafts-Sinking Concrete?



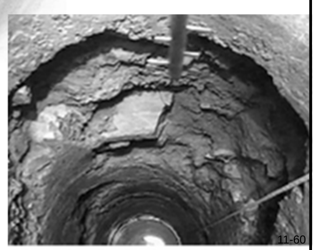
More of the same!

Name two things wrong with this shaft.




08/02/2012

Inside 36" rock socket



11-60

Clay filled cavity in sidewall of 36" rock socket.

TYPICAL PROBLEM

Dirty

Hole

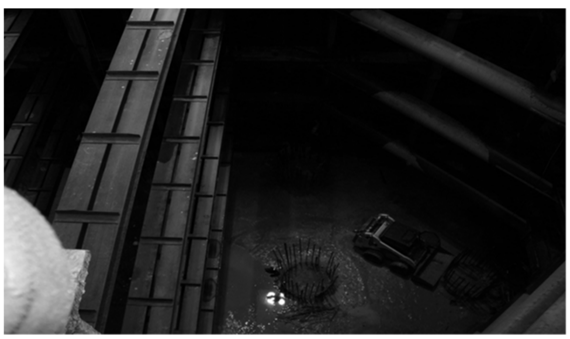
11-65

Atchison River Coffer Dam Drop

Coffer Dam issues

High water and debris

Seal Coarse and 1 Bad Shaft!



Lots of water when 60 feet below the river!

Looking Up!

What the finished base is like.

Very large defect found by Sonic Echo test. Probably due to dirty hole.

No concrete

11-67

Sometimes you have to be careful leaving casing lay around to long!

Any Questions?