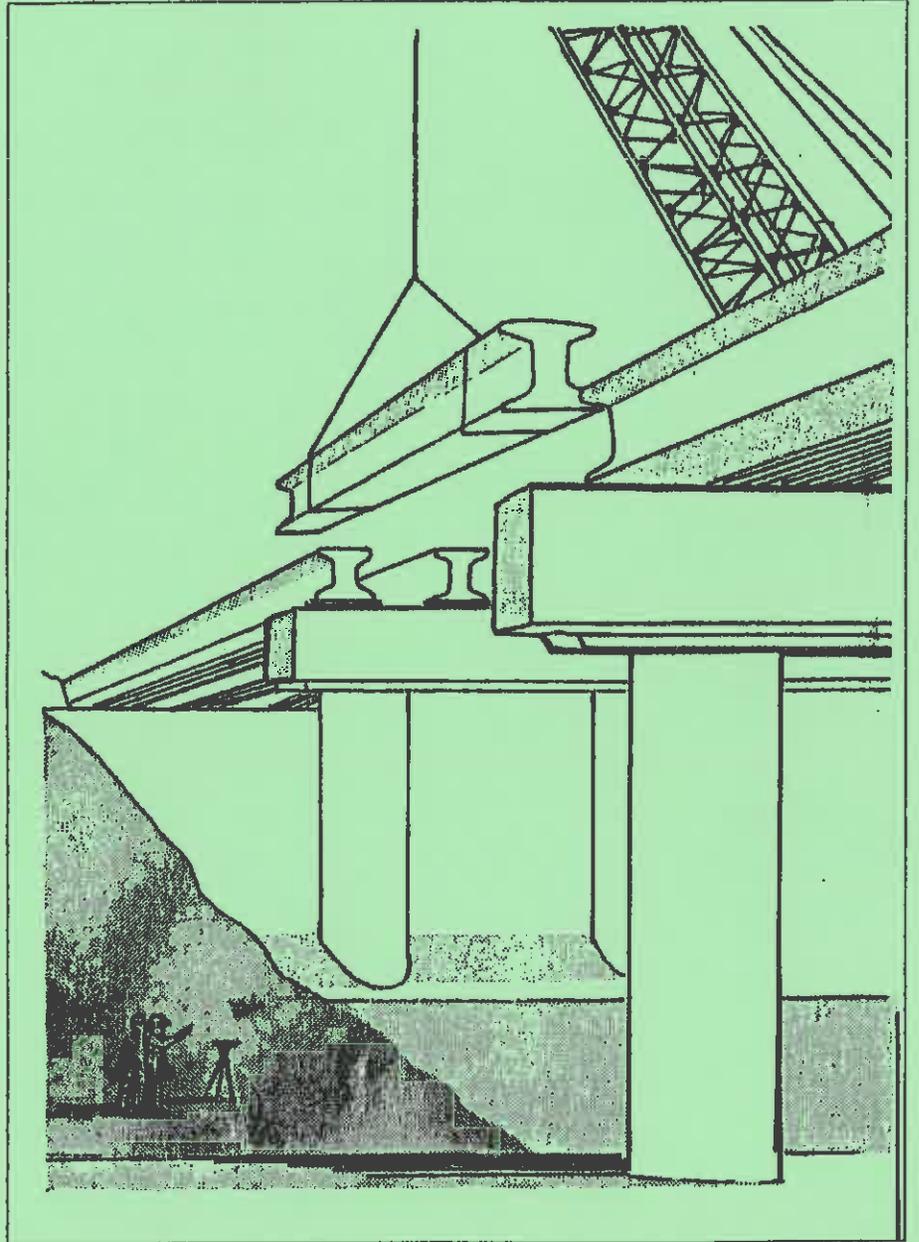


# **STRUCTURES INSPECTION SELF STUDY TRAINING COURSE**



**PART ONE**

**2006**



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**PART ONE  
2006**



**STATE CONSTRUCTION OFFICE**

This 2006 update was produced by Steven Plotkin, P. E., State Construction Structures Engineer,  
with the cooperation of district reviewers and State Construction Office training staff.

State Construction Training Administrator - Yvonne Collins

# FOREWORD

Structures Inspection is a training course in two parts. The course covers most of the inspection activities that are necessary to ensure the proper construction of structures not including foundations which are covered in a separate Construction Training and Qualification Program (CTQP) course.

The inspection activities discussed in Part One of this course include:

- Office and field preparations
- Staking procedures
- Structure foundation inspection, including excavation and backfilling
- Falsework and forms
- Reinforcement
- Documentation

Part Two covers superstructure construction and includes the following main topics:

- Beam erection
- Bolting
- Welding
- Deck construction
- Grinding
- Grooving

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# DIRECTIONS TO COURSE USERS

## TRAINING TECHNIQUE

This course has been designed for self-instructional training:

- You can work alone.
- You can make as many mistakes as are necessary for learning -- and correct your own mistakes.
- You can finish the training at your own speed.

You will keep both books as your references, so work neatly.

## PREREQUISITES

The Department Construction Training Policy requires that you take two courses within the first year of your employment: Construction Mathematics and Contract Plan Reading. For Structures Inspection -- Part One, you will need both. In addition, you should have completed two other training courses or know their subject matter thoroughly. These courses are: Earthwork Inspection and Portland Cement Concrete Testing, Placement and Control.

## HOW TO USE THESE BOOKS

These are not ordinary books. You cannot read them from page to page as you do other books. These books give you some information and then ask a series of questions about that information. The questions are asked in such a way that you will have to think carefully and draw some conclusions for yourself. If you have difficulty answering the questions, review the sections that give you trouble before going on.

The answers to the questions will be in the back of each chapter.

## EXAMINATION

Two examinations have been developed for Structures Inspection -- one for each Part.

The Exams contain questions and problems only -- no answers. To help you prepare for the examinations, review quizzes are included at the end of each Part. If you do well on the review quizzes, the examinations will present no problems.

Together, the two examinations comprise the examination for the whole course but you must pass the examination for Part One before you begin Part Two.

# CHAPTER ONE

## Introduction to Structures

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# INTRODUCTION TO STRUCTURES

## BASIC INFORMATION

A well-built structure is the result of good design and careful construction inspection. As a Structures Inspector, you will have the important task of inspecting the various operations involved in the satisfactory completion of a structure.

The purpose of this course is to help you with your inspection activities. This will be done by presenting instructional material, procedures and policies which have been developed to achieve uniformity among the activities of Structures Inspectors.

In Chapter One, we will review the parts of box culverts and bridges. In order to follow this chapter -- and the remainder of the course -- you must be able to read contract plans. If you need to, review the Contract Plan Reading training course before taking this course.

Let's begin by reviewing box culverts.

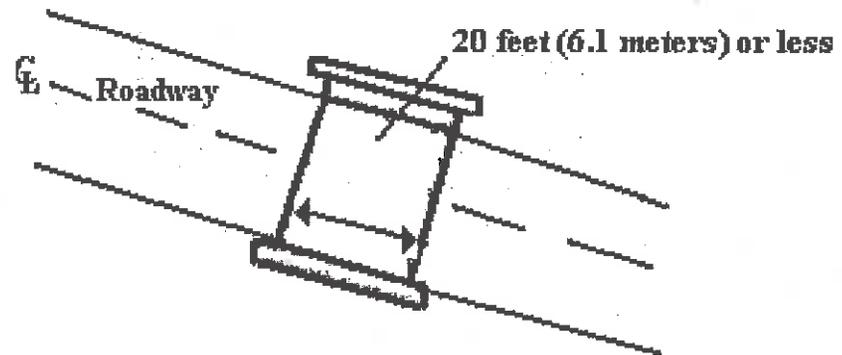
## BOX CULVERTS

### DEFINITION

A box culvert is a rectangular shaft, or tunnel, usually under a roadway. This shaft should have a clear span or a sum of spans of 20 feet (6.1 m) or less, as measured along the roadway centerline. Box culverts are constructed when other structures are too small to allow large volumes of water to pass under roadways. Also, large box culverts are sometimes used to allow persons, cattle or equipment to pass safely under the roadway.

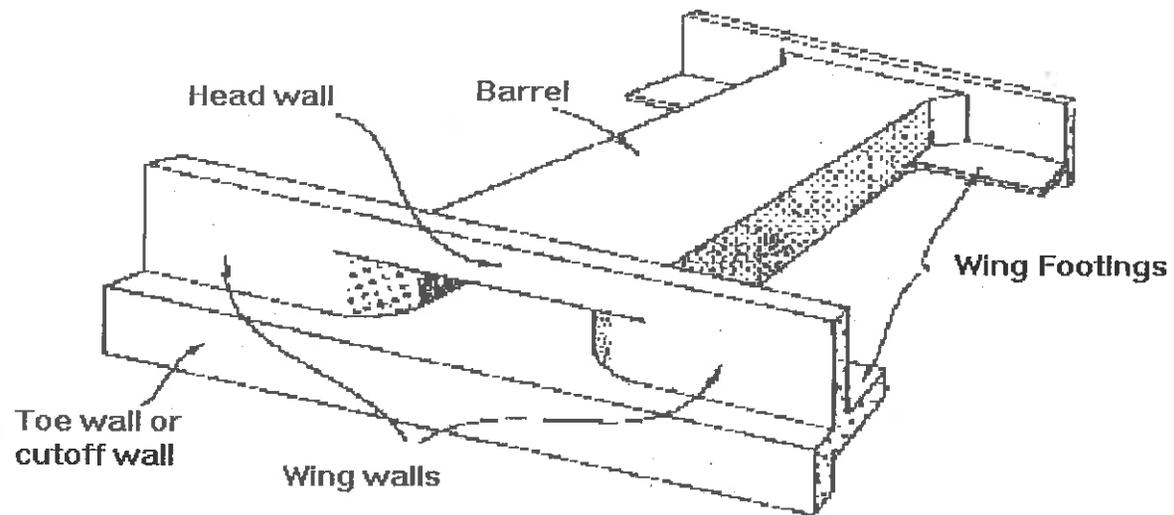
Box culverts are constructed of reinforced Portland cement concrete. The various parts of box culverts -- barrel, headwalls, toe walls, wingwalls, and wing footings -- are cast in place to form one structure or are cast off site in a precast yard then delivered to the site for assembly.

Before going any further, let's review quickly the common terminology used for the parts of box culverts.



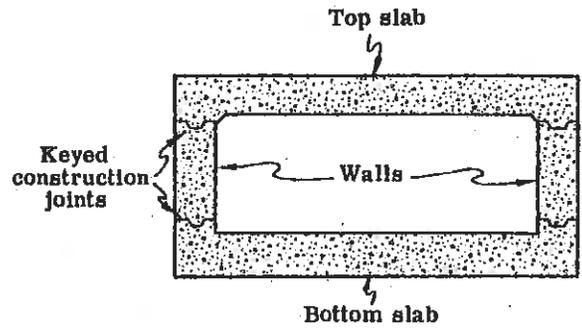
## TERMINOLOGY

A box culvert is shown below -- study the names of its parts.

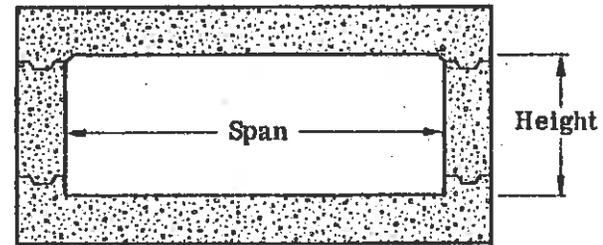


This page and the next are taken from the Contract Plan Reading course. If you have any questions about the terminology or how to read plans for box culverts, go back and review the course now.

The barrel has these parts



Culvert barrel dimensions are measured like this



Dimensions of box culverts are often written as 8' x 4' or 10' x 8' (2400 mm x 1200 mm or 3000 mm x 2400 mm), etc. The first number always refers to the span and the second number always refers to the height.

## QUIZ

Box culverts are constructed of \_\_\_\_\_.

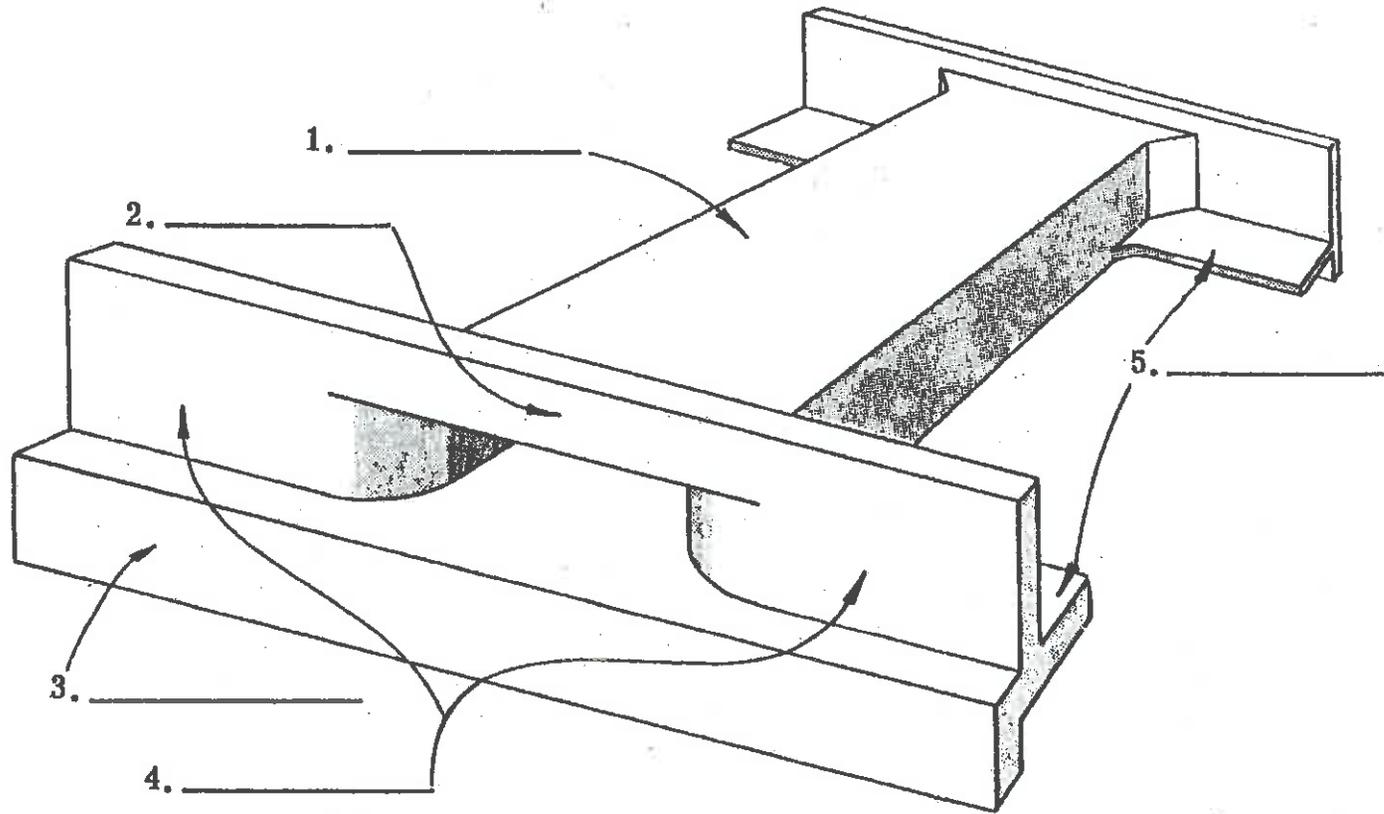
Are box culverts usually constructed monolithically -- as one piece -- or are the various parts cast separately, but still joined?

A box culvert is a structure under the roadway which has a clear span of \_\_\_\_\_ than \_\_\_\_\_ feet, as measured along the \_\_\_\_\_.

If a box culvert is on a skew, will the roadway centerline be perpendicular to the box culvert centerline?

### QUIZ, continued

Name the parts of the box culvert shown below:



Use this quiz as a quick review of the parts of box culverts. When you know all the parts, go on to the next page.

## BRIDGES

In your daily driving, you have no doubt crossed many types of bridges without really knowing why bridges are constructed or their purpose. This question can be answered with a simple statement.

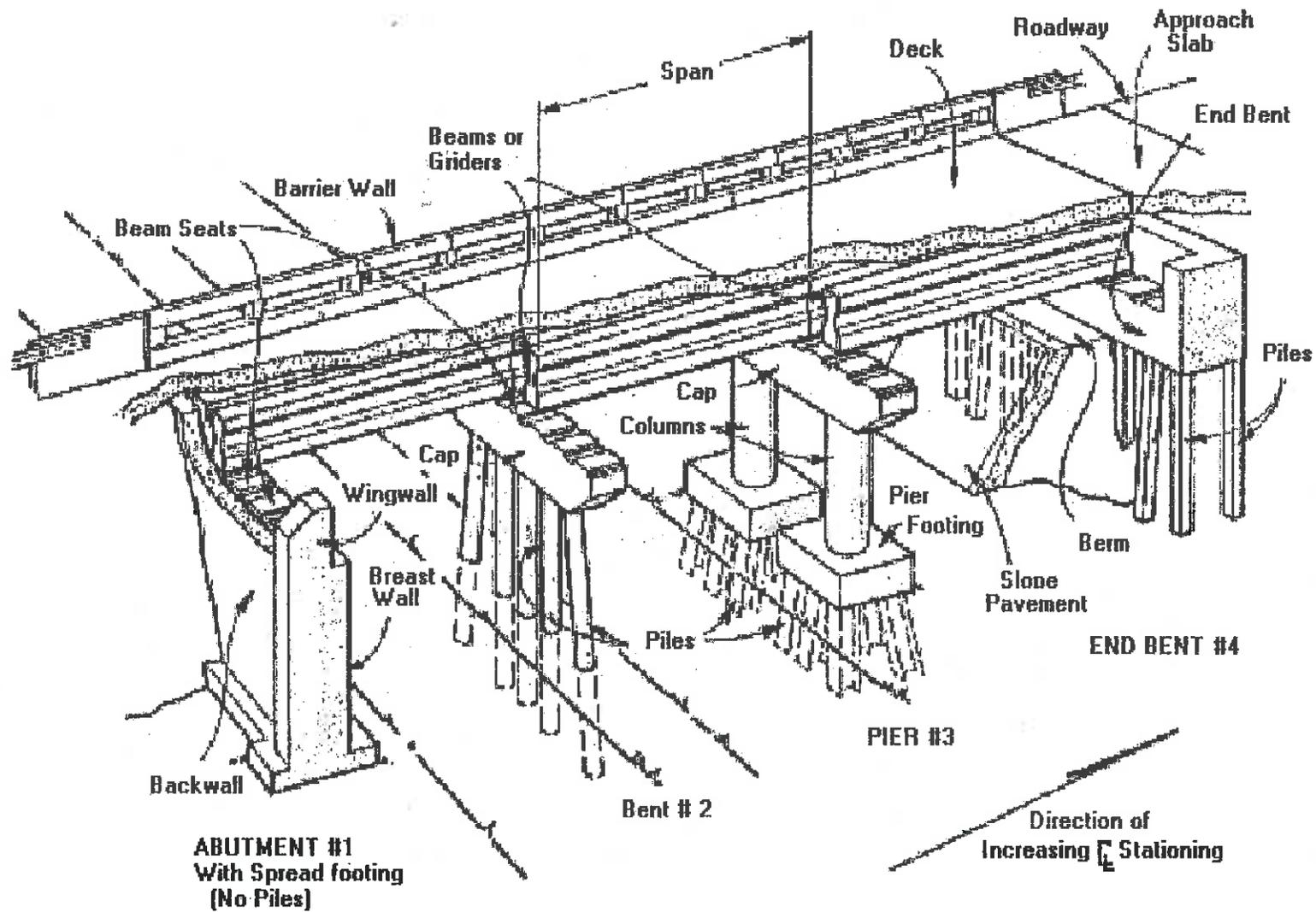
*Bridges are structures which span and allow passage over obstructions such as rivers, intercoastal waterways, lakes, canals, roadways, railroads, pedestrian ways and trails.*

### TERMINOLOGY

With that simple explanation, we can discuss bridges in more detail. Let's begin by reviewing the basic parts of bridges. A typical bridge consists of many parts. The major parts are described below and are shown on the next page.

- The SUBSTRUCTURE includes the abutments, bents and piers -- the parts that support the girders and deck.
- The SUPERSTRUCTURE includes those parts of the bridge supported by the substructure - everything from the girders up, including the bearing devices and the girders. The girders are the major spanning members of the bridge.

Study this diagram. Then check yourself by taking the quiz on the next page.



## QUIZ

The supporting structures of the bridge are called? \_\_\_\_\_.

The substructure includes everything below the \_\_\_\_\_.

The end substructures are either \_\_\_\_\_, which have a vertical wall the full height of the bridge, or \_\_\_\_\_.

Vertical support members of bents are \_\_\_\_\_.

Columns provide \_\_\_\_\_ support in piers: they rest directly on a \_\_\_\_\_.

On top of caps, the \_\_\_\_\_ support the beams.

The flattened portion of an earth fill is a \_\_\_\_\_.

The "roadway" of the bridge is the \_\_\_\_\_.

What is the distance from one substructure to the next substructure called?

The \_\_\_\_\_ prevents vehicles from veering off the bridge.

The piles, footings, columns, walls and caps form the bridge \_\_\_\_\_.

Any bridge part not in the substructure is in the \_\_\_\_\_.

Linking the deck and the roadway are \_\_\_\_\_ slabs.

If you had some difficulties with this quiz, go back and review pages 1-8 and 1-9 before continuing on to the next section, TYPES OF BRIDGES.

## TYPES OF BRIDGES

The Department uses a wide variety of bridge types and some are used much more commonly than others. This means that as a bridge inspector, it is highly likely that you will work on a job with one of the more common bridge types and very unlikely that you will work on a job with an uncommon type. However, it is important to be familiar with all the types. There are four broad types of bridges constructed by the Department as identified by their type of superstructure: beams or girders, slabs, draw or movable and suspension. Other types, such as trusses and arches, exist many places in Florida but are obsolete designs and are no longer used for new bridges. What follows is a description of each type of bridge starting with the most common and ending with the least common.

### BEAM OR GIRDER BRIDGES

Generally, the terms "Beam" and "Girder" mean the same thing; however, the term, Beam, is often used when talking about members in the shorter span range - say up to 60 or 70 feet (18.3 or 21.3 meters) - or for steel members that are manufactured in one solid piece, called a "Rolled Section", and which is also in the shorter span range. The term, Girder, is most often used when talking about longer members - greater than 70 feet (21 meters) - or for any steel member that is manufactured by connecting separate flange and web plates by welding or bolting in order to make a much longer member, called a "Plate Girder". Unlike rolled sections, plate girders are too long to be manufactured in one piece. All beam bridges are constructed by using beams to span across bents, abutments or piers and then building a concrete or steel deck on top of the beams in order to provide a riding surface for vehicles, bicycles, or pedestrians.

**Concrete Precast Prestressed Beam Bridges:** For this type of bridge - the most common type used in Florida - concrete beams are produced in a manufacturing plant called a "Precast or Prestress Yard or Plant", that is almost always located some distance from the actual bridge construction site. The beams are stored in the prestress yard until they are ready to be shipped to the construction site by barge or truck. The Department has personnel at the prestressed yard to make sure that the beams have been manufactured according to the specifications. Beams must have an approval stamp before they can be used in the project and this stamp is affixed by the producer. Prestressed beams are built by stretching or stressing steel cables or strands, and while keeping them stretched, encasing them in

the beam concrete. Once the concrete is hard enough, the strands are released which squeezes or compresses the beam concrete resulting in a very efficient use of both concrete - which can take a large compression force but can not take much stretch or tension force - and steel strand which can take very high tension force. The beams are manufactured or cast preliminary to being delivered to the construction site; hence the term "Precast" and the steel strands are stressed preliminary to the placement of concrete, hence the term "Prestressed."

There are five types of precast prestressed beams used by the Department: AASHTO, Florida Bulb-T, Florida U-Beam, Inverted-Tee and Florida Double-Tee and these come in various sizes. The AASHTO and Bulb-T beams are shaped like "I" beams, the U-Beam like the letter "U" but with a flat bottom, the Inverted Tee like an upside down letter T (  ) and the Double-Tee like two letter "T's" connected together at the top (TT). For detailed drawings of these beams see the latest Florida Department of Transportation, Structures Design Office, Standard Drawings. The AASHTO and Bulb-T beams are by far the most commonly used.

**Concrete Precast Post-tensioned Beam Bridges:** These beams are manufactured just like prestressed beams including just enough prestressed strands to allow the beams to be transported and to support their own weight once they span between supports. However, at the construction site, the beams receive additional steel strands that are threaded through pipes or ducts that are encased in the beam concrete and go from one end of the beam to the other. The strands can also go continuously through more than one beam and often through as many as three beams before they are stressed and permanently fastened or anchored at the ends of the beams. The strands added at the site, give the beams the strength to support the deck and all other permanent loads or dead loads as well as the loads of vehicles and pedestrians or live loads. This process results in what is called a, "Continuous beam", because the separate beams are connected together not only with the strands but also by pouring concrete connecting joints between each beam. Strand placement and stressing is postponed until after the beams are in place at the construction site, hence the term "Post-tensioned."

**Concrete Precast or Cast-In-Place (CIP) Post-tensioned Segmental Box Girder Bridges or Segmental Bridges:**

Segmental bridges are constructed using post-tensioned strands only, without any pretensioned strands. Box shaped girder segments which are usually not longer than 20 feet (6.1 meters) and which include the deck are assembled on a temporary truss and are then post-tensioned together or they are post-tensioned together one segment at a time to make a full span. Segmental bridges are used for longer spans that are usually at least 140 feet (42.7 meters) long. Segmental bridges are constructed with precast segments that are produced in a casting yard and transported to the job site or are constructed with segments that are cast-in-place in their final position by using temporary supports to hold up the segments until the concrete is hard and can be post-tensioned. These type girders can also be constructed in curved shapes. More detailed information on segmental bridges is available in the Florida Department of Transportation, Segmental Manual, A Guide to the Construction of Segmental Bridges and in the American Segmental Bridge Institute (ASBI) publication entitled Construction Practices Handbook for Segmental Concrete Bridges.

**Concrete Cast-In-Place Post-tensioned Box Girders:** For these bridges, a box shaped girder is formed and is held in place by temporary supports or false work until the concrete is poured and is hard. Then post-tensioned strands are installed and stressed which gives the strength needed for the bridge to be self supporting and to allow the false work to be removed. Cast-in-place girders are usually continuous up to three or four spans and can be constructed in curved shapes.

**Steel Rolled Beam or Plate/Box Girder Bridges:** Steel bridges are constructed by using rolled " I " shaped beams with wide flanges which are generally for shorter spans or by using plate/box girders which are used for long and/or curved spans. Rolled beams are usually delivered from the supplier in one piece that is the full span length. Plate/box girders are usually too long to transport in one piece and; therefore, are fabricated in pieces that are spliced together with bolts and splice plates at the job site. Plate/box girder spans routinely reach lengths of 250 to 300 feet (76.2 to 91.5 meters) and on occasion much longer. Plate girders have an " I " shape with wide flanges and box girders have a shape like a squared off letter "U" or a trapezoidal letter "U." Steel beam/girder bridges use a concrete deck.

## SLAB BRIDGES

**Concrete Cast-In-Place Flat Slab Bridges:** These bridges use thick concrete slabs to span between supports. Slabs can be as thick as 24 inches (610 mm). They are formed on false work and reinforcement is provided by rebars only, without post-tensioning, and may be continuous for up to five or six spans. Span lengths rarely exceed 35 to 40 feet (9.1 to 12.2 meters).

**Concrete Precast Prestressed Slab Bridges:** Precast prestressed slabs are manufactured in widths that can be transported by truck. It is customary to pull the individual slabs together on site with transverse post-tensioning strands to make up the full bridge width and sometimes an asphalt or concrete surface is added. Span length and thickness ranges are approximately the same as for CIP slabs.

## DRAWBRIDGES OR MOVABLE BRIDGES

**Bascule Bridges:** This is by far the most common type of drawbridge and has steel plate girder main beams with secondary rolled beams to support the steel grid, or steel grid with concrete filled, decking. One end of the span is mounted on a horizontal steel shaft called a trunnion that allows the span to be rotated up and down to allow tall boats and barges to pass. These bridges have complex mechanical and electrical systems associated with the movable capability of the span. Bascule bridges can have one or two spans. One span bridges are commonly referred to as single leaf bascules and two spans are called double leaf.

**Vertical Lift Bridges:** This type of movable bridge is no longer used for new construction in Florida. It is essentially a steel girder bridge with an entire center span that can be raised or lowered vertically by hanging the ends of the span from large steel cables that are attached to high towers.

**Swing Bridges:** Swing bridges are no longer used for new construction by the Department. These are steel girder bridges that are supported at the middle of the span by a horizontally rotating or pivot pier. The span rotates ninety degrees to a position that allows tall boats to pass without obstruction.

## SUSPENSION BRIDGES

**Cable Stayed Bridges:** The Department currently has two cable stayed bridges both of which have center span lengths of greater than 1200 feet (366 meters). Cable stayed bridges have steel or concrete superstructures that are held up by large steel cables or bars that are attached to high towers. One end of Individual Cables/bars is attached to the tower and the other end is attached to the superstructure, which gives a spider web like overall cable/bar pattern. Suspension bridges are used in Florida, when long center spans are required so that very large ocean going ships can pass beneath the bridge without getting dangerously close to the piers. They are also used in other parts of the world, when natural barriers, such as deep gorges or very deep bodies of water, make it less expensive to span across the barrier.

**Main cable suspension bridges:** The Department has only one of these suspension bridges which has a classic style main cable that is draped between towers with vertical hanger cables that attach the main cable to the superstructure. The Department's main cable suspension bridge has a center span of over 400 feet (122 meters) but these type bridges, in other parts of the world, have been built with spans of over one mile (1610 meters).

## QUIZ

Precast Prestressed Beams are manufactured where?

Before a beam can be used in the project it must have an \_\_\_\_\_ applied at the plant.

Beams are called "Prestressed", because steel strands are stressed when?

Stands are added at the job site to give the beam the capacity to carry the \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_ loads.

Beams are called "Post-tensioned", because steel strands are stressed when?

True or false: Segmental bridge segments are assembled in the prestressed plant.

\_\_\_\_\_, are used to reinforce CIP Flat slab bridges.

Bascule bridge spans rotate on a large steel shaft called a \_\_\_\_\_.

True or false: Florida suspension bridges are used because they are the least expensive type bridge to span across very deep water.

If you had trouble with the quiz, review the sections of the text that caused the difficulty. If you had no trouble with the quiz, go directly to Chapter Two.

## TO MAKE THE BEST USE OF THIS COURSE

- Take the time to study. Don't expect to learn well by just reading -- you must study.
- Studying is not the same as memorizing all the material. Don't try to memorize everything mentioned. Instead, study well enough to understand everything and remember the main points and the special terms.
- Be guided by how well you do on the QUIZZES in this text. If you cannot answer all the QUIZ questions easily, restudy the text until you can. If repeated study does not help, get help from someone that has experience and knowledge in your area of difficulty.

## ANSWERS TO QUESTIONS

### Page 1-6

- reinforced Portland cement concrete
- cast separately
- less, 20 feet (6 meters), roadway centerline
- no

### Page 1-7

(1) barrel, (2) headwall, (3) toe wall or cutoff wall  
(4) wingwalls, (5) wing footings

### Page 1-10

- substructures
- beams or girders
- abutments, end bents
- piles
- vertical, footing
- beam seats
- berm
- deck
- span
- barrier wall
- substructure
- superstructure
- approach

### Page 1-16

- precast or prestressed yard or plant
- approval stamp
- before the concrete is placed
- deck, other permanent loads, live
- after the concrete has hardened
- false, they are assembled at the job site
- rebars
- trunnion
- false, they are used to provide a safe distance between piers and large ship

# CHAPTER TWO

## Preconstruction Preparations

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## 2

# PRECONSTRUCTION PREPARATIONS

## OFFICE PREPARATIONS

Before construction begins, you should take time to thoroughly review all the contract and project related documents such as the Plans, Shop Drawings, Specifications - Standard, Supplemental, Special Provisions and Technical Special Provisions - Contractor Quality Control Plan, Job Guide Schedule for materials sampling, Contractor Pile/Drilled Shaft Installation Plans, Computation Book and Inspection Guidelists. Be sure that you are familiar with all the elevations and dimensions of the structure and the specified quantities of concrete and reinforcing steel that are shown in the plans and Computation Book. In this chapter we will discuss how these reviews and preparations can be done.

### REVIEW OF THE COMPUTATION BOOK

Before any construction begins you should do a thorough review of the Computation Book. This document contains a detailed tabulation of the quantities of materials used in the project. By reviewing the Computation Book you will familiarize yourself with the plan, elevation and profile views of the parts of the bridge; with the types and quantities of materials that will be used on the job and where they will be used; and with how the quantities of materials were calculated. You should study the plans very carefully to determine where the tabulated quantities will be used in each part of the bridge. This will also result in a check of the computation book since you may find errors in quantities or you may find bridge elements that have no quantities tabulation in the Computation book or in the plans. If this takes place, report your findings to the Project Administrator.

The Computation Book contains all calculations and quantity summaries organized in pay item number order. Some backup calculations and computer output that substantiate the summary are also contained in the Computation Book. The Computation Book becomes part of the Final Estimate which are documents that justify exactly how much the Contractor is due to be paid for his work at the end of the job. The following standard forms are used in the Computation Book to summarize the quantities and each form has two sections: an Original Design section which is filled out by the bridge designer and a Final Construction section which is filled out by the Project Administrator or other person directly involved with construction of the project.

- Linear Measurement, Component Weight, per Hour, per Day or per Each Computations
- Area Computations
- Concrete and Reinforcing Steel Computations
- Piling Tabulation
- Lump Sum Quantities

The Original Design section is filled out by the designer prior to bid and the Contractor's bid is based on these quantities. The Final Construction section is filled out after the actual quantities used in the project can be determined and this is what the Contractor's final payment is based on. As with the Original Design section, the Final Construction section may require backup calculations to justify quantities that differ from those in the Original Design section and you may have to perform these calculations. Your Project Administrator will provide training to prepare you for this task.

## REVIEW OF QUALITY CONTROL AND OPERATION PLANS

**Contractor Quality Control Plan:** The Contractor is required to submit for Department approval, a quality control plan which must provide detailed policies, methods and procedures for making sure that the quality of all materials used on the project is in full compliance with the contract documents. You will need to be thoroughly familiar with what the approved plan requires. It will be your responsibility to verify that the Contractor performs according to his plan. Any significant deviations from the plan should be reported to the Project Administrator immediately.

**Contractor Pile/Drilled Shaft Installation Plan:** Pile and/or drilled shaft plans are submitted for concurrence or approval of the Department by the Contractor before any foundation construction can begin. These plans tell the Department what equipment the contractor is planning to use and also indicates the steps that will be taken in the installation process. It will be your responsibility to make sure that the Contractor actually performs the installation as documented in his plan. Deviations from the plan should be reported to the Project Administrator immediately.

## REVIEW OF CHECKLISTS AND/OR GUIDELISTS

As an inspector your most important responsibility is to verify that the Contractor builds a bridge as required by the contract plans and specifications. These documents are very comprehensive and contain numerous requirements of which you must be aware. In order to help you avoid missing a critical inspection requirement, the Department has developed checklists or guidelists that put the inspection requirements in a greatly shortened list type format. Since each item is in a shortened form and does not go into detail, you must be familiar with the specification or plans section that the checklist/guidelist covers. If a guidelist item is not clear to you, it is critical that you study the applicable specification carefully, prior to relying on the list.

Some of the lists, called "Checklists", have a box or blank space next to each item in which to make a check mark, indicating that you have verified the list item. Other lists, called "Guidelists", require no marking and are intended to be used only as a reference.

Lists can also be given to, and discussed with, the Contractor before a construction operation is performed for the first time, to help increase awareness of the contract requirements. You will be able to get copies of the guidelists from the FDOT State Construction Office website. It is very important that you always review the applicable list thoroughly, just before you begin your inspection of a specific part of the construction.

## QUIZ

Each standard form in the Computation Book has two parts: who fills out part one and who fills out part two?

At the end of the project, the standard computation book forms are used to prepare the \_\_\_\_\_.

The Contractor's quality Control Plan must provide detailed \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_ for ensuring that all materials have acceptable quality.

True or false: The pile installation plan tells the Department what length piles the Contractor plans to use.

What is the difference between a checklist and a guidelist.

Before the Contractor begins a phase of construction for the first time, is it a good idea to discuss the applicable checklist/guidelist with the Contractor's personnel and provide a copy?

## REVIEW OF CONTRACT DOCUMENTS

One of the most important preconstruction preparations is the review of the contract documents which include the Special Provisions; Technical Special Provisions; Plans; Road Design, Structures and Traffic Operations Standards; Developmental Specifications; Supplemental Specifications; and Standard Specifications. You should take the time to highlight and be as familiar as possible with critical, new, and unusual items in the contract documents. The use of tabs or other page identification methods will help you find specification items quickly when the pressure is on in the field and everyone is anxious for an immediate answer. By being familiar with the details of the structure, many of the problems that arise during actual construction -- such as errors in dimensions or quantities -- can be avoided.

You should begin your review by studying each plan sheet paying particular attention to notes on the plans which often cover issues that are unique to the project and that are very important. At the same time, keep in mind that some of the first things you need to know are:

- The location of the structure
- The type of structure
- The size of the structure
- Structural excavation
- Maintenance of traffic.

As you read through the plans, you will need to be familiar with all dimensions, elevations and types and quantities of materials. We will cover each, but first try the quiz on the next page.

## QUIZ

Which of the following are among the first things you should know when studying the plans?

- A. The location of the structure
- B. The size of the structure
- C. Structural excavation
- D. The construction equipment to be used
- E. The names of the Contractor's personnel

What should you be familiar with when reading the plans?

What three measurements must you consider in verifying the dimensions of structures?

Miss the last question? If so, don't worry. We will discuss it next. Go on to ELEVATIONS AND DIMENSIONS.

## ELEVATIONS AND DIMENSIONS

Three measurements must be considered as you verify the elevations and dimensions of structures. These measurements are:

- Elevations
- Widths
- Lengths

### Elevations

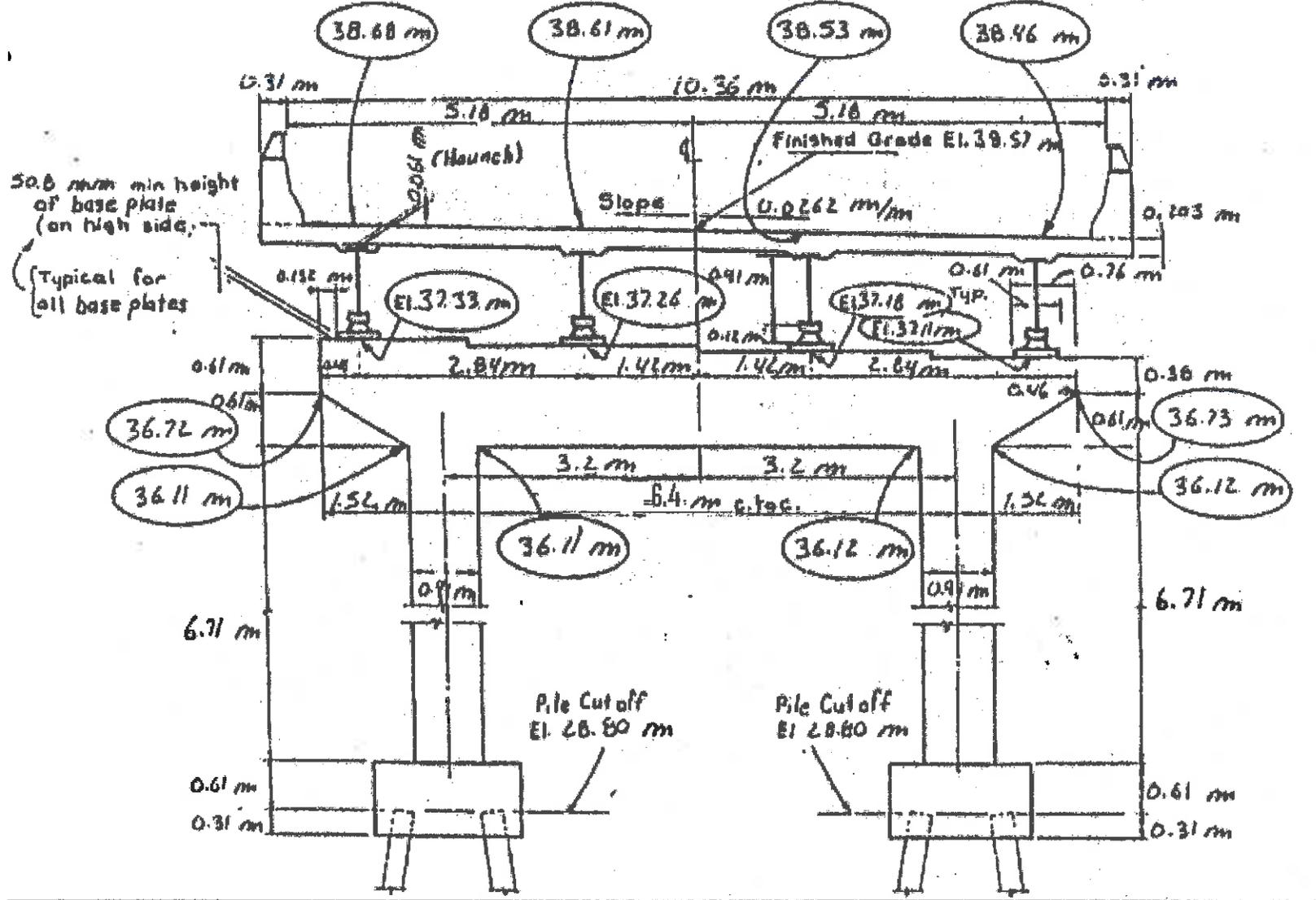
As an Inspector, you should (1) verify the elevations that are shown on the plans and (2) determine the elevations of working points -- points that will be important during construction.

In general, you will need to determine the following:

1. finished grade elevations above the girders
2. beam seat elevations
3. elevations of the top of the cap on the high side and the low side
4. elevations of the bottom of the cap on the high side and the low side
5. elevations of the tops of the columns at all edges
6. elevations of the tops of the footings
7. elevations of the bottoms of the footings
8. elevations of the tops of the piles (pile cutoff elevation)



# Metric Units



Now, let's see how to determine the elevations listed on page 2-8.

1. First, we will determine the finished grade elevations that are needed. This is done by using the centerline finished grade elevation and cross-slope rate shown on the plans. Four points are needed: the elevations above the four girders.

The finished grade elevations above the girders equal the shown centerline elevation plus or minus the cross-slope rate times the distances to the girders from the centerline.

In our example, the distance to the near girders is 4.67 feet (4 feet 8 inches) (1.42 m) and the distance to the far girders is 14.00 feet (4.27 m). So the elevations are calculated in the following manner:

Above the near girders:

$$\begin{aligned} 4.67 \text{ ft. (1.42 m)} \times 0.0262 \text{ ft./ft. or (mm/mm)} &= 0.12 \text{ ft (0.037 m)} \\ \text{Elev. 126.54 ft. (38.57 m)} + 0.12 \text{ ft. (0.037 m)} &= 126.66 \text{ ft. (38.61 m)} \\ \text{Elev. 126.54 ft. (38.57 m)} - 0.12 \text{ ft. (0.037 m)} &= 126.42 \text{ ft. (38.58 m)} \end{aligned}$$

Above the far girders:

$$\begin{aligned} 14.00 \text{ ft. (4.27 m)} \times 0.0262 \text{ ft./ft. or (mm/mm)} &= 0.37 \text{ ft. (0.11 m)} \\ \text{Elev. 126.54 ft. (38.57 m)} + 0.37 \text{ ft. (0.11 m)} &= 126.91 \text{ ft. (38.68 m)} \\ \text{Elev. 126.54 ft. (38.57 m)} - 0.37 \text{ ft. (0.11 m)} &= 126.17 \text{ ft. (38.46 m)} \end{aligned}$$





2. Next, we will verify the beam seat elevations. To do this, we need to subtract the thicknesses of the slab and base plates, and the heights of the girders and bearing devices from the finished grade elevations.

By adding these thicknesses and heights we get:

slab thickness	0.67 ft. (0.204 m)
haunch thickness	0.20 ft. (0.061 m)
girder height	3.00 ft. (0.914 m)
bearing device	0.39 ft. (0.120 m)
base plate	<u>0.17 ft. (0.052 m)</u>
	4.43 ft. (1.351 m)

By subtracting this amount from the four finished grade elevations above the girders, we arrive at the beam seat elevations:

	<i>126.91</i>	<i>126.66</i>	<i>126.42</i>	<i>126.17</i>
	<u>-4.43</u>	<u>-4.43</u>	<u>-4.43</u>	<u>-4.43</u>
Beam seat elev. (feet)	<i>122.48</i>	<i>122.23</i>	<i>121.99</i>	<i>121.74</i>
	<i>38.68</i>	<i>38.61</i>	<i>38.53</i>	<i>38.46</i>
	<u>-1.35</u>	<u>-1.35</u>	<u>-1.35</u>	<u>-1.35</u>
Beam seat elev. (meters)	<i>37.33</i>	<i>37.26</i>	<i>37.18</i>	<i>37.11</i>

3. In our example, the elevations of the top ends of the cap -- on the high and low sides -- are the same as the beam seat elevations nearest those points:

122.48 ft. (37.33 m)      121.74 ft. (37.11 m)

4. The elevations of the bottom ends of the cap are determined by subtracting the thickness (height) of the end of the cap from the elevations of the top ends of the cap:

<i>122.48 ft.</i>	<i>(37.33 m)</i>	<i>121.74 ft.</i>	<i>(37.11 m)</i>
<u><i>- 2.00 ft.</i></u>	<u><i>-(0.61 m)</i></u>	<u><i>- 1.25 ft. (1'3")</i></u>	<u><i>-(0.38 m)</i></u>
<i>120.48 ft.</i>	<i>(36.72 m)</i>	<i>120.49 ft.</i>	<i>(36.73 m)</i>

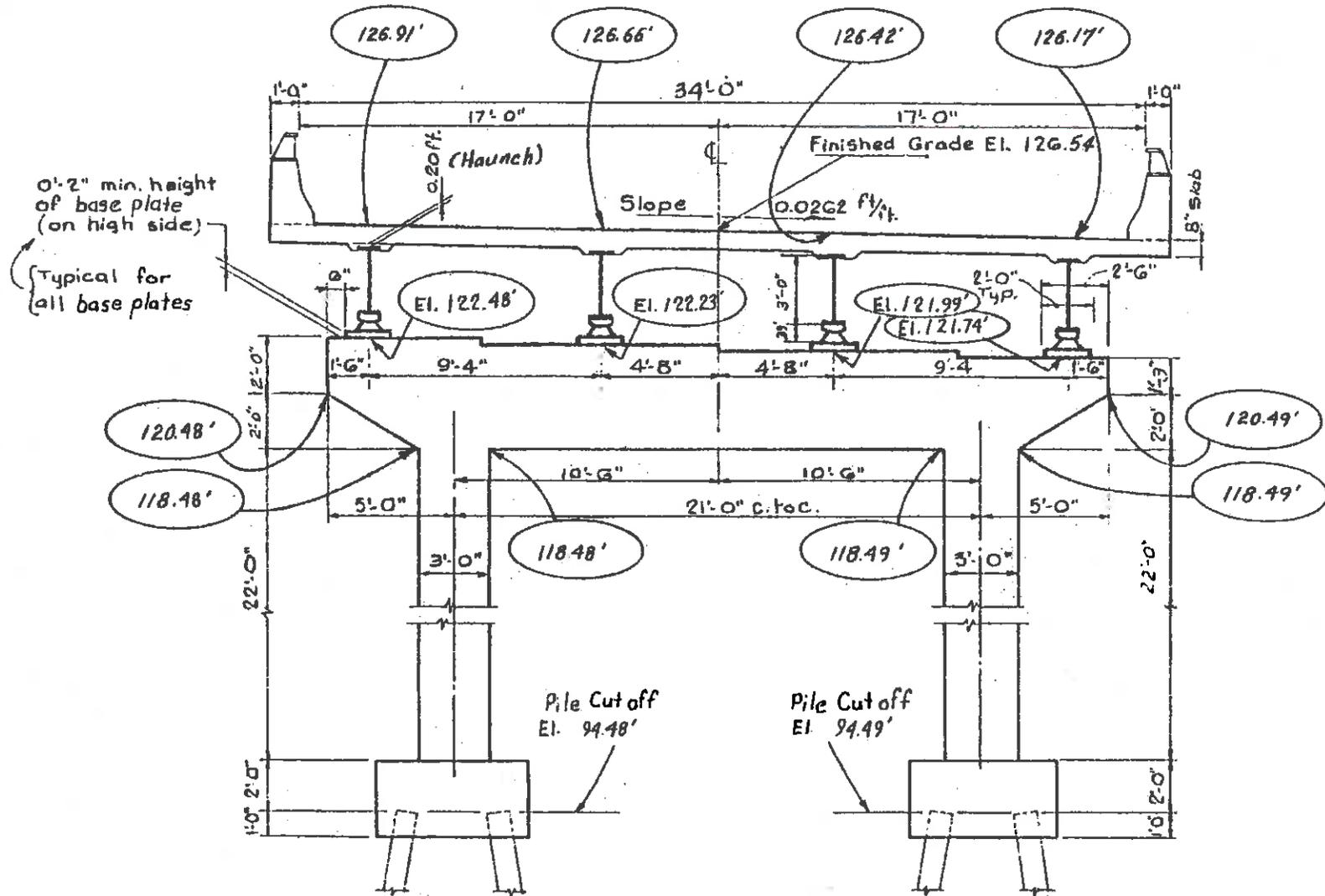
5. Next, the elevations of the tops of the columns can be determined like this:

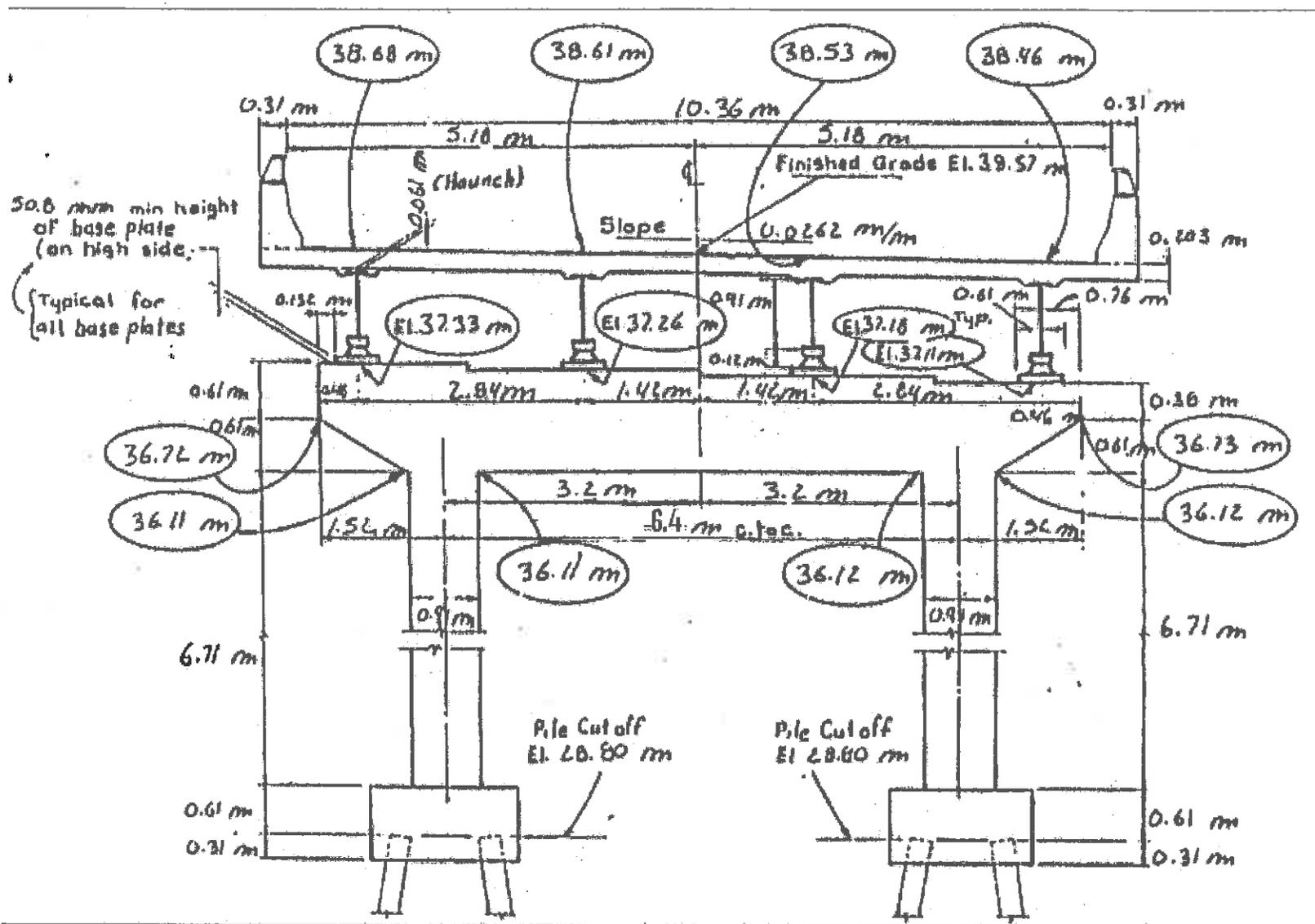
Subtract the thickness of the remainder of the cap 2.00 ft. (0.61m) from the elevations of the bottom ends of the cap:

<i>120.48 ft.</i>	<i>(36.72 m)</i>	<i>120.49 ft.</i>	<i>(36.73 m)</i>
<u><i>- 2.00 ft.</i></u>	<u><i>-(0.61 m)</i></u>	<u><i>- 2.00 ft.</i></u>	<u><i>-(0.61 m)</i></u>
<i>118.48 ft.</i>	<i>(36.11 m)</i>	<i>118.49 ft.</i>	<i>(36.12 m)</i>

In the diagram below, circles show the elevations that we have verified and determined so far:

English Units





Metric Units

The final elevation determinations are simple. By subtracting the heights of the columns and the heights of footings, we can determine the elevations of the tops of the footings and the bottoms of the footings. Let's see how this is done.

6. Elevations of the tops of the footings:

elevations of tops of columns	118.48 ft. (36.11 m)	118.49 ft. (36.12 m)
heights of columns	<u>-22.00 ft. (- 6.71 m)</u>	<u>-22.00 ft. (- 6.71 m)</u>
	96.48 ft. (29.40 m)	96.49 ft. (29.41 m)

7. Elevations of the bottoms of the footings:

top-of-footings elevation	96.48 ft. (29.40 m)	96.49 ft. (29.41 m)
height of footings	<u>-3.00 ft. (-0.92 m)</u>	<u>-3.00 ft. (-0.92 m)</u>
	93.48 ft. (28.48 m)	93.49 ft. (28.49 m)

8. The pile cutoff elevations can be verified by subtracting from the top-of-footing elevations or by adding to the bottom-of-footing elevation:

<u>96.48 ft.</u>	or	<u>93.48 ft.</u>		<u>96.49 ft.</u>	or	<u>93.49 ft.</u>
<u>-2.00 ft.</u>		<u>+1.00 ft.</u>		<u>-2.00 ft.</u>		<u>+1.00 ft.</u>
94.48 ft.		94.48 ft.		94.49 ft.		94.49 ft.
<u>(29.40 m)</u>	or	<u>(28.49 m)</u>		<u>(29.41 m)</u>	or	<u>(28.50 m)</u>
<u>-(0.61 m)</u>		<u>+(0.30 m)</u>		<u>-(0.61 m)</u>		<u>+(0.30 m)</u>
(28.79 m)		(28.79 m)		(28.80 m)		(28.80 m)

Either way, it should be the same.

Let's review what we have done:

1. We have verified the elevations shown on the plans.
2. We have determined the elevations of the working points that will be used during construction.

But what do our calculations tell you? If everything fits, then you know that the plans are correct and the structure must be constructed as shown.

If the parts do not fit, then you must do some figuring. Are any dimensions wrong? Or are the elevations wrong? When you locate the errors, contact your supervisor and tell him what you have found. He will get in touch with the District Structures Design Office or the Engineer of Record (Department or Engineering Consultant) to make the proper changes.

Determinations similar to the ones we have discussed here can be used to verify and determine the elevations of any structure. Be sure that the parts fit -- the dimensions of the structures must add up to the elevations shown on the plans and the elevations themselves must be correct.

## QUIZ

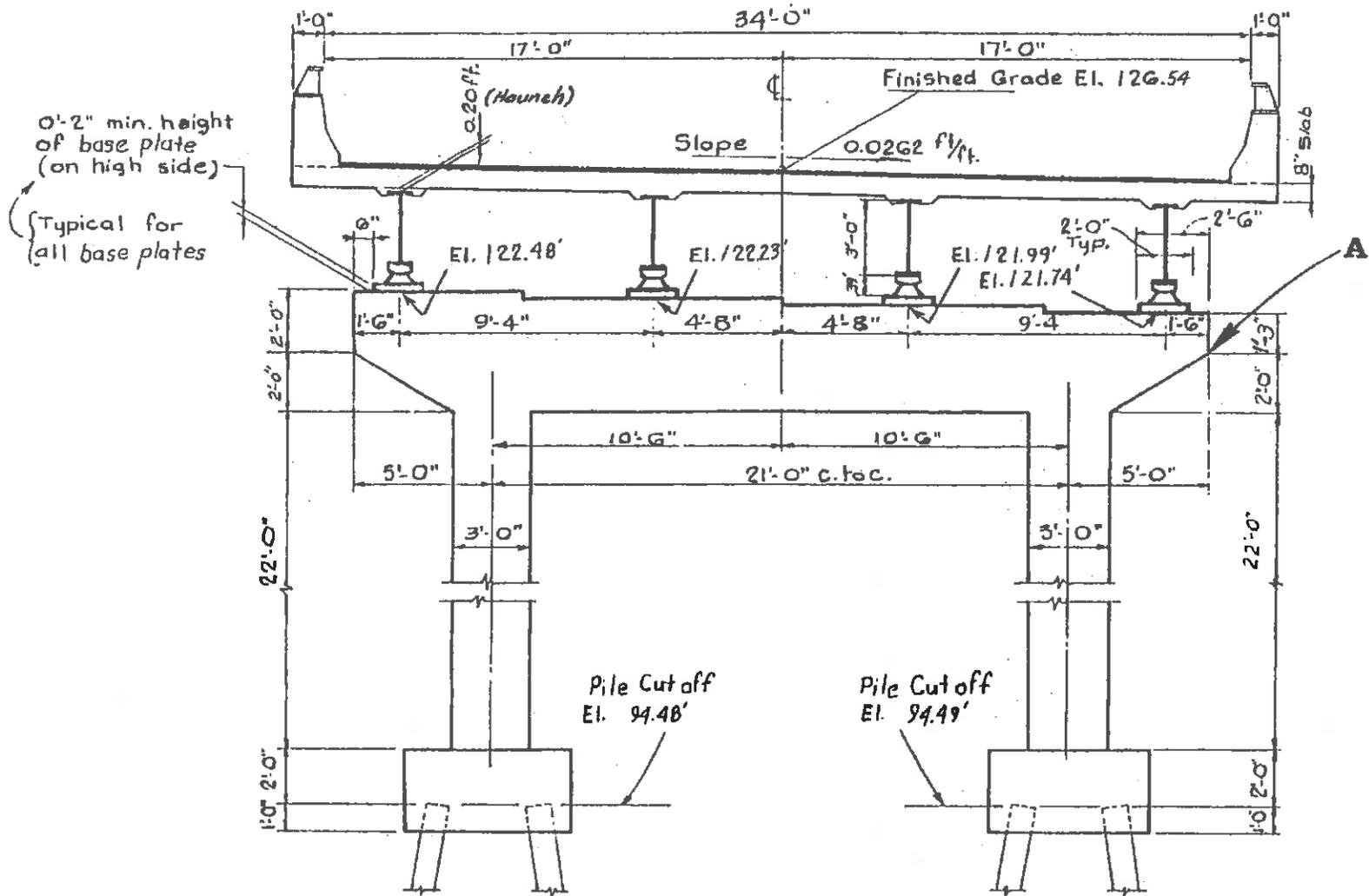
Use the elevation view on the next page to answer the following questions:

What is the centerline finished grade elevation of the bridge?

How high above the bottom of the footing is the top of the cap at the left edge?

What are the finished grade elevations above the outside girders?

English Units





## QUIZ, continued

Use the diagram on page 2-21 to answer the following questions:

What are the finished grade elevations of the tops of the left and right columns?

Left: \_\_\_\_\_

Right: \_\_\_\_\_

What are the elevations of the top ends of the cap on the left and right sides?

Left: \_\_\_\_\_

Right: \_\_\_\_\_

Determine the elevation of the bottom of the end of the cap on the right side.  
How thick (high) is the right end of the cap?

What are the elevations of the bottoms of the footings?

Left: \_\_\_\_\_

Right: \_\_\_\_\_

What is the pile cutoff elevation at the left footing?

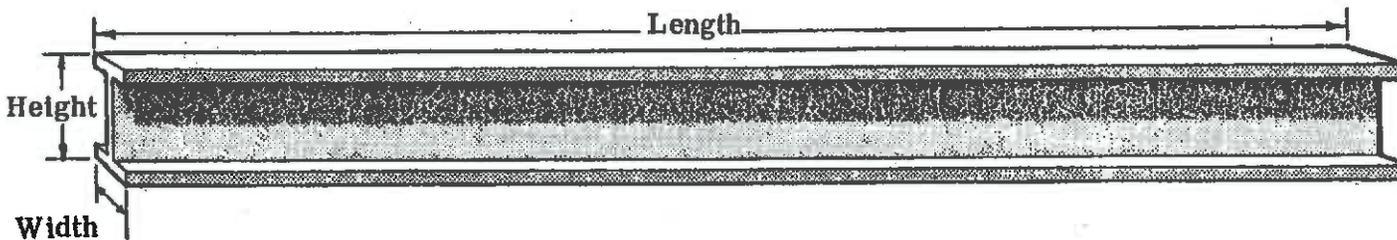
If you had any difficulties with this quiz, review pages 2-8 through 2-22 and then try the quiz again. When you are ready, go on to Lengths and Widths.

## Lengths and Widths

After checking the necessary elevations in the plans, you should verify the lengths and widths of the structure -- particularly of all girders, piles and steel reinforcing bars (rebars). Add the span lengths (pier to pier or pier to abutment) to see if they add up to the total length of the bridge. Then check the widths of the caps, roadway and abutments.

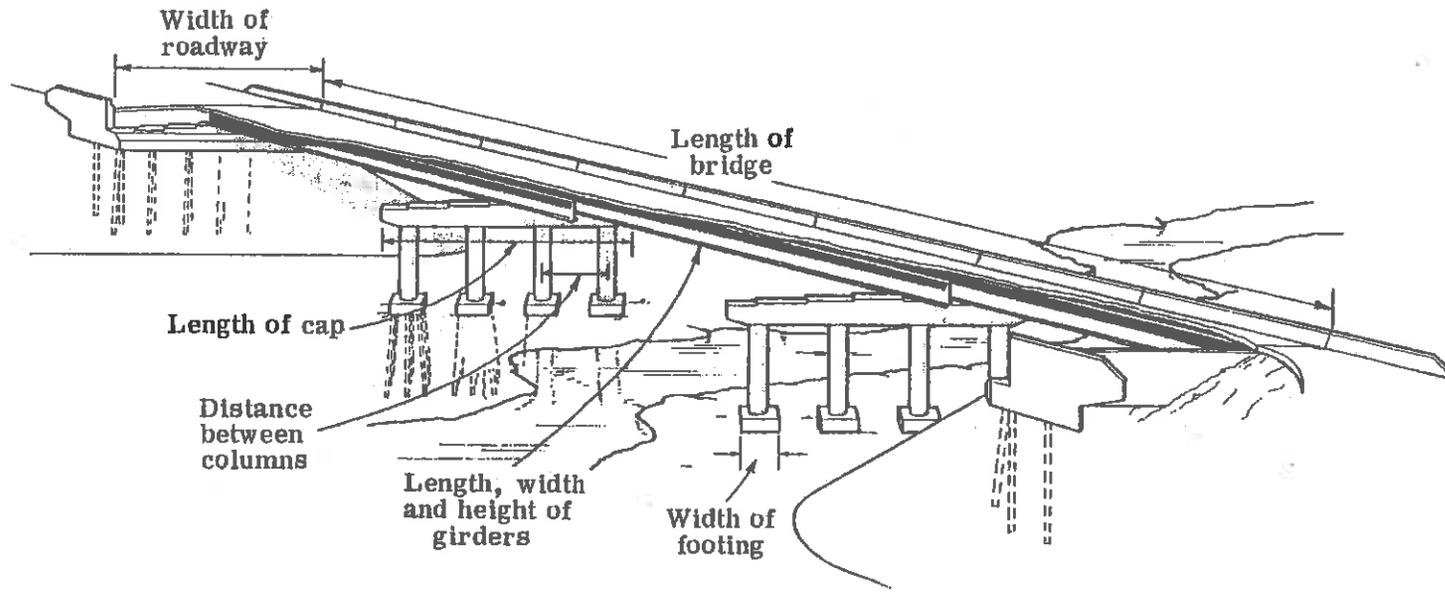
In addition, note the lengths of all girders and piles. Below is an illustration of a steel girder. Notice that the length, width and height are dimensioned. The length of girders is particularly important since they must fit between piers with very little room for error -- they must not be too long or too short. The length of girders is always measured along the centerline.

To verify the size of rebars, review the quantities tables shown in your plans. Compare the table requirements to the lengths of rebars drawn on the plans. If any discrepancies occur between the drawings and tables, report them immediately to the Project Administrator.



**STEEL GIRDER OR STEEL PILE**

Below is a review of some of the lengths and widths which you must verify. Particularly important is the length of the girders. You must be sure they are long enough to span between piers and abutments. It's a good idea to measure beams and girders as soon as they arrive at the site.



## QUIZ

In addition to checking elevations, you must also verify the \_\_\_\_\_ and \_\_\_\_\_ of a structure.

What three dimension checks must be made on a steel girder or pile?

Why is it especially important to measure the length of girders?

You will need to consult the \_\_\_\_\_ to verify the size of rebars.

What action should be taken if you find girders that are too short?

The length of all spans added together should equal the \_\_\_\_\_ of the bridge.

Go on to QUANTITIES OF MATERIALS.

## QUANTITIES OF MATERIALS

The quantities of materials needed to build structures are tabulated in Estimate of Quantities tables in the plans. You should review and familiarize yourself with these quantities. Depending on the type of structure, the Estimated Quantities tables will include how much excavation, structural steel, concrete and reinforcing steel will be needed. You should cross-check the plan requirements with the Estimated Quantities tables to be sure they correspond.

### Concrete

Quantities of concrete are shown by class and in cubic yards. One method of checking concrete quantities is to look at the dimensions of a specific concrete part or element and then compute its volume. For example, if the plans show a concrete footing to be 5 feet x 10 feet x 10 feet (1.52 m x 3.05 m x 3.05 m), its volume is 500 cubic feet or 18.52 cubic yards (14.16 cubic meters). This volume should match the total quantity of concrete shown for that footing of the substructure in the Estimated Quantities tables.

### Steel

Both structural and reinforcing steel quantities are given in pounds. Most of your steel quantity checks may be made at the same time that you are making your other plan checks. For example, the number of reinforcing bars can be counted when you are checking on the location and spacing of each type of bar. Count the number of each type of bar shown or identified on the detail sheets. Compare your count with the number of bars specified in the Bill of Reinforcing Steel Bars in the plans.

After you have counted each type of bar and compared your count against the Bill, you have to convert the sizes and the lengths of the bars into pounds of steel. You do this by referring to the table shown on the next page.

The table below shows the weight per linear foot (meter) for each size of steel reinforcing bar. To compute the pounds (kilograms) of steel reinforcing bars, you need to know the following:

- the sizes of the bars;
- the lengths of the bars; and
- the weights per linear foot (meter) of the bars.

The first two are easy to obtain. You can get this information from the Bill. For the weights per linear foot (meter), refer to the table below:

Bar Designation	Weight per L.F. in lbs (kg/m).	Bar Designation	Weight per L.F. in lbs (kg/m).
1/4"	0.167 lbs.	8 (30M)	2.670 (5.495)
3 (10M)	0.376 (0.785)	9 (30M)	3.400 (5.495)
4 (15M)	0.668 (1.570)	10 (35M)	4.303 (7.850)
5 (15M)	1.043 (1.570)	11 (45M)	5.313 (11.775)
6 (20M)	1.502 (2.355)	14S (45M)	7.650 (11.775)
7 (25M)	2.044 (3.925)	18S (55M)	13.600 (19.625)

Compute pounds of rebar as follows: if a 5 (15M) bar is 6 feet 4 inches (1.95 m) long, its weight is 6.605 pounds (6.333 ft. x 1.043 lb. per L.F.) (3 kg (1.93 m x 1.57 kg per m)). This is rounded to 6.61 pounds (3 kg).

## QUIZ

Quantities of concrete are measured in \_\_\_\_\_.

Quantities of steel are measured in \_\_\_\_\_.

A concrete bridge footing in your plans measures 10 feet x 12 feet x 6 feet (3.05 m x 3.66 m x 1.83 m). What is the proper quantity of concrete for that footing?

Where do you find the tabulation of the quantities of materials needed to build a structure?

How much do five 10-foot, 4-inch (3.15 m) #10 (35M) bars weigh? \_\_\_\_\_ (Use the table on page 2-28.)

The correct numbers of bars for a structure are found in what section of the plans?

Have any trouble with this quiz? If so, be sure to review the material until you understand it. When ready, go on to FIELD PREPARATIONS.

## FIELD PREPARATIONS

Once you have started your structures book and reviewed the contract plans, you are ready to make field preparations. You should visit the structure site and familiarize yourself with utility locations, soil conditions, topography and water conditions -- before construction begins. Pay particular attention to the existing stakes. The stakes may have subsided or been destroyed if there has been considerable time between the design of the structure and the start of construction. You should note any errors in your daily report and be sure that they are corrected.

### UTILITY LOCATIONS

As an Inspector, you should know:

- WHO is responsible for removing or relocating utilities
- WHICH utilities are being removed or relocated
- WHERE utilities are being relocated, whether within the construction area or connected to the structure.

Answers can be found in the contract plans and approved utility relocation schedule. The locations and relocations of utilities are shown in the plans. It is important to know where the utilities are and where new ones will be placed. Before the Contractor begins other operations, you must be sure that all utilities are removed or relocated as called for in the plans and utility relocation schedule. You must also note if the utility adjustments are reimbursable or non-reimbursable and record the relocation work on the appropriate diary or reimbursable utility form. For more information, you can take the training course on Utility Relocation and Clearing and Grubbing Inspection.

## SOIL CONDITIONS

Soil conditions in the field should be checked against the soil surveys compiled in the boring data sheets that are part of the plan sheets. The boring data sheets include the following information:

- boring locations in relation to centerline
- descriptions of anticipated soils along the roadway
- depths at which these soils occur

Boring data sheets include legends that describe the various soil types. They also include descriptions of the core borings taken around the proposed bridge.

As an Inspector, you should be able to use the soil data to anticipate suitability of materials for use in embankments. These sheets are discussed in the Contract Plan Reading course.

## TOPOGRAPHY

Plan and profile sheets show the topography of the construction site. Topography consists of natural elevations, ground depressions, embankments, river basins and vegetation. Be sure that there are no inconsistencies between what is shown on the plans and what you find at the construction site. Any natural obstructions that are not shown on the plan sheets must be reported to the Project Administrator.

## WATER CONDITIONS

You should be aware of water conditions at the construction site -- particularly if the structure is to be built in or near a body of water. If a structure is erected near water, state and federal water pollution laws must be considered. For example, the amount of silt created by construction in or near a river is often subject to water pollution standards. These standards will be covered at the preconstruction conference.

## TRAFFIC MAINTENANCE

As an Inspector, you must be sure that traffic is maintained and that the driving public is warned about and protected from the construction area. The Contractor must comply with the FDOT Traffic Design Standards covering maintenance of traffic Index No. 600, as well as the Manual on Uniform Traffic Control Devices (MUTCD) -- Keep in mind, however, that the MUTCD describes minimum safety requirements and the FDOT Design Standards take precedent over them --there may be a need for more, in which case the Contractor must provide them.

In most cases, the Traffic Design Standards Index No. 600, and the MUTCD will prescribe the required barricades, signs and other warning devices during construction, but there are some special problem areas that you should be aware of:

- Footings constructed adjacent to traveled pavement are dangerous and should be well protected from traffic.
- Detour systems for bridge construction should be laid out and operational before work begins.
- The erection of beams during heavy traffic is a common traffic hazard. For this work, flagmen and police may be needed. Be sure to check with your Project Administrator.
- The traveling public must be well protected from overhead deck construction, so be sure that the traffic maintenance is adequate.

## QUIZ

Information on the location of utilities is found in the \_\_\_\_\_.

Is the Inspector responsible for knowing where utilities are being relocated?

Soil data which show the characteristics of the soil can be used to anticipate the suitability of materials for use in \_\_\_\_\_.

Information about the soils under a bridge are plotted on \_\_\_\_\_ sheets.

Federal and state water pollution standards will be discussed at the \_\_\_\_\_.

Where can you find traffic maintenance and safety requirements?

Go on to PRECONSTRUCTION CONFERENCE.

## **COORDINATION MEETINGS**

Before the project begins and during the project, coordination meetings between the Contractor and the Department take place on numerous occasions in order to encourage and maintain open lines of communication. These meetings are very important because they clarify both the Department's and Contractor's intent and expectations before work takes place and they help head off problems. The following types of meetings should always take place: preconstruction conference, periodic construction progress meetings, and pre-operations meetings.

### **PRECONSTRUCTION CONFERENCE**

The preparations for construction vary from project to project -- they depend on the area's conditions, the Contractor and the Project Administrator. For this reason, and prior to any work starting, the Project Administrator will hold a conference with the Contractor to discuss a lengthy list of project requirements, arrangements, and schedules. A sample list of issues that should be covered at the preconstruction conference is included in Chapter 3, Section 1 of the FDOT Office of Construction, Construction Project Administration Manual (CPAM). You should read the minutes of this meeting as a part of your preparation.

### **PERIODIC CONSTRUCTION PROGRESS MEETINGS**

Many activities and operations take place on a busy construction project from day to day. In order for the Department and Contractor to keep each other informed and up to date about what is taking place, a regular meeting is held with the Project Administrator and the Contractor's Project Manager. Other Contractor and Department personnel also attend on an as needed basis. Meetings are usually conducted each week in the early stages of a project and may eventually be only once a month by the end of the project. At the weekly meetings the following key issues are usually discussed: utility conflicts and relocation schedules; job progress including controlling items of work and percent complete; design changes and conflicts; status of contractor submittals such as shop drawings; and the status of monitored items such as maintenance of traffic, erosion control, safety and contract changes. If possible, you should read the minutes of these meetings.

## PRE-OPERATIONS MEETINGS

The Contractor's construction operations can often be very complicated and are usually critical in terms of how much time activities take. When things go wrong or are inadequately planned, it disrupts the progress of construction and can lead to claims or delays by the Contractor. In order to reduce the likelihood of this happening, a meeting, called a pre-operations meeting, should take place before the Contractor performs a construction activity or operation for the first time on the project. Examples of activities that should always have a pre-operations meeting include: pile driving, any type of concrete placement - footings, columns, caps, decks, etc. - beam erection, form setting, slip forming, rebar placement, post-tensioning: just to name some of the more important ones.

Department and Contractor personnel that will actually be involved directly in the activity should attend the meeting such as foremen, work crew members, Project Administrator and inspectors. All applicable specifications should be available for review at the meeting as should any checklists or guidelists for an item by item review. A copy of the checklists or guidelists can be given out at or prior to the meeting, so that the Contractor has a written document for later reference. At the meeting the applicable specifications should be thoroughly reviewed with the Contractor and a "What If" discussion should take place with regard to what the Contractor plans to do if something unexpected happens. The meeting should have summary minutes that cover any outstanding issues or questions that come up during the meeting and any unresolved questions or issues should be addressed before the Contractor begins work.

If you will be inspecting this operation, you should attend the meeting; however, if you are unable to attend, then a thorough review of the meeting minutes is a must.

## QUIZ

A sample list of issues that should be covered at the preconstruction conference can be found in the FDOT Office of Construction, \_\_\_\_\_, Chapter \_\_\_\_\_, Section \_\_\_\_\_.

True or false: construction progress meetings help keep the Department and the Contractor up to date and informed about what is happening on the project.

Progress meetings usually take place \_\_\_\_\_ per week at the beginning of a project and eventually take place \_\_\_\_\_.

True or false: Reading the minutes of coordination meetings is unnecessary for inspectors.

A pre-operations meeting should take place before a construction activity is performed for the \_\_\_\_\_.

Should checklists/guidelists and applicable specifications be available for review at the pre-operations meeting?

True or false: what if discussions are of little value since unexpected events seldom happen on construction projects.

This is the end of Chapter Two. If you need to review any sections of this chapter, do so before continuing. When you feel ready, go on to Chapter Three.

## ANSWERS TO QUESTIONS

### Page 2-5

- designer, Project Administrator
- final estimate
- policies, methods, procedures
- false, it tells equipment to be used and the installation process
- checklist is marked off item by item and a guidelist is not
- yes

### Page 2-7

- A  
B  
C
- dimensions, elevations, types and quantities of materials
- elevations, lengths and widths

### Page 2-20

- 126.54 ft. (38.57 m)
- 29.00 ft. (8.84 m)
- 126.17 ft. (38.46 m)
- 126.91 ft. (38.68 m)

### Page 2-23

- 118.48 ft. (36.11 m), 118.49 ft. (36.12 m)
- 122.48 ft. (37.33 m), 121.74 ft. (37.11 m)
- 120.49 ft. (36.73 m)
- 1 ft.-3 in. (0.38 m)
- Lt. 93.48 ft. (28.49 m), Rt. 93.49 ft. (28.49 m)
- 94.48 ft. (28.80 m)

### Page 2-26

- lengths widths
- length, width, height (depth)
- to be sure they are long enough to span the distance between piers and abutments
- plans
- report them to your Project Administrator
- total length

### Page 2-29

- yards (cubic meters)
- pounds (kilograms)
- 26.7 cu. yds (20.43 m<sup>3</sup>).
- estimated quantities tables in plans
- 222.31 pounds (123.64 kg)
- bill of reinforcing steel bars

Page 2-33

- plans
- yes
- embankments
- boring data
- preconstruction conference
- FDOT Traffic Design Standards and Manual on Uniform Traffic Control Devices

Page 2-36

- Construction Administration Manual (CPAM), 1, 8
- true
- once, once per month
- the first time
- yes
- false, unexpected events happen often

< false, inspectors should read minutes

# CHAPTER THREE

## Staking Structures

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# 3

## STAKING STRUCTURES

### PURPOSES AND RESPONSIBILITIES

As an Inspector, your job will require that you understand the Contractor's staking methods before the stakes are placed. Different staking methods are used, but the purpose of staking always should be the same: to establish and maintain controls for construction.

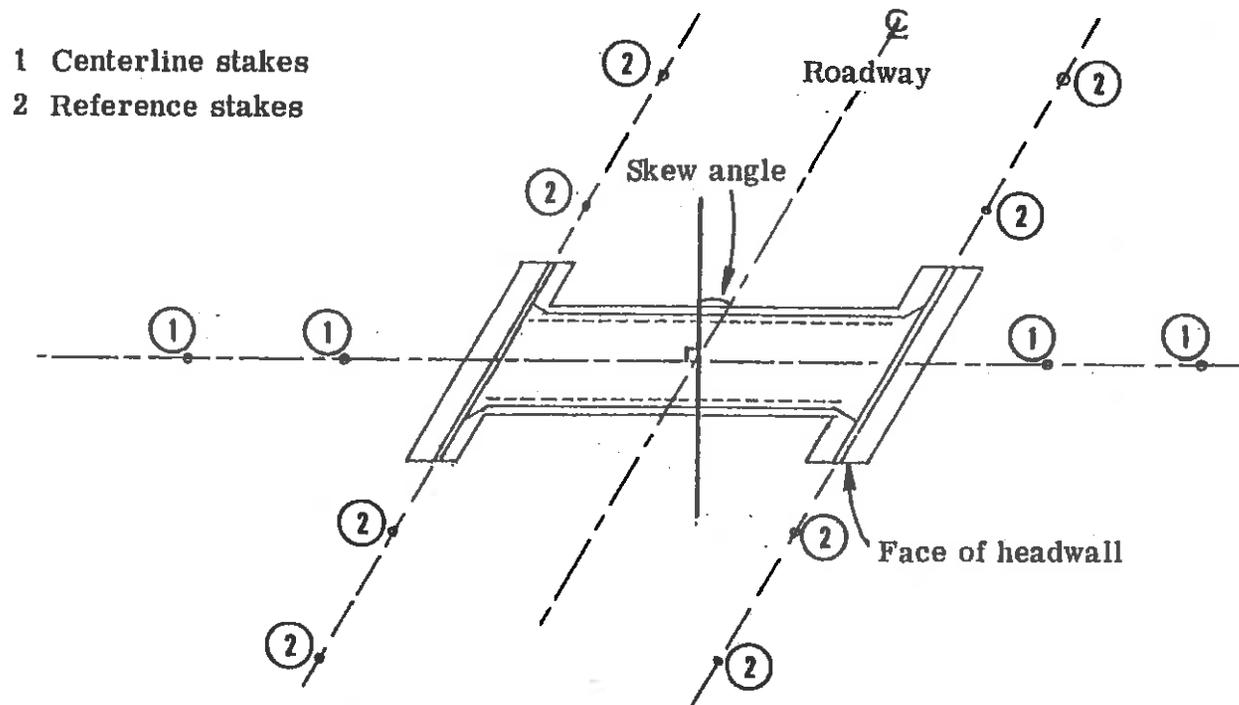
Basically, there are two controls necessary -- layout and grade. Layout control refers to the horizontal alignment of the structures, while grade control refers to the elevations or vertical location of the structures.

The Contractor has the responsibility of building the structure according to the alignment and elevations shown on the plans. To help the Contractor transfer the layout information from the plans to the construction site, the Department locates and references the centerline given on the plans. Also, the Department establishes bench marks for the grade control of the project. The Contractor's survey crew will then make all the necessary calculations, do the layout, and grade the stakes.

One note before we start; methods of staking and ways to mark stakes vary from survey party to survey party. We will discuss a typical method in this chapter, but do not expect to see only this method. It will be extremely important for you to meet with the Party Chief beforehand, to familiarize yourself with the methods of staking. This will ensure that layout methods that the Party Chief intends to use are satisfactory procedures to do the job.

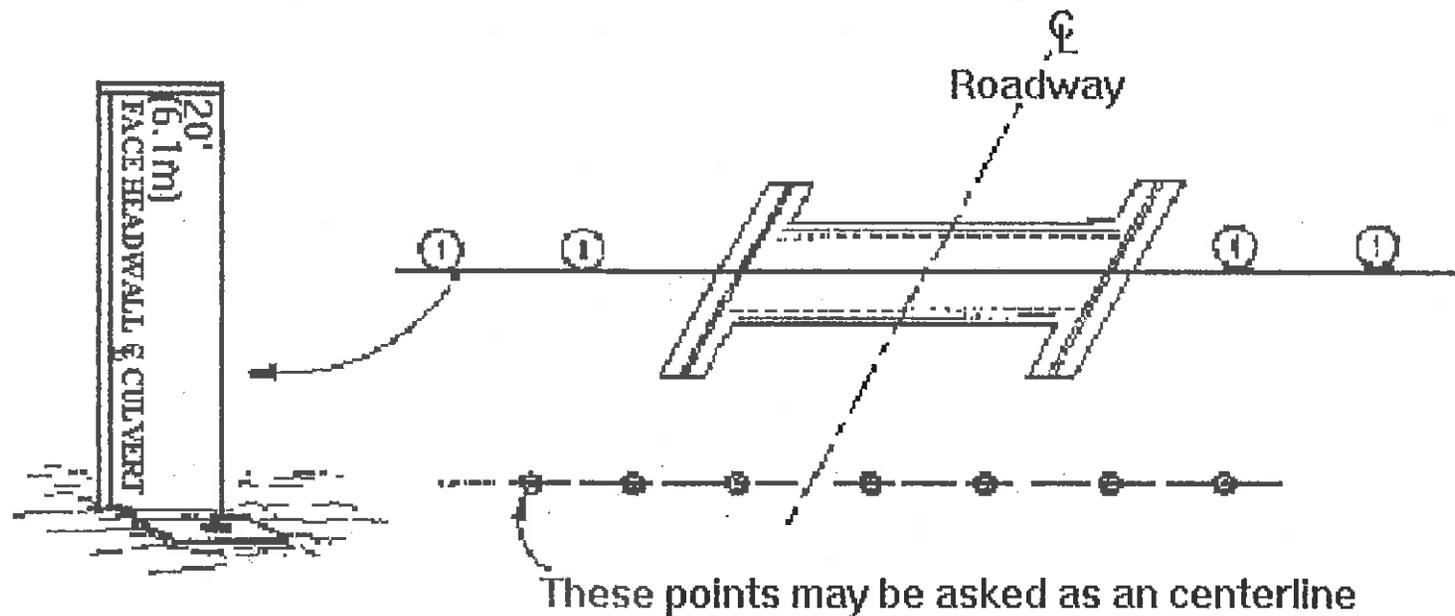
## BOX CULVERT STAKING LAYOUT

The Contractor's survey party will be responsible for laying out the box culvert to be constructed. The survey party usually will set two types of stakes, as shown below. From these basic control points, other stakes may be set by the Contractor -- closer to the flow line and forms. He may set stakes along a line offset to the culvert centerline, from which he can control the elevations.



## CENTERLINE STAKES

Centerline stakes are offset from the ends of box culverts and aligned to mark the location of the centerline of the culvert. These stakes usually are set only if the stakes can be set in dry ground. If the area is under water, you will have to rely on the reference stakes, or offset centerline stakes, like the ones described below.



In addition to marking the centerline of box culverts, centerline stakes also help control the alignment and grade of forms for the barrel and ends of the box culvert. As you can see in the diagram above, offset centerline stakes are set parallel to the culvert centerline.

## QUIZ

Points of known elevation used for vertical control are called \_\_\_\_\_.

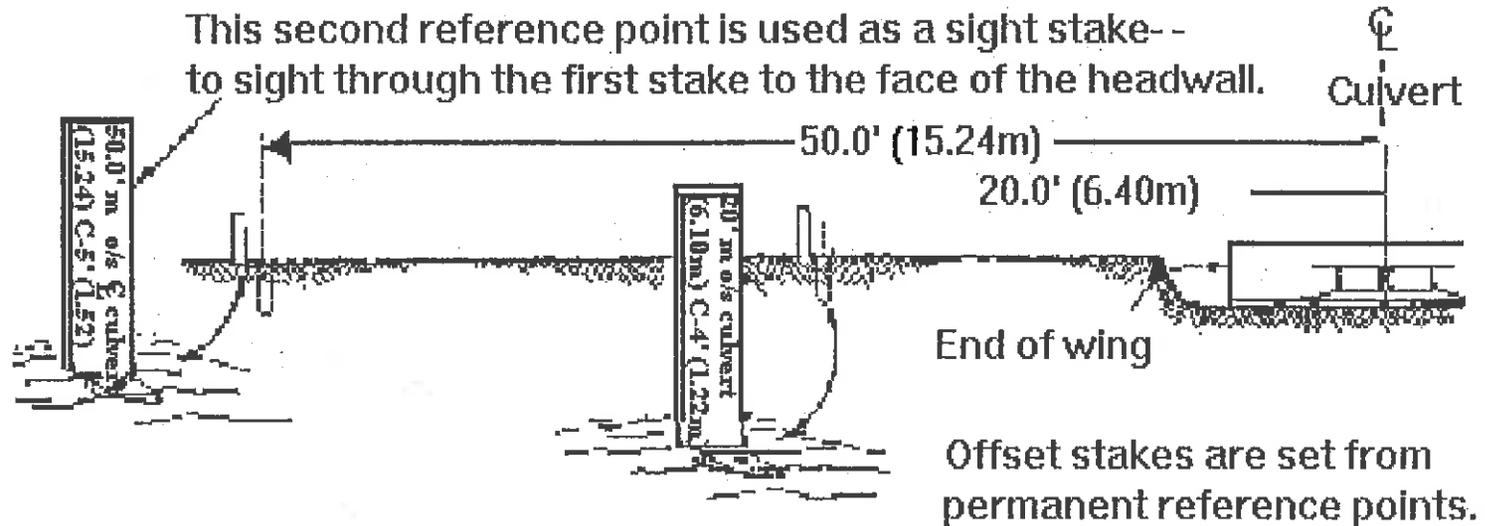
Stakes that control horizontal alignment and elevations are also known as \_\_\_\_\_ and \_\_\_\_\_ stakes.

The survey crew usually sets \_\_\_\_\_ stakes and \_\_\_\_\_ stakes.

If the area is under water \_\_\_\_\_ or \_\_\_\_\_ stakes must be used.

## REFERENCE STAKES

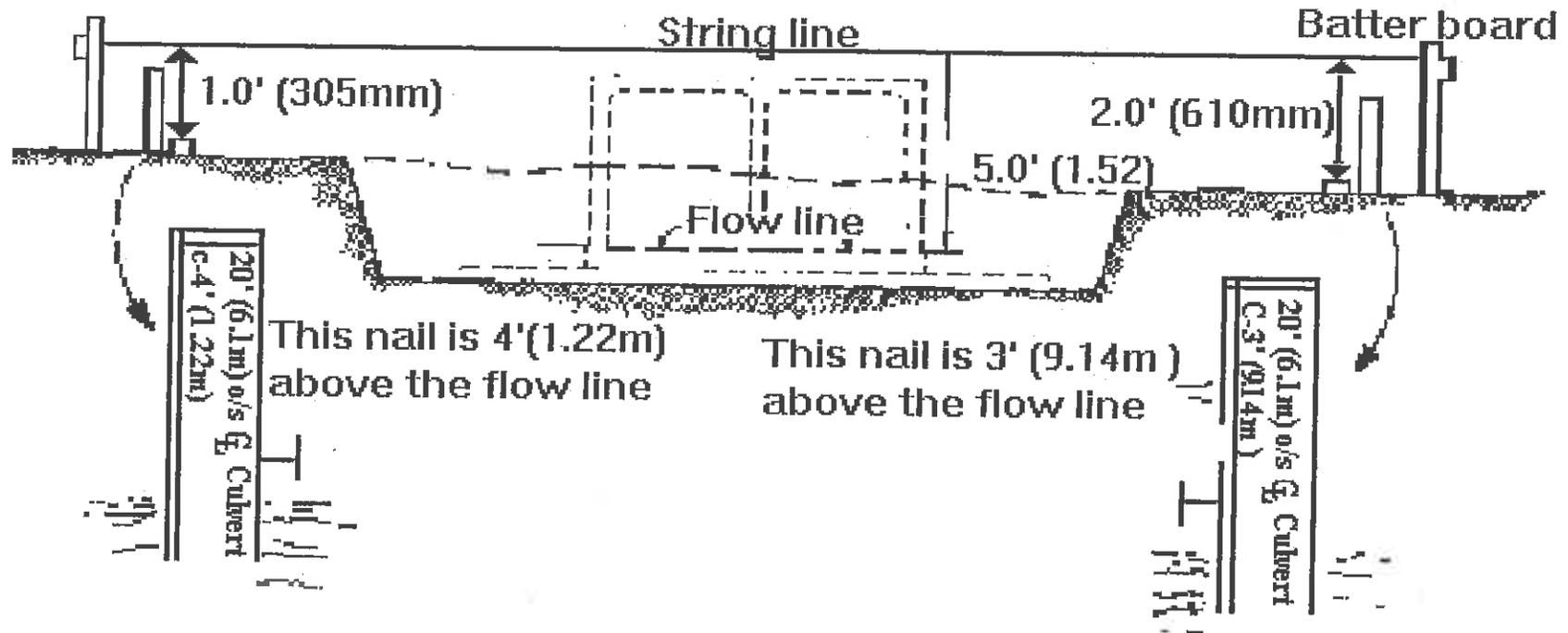
Reference points are indicated by offset stakes like the ones in the diagram below:



These offset stakes can be used for horizontal and vertical alignment. The tacks in the hubs are used to set the line along the wings. The hubs and tacks are offset from the culvert centerline. The nail in the side of the guard stake is graded to the flow line.

As an Inspector, you are responsible for checking the culvert layout and determining that the stakes are adequate in number and position, and that they appear to be realistic.

The diagram on the previous page mainly shows how reference stakes offset from a box culvert can control horizontal alignment -- line. But we also mentioned that the reference stakes can be used to control vertical alignment -- grade. A different look at the field situation on the previous page shows how this is done.



Batter boards with a string line may be set by the Contractor, so that the flow line elevation can be checked. According to the stakes, the flow line is 4 feet ( 1.22 m) below one nail and 3 feet ( 914 mm) below the other. The stringline is set 1 foot ( 305 mm) above one nail and 2 feet (610 mm) above the other. This means that the flow line must be 5 feet ( 1.52 m) below the string line. You can check this with a rule and tape, or level rod.

After the foundation is prepared, the floor slab of the box culvert can be constructed. To control the floor elevation, the Contractor will set hubs at the working points and grade to the elevation of the floor. From string lines stretched between these hubs, the foundation can be fine graded and the footing and slab forms placed. As an Inspector, you must be familiar with the method the Contractor uses, so you can check the work being done.

Footing forms will be set by measuring from string lines stretched between working points and from working points to wingwall reference points. Grade nails are then set on the forms by leveling from the string line. Once the grades are established on the forms, the hubs are pulled out.

After the slab concrete has set, the survey crew will mark the slab at the working points -- so that the wingwall and barrel forms can be graded.

Each Contractor will have his own request for stakes. Some may want stakes offset from the centerline, or some may not want any offset stakes. Be sure that you know which stakes the Contractor wants or which stakes he will set himself.

#### **POINTS TO REMEMBER**

Staking a box culvert for grade is not complicated. Just remember these points:

- The initial excavation -- cutting -- is controlled by cut or grade stakes that show the amount of original ground that must be removed.
- The foundation that is prepared as a bed for the box culvert bottom slab must be graded to the bottom of the slab elevation. This is controlled by stakes set in the foundation at the working points.
- The flow line grade is controlled by offset hubs.

With these points in mind, try the quiz on the following page.

## QUIZ

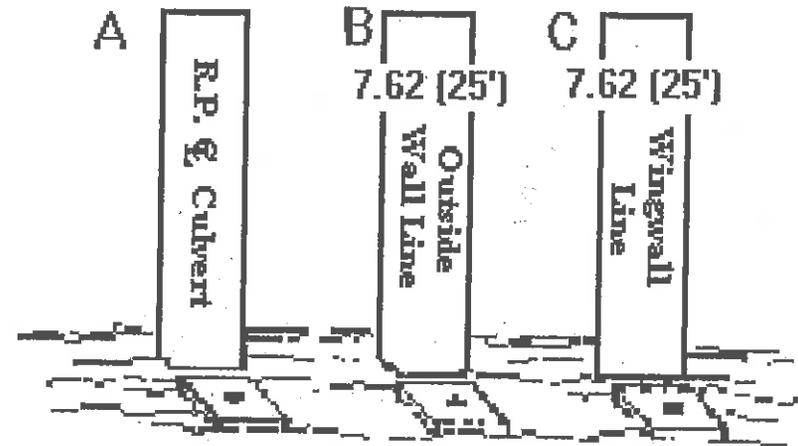
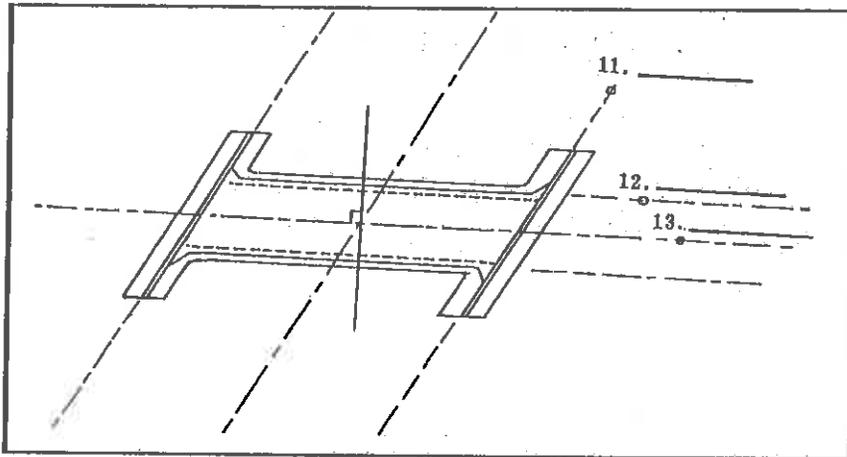
What stakes are used to make the centerlines of box culverts?

Which stakes act as reference points for the wingwalls and barrels of box culverts?

The flow line grade is controlled by \_\_\_\_\_.

Do offset stakes help to control horizontal form setting?

Place the stakes at the right in their proper locations below.



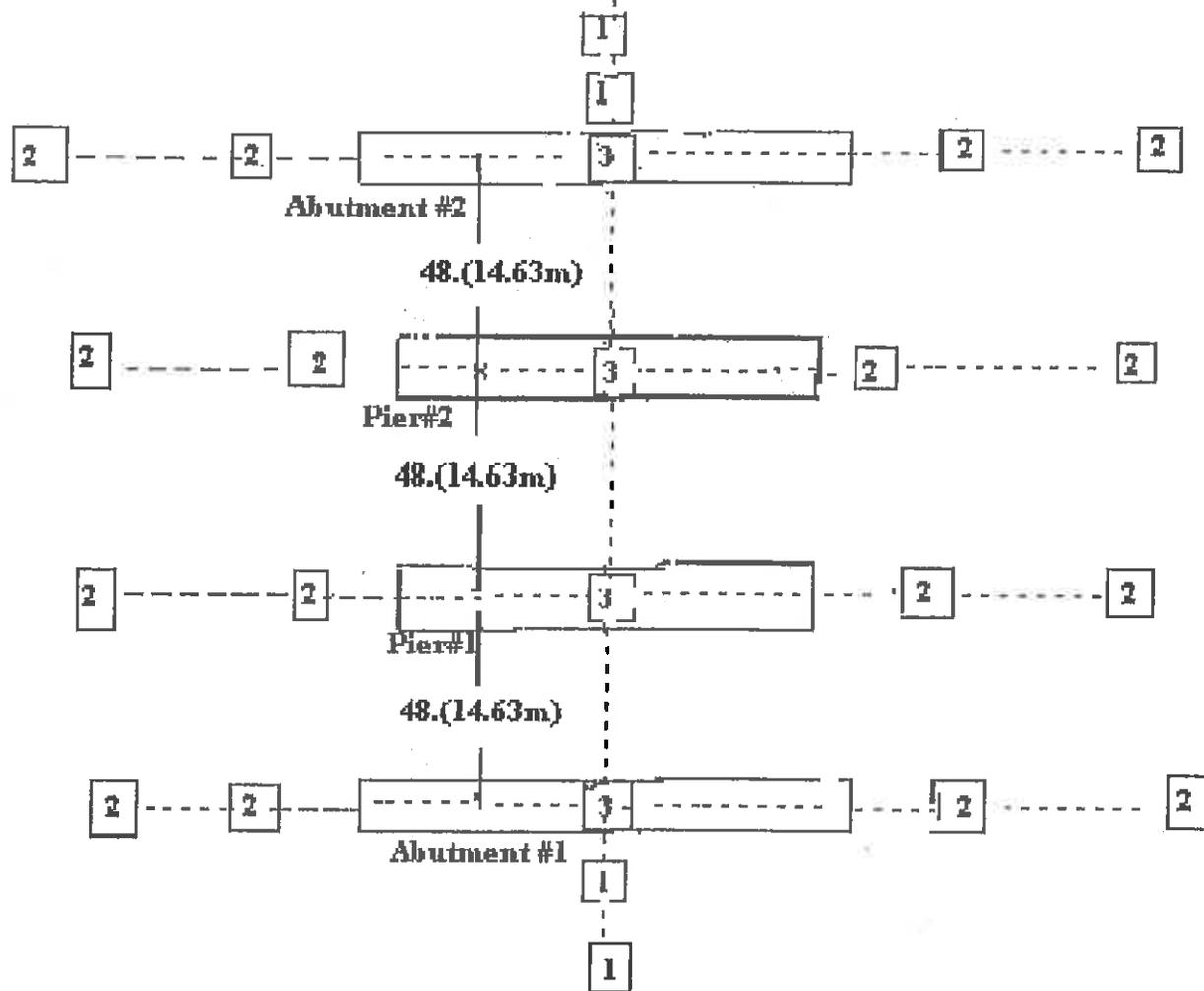
## BRIDGE LAYOUT CONTROL STAKES

A typical bridge layout is shown on the next page. These types of stakes are shown:

1. Bridge centerline stakes -- are established from centerline control points and are set by the survey crew.
2. Reference control stakes -- also called offset stakes -- are set by the survey crew from the bridge centerline.
3. Substructure centerline stakes -- are set by the survey crew to locate the centerlines of the piers, bents or abutments.

Each type of stake is numbered on the next page. The following pages explain the stakes in detail.

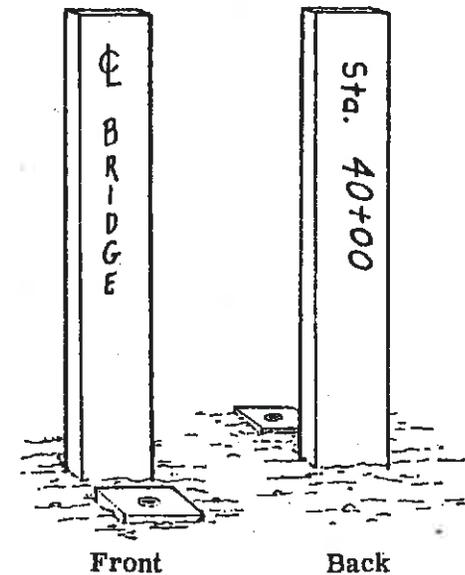
Roadway and Bridge C.



## 1. Bridge Centerline Stakes

Bridge centerline stakes mark the centerline of the structure. The stake below is one way to mark the centerline. In other cases the centerline may be marked by a nail or tack driven into asphalt pavement or by a cross etched into concrete pavement. In any case, the essential information should be the same:

- "⊕ Bridge or Roadway"
- a definite, marked point
- the station number



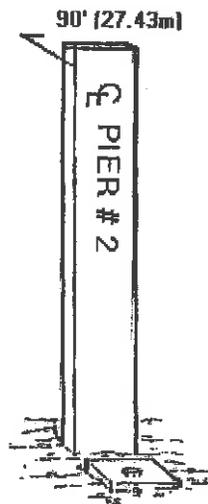
The stake above is located on the bridge centerline at Sta. 40+00.

## 2. Reference Control Stakes

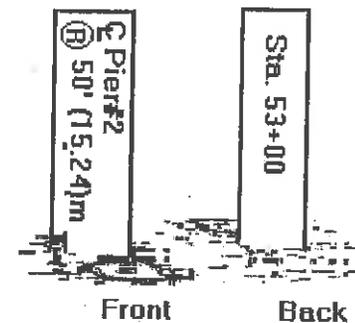
Reference control stakes -- like the ones below -- are offset from the substructures along the substructure centerlines. These "offset" stakes are used to control the location of the substructures and the alignment of forms.

For each interior offset stake, a second one is placed farther out from the structure, so that if the first is damaged or knocked out during construction, a reference is still available.

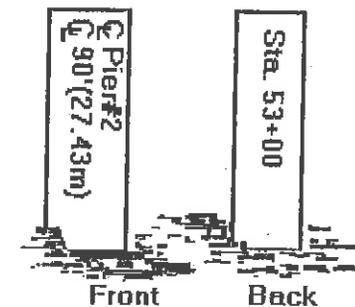
The offset is noted by the symbols below or by a double line.



An offset can be noted by a double line.



This stake is offset 50' (15.24) from the intersection of the bridge and pier centerlines at station 53+00.



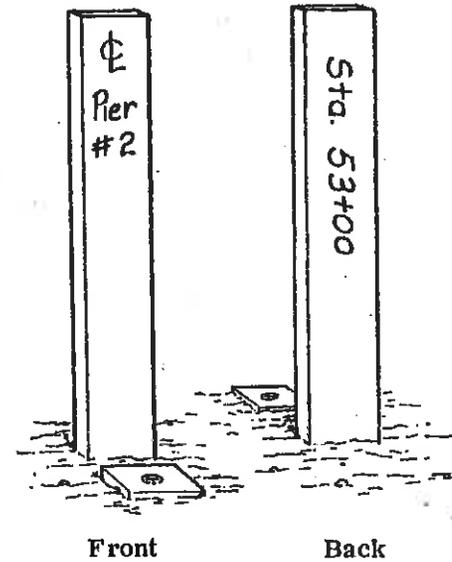
This stake is set 40' (12.19m) beyond the first stake.

### 3. Substructure Centerline Stakes

Substructure centerline stakes are set at the intersections of the bridge centerline and the abutment, bent or pier centerlines.

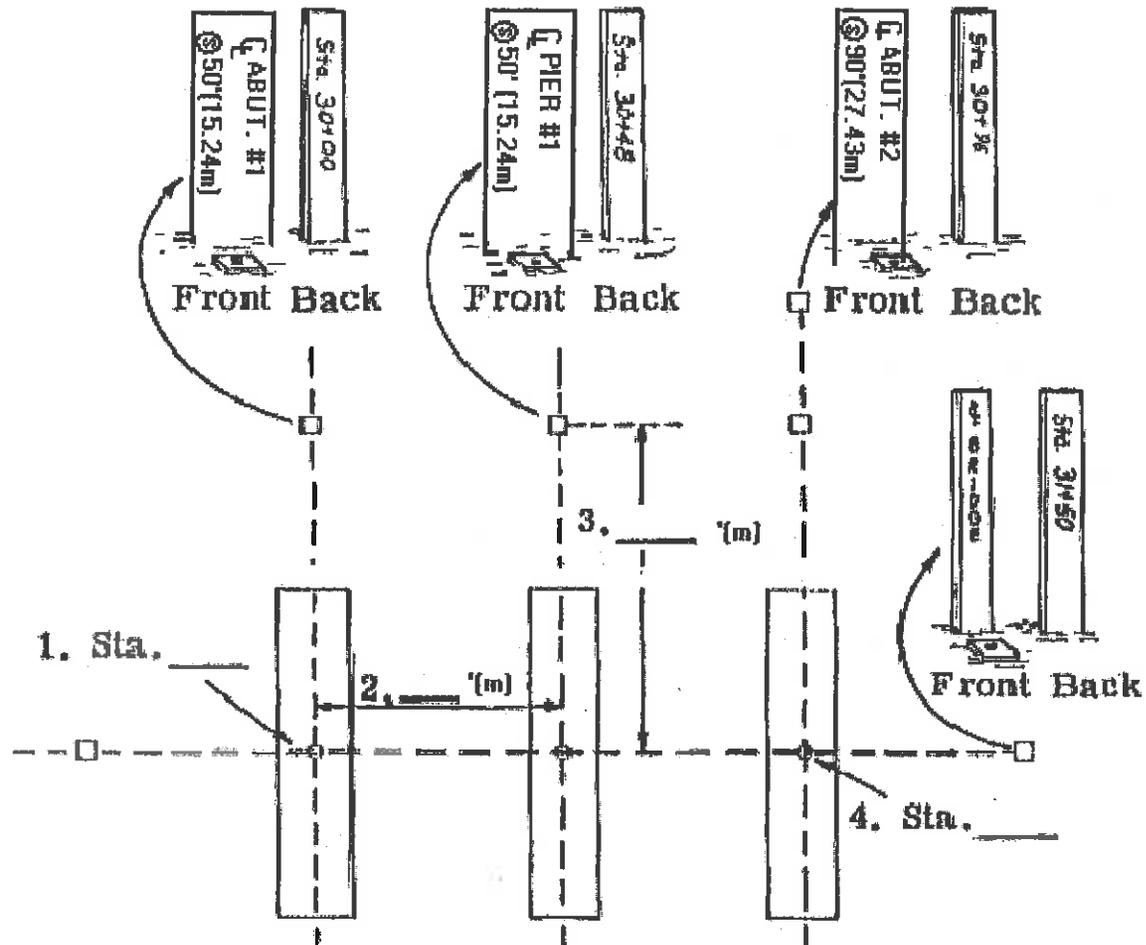
These stakes are similar to bridge centerline stakes -- they name the centerline, mark a point and give the station number.

The stake at the right is set at the intersection of the bridge centerline and the centerline of Pier #2 at station 53 + 00.



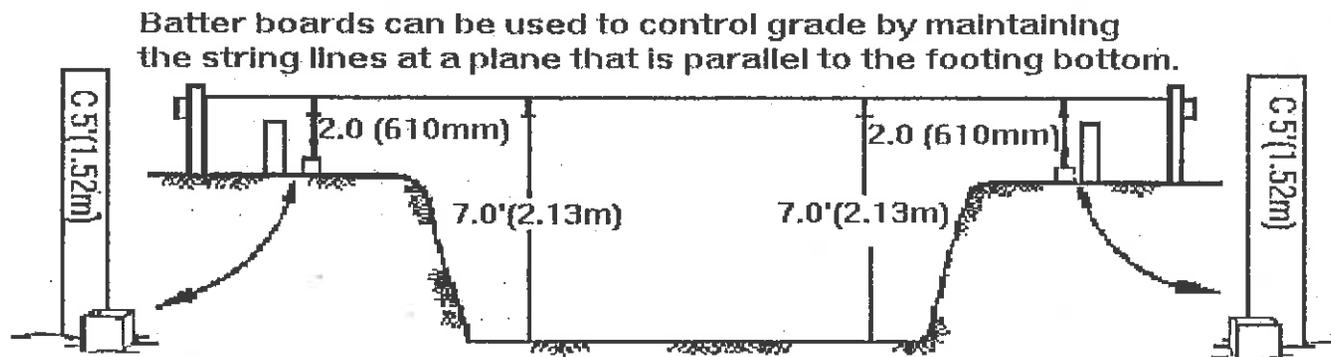
## QUIZ

Use the information on the stakes to complete the diagram below. Complete the numbered blanks with distances or station numbers.



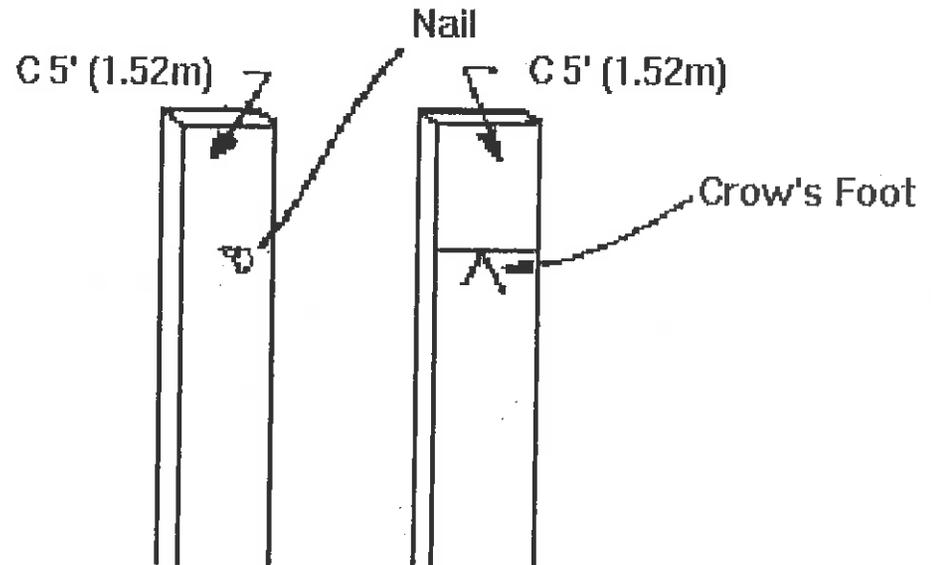
## BRIDGE GRADE CONTROL STAKES

Grade or cut stakes are set near footing excavations to control the grade of the bottom of the excavation as shown below. Batter boards can be used to control grade by maintaining the string lines at a plane that is parallel to the footing bottom.



These stakes tell the Contractor to excavate 5.00 feet ( 1.52 m) below the elevations of the hubs.

Other types of stakes can be used. Sometimes only a single stake will be used -- without hubs -- and the top will be painted blue. In these cases, the elevation is taken from the top of the stake.



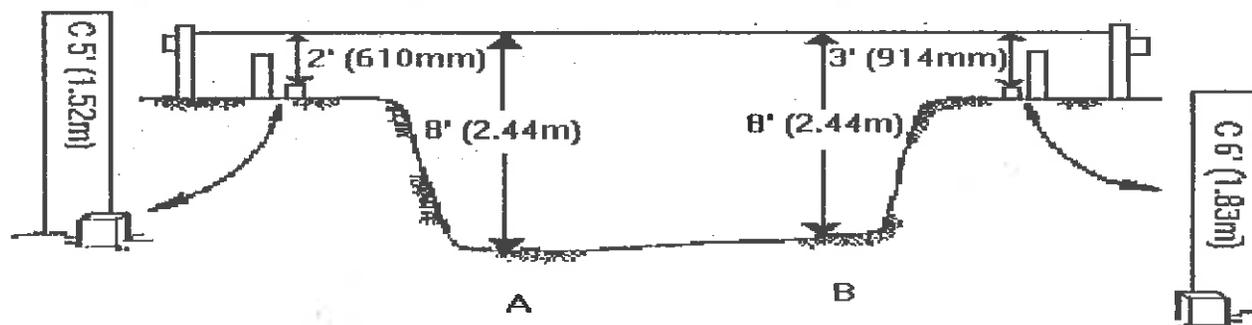
Other types are shown at right. One has a nail to mark the reference point, while the other has a "crow's foot" marking the reference point from which the cut distance is measured.

Once the footings have been excavated, the forms will then be built and the footing concrete placed. You will still need to use the bench mark of the set grade for elevation, but you can use the tops of the footings or any other permanent substructures as references for checks.

As an Inspector, your job will be to check all stakes often -- to watch for damage or movement -- and to measure and verify the distances indicated by the stakes.

# QUIZ

Indicate what is wrong at A and B below.



- A. \_\_\_\_\_
- B. \_\_\_\_\_

## SUMMARY

Before going on to the next chapter, review some of the important points about staking:

- Stakes mark the reference points that control the dimensions and elevations of the structures shown in your contract plans.
- Be sure that the information on your plans is the same as the information on the stakes. You will use this information later, to verify dimensions and elevations of structures as they are built.
- Be sure that all stakes remain in place during construction. If stakes are damaged or moved, the survey crew should be called in to replace the stakes.

## ANSWERS TO QUESTIONS

### Page 3-5

- bench marks
- line, grade
- centerline, reference
- reference, offset centerline

### Page 3-9

- centerline stakes
- offset stakes
- offset hubs
- yes
- 1. C
- 2. B
- 3. A

### Page 3-15

1. 30+00
2. 48 feet (14.63m)
3. 50 feet (15.24m)
4. 30+96

### Page 3-18

- line, grade
- A. The footing excavation has been graded  
1 foot (305 mm) too deep
- B. The footing excavation has been graded  
1 foot (305 mm) too shallow

- centerline stakes
- offset stakes
- offset hubs
- yes

12. B
13. A

30+00

# CHAPTER FOUR

## Structure Excavation

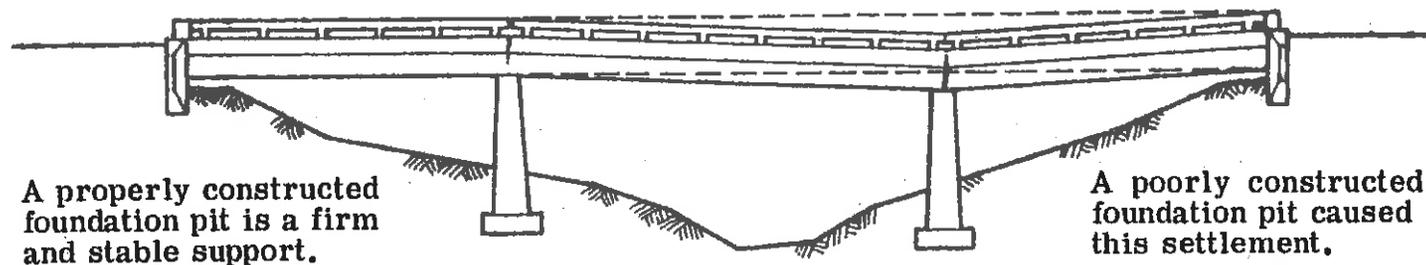
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## STRUCTURE EXCAVATION

### INTRODUCTION

After the construction site has been staked, foundations on which the structures will rest must be constructed. As an Inspector, it will be your job to verify that the Contractor excavates all foundation pits according to the plan requirements. This is particularly important because foundations which are improperly constructed may result in settlement and damage to the structure, as shown in the diagram below.



In this chapter, we will discuss the excavation work for structure foundations including excavation requirements, classification of materials, disposal of surplus materials, backfilling, and measurement and payment of excavation.

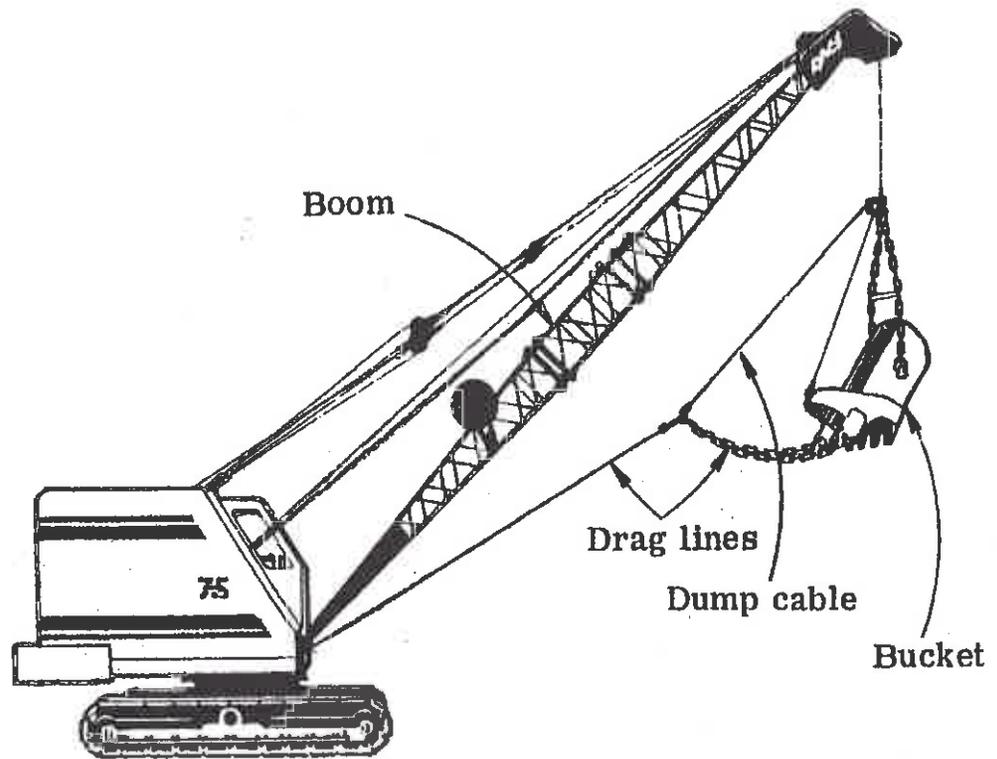
## EXCAVATION EQUIPMENT

After staking has been completed, the areas where the foundation pits will be located must be excavated. The Contractor will use special equipment to excavate the site according to the plan requirements.

Before excavation begins, you should familiarize yourself with the equipment to be used. Let's look at some typical equipment that you will encounter.

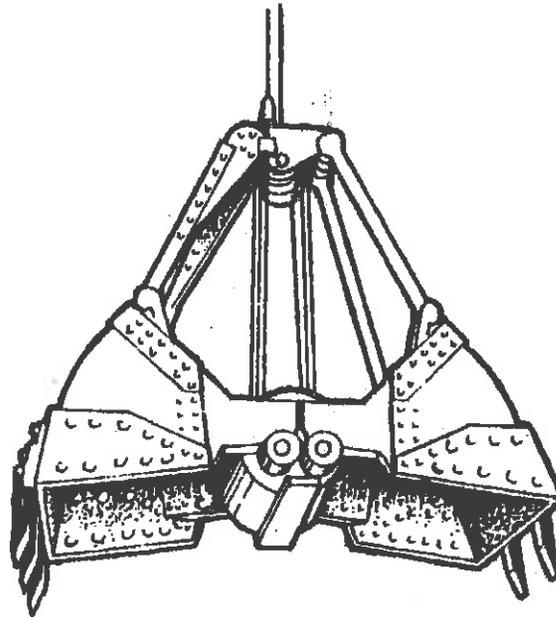
- DRAGLINES are used for major excavation work. Drag lines and buckets are attached to the booms of light cranes. They have several parts with which you should be familiar -- so study the drawing on the next page.

An important part of the dragline is the bucket. Dragline buckets come in different weights and capacities. Softer materials are excavated with light buckets. Heavier buckets are used for rocky materials. Wet materials are excavated with perforated buckets.



- Clamshells can be used in place of buckets on draglines. Clamshells consist of two jaws on a movable bar. This type of equipment is used for digging deep, narrow excavations with vertical sides.

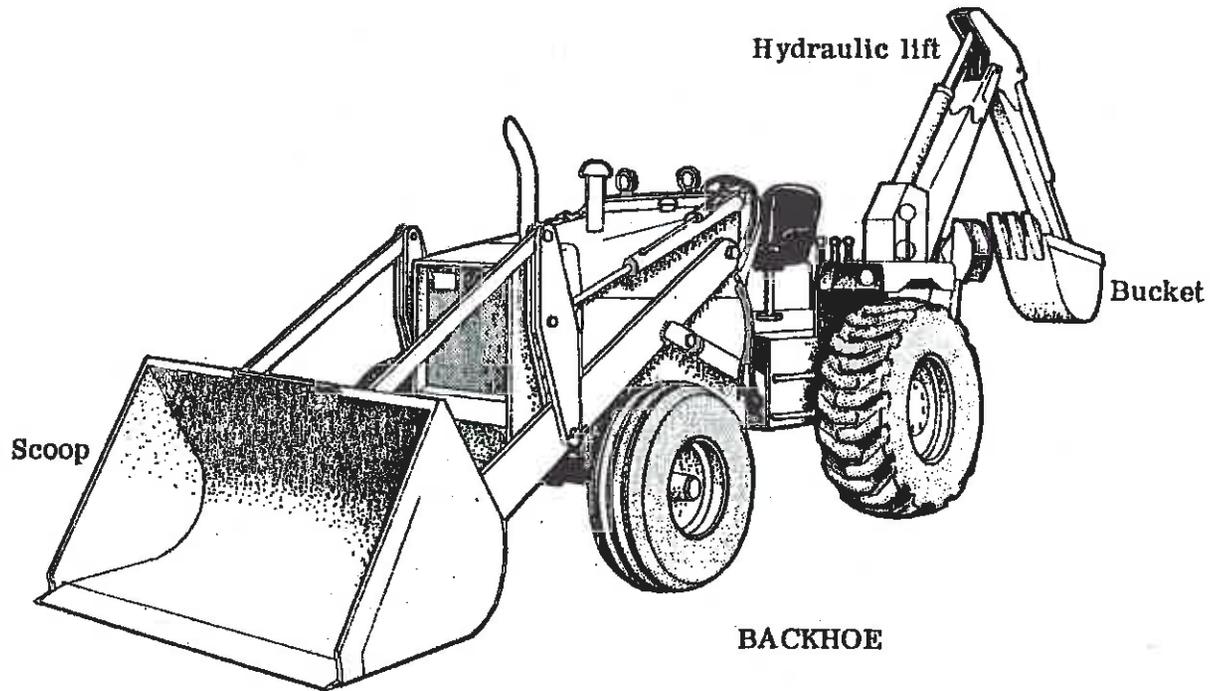
Different weight clamshells are used for different soils -- similar to dragline buckets. Muddy or other wet materials are excavated with the lighter clamshells.



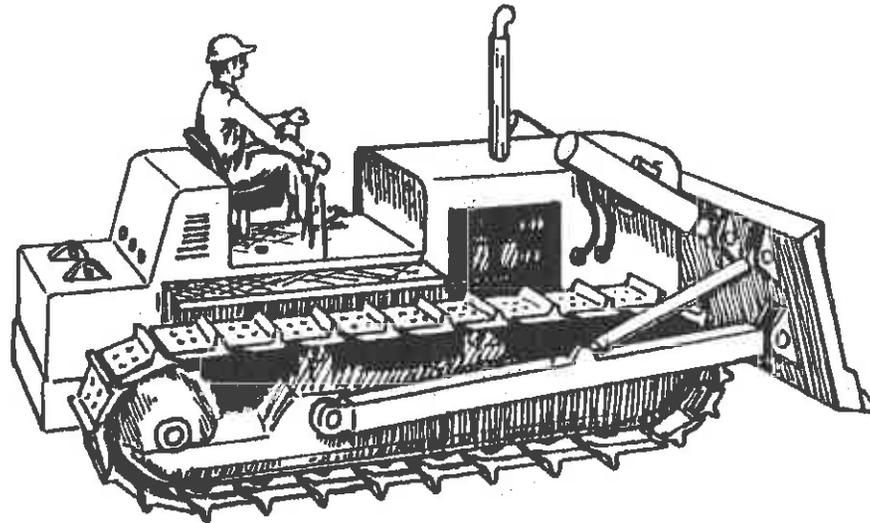
**CLAMSHELL**

- Backhoes are used for digging shallow vertical cuts into the soil -- such as for digging up and relocating utility lines. They are also used for excavation work for small culverts.

Backhoes are usually tractor-mounted with a hydraulically operated bucket attached to the rear, as shown below:



- Bulldozers are used for excavation in shallow, firm foundations, where a dragline is not needed.
- Bulldozers are particularly efficient for moving large quantities of material short distances. Generally, they are not used on unstable soil and muck.



**BULLDOZER**

Try the quiz on the next page.

## QUIZ

Excavation begins after \_\_\_\_\_ is completed.

What type of dragline bucket is used for excavating wet materials?

The type of crane used most for excavation work is called a \_\_\_\_\_.

What piece of equipment is used for digging shallow, vertical cuts in the soil?

Go on to EXCAVATION.

## EXCAVATION

### GENERAL REQUIREMENTS

Your job will be to verify that foundation pits are excavated so that footings can be constructed as shown in the plans. The pits must be wide enough and long enough to allow the footings to be placed. The pit dimensions must be larger than the actual footings so that men can work in the pit. In addition, the beds of the pits must be horizontal, so that there are no rounded or undercut corners on the footings.

The elevations of foundation pits will be shown on the plans, but you should know that the excavation must be continued until satisfactory materials are encountered -- regardless of the plan excavation. Two situations have special requirements:

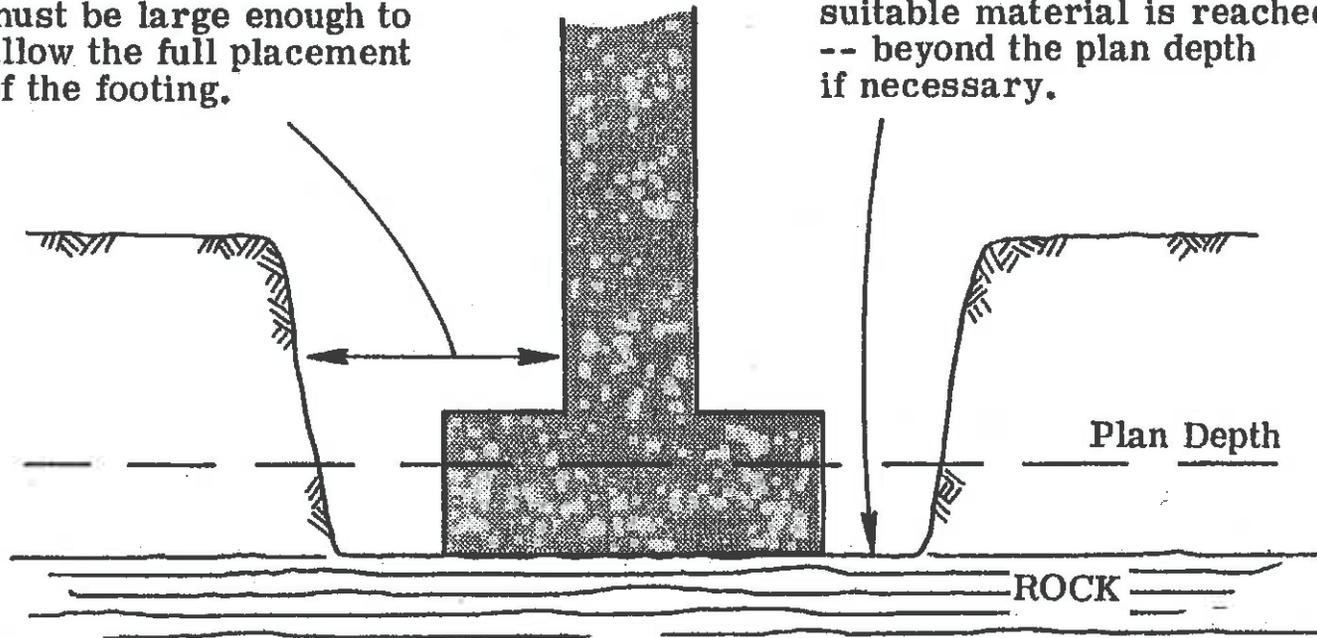
- Excavation in stream beds must be continued to a depth of at least 4 feet (1.22 m) below the permanent bed of the stream. If there is a danger of undermining, the excavation will need to be continued until a firm footing can be established.

There is one exception to this rule. If a firm footing can be established on solid rock before the excavation is 4 feet (1.22 m) below the bed, then the excavation can be stopped.

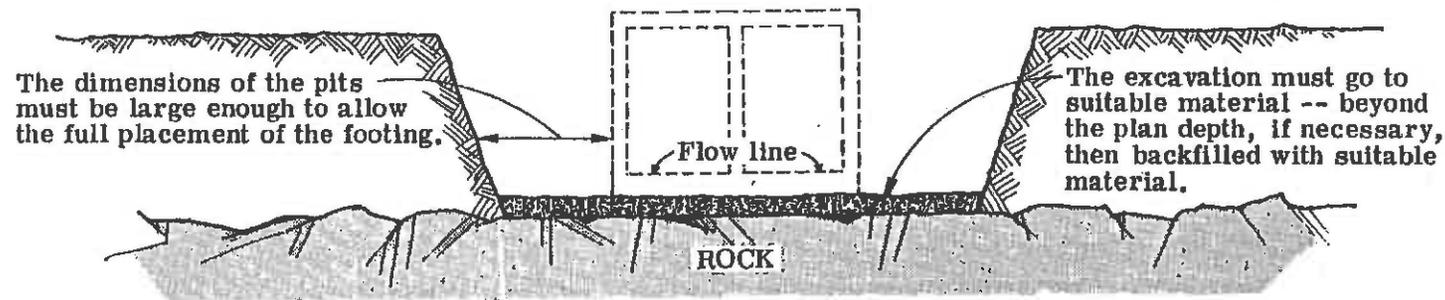
- Whenever a rock bottom is secured, the Contractor must expose the solid rock and prepare the horizontal bed in it. This will involve removing all loose or disintegrating rock materials.

The dimensions of the pit must be large enough to allow the full placement of the footing.

The pit is excavated until suitable material is reached -- beyond the plan depth if necessary.



- If the material in place is suitable as a foundation, the foundation is graded to the elevation of the bottom of the footing. If the material in place is unsuitable, it is undercut, backfilled with select backfill material and compacted to the elevation of the bottom of the footing. The height of the backfill is controlled by stakes set at the working points.



## QUIZ

A properly constructed foundation pit will offer a firm and stable \_\_\_\_\_ for the structure.

In general, what is your job when inspecting footings excavation?

Under normal conditions, if the plans call for a 12-foot (3.66 m) wide footing, should the excavation be 12 feet (1.22 m) wide, or wider?

The plans show a foundation pit plan elevation of 5.00 feet (1.52 m), but muck is encountered at that depth. What should the Contractor do?

We have looked at the general excavation requirements, but there are particular requirements for earth and rock excavation. We will discuss these next.

## EARTH EXCAVATION

Where rock is not encountered, the excavation is considered earth excavation. The general requirements apply, but there are some additional items you will have to inspect:

- Be sure that all boulders, logs or other obstructions are removed from the floor of the excavation.
- If the foundation material is soft or mucky, the Contractor may be required to excavate below the bottom of footing elevation and then backfill with more suitable material. Be sure that the proper depth is reached and that the backfill material is approved.
- When foundation piles are driven to provide support for the structure, be sure that the excavation of the pit is completed before pile driving and that all loose material is removed after pile driving.

The important point is this: the excavated bed must be smooth and level before the footings are placed. This is more likely to happen if excavation of the final few inches of soil as well as final preparation of the excavation bed is performed just before concrete placement.

## ROCK EXCAVATION

Where rock is encountered, there are two important inspection items:

- The rock must be cleaned and cut to a firm foundation. This foundation may be level, stepped vertically or horizontally, or serrated -- as directed by the Engineer. Be sure you know the requirements.
- All seams that are encountered must be cleaned out and filled with mortar.

## QUIZ

The excavation of a foundation pit includes excavation of muck and the replacement of it with suitable material. What are two important points you must ensure?

1. \_\_\_\_\_
2. \_\_\_\_\_

Foundation piles are to be driven to add support for the structure, but the Contractor wants to start pile driving before the plan grade is reached, claiming that he will clean up, smooth and level the pit later, when it can be done better. What is your response?

Rock is encountered during excavation and the Contractor wants to know if he should step or serrate the pit. How will you know what should be done?

Must seams be filled with portland cement concrete?

If you did well on the quiz, go on to DISPOSAL OF SURPLUS AND UNSUITABLE MATERIALS. If you need to, go back and study EXCAVATION some more.

## DISPOSAL OF SURPLUS AND UNSUITABLE MATERIALS

As we mentioned earlier, when unsuitable materials are excavated, they are replaced with suitable backfill. This will leave surplus materials when the backfilling is completed. These surplus materials remain in the ownership of the Department until the final job requirements for fill or backfill have been met, then they become the property of the Contractor, unless otherwise provided for by the plans or special provisions. The Contractor is responsible for the disposal of these surplus materials.

There are some requirements for these materials that you should be aware of. There are requirements for:

- storage
- general disposal
- muck disposal
- paving materials disposal

We will discuss each of these on the next pages.

## STORAGE

Where practicable, the Contractor should temporarily stockpile materials in the right-of-way until the materials are declared surplus by the Project Administrator.

Where temporary storage in the right-of-way is impracticable -- such as in urban areas -- the Contractor has a couple of options:

- He may stockpile materials outside the right-of-way until the materials can be used or are declared surplus. If on private property, the Contractor must have a letter from the property owner giving him permission to use his property to stockpile material from the project.
- He may dispose of the materials, with the written approval of the Engineer. In this case, the Contractor will be required to replace the materials if the need arises later.

## GENERAL DISPOSAL

If surplus materials are muck or other unsuitable materials, they must be disposed of as shown in the plans. If the plans do not show disposal locations, then they must be disposed of outside the right-of-way, in disposal areas provided by the Contractor.

## MUCK DISPOSAL

As an exception to the general disposal requirements, muck may be placed on the side slopes in the following situations:

- The Engineer must approve the work.
- In rural undeveloped areas muck may be placed on the slopes, or may be stored alongside the roadway, provided there is a clear distance of at least six feet (1.83 m) between the roadway grading limits and the muck, and the muck is dressed neatly.
- In developed areas, the disposal must result in a pleasing appearance and have no harmful effect on the adjacent developments.
- The disposed muck must not interfere with channels or side ditches. The Project Administrator will know the allowable limits of muck disposal.

## PAVING MATERIALS DISPOSAL

Unless otherwise indicated in the plans, paving materials excavated in the removal of existing roadways, such as paving brick, asphalt pavement, concrete slab, limerock, sidewalk, curb and gutter, etc. become the property of the Contractor and must be disposed of outside the right-of-way. If the materials are to remain the property of the Department, they must be placed in neat piles as directed.

Areas provided by the Contractor for disposal of removed paving materials, must be out of sight of the project and at least 300 feet (91.44 m) from the nearest roadway right-of-way line of any State-maintained road. The 300-foot (91.44 m) limitation will not apply, however, if the materials are buried.

## QUIZ

Temporary storage of possible surplus materials should be \_\_\_\_\_ the right-of-way where practicable, and \_\_\_\_\_ the right-of-way where not practicable.

Declared surplus materials may be disposed of only when the \_\_\_\_\_.

If surplus materials must be disposed of, where should you look to find the requirements for the location and method of disposal?

If you do not find disposal areas in the above document, what must the Contractor do?

If muck may be placed on slopes, how far from the roadway grading limits must it be?

Paving materials must be disposed of at least \_\_\_\_\_ feet (meters) from the nearest right-of-way line, unless the materials are \_\_\_\_\_.

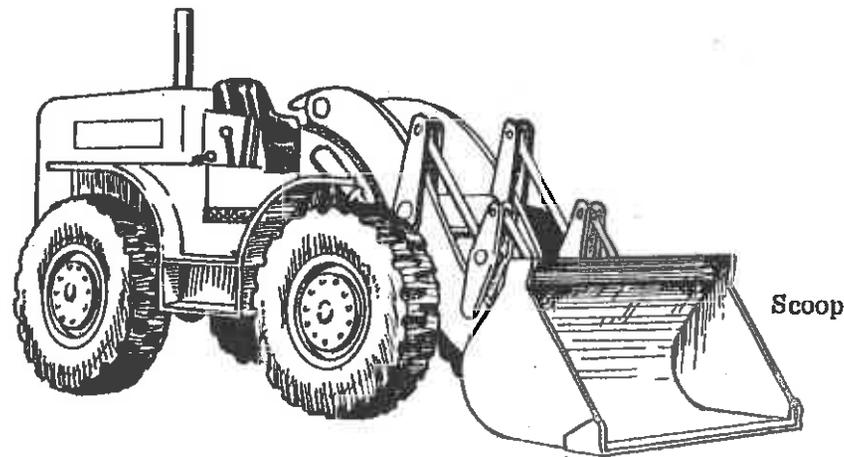
## BACKFILLING

Backfilling is the operation of placing and compacting materials around bridge footings and around box culvert barrels and wing walls. Of course, footings are constructed long before any backfilling is done; but since backfill is basically a foundation operation, we will discuss it here. This section will cover all phases of backfill operations, including equipment, materials, special preparations, placement, compaction and payment.

### EQUIPMENT

Two types of equipment used for backfill operations are front-end loaders and power tampers.

- Front-end loaders are used to place backfill in the excavation. They are similar to backhoes, except they have a scoop mounted on the front. In fact, sometimes the same tractor is used for both. Study the drawing below.

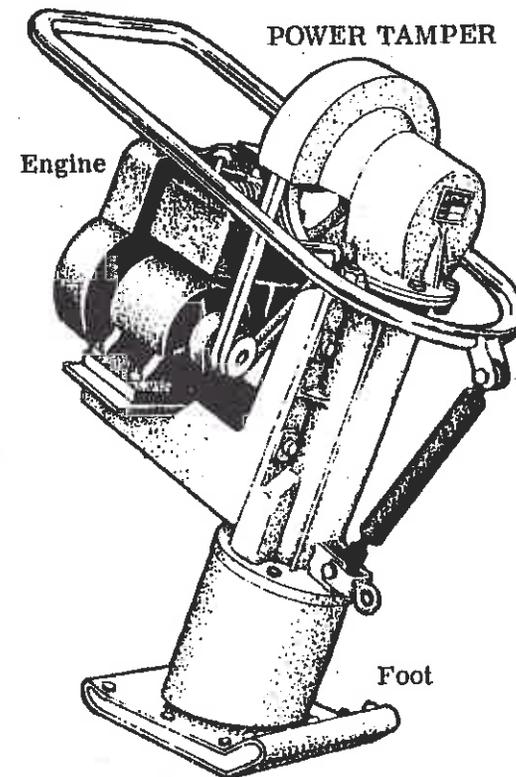


FRONT-END LOADER

- Power tampers are just what the name implies. They tamp -- compact -- the soil in layers as it is placed in the excavation.

Many types of power tampers are commonly used to compact backfill layers. A hand-held gasoline-powered tamper is shown at right. The foot of the tamper vibrates up and down to compact the soil.

Where space permits, backfill may be compacted with rollers.



As an Inspector, you should become familiar with all compaction equipment used in backfill operations.

## MATERIALS

The materials used to fill excavations can be called ordinary backfill and select backfill.

- Ordinary backfill is soil taken from the structural excavations or from a nearby road excavation. It should be free of lumps and foreign materials such as wood, weeds and trash. Ordinary backfill must be obtained from the various classes of granular material. When compacted properly, suitable granular material will not settle with time. Bumps at the ends of bridges commonly are caused by such settlement of backfill materials behind bridge abutments. For ordinary backfill, the best materials to use behind bridge abutments are mixtures of sand and gravel. Besides resisting settlement, these materials are strong and provide good drainage.
- Select backfill is used where there are special drainage requirements. For example, select backfill commonly is used behind abutments, to replace muck in cofferdams or to correct unstable conditions. Select backfill is usually hauled to the construction site by the Contractor. It may be composed of clean river sand, crushed rock, crushed gravel, or other suitable materials -- and be uniformly graded. Of course, like ordinary backfill, select backfill must be free of lumps and foreign materials.

## QUIZ

Backfilling is the operation of \_\_\_\_\_ and \_\_\_\_\_ material around bridge footings and box culvert barrels and wingwalls.

What equipment is used in the following backfill operations?

placement:

compaction:

Backfill materials must be free of \_\_\_\_\_ and \_\_\_\_\_.

When is select backfill used?

Select backfill may be composed of \_\_\_\_\_, \_\_\_\_\_,  
\_\_\_\_\_ or a \_\_\_\_\_.

## TESTING

Backfill is tested as it is being placed for moisture content and density to ensure that it meets specified compaction requirements. Samples for soil classification may be required from select backfill and submitted to the District Laboratory for testing. You may not be responsible for actual testing, but you are responsible for seeing that tests are performed and that results are recorded. In other words, you must "follow up" on any testing that you have requested.

### Soil Compaction

The term "compaction" refers to increasing the density or the unit weight of a soil mass by artificial means such as rolling, tamping or vibrating. The density of a soil is measured in terms of its weight per unit volume and usually is expressed in pounds (kilograms) of dry soil per cubic foot (cubic meter) of soil.

The backfill around structures must be compacted to a density of not less than 100% of the maximum density determined by the District Laboratory.

There is an exception to this requirement. When the backfill must be placed in water, hand tampers may be used with backfill material that compacts well underwater such as sand. When the hand tamped backfill reaches a level above the water that will allow the use of a mechanical compaction device, then one of these devices must be used until the previously hand tamped areas are compacted as well as possible. The soil above the water must meet the 100% density requirement previously mentioned.

## Moisture-Density Relationships

There are several factors that influence the value of density obtained by compaction. These factors are of primary importance:

- the moisture content of the soil
- the nature of the soil -- that is, its gradation and physical properties
- the type and amount of compactive effort

For a given moisture content and a given compactive effort, a soil will have a corresponding density. This is important, because a soil's structural properties vary with moisture content and density. For example, a clay soil at low density will have a relatively high load-carrying capacity when dry, but a relatively low load-carrying capacity when saturated.

Consequently, when a soil's structural properties are being determined, its moisture content and density must be defined and controlled -- in order to permit an accurate evaluation of the soil in that particular condition.

These facts about the moisture-density relationship can be learned by comparing the moisture-density test results of soils of many types. For more information concerning moisture-density, consult the Earthwork Training Course.

## QUIZ

Backfill is tested for \_\_\_\_\_ and \_\_\_\_\_ to ensure that it meets specified compaction requirements.

In what terms is density usually measured?

Which of the following are primary factors that influence compaction?

- A. the nature of the soil; gradation and physical properties
- B. the type and amount of compactive effort
- C. the temperature of the soil
- D. the moisture content of the soil

Backfill must be compacted to a density of at least \_\_\_\_\_.

## PREPARATIONS AND REQUIREMENTS

Before actual backfill operations begin, there are several preparations to be made and requirements to be observed:

- Backfill should not be placed against any newly constructed masonry or concrete structures until the structure has been in place for a minimum of 7 days.
- The backfill next to a structure must be placed on a solid foundation. Before any material is placed, you should be sure that all forms, loose material and rubbish have been removed from the foundation area.

## PLACEMENT AND COMPACTION

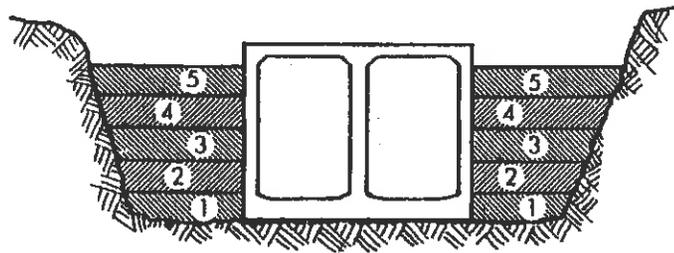
All excavated spaces not occupied by abutments, piers or other structures must be backfilled to the surface of the surrounding ground, thoroughly compacted and neatly graded.

The backfill should be deposited in loose layers not more than 6 inches (150 mm) deep, as soon after the removal of forms as possible. If hand tampers are being used, it is good practice to keep layer thicknesses at 4 inches (100 mm) or less. The depth of the backfill layers is a common area of noncompliance. So, as an Inspector, you should be especially aware of this requirement.

Each layer must be compacted thoroughly before the next layer is started. Also, the moisture content of the material should be adjusted so that the material can be compacted to the required density. When conditions are wet, and with approval by the Project Administrator, granular material that compacts well in a wet condition can be used with a hand tamper until the backfill is up to a level dry enough to use a mechanical tamper.

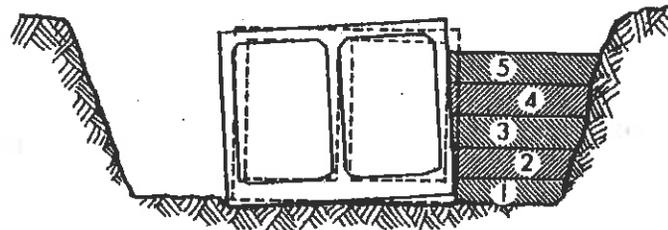
When backfill is being placed around or over an arch or a rigid-frame structure, the material must be kept at the same level on both sides of the structure in order to prevent unbalanced loading. This procedure and the problems that may result if it is not followed are illustrated on the next page.

The reason for backfilling layers alternately on both sides of a structure is demonstrated below. The circled numbers indicate the sequences in which the layers are backfilled.



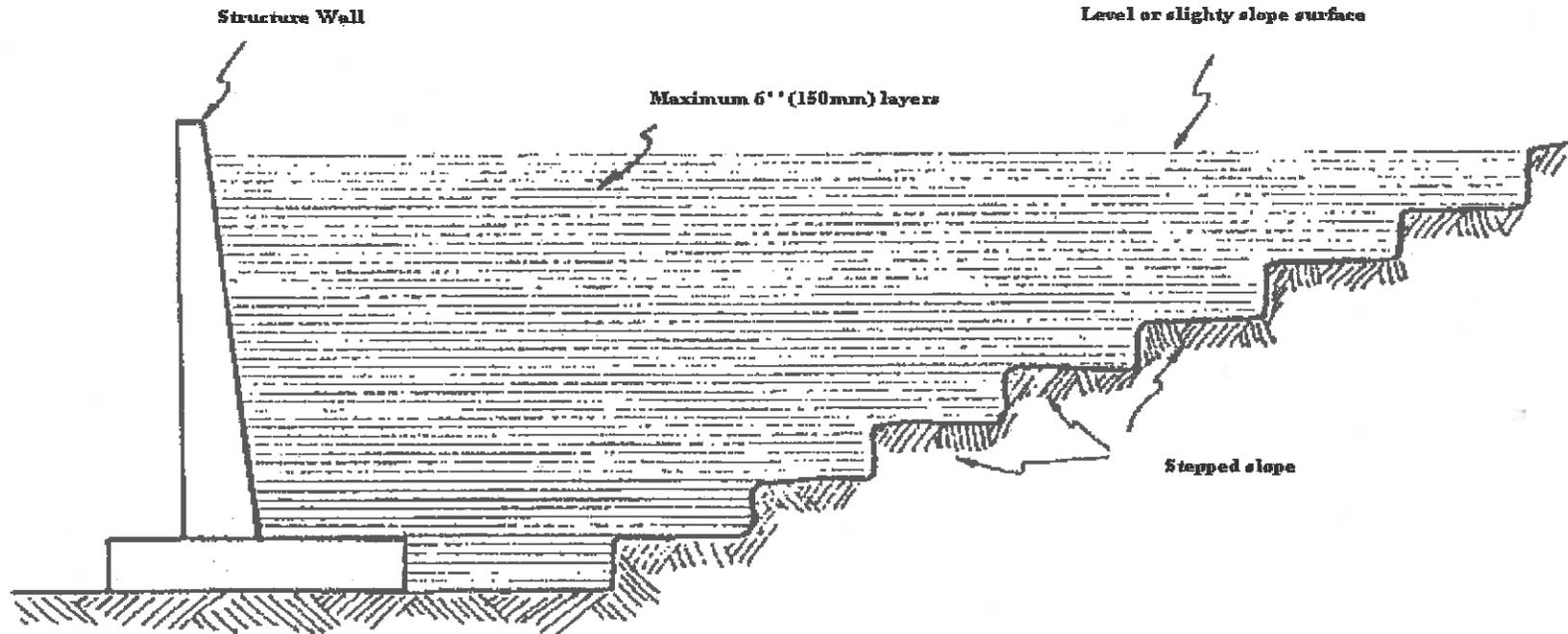
Uniform backfilling helps support the structure.

Uneven backfilling can shift or even topple a box culvert and can cause overstressing.



Where limited areas need to be compacted, hand tampers must be used until the cover is at least one foot (0.305 m) above the structure. These hand tampers are restricted to a maximum face area of 100 square inches (0.0645 m<sup>2</sup>).

If any part of the structure is to function as a retainer for backfill -- such as abutments, retaining walls, wingwalls, arches, or minor structures -- the boundary slopes should be stepped in order to prevent any wedge action. Wedge action puts extreme lateral pressure on the structure and may cause it to topple or shift in position. The top surface of compacted backfill must be level -- or slightly sloped -- to drain adequately. In other words, there should be no ruts or depressions that will catch and hold water on the backfill surface.



## QUIZ

If an equal amount of backfill is not placed and compacted alternately on both sides of the walls of a structure, what could happen to the structure?

Structural Contractors are responsible for backfilling excavations to the level of the \_\_\_\_\_.

In limited areas, hand tampers are used until the cover is \_\_\_\_\_ above the structure.

How thick should the loose layers of backfill be when rollers are used to compact?

Who is responsible for the removal of rubbish, forms and loose material in the excavation?

What is good practice thickness for the loose layers of backfill when hand tampers are being used?

What should be done to the boundary slopes adjacent to parts of structures that function as retainers for backfill?

When muck disposal may interfere with channels or side ditches, where will you find out the allowable limits of disposal?

Name three factors which influence the value of density obtained by compaction.

## ANSWERS TO QUESTIONS

### Page 4-8

- staking or layout
- perforated
- dragline
- backhoe

### Page 4-12

- support
- ensure that pits will contain the entire footing
- wider
- excavate to firm, satisfactory material

### Page 4-14

- 1. proper depth, 2. approval of material
- excavation should be complete before driving
- check with the Project Administrator
- no, with mortar

### Page 4-18

- Inside, outside
- Engineer approves
- plans
- dispose of material outside the right-of-way
- 6 feet (1.83m)
- 300ft. (91.44m), buried

### Page 4-22

- placing, compacting
- front-end-loaders, power tampers
- lumps, foreign materials
- when special drainage requirements must be met
- crushed rock, crushed gravel, crushed slag, combinations of these

### Page 4-25

- moisture content, density
- pounds per cubic foot (kilograms per cubic meter (kg/m<sup>3</sup>))
- A, B, D
- 100% of maximum density

### Page 4-29

- it could be shifted out of position of toppled
- original ground
- ~~at least~~ 1 foot (300 mm)
- 6 inches (200 mm)
- Contractor
- 4 inches (100 mm)
- they should be stepped
- from the Project Administrator
- the moisture content of the soil
- the nature of the soil
- the type and amount of compactive effort

# CHAPTER FIVE

## Falsework and Forms

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# 5

## FALSEWORK AND FORMS

### INTRODUCTION

In this chapter, we will cover the use of falsework and forms. Since the concrete work is similar for both box culverts and bridges, we will make distinctions only where methods or requirements conflict.

As an Inspector, you are responsible for inspecting all concrete construction operations from building falsework to finishing concrete surfaces. In this phase of structures inspection, you will depend heavily upon the contract plans, so do not hesitate to check them if you are in doubt about sizes, dimensions, etc.

### FALSEWORK AND FORMS

Falsework and forms are erected together as temporary structures to hold and support fresh concrete. Once the concrete has gained enough strength to become self-supporting, the falsework and forms can be removed.

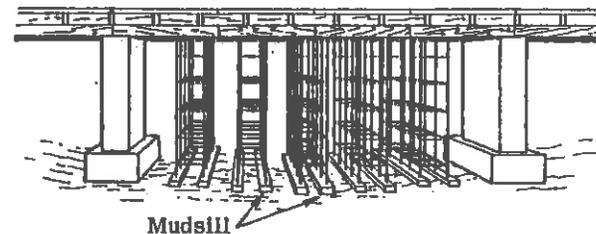
The Contractor is responsible for the design and construction of all falsework and forms. However, the Project Administrator may request that the Contractor submit the plans for constructing falsework and forms for review and when public safety is an issue, approval. Keep in mind that the Project Administrator's approval of the Contractor's falsework plans does not relieve the Contractor of the responsibility for properly designing, constructing and maintaining the falsework and forms.

As an Inspector, your responsibility includes the inspection of falsework so that the finished structure will meet all the requirements of the plan dimensions.

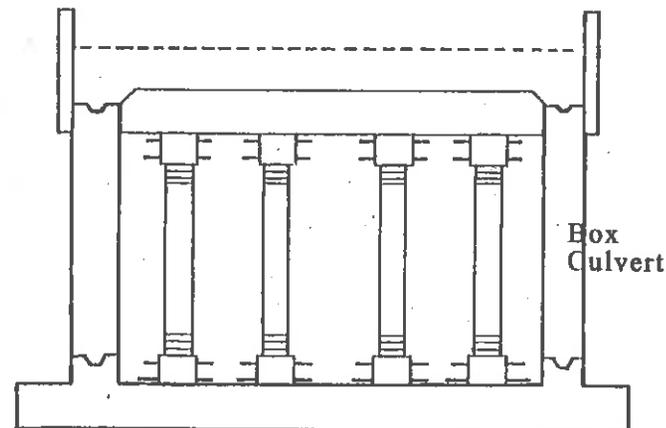
## FALSEWORK

Falsework is any temporary structure used to support the forms for concrete. Falsework supports the forms until the concrete can support itself. It is essential that falsework be strong enough to support the weight of three things: the forms, the fresh concrete and any construction equipment and workers. Falsework also must be capable of maintaining the correct elevations. To do this, suitable jacks, wedges or other approved devices must be used as part of the falsework. These devices also will permit the falsework to be lowered gradually. In the illustration below, one type of falsework, temporary piers, is supporting the forms between the permanent piers.

The temporary piers can be metal or wood frameworks set on mudsills -- pieces of timber that rest on wide, rigid foundations (solid rock or piles). Concrete pedestals placed on the ground may be used as mudsills.



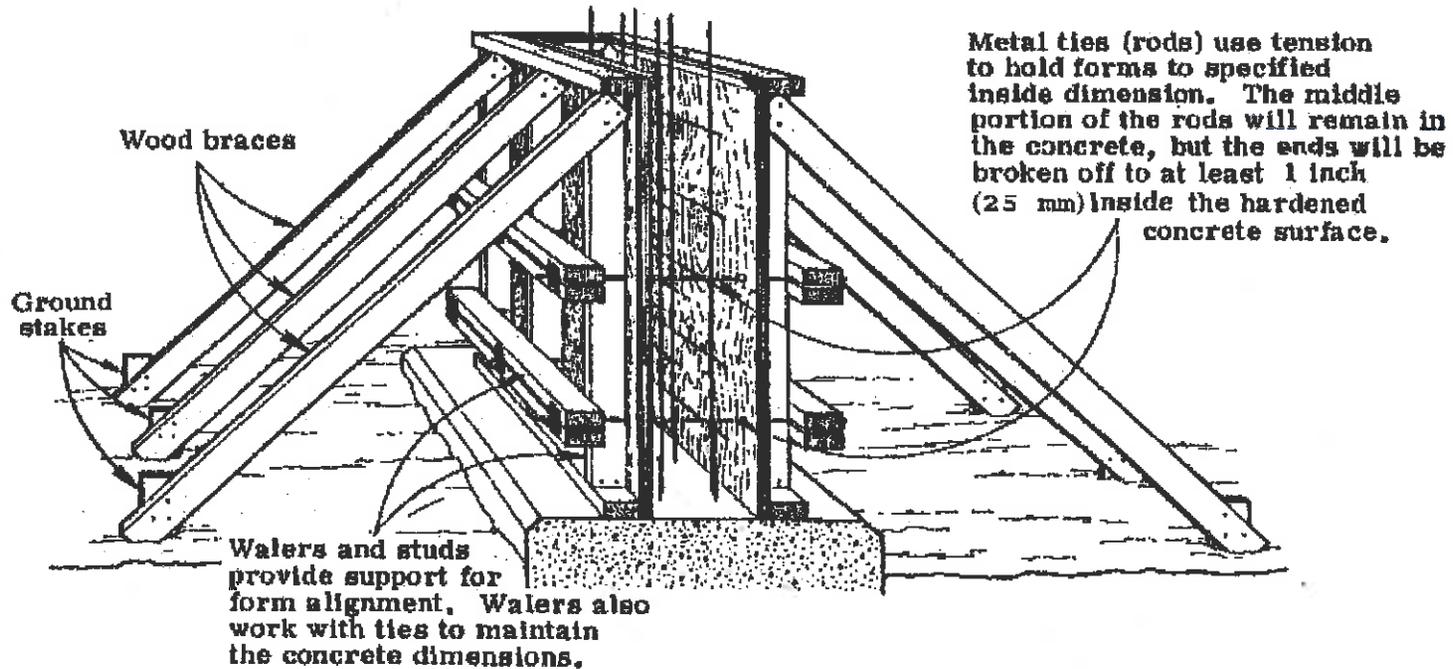
More recently, slip forms -- metal forms that roll along the slab -- have been used. Slip forms allow the same forms to be reused by loosening tension and rolling the forms to the next section of the box culvert.



## BRACES AND TIES

Braces and ties are smaller types of falsework and are used to hold forms in place. Look at the wood braces, walers and metal ties in the wall below:

In order to hold the forms in proper positions, all bracing should be rigid and must be firmly secured to the forms.



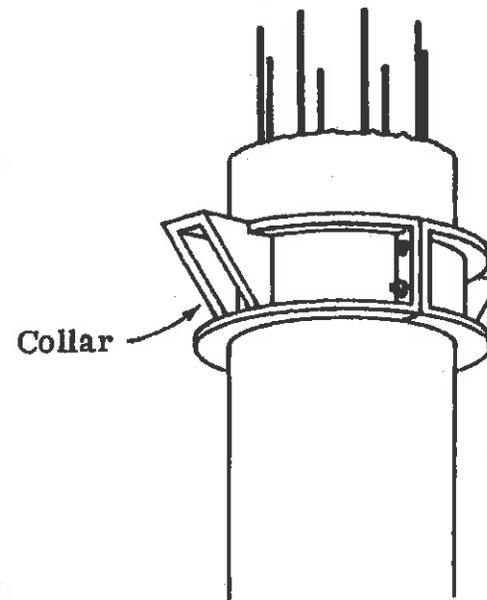
## Falsework Piles

The mudsills under falsework must be properly supported or they will settle, causing the falsework to collapse. Sometimes temporary piles are used as the base for falsework. You should make a visual check while these temporary piles are being driven, to be sure that they encounter resistance.

When falsework piles are no longer needed, they must be removed. They should be completely pulled out or, if they remain, should be cut off below the ground level.

## Collars

Collars -- another type of falsework -- are nothing more than metal bands that fit around finished columns. They are used to support the forms needed to construct caps. The friction between the concrete and the bands holds them in place. If a collar does not fit the column, there is a chance that it could slip.



## QUIZ

Concrete is held in position by \_\_\_\_\_ until it is strong enough to be self-supporting.

When necessary, concrete forms are supported by temporary structures called \_\_\_\_\_.

Falsework usually is set on pieces of timber or concrete called \_\_\_\_\_.

What purpose do wood braces and metal ties serve? \_\_\_\_\_

What prevents collars from slipping? \_\_\_\_\_

To hold forms firmly in place, bracing should be \_\_\_\_\_.

Name three things which falsework must be strong enough to support:

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Who is responsible for the design and construction of falsework?

Falsework must be adjustable to the correct \_\_\_\_\_. To do this, \_\_\_\_\_ or \_\_\_\_\_ other suitable devices may be used.

Now go on to FORMS.

## FORMS

Forms hold the plastic concrete in place until it gains enough strength to hold up itself. The forms must be strong enough to support the pressure and the weight of the fresh concrete and any construction loads such as finishing equipment and workers. In addition, the forms should be able to withstand the effects of vibration caused by vibrators that are used for consolidation.

It is especially important that you inspect the condition of the forms and how they are put together. If the job is not done correctly, the finished surfaces of the structure will be unsatisfactory.

Two types of release oil are used for forms -- paraffin-base oil for wooden forms, and petroleum-base oil for steel forms.

### Material Requirements for Forms

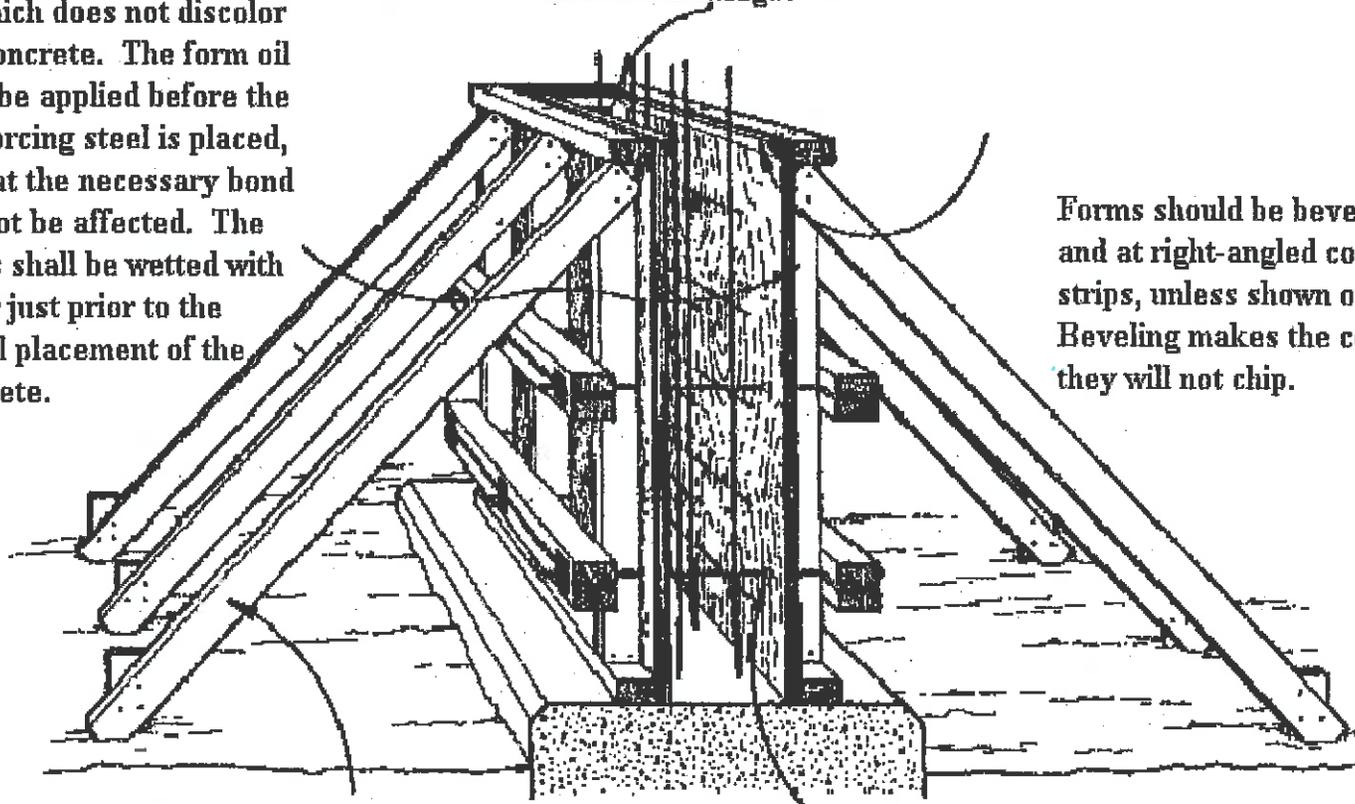
Forms can be made of wood or metal. Whichever type of form is used, you should make sure it is constructed and shaped according to the lines and grades specified in the plans.

On the next page, study the requirements that are not usually listed in plans, but which are essential for proper forming.

The inside surfaces of the forms should be oiled, prior to erecting forms, with an oil which does not discolor the concrete. The form oil shall be applied before the reinforcing steel is placed, so that the necessary bond will not be affected. The forms shall be wetted with water just prior to the actual placement of the concrete.

Form joints should be mortar-tight. Be sure that wood forms are well construction to prevent joint from opening from lumber shrinkage.

Forms should be beveled at exposed corners and at right-angled corners with chamfer strips, unless shown otherwise in the plans. Beveling makes the corners stronger and they will not chip.



Braces should be used to prevent buckling or displacing of forms.

Metal ties must be rods and must later be cut off at least 1 inch (25 mm) below the finished concrete surface.

## Wood Forms

Wood is a commonly used form material. Generally, form faces are made of plywood that is braced by wooden studs. Wood forms for all exposed concrete surfaces should be made of lumber that is dressed and free of defects. When constructed, the forms should provide mortar-tight joints that produce smooth and even concrete surfaces.

Be sure to check the condition of the wood that is used as forming material. Lumber that is too dry will warp due to rain or the moisture in concrete. Lumber that is too green will shrink, causing joints to open in the surface.

Plywood forms, or forms face-lined with plywood can be used:

- if they are strong enough to resist bending.
- if they are of uniform thickness.
- if they will be mortar-tight when set in position.

One more point: forms for high walls must be built so that dirt and debris can be removed immediately prior to concrete placement. To accomplish this, the lower forms should be left loose for easy removal and replacement or a cleanout opening should be cut into one of the forms to allow cleaning to take place.

## Metal Forms

In addition to wood forms, metal forms may be used. However, precautions must be taken to ensure that the following requirements are met before metal forms are used.

- The metal should be thick enough to hold its shape.
- All bolts and rivet heads must be countersunk to prevent them from marring the finished surface.
- Clamps, pins or other connecting devices should be designed to hold the forms rigidly together and to allow removal without damage to the concrete.

If you notice any metal forms that do not have smooth surfaces, are bent, or otherwise damaged and do not line up properly, have the Contractor remove them. Also you must be sure that the forms are free of corrosion, grease or other matter which would discolor the concrete.

## QUIZ

In addition to supporting the pressure and the weight of fresh concrete and construction loads, forms should also be able to withstand the effects of \_\_\_\_\_.

How can the Contractor prevent wood forms from buckling during concrete placement? \_\_\_\_\_

What is the most important point about form joints that you must ensure? \_\_\_\_\_

The exposed corners of forms should be \_\_\_\_\_ with, \_\_\_\_\_, according to the plans.

What must be done to bolts and rivet heads used in metal forms? \_\_\_\_\_

List two reasons why clean form oil must be used to lubricate the inside of forms.

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What will happen if lumber that is too green is used as forming material? \_\_\_\_\_

Why are right-angled corners beveled? \_\_\_\_\_

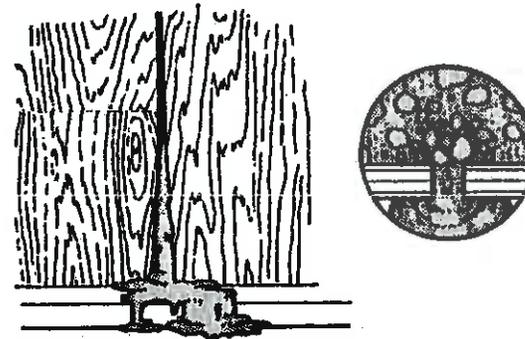
A wall 30 feet (9.14 m) high, 12 feet (3.66 m) long and 12 inches (0.304 m) thick is being formed. How can you ensure that the bottom area between the forms will be cleaned? \_\_\_\_\_

When should the Contractor oil the forms for the wall described in the previous question? \_\_\_\_\_

## CHECKING FORMS FOR WORKMANSHIP

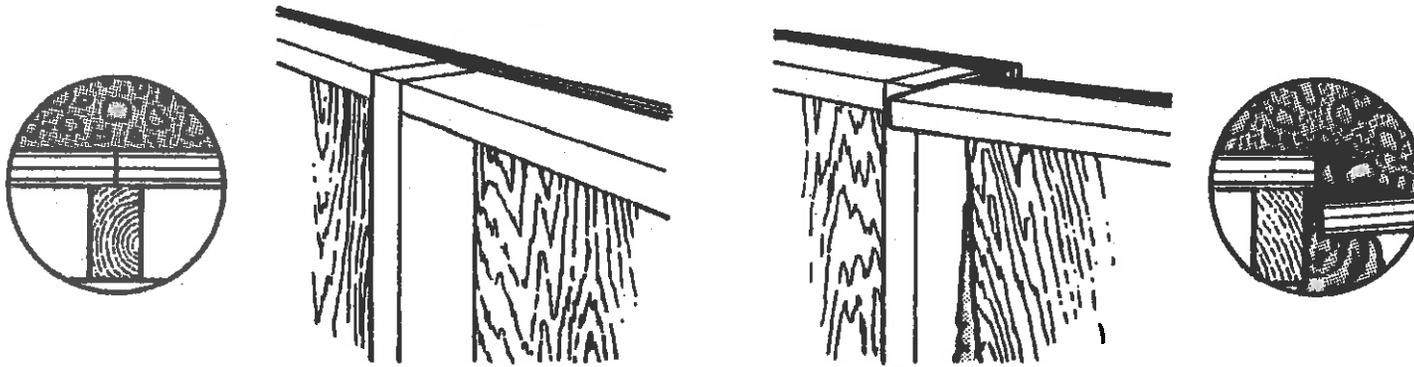
The way the forms are built will determine to a large degree what the finished product will look like. If the Contractor does not fully comply with the plan requirements, the result may be a weak and badly constructed bridge deck. To ensure compliance with the plans, you should be sure the forms are built to the correct dimensions and elevations. Typical faulty work that would cause the wrong dimensions and elevations includes the following:

- Loose forms will cause movement of the forms after concrete placement allowing leaks like the one shown here.



Large openings allow mortar to leak.

- Poorly supported forms will cause bulges in the finished surface if the forms come apart from lack of support. Examples of properly supported forms and poorly supported forms are shown below:



**PROPERLY SUPPORTED**

**POORLY SUPPORTED**

- You should be sure that supporting studs cover both forms, as in the example on the left -- not just one form, as in the example on the right.
- If forms are poorly aligned and not corrected before concrete is poured, the following results may occur:
  - Decreased concrete cover over reinforcement will cause reinforcement to corrode and concrete to spall with time.
  - Added dead weight in areas where the forms are too far apart will allow a wall or slab to be poured thicker than designed. Added weight may cause overstress in the reinforcing steel or foundation.
  - Poorly aligned forms will lead ultimately to a sloppy-looking job.

As an Inspector, you must be sure that any misaligned forms are realigned before concrete is placed. In most cases, this will involve minor adjustments of 2-inch (12.7 mm) or less.

- Frequent reuse of forming material should be avoided because it will cause:
  - rough finished surfaces.
  - difficulty in form removal.
  - possible form failure.
  - discoloration of the concrete, particularly if new and old forms are intermixed.
- If you discover any splintered or worn wooden forms or any bent metal forms, have the Contractor repair or replace them immediately.
- The improper use of form oil will cause the following problems:
  - The excessive use of form oil will discolor the concrete and possibly coat the steel -- resulting in a weak bond between steel and concrete.
  - Not enough form oil will increase the difficulty of form removal and will allow the wood forms to absorb water from the concrete.

If you see any of the problems described in this section, contact the Contractor immediately and ask that the situation be corrected. Any problems encountered should be discussed with your Project Administrator. You must be sure to learn from previous errors in order to prevent future errors. If any of the above problems arise during the first pour, be sure that you watch closely for the causes during forming for the next pours.

## QUIZ

Loose forms cause form movement and gaps between the forms, which allow the concrete to \_\_\_\_\_.

Properly braced forms -- with joints fully supported -- are necessary to eliminate \_\_\_\_\_ in the finished surface.

Decreased concrete cover over reinforcement will cause reinforcement to \_\_\_\_\_ and concrete to \_\_\_\_\_.

After forms are removed, you discover blocks of discoloration. What is the probable cause?

\_\_\_\_\_

If too little form oil is used, what problem will occur? \_\_\_\_\_

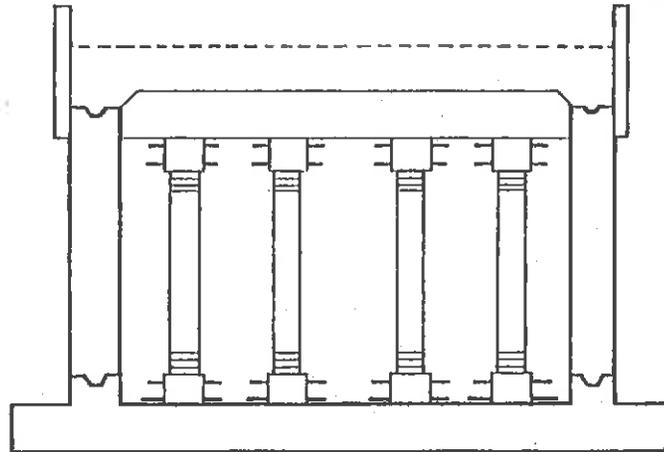
## INSPECTING FORMS FOR DIMENSIONS, GRADES AND ALIGNMENT

Measurements should be taken often during forming to ensure that the Contractor builds forms that comply with the plan specifications. Once the forms are completed and in place, you will have to measure all lengths, widths and heights and compare them with plan dimensions. These measurements are very important. There is no room for error since dimensional errors may result in the removal of concrete structures. By referring to the contract plans and by using a 6-foot (2 m) rule or a tape measure, you should be able to take accurate measurements.

Inspecting the forms will require that you check the quality of workmanship in aligning the forms. A string line and a plumb bob will be useful to you for checking smooth lines -- vertical and horizontal. Also, since many parts of a structure must have pleasing appearances, you can "eyeball" many of the edges, such as the edges of parapets and curbs, and the exposed edges and corners of rails, caps and columns.

Before concrete is placed, you must be sure that the grades and alignments are checked thoroughly by the Contractor's survey crew. You will be able to check some grades when you check dimensions by measuring up from known elevations of previously placed sections, but the survey crew still must check all the critical points on the forms for grades and alignment.

Here is the end view of a box culvert. The Contractor has jacks in place and forms set to place the top of the barrel. You are to inspect falsework and forms before work begins. Follow the checklist on the next page. What would you be looking for? Check what you would inspect.



- 1. Will the forms hold the weight and pressure of the wet concrete?
- 2. Will vibrators affect the position of the forms?
- 3. Will the materials used for forms be rigid and unbending enough?
- 4. Are the joints "mortar-tight?"
- 5. Are exposed corners of joints beveled or chamfered ?

- \_\_\_ 6. Are the supports properly spaced to avoid sagging of the forms?
- \_\_\_ 7. Should elevation or grade be checked?
- \_\_\_ 8. Should you compare dimensions of the forms -- length, width and depth -- to the plans?
- \_\_\_ 9. Do temperature and weather conditions enter in?
- \_\_\_ 10. Is the Contractor prepared to place the entire slab?

Look at the discussion below.

If you checked all ten, you understand your responsibility. Faulty judgment, here, could result in real problems. Replacing any slab would be costly and time consuming.

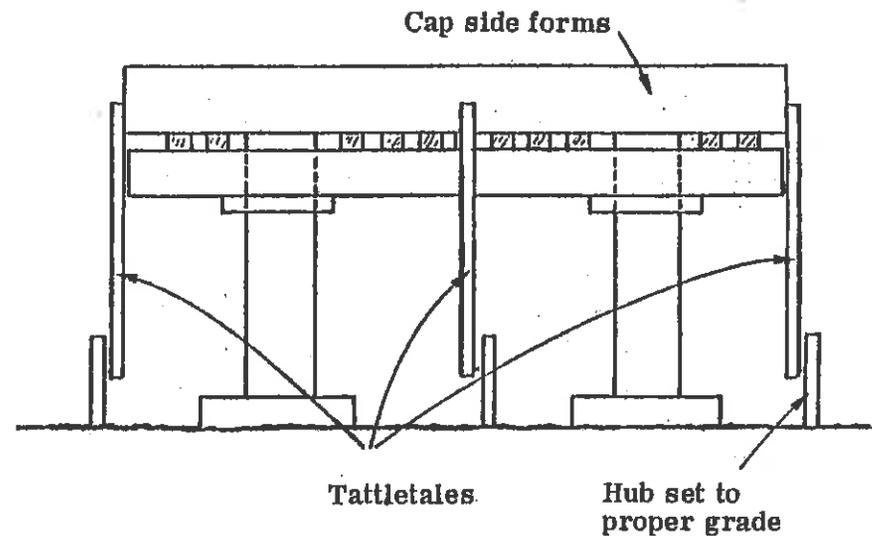
Remember -- when in doubt:

- LOOK AT THE PLANS
- REVIEW THE SPECIFICATIONS
- ASK QUESTIONS
- MEASURE AGAIN
- TALK TO THE CONTRACTOR

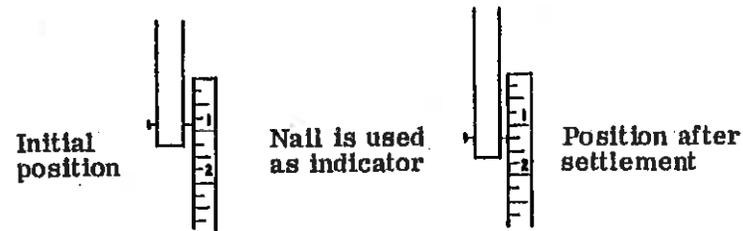
As we mentioned, when the forms are in place, the dimensions -- length, width and depth -- of that part of the structure should be checked to see that they agree with the plan requirements. But another consideration needs to be made for forms that are not totally supported, such as pier caps: what will happen to the forms when concrete is poured? Obviously, the forms will settle. To check against this, tattletales can be used.

Before concrete is placed, tattletales are suspended from the cap. Tattletales will indicate how much settlement, if any, takes place.

You should check and record the initial tattletale point. Then, as the concrete is placed, you must check the tattletales for any settlement.



Here is an example of how a tattletale records settlement:



If the tattletales show settlement, one of the following may be responsible:

- The forms or collars may be slipping.
- The forms may be settling into place.
- The support under the forms may not be sufficient.

In most cases, it is not advisable to change elevations. However, you should inform the Contractor of the settlement so that corrective action may be taken to prevent further settlement of the present forms and so that consideration is given to the settlement in future instances.

We will discuss tattletales again when we talk about bridge deck construction.

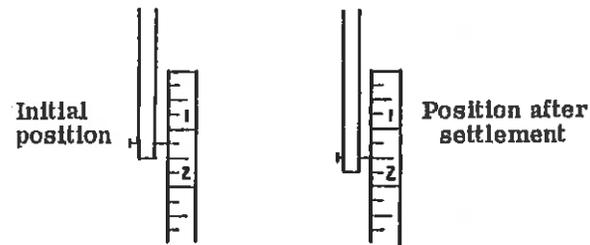
## QUIZ

Who is responsible for setting the forms? \_\_\_\_\_

What can you use to check vertical and horizontal lines of structures? \_\_\_\_\_

What is the purpose of attaching tattletales to cap forms? \_\_\_\_\_

In the diagram below, how much settlement has taken place? \_\_\_\_\_



In the case above, what action should you take? \_\_\_\_\_

## REMOVAL OF FALSEWORK AND FORMS

Falsework and forms may be removed when the concrete that they are supporting has cured for a minimum period of time or has a minimum percentage of required 28-day strength. Refer to Section 400-14 of the Standard Specifications for these times and percentages. Regardless of whether or not the time and percentage requirements are met, forms and their supports must not be removed without the approval of the Project Administrator.

When you are inspecting form removal, you should:

- be sure that any honeycombed areas (areas that have air pockets due to insufficient consolidation) are patched properly.
- be sure that no excessive jarring, prying or banging takes place when removing the forms. This can cause hairline cracks or spalling.
- be sure that any holes left by the removal of projecting wire ties or other metal devices are filled with cement mortar (sand, cement and water). This cement mortar should be mixed in the same proportions as that which was used for the concrete contained by the forms.
- be sure that forms that will be reused are handled properly -- that shape, strength, rigidity, water-tightness and surface smoothness are maintained.

### QUIZ

As an Inspector, you must ensure four main points during form and falsework removal. Name them.

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## ANSWERS TO QUESTIONS

### Page 5-6

- Forms
- Falsework
- Mudsills
- To hold forms in the proper position
- The friction between the concrete and collar bands
- Rigid
- Forms
- Fresh concrete, Construction equipment, workers
- Contractor
- Elevation, jacks, wedges

### Page 5-11

- Vibration
- By supporting the forms with rigid bracing
- They must be mortar-tight
- Beveled, chamfer strips
- They must be counter sunk to prevent them from marring the finished surfaces
- To prevent the concrete from sticking to the forms and to prevent discoloration of the concrete
- It will shrink, causing joints to open in the forms
- So that the corner is not weak and will not chip
- Leave bottom forms loose or make cleanout
- Before the forms are set in place

### Page 5-15

- Leak
- Bulges
- Corrode, spall
- Excessive form oil
- Difficult form removal

### Page 5-21

- Contractor
- String line and plumb bob
- To check for settlement
- ¼ inch (6.35 mm)
- Inform the Contractor so that he can take corrective action

### Page 5-22

1. Be sure honeycombed areas are patched properly
2. Be sure no jarring, prying or banging occurs that could cause hairline cracking or spalling
3. Be sure small holes are filled with mortar
4. Be sure that forms to be reused are not damaged

# CHAPTER SIX

## Reinforcement

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# 6

## REINFORCEMENT

### TYPES OF REINFORCEMENT

Concrete is a material that is strong when compressed (in compression) but weak when stretched (in tension). Therefore, reinforcing steel is placed in the concrete to increase its ability to resist tension. You will encounter two types of reinforcing steel during your inspection:

- wire mesh
- deformed bars

Deformed bars have irregular surfaces so that the concrete will grip and bond with the bars. Bonding enables the concrete to use the strength of the steel. The bars are used either straight or bent to some specific shape. Unless the plans or the Engineer state otherwise, all bending should be cold bending done at the shop prior to delivery. Bars should not be hot bent or straightened, welded, or cut with heat such as a torch, unless it is allowed by the contract documents.

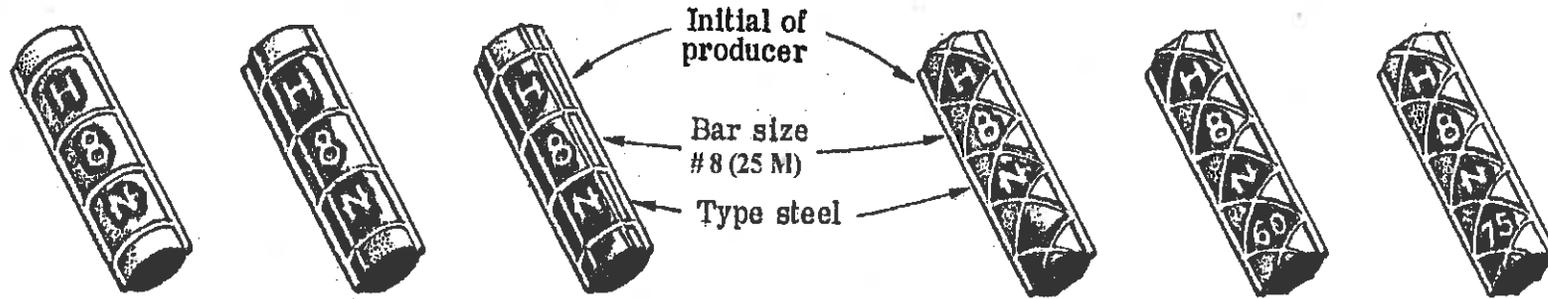
## DELIVERY AND STORAGE OF REINFORCEMENT

Before any reinforcing steel is placed, you must be sure that the proper bars are delivered and that they are stored properly. When reinforcing steel is delivered you must check the following:

- Check the producer's delivery tickets and heat number tags. These tickets should be compared to the Bill of reinforcing Steel, in the plans.
- Check the bars against the plan requirements for proper grades, lengths, sizes, numbers and bends. An identification tag should be attached to each bundle or group of bars.
- Check all of the bars for corrosion. A thin film of rust or mill scale that cannot be removed by rubbing with burlap does no harm, but any loose rust or scale must be removed before the bars can be used.
- Typically, a 7 foot (2.13 meter) long random sample of rebar must be taken for every 80 tons delivered to the site and the sample is sent to the State Materials Office in Gainesville. However, the exact rebar sampling requirements of your project must be in accordance with the Material Guide Schedule.

Reinforcing steel bars can be identified according to the designations shown in the plans. In order to do this, you must be able to interpret the manufacturer's markings. Let's take a look at these. Reinforcing steel, by requirement of AASHTO and ASTM specifications, must be identified by sets of marks rolled into the surfaces of the bars. The bar will have three or four marks depending on whether it is grade 40 or 60 and they will be as follows and in the order they will appear on the bar:

### AMERICAN STANDARD BAR MARKS



#### CONTINUOUS LINE SYSTEM

	ONE VERTICAL LINE	TWO VERTICAL LINES
ENGLISH:	Grade 40	Grade 60
METRIC:	Grade 300	Grade 400
		Grade 500
COMMON GRADES	HIGH- STRENGTH GRADES	

#### NUMBER SYSTEM

Grade 40	Grade 60	Grade 75
Grade 300	Grade 400	Grade 500
COMMON GRADES	HIGH- STRENGTH GRADES	

The bar size in English units is its diameter, in eighths of an inch: a number 8 bar has a one inch diameter. ( In metric the bar size is approximately its diameter in millimeters: a 25M bar is 25.2 mm in diameter.)

After you have checked the bars for certification and markings, the bars can be stored until ready for use. Be sure they are stored above ground -- on platforms, skids, or other supports -- and are protected at all times from damage, corrosion, dirt, scaling, paint, oil or other foreign substances.

Storage is important. As an Inspector, you should be looking for the following:

- Reinforcing steel should be separated and stored according to the part of the structure that the steel will be used in.
- The reinforcing steel that will be used first should be closest to the job site.
- The reinforcing steel should be protected as much as possible from damage or exposure to corrosive conditions. It may be necessary to have protective covers on the steel.
- Reinforcing steel for different structures should be separated.

## QUIZ

To verify the quantity, size and shape of reinforcing steel bars, you should consult the \_\_\_\_\_.

In what unit of weight is the quantity of reinforcing bars recorded? \_\_\_\_\_

A bar's size is its \_\_\_\_\_, measured in \_\_\_\_\_ of a an inch or mm.

When reinforcing steel is delivered to your project you will have to check for four things. One of them is a check for corrosion. What are the other three?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_

To be stored properly, reinforcing steel should:

- A. be separated according to the part of structure.
- B. have protective covers.
- C. be stored above ground.
- D. be separated for different structures.
- E. be stored close to the site, for steel to be used first.

A "60" ("400") marked on a steel bar indicates the bar's \_\_\_\_\_.

## QUIZ, continued

An "8" ("25") marked on a steel bar indicates the bar's \_\_\_\_\_.

What grade of steel bar is indicated by two continuous lines? \_\_\_\_\_

What does the marking "N" mean on a steel bar? \_\_\_\_\_

## PLACEMENT OF REINFORCEMENT

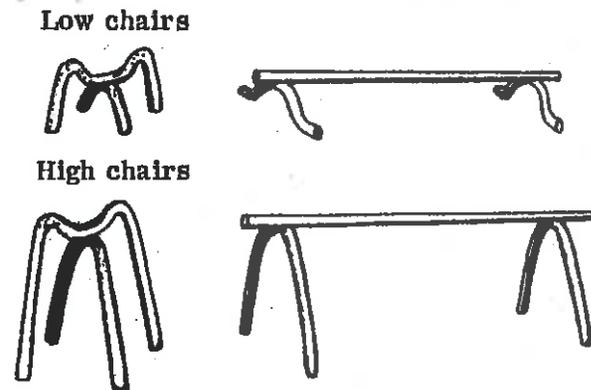
All reinforcing steel must be accurately placed and securely held in position. The Contractor has the option of placing the reinforcing steel either by the piece or in sections. Your job during placement is to see that the correct bars have been installed in the specified locations and that they are firmly held in position during the placing of concrete.

Proper cover -- the distance between the finished surface of the concrete and the nearest surface of the steel -- must be maintained by supporting devices which do not require removal after the concrete is placed, such as stays, spacer blocks or wheels, mortar blocks, ties, hangers, chairs, bolsters. In addition, the bars must be spaced according to the plan requirements.

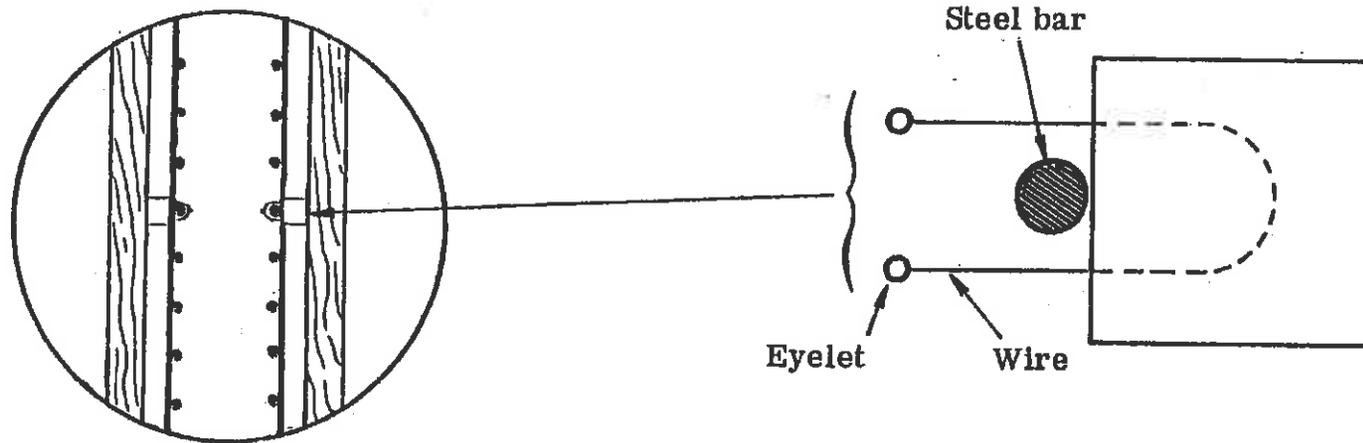
The concrete cover between the rebar and the outside surface is for corrosion protection. Too little cover means insufficient protection; too much cover can lead to cracking because of shrinkage, temperature or stress. The designer considers all of these issues prior to specifying the cover required in the plans. In practice, however, the exact, planned cover is not always achievable. Consequently, the Specification allows rebars to be slightly out of position which is referred to as a tolerance. Refer to specification Section 415, for the permitted tolerances.

Some of the hardware that may be used to maintain the proper cover and spacing are listed below and on the next few pages.

- Metal chairs are placed under and tied to rebars. They may be in the configuration shown here. Whatever the shape, be sure that the heights of the chairs are correct. Also, the tips of all metal chairs in contact with the outside surface of the concrete must be molded plastic or plastic coated a minimum of 1/2 inch (13 mm) from the outside surface.
- Plastic chairs and bolsters are also permitted.



- Precast mortar blocks with tie wires cast into them also are used for spacing reinforcing steel. The size of the blocks is usually 2 inches by 2 inches (50 mm x 50 mm) by the specified concrete cover. The faces of the blocks should rest on or against the forms to prevent the blocks from being dislodged when the forms are removed. Pebbles, broken stones, metal pipes or wood blocks are not acceptable substitutes for precast mortar blocks.



When the Contractor is making mortar blocks, be sure that the bottom of the loop is satisfactorily anchored in the mortar. Also, when the loops are tied, the wire should be bent in such a way as to be as far as possible from the outside surface of the concrete to provide maximum concrete cover. This is to prevent or minimize corrosion.

- Check the bar laps at splices. Overlap distances should be shown in the plans. If the lap distance does not appear in the plans, ask the Project Administrator what the distance should be. Bar overlap at splices must not be less than 30 bar diameters unless shown otherwise in the plans.

Keep in mind that the splices should be arranged to obtain the specified clearance between the splice and the surface of the completed concrete. The clear distance between adjacent splices must be at least 1 inch (25 mm).

Also check to be sure that the bars are rigidly clamped and wired at each splice. They must be fastened together tightly. Before any splicing takes place, you must consult your Project Administrator.

- Splicing by welding will be permitted only if indicated in the plans or if authorized by the Engineer in writing. When a weld is specified, consult your Project Administrator as to what is required of the Contractor and as to what you will need to inspect.
- You must verify rebar spacing and location. It is difficult and sometimes impossible to place the bars exactly as shown in the plans. However, the steel should be placed as close to the planned location as possible. Equal distribution of the reinforcing steel is important so that each reinforcing bar carries its proportionate share of the load. Uneven distribution of the steel can cause the concrete to crack. A bar should never be omitted or cut without the approval of the Engineer. Similarly, bars should never be displaced vertically by increasing or decreasing the cover.

- Watch for bent bars. If you find a bar with a major kink or bend that is not called for in the plans, the bar should be rejected. If the bend or kink is minor, it may be straightened with a rebar bending device commonly referred to as a Hickey Bar and which is specifically designed to bend or unbend rebars without damaging them. However, keep in mind that if a bar is repeatedly bent, it will be weakened. When rebars are fabricated they are bent around pins, which eliminate sharp-angle bends.
- Heating reinforcing bars for bending is not allowed, since heating can change the characteristics of the steel and weaken it.
- Check the conditions of the bars. The surfaces should be free of dirt, oil, grease, mortar or any other foreign material which may prevent the steel from bonding with the concrete.

Study your responsibilities again, starting on page 6-11, then try the quiz on the next page.

## QUIZ

Name two ways in which the Contractor can place reinforcing steel.

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Why are steel bars supported by chairs or mortar blocks? \_\_\_\_\_

A mortar block is generally 2 inches by 2 inches (50 by 50 mm) by \_\_\_\_\_.

The twisted ends of wire ties should project \_\_\_\_\_ exterior surfaces.

Never allow \_\_\_\_\_ instead of tying reinforcing steel.

Unless shown otherwise on the plans, bar overlap at splices must be at least \_\_\_\_\_ bar diameters.

Splices should be made away from areas of \_\_\_\_\_ stresses.

What may happen to the concrete if the reinforcing steel is unevenly distributed? \_\_\_\_\_

Two #6 (20M) bars are spliced. If the plans do not indicate a splice distance, what is the minimum overlap distance that you must measure when you check the splice? \_\_\_\_\_

Are reinforcing steel bars bent by heating? \_\_\_\_\_

O.K.? Go on to CONTRACTOR NONCOMPLIANCE.

## CONTRACTOR NONCOMPLIANCE

The placement of reinforcement is a critical operation. A poor job of placement, if not corrected, will produce a structure of questionable strength and service life -- or can cause immediate and total failure of the structure. For this reason, the Contractor should take extreme care in this portion of the work.

Improper spacing of bars or missing bars will cause too much stress on properly placed bars, reducing the structural strength. And, it can cause concrete damage.

It has been determined that, in a deck 6 inches (152 mm) thick, a 1/2-inch (12.7 mm) mistake in the vertical placement of the bars will affect the load-carrying capacity of the deck by as much as 20% -- you can see just how important positioning of steel is.

Too little concrete cover -- a result of improper spacing -- could cause cracking, spalling, reduced strength and, finally, failure. Also, too little cover can expose reinforcing steel, which will corrode, causing further damage.

This can be a serious problem in Florida. In coastal areas, the harsh salt water environment accelerates corrosion which leads to spalling, which leads to further corrosion and -- ultimately -- failure.

- The use of wrong size bars will cause:
  - reduced strength, if smaller bars are used.
  - difficulty in concrete consolidation and too little concrete cover -- especially in walls and other confined areas -- if larger bars are used.
  
- The use of dirty or oily reinforcing steel bars will cause:
  - poor bonding.
  - reduced structural strength.
  - possible concrete failure.

In all cases, your response to noncompliance is the same. You should tell the Contractor of your findings and tell him that the situation must be corrected before concrete operations begin. Also, keep your supervisor informed of any problems. If the problems are not corrected within a reasonable amount of time, you should contact the Project Administrator and advise him of the situation. An Inspector should never attempt to suspend operations or shut a Contractor down. This must be done by the Project Administrator.

## COMPENSATION

Reinforcing steel is usually measured and computed for payment by the pound. Payment is based on or computed from the dimensions specified in the plans. Also, the table below should be consulted. Keep in mind that this table may be updated, so consult the latest Standard Specifications or Special Provisions.

The Contractor is responsible for the proper positioning of the bars and will not receive extra compensation for any device used for splicing, clamping, tying or positioning of reinforcement.

Bar Designation	Weight in lbs./LF (kg/m)	Bar Designation	Weight in lbs./LF (kg/m)
#4 (10M)	0.668 (0.785)	#9 (NA)	3.400
#5 (15 M)	1.043 (1.570)	#10 (30M)	4.303 (5.495)
#6 (NA)	1.502	#11 (35M)	5.313 (7.85)
#7 (20M)	2.044 (3.925)	#14S (45M)	7.650 (11.775)
#8 (25M)	2.670 (5.495)	#18S (55M)	13.600 (19.625)

## QUIZ

Match one or more items from the CAUSES column below with each result in the RESULTS column and enter the choice/s in the blank to left of the results item.

### RESULTS

- \_\_\_ 1. Concrete cracking, and accelerated corrosion
- \_\_\_ 2. Too much stress on properly placed bars
- \_\_\_ 3. Reduced strength, if smaller bars are used
- \_\_\_ 4. Exposed reinforcing steel resulting in corrosion
- \_\_\_ 5. Exposed reinforcing steel resulting in corrosion
- \_\_\_ 6. Difficulty in concrete consolidation and too little concrete cover, if larger bars
- \_\_\_ 7. Poor bonding

### CAUSES

- A. Use of wrong size bars
- B. Improper spacing of bars or missing bars
- C. Use of dirty or oily reinforcing steel bars
- D. Too little concrete cover

What should you do if you find one of the "Causes" above before concrete is placed? \_\_\_\_\_

What should you do if you find one or more of the "Results" after concrete is placed? \_\_\_\_\_

Refer to the table on page 6-17. What is the weight of fifteen, 6-foot (1.83 m), #4 (10M) bars? \_\_\_\_\_

## ANSWERS TO QUESTIONS

### Page 6-6

- Plans
- Pounds (Kilograms)
- diameter, eighths of an inch or millimeters
- 1. Delivery tickets and heat number tags
- 2. Proper grades, lengths, sizes, numbers and bends
- 3. 7 foot (2.13) long sample per 20 tons (18,144 kg) delivered
- All of them
- grade

### Page 6-7

- size
- 75 (500)
- The type of steel

### Page 6-14

- By the piece, Assembled in Sections
- To maintain proper cover (clearance)
- specified clearance
- away from
- tack welding
- 30

- maximum
- The concrete may crack
- 22.5 inches (572 mm)
- No

### Page 6-18

1. A, B, D
  2. A, B
  3. A
  4. A, B, C, D
  5. D
  6. A, B
  7. C
- Tell the Contractor to correct the situation
  - Inform Contractor and Project Administrator and watch for the cause in the next placement.
  - 60.12 pounds (21.55 kg)

## CHAPTER SEVEN

### Review Quiz

Things you have learned in this course are going to help you do a better job as an Inspector. This Review Quiz is designed to help you find out how well you learned the material. It is also designed to prepare you for the Examination.

Listed below are instructions on how to take the quiz.

1. Do not take this quiz immediately after you finish the course.
2. Do not cram the night before you take the quiz. Remember that the objective is not to test your memory. The objective is to help you evaluate how well you have learned the material and how well you can think through your everyday work problems.
3. When you take the quiz, make sure that you will not be disturbed for about two hours.
4. Attempt all questions.
5. You may refer to the course material if you get stuck on a question. But first try to reason out the problem.
6. Finally, keep track of your wrong answers. Instructions on how to grade yourself follow the Review Quiz. If you score less than 90% on the quiz, do not be disappointed. Go back and study the course materials once again and retake the quiz.

GOOD LUCK

## REVIEW QUIZ

Box culverts are constructed of \_\_\_\_\_ and \_\_\_\_\_.

If a box culvert is 8' x 4' (2.44 m x 1.22 m), the first number refers to \_\_\_\_\_ and the second number refers to \_\_\_\_\_.

Columns are the vertical supports of \_\_\_\_\_.

Intermediate substructures that consist of piles and caps only are called \_\_\_\_\_.

Piers are comprised of four main parts, \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_.

The "roadway" of a bridge is called a \_\_\_\_\_.

Bearing devices are placed on the \_\_\_\_\_.

What are the broad types of bridges constructed by the Department: \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_.

What is the most common type of bridge used by the Department?

For concrete precast post-tensioned beam bridges, \_\_\_\_\_ are encased in the concrete to allow strands to be threaded through at the job site.

True or false: segmental bridges can only be constructed in a straight alignment.

How are the forms held in place for a cast-in-place post-tensioned box girder?

Can a complete plate girder be produced by rolling a single plate of steel?

Flat slab bridges can be used for span lengths as long as \_\_\_\_\_ feet.

True or false: precast prestressed slabs are cast in place at the job site in their final position.

Bascule bridges have complex \_\_\_\_\_ and \_\_\_\_\_ systems.

New \_\_\_\_\_ and \_\_\_\_\_ bridges are no longer built by the Department.

Suspension bridges that have a cable pattern that looks like a spider web are called what?

If you find computation book errors who should you report them to?

What is your responsibility as it relates to the concrete quality control plan?

True or false: the contractor may start drilled shaft construction no more than ten days before the installation plan is approved.

True or false: experienced inspectors do not need to use checklists since they always remember everything that is required.

Use the diagram on the next page to answer the following questions:

What is the finished grade elevation of the bridge at centerline?

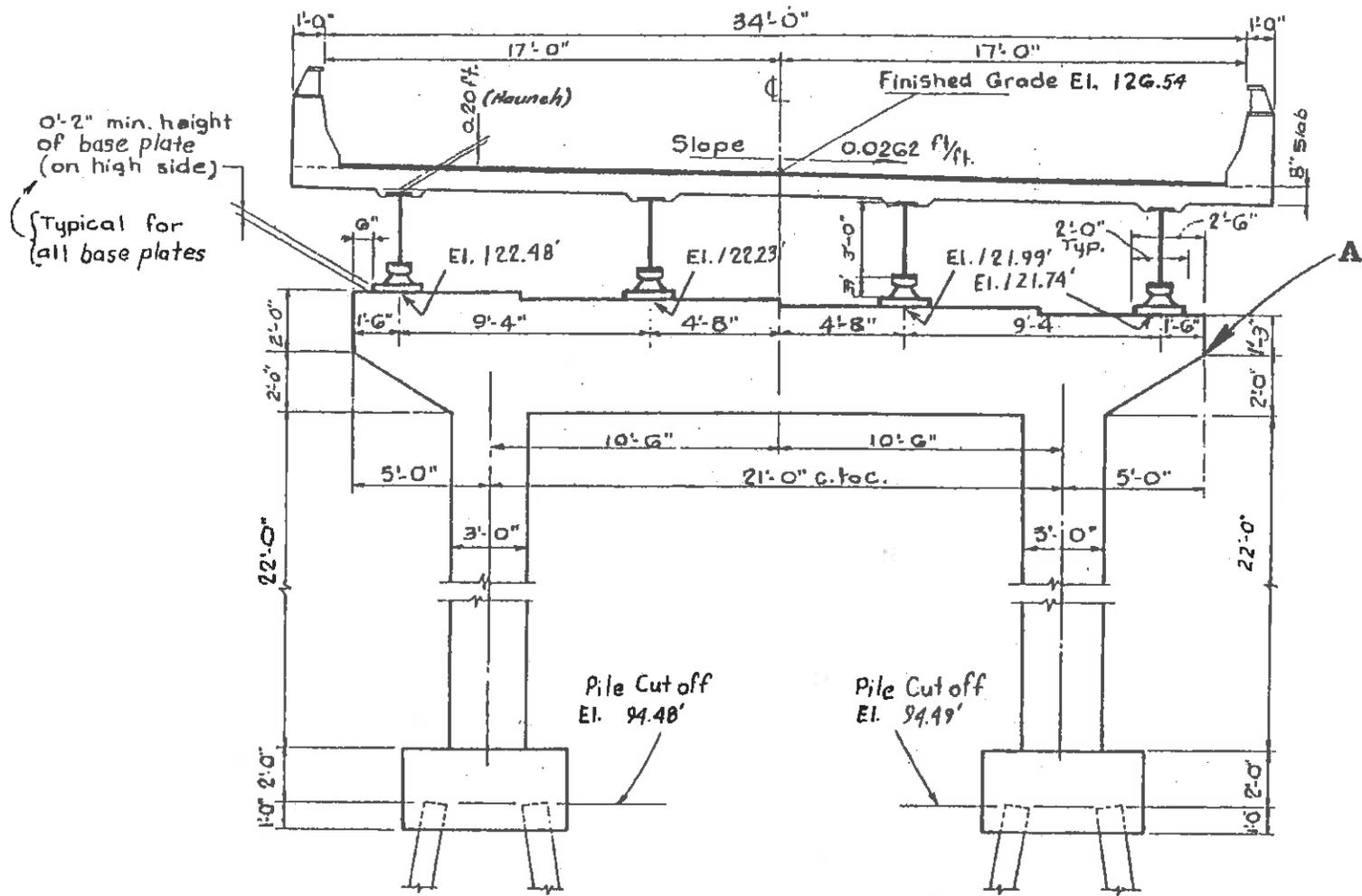
What are the elevations of the tops of the footings?

Left:

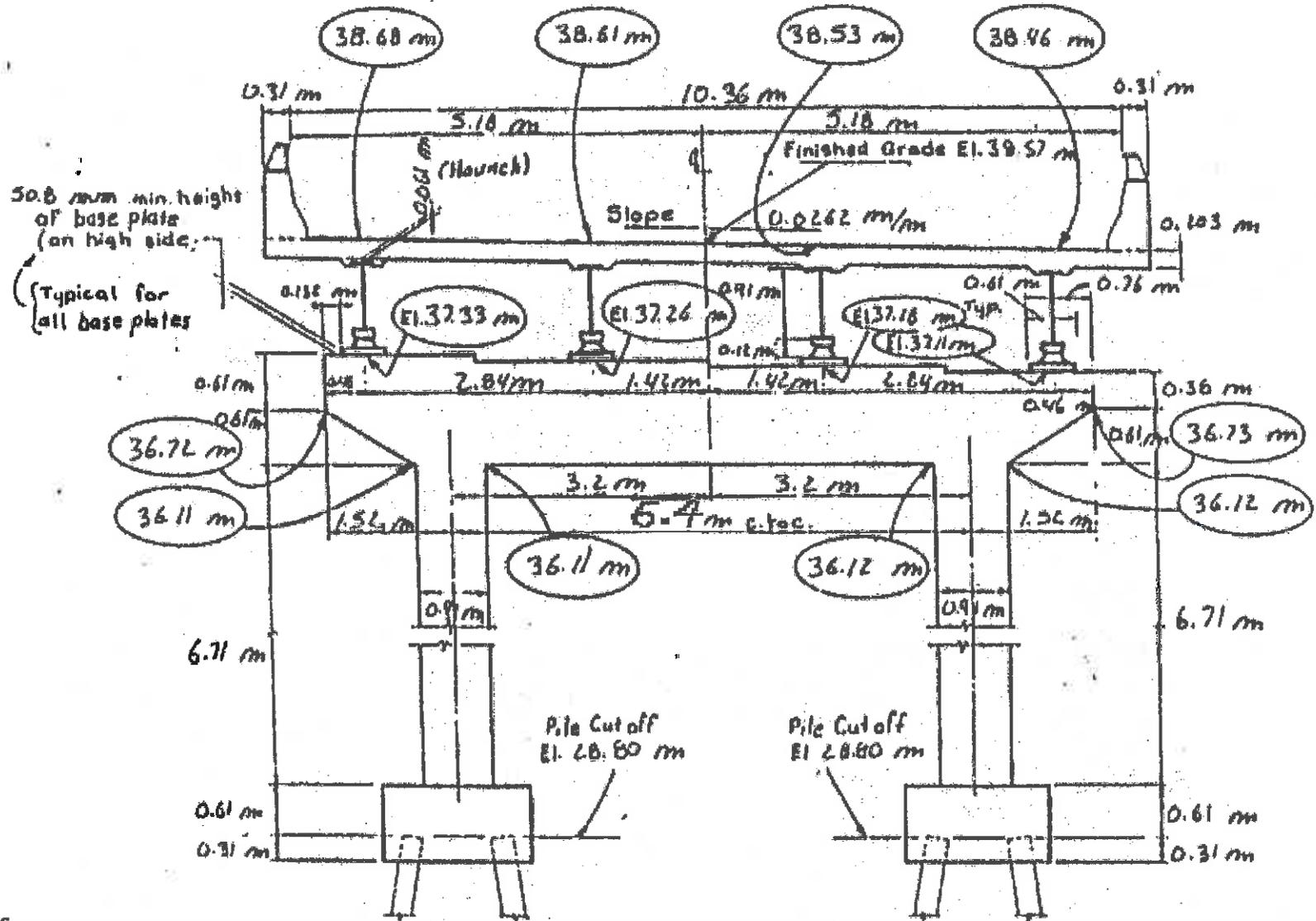
Right:

Determine the elevation of the cap at Point A.

What is the distance between the columns, centerline to centerline?



Metric



Units

What three dimension checks must be made on a steel girder or pile?

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What action should be taken if you find girders that are shorter than the shop drawings?

In what units are the following materials measured?

Steel:

Concrete:

What section of the plans shows the correct number of bars for a structure?

Match the following:

\_\_\_ A. Discussion of federal and state water pollution standards

\_\_\_ B. Information on the location of utilities

\_\_\_ C. Plotting of soil data for bridges

1. Plans

2. Preconstruction Conference

3. Boring data sheets

Why should you be familiar with the materials delivery schedule?

Use this table to answer the questions below.

Bar Designation	Weight per L.F. in lbs (kg/m).	Bar Designation	Weight per L.F. in lbs (kg/m).
1/4"	0.167 lbs.	8 (30M)	2.670 (5.495)
3 (10M)	0.376 (0.785)	9 (30M)	3.400 (5.495)
4 (15M)	0.668 (1.570)	10 (35M)	4.303 (7.850)
5 (15M)	1.043 (1.570)	11 (45M)	5.313 (11.775)
6 (20M)	1.502 (2.355)	14S (45M)	7.650 (11.775)
7 (25M)	2.044 (3.925)	18S (55M)	13.600 (19.625)

What is the weight of seven 8 ft No. 6 ( 2.44 m 20M) bars?

Your total estimated weights can be compared to the estimated weights shown on the \_\_\_\_\_ tables in the plans.

For answers to questions about utilities relocations, consult your \_\_\_\_\_.

Traffic maintenance must comply with the \_\_\_\_\_.

Does the above mentioned reference describe the maximum amounts of traffic control?

Which of the following would you expect to be discussed at the preconstruction conference?

- A. Method of staking
- B. Safety regulations
- C. Work hours
- D. Anticipated delays

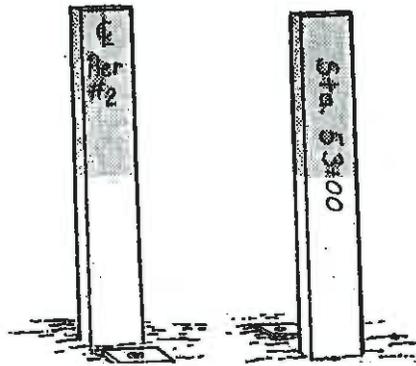
Box culvert flow line grade is set from \_\_\_\_\_.

Bridge centerline stakes are established from \_\_\_\_\_ and are set by the \_\_\_\_\_.

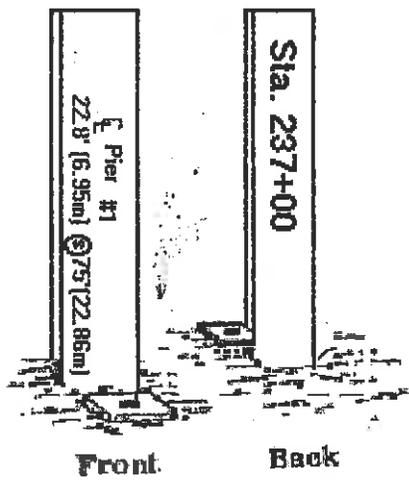
Reference control stakes are established from \_\_\_\_\_ and are set by the \_\_\_\_\_.

Substructure centerline stakes are established from \_\_\_\_\_ and are set by the \_\_\_\_\_.

The stake on the right is located on the \_\_\_\_\_ of \_\_\_\_\_ at \_\_\_\_\_

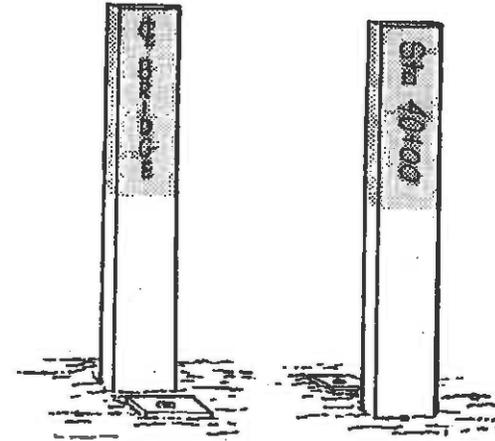


The stake below is \_\_\_\_\_ 75 ft  
( 22.86 m ) from \_\_\_\_\_ at \_\_\_\_\_

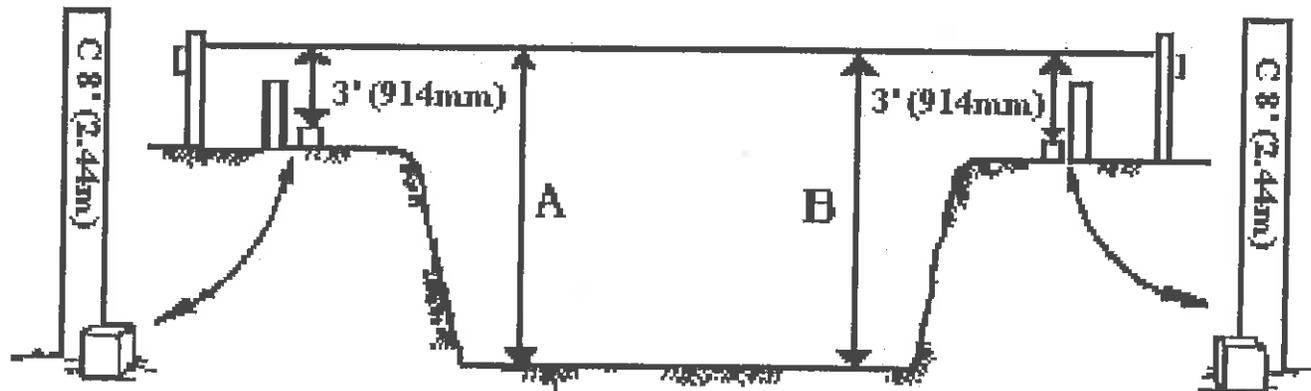


Where is the stake on the right located?

Could the same spot be marked by nail driven into the pavement?



What are the distances labeled A and B below?



Wet materials are excavated with \_\_\_\_\_ buckets.

\_\_\_\_\_ are used for digging shallow vertical cuts.

Foundation piles must be driven \_\_\_\_\_ pit excavation.

What two points must you ensure compliance with when muck is undercut and backfilled?

- 1.
- 2.

When rock is encountered, the proper construction procedures will be given by the \_\_\_\_\_.

Muck may be placed on slopes, provided there is a clear distance of 6 feet ( 1.83 m) between the \_\_\_\_\_ and \_\_\_\_\_.

Under normal conditions, elevations of foundations are found in the \_\_\_\_\_.

A special exception to the statement above is when excavation takes place in \_\_\_\_\_.

Excavation in a stream bed must be continued at least \_\_\_\_\_ feet below the permanent bed, unless:

- A. there is danger of undermining.
- B. the stream is over 5 ft ( 1.52 m) deep.
- C. a firm footing on rock is encountered first.

Pit excavations must be large enough to contain the \_\_\_\_\_.

Backfill density around structures must not be less than \_\_\_\_\_ % of \_\_\_\_\_.

Backfill lifts should not be more than \_\_\_\_\_ deep, unless hand tampers are used and the lifts must be no more than \_\_\_\_\_.

Falsework must be strong enough to support \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_.

Metal ties used in forms must be broken off at least \_\_\_\_\_ inside the concrete surface.

The inside of forms should be soaked with \_\_\_\_\_, then they should be coated with a thin film of clear \_\_\_\_\_.

If lumber that is used for forms is too dry, it will \_\_\_\_\_.

Lumber that is too green will \_\_\_\_\_, causing joints to open.

If too much oil is used on wooden forms, the concrete will be \_\_\_\_\_.

When reinforcing steel is delivered, you must check the producer's \_\_\_\_\_, and the \_\_\_\_\_.

A Number 8 (30M) reinforcing steel bar has a \_\_\_\_\_ inch (millimeter) diameter.

Is it O.K. to tack weld reinforcing steel bars rather than to tie them?

Overlap distances in bar splices must not be less than \_\_\_\_\_ bar diameters, unless shown otherwise on the plans.

Splicing reinforcing steel is allowed only if indicated in the \_\_\_\_\_ or if authorized by the \_\_\_\_\_.

Can uneven distribution of reinforcing steel cause the concrete to crack -- the structure to fall?

Generally, all reinforcing steel bending is done in the shop, without the use of heat. True or false?

Why are steel bars supported by chairs or mortar blocks?

What information can you obtain from the steel bar shown to the right?

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TO GRADE YOURSELF ON THE REVIEW QUIZ, TOTAL YOUR INCORRECT ANSWERS. THERE ARE ABOUT 110 ANSWERS IN THE QUIZ.

IF YOU SCORED LESS THAN 90% -- THAT'S MORE THAN 11 INCORRECT ANSWERS -- GO BACK AND STUDY THE PARTS OF THE COURSE THAT GAVE YOU TROUBLE. THEN, TAKE THE REVIEW QUIZ AGAIN. WHEN YOU CAN ANSWER THE REVIEW QUIZ QUESTIONS CORRECTLY, YOU WILL HAVE NO TROUBLE WITH THE EXAMINATION.