Bridge and Structures Inspection

Georgia Department of Transportation

TO THE STUDENT

This is a self-instructional study course, which allows you to proceed at your own speed. The course is designed to provide you with information, then to test your recall by immediately providing questions about the material just presented. This process allows you to read the information, actively participate in the course by answering questions, and learn promptly if you are correct. This procedure reinforces what you have just read and should enable you to retain what you have studied for a longer period of time than from a lecture or a regular textbook.

The inspection of the building of a concrete structure is a complicated task. The inspector must be familiar with all equipment, testing, and work procedures, which will be encountered during each phase of construction. The complexity of inspection in this area of construction is increased by the fact that while all concrete structures are built in accordance with certain basic rules of construction technology, each structure usually is a unique design, demanding more careful attention to detail than is normally required in other areas of highway construction.

This study course is designed to be a comprehensive treatment of the area of structural inspection. It provides the background knowledge, which coupled with experience, will prepare the inspector for the performance of his duties. An Inspector should have completed the Department's basic training courses (Basic Plan Reading, Basic Math, Introductory Text and Basic Construction Surveying, and should be familiar with the department's construction reference manuals (Standard Specifications, Construction Manual, Materials Sampling Manual, Testing Procedures Manual and Bridge Manual), before beginning this course.

HOW THIS PROGRAM WORKS

You will be given blocks of information in sequence, followed by questions. You are to follow the instructions for the type of question being asked. After you have responded to the questions, you should slide back the page on which you are working to see the correct answers.

The answers to the questions on page 4 would be on page 2.

If you have missed any answers, you should re-read the appropriate section and make a special effort to recall this information.

Each chapter will be followed by a short quiz over the information contained in the chapter. If you answer all of the questions correctly, you are to go on to the next chapter. If you miss any of the answers, you should review the section covered by that question.

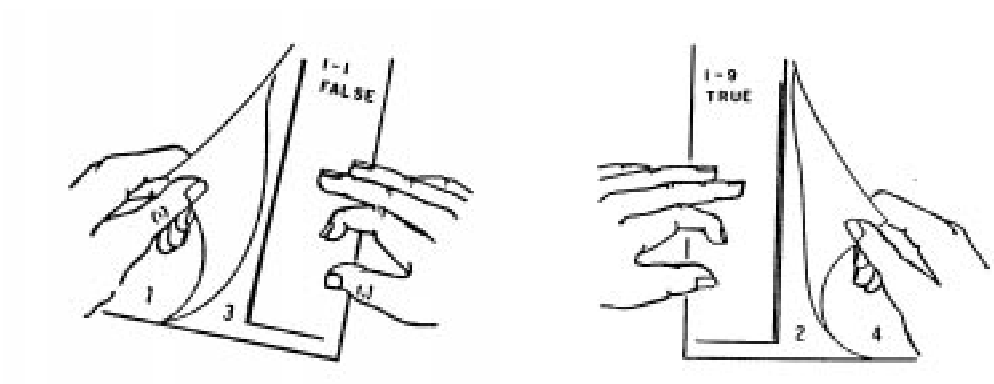


TABLE OF CONTENTS

CHAPTER I: INTRODUCTION TO STRUCTURES

CHAPTER II: PROJECT PREPARATION

CHAPTER III: PILE DRIVING OPERATIONS

CHAPTER IV: STRUCTURAL PREPARATION

CHAPTER V: CULVERTS

CHAPTER VI: DECK POUR

Glossary

CHAPTER I: INTRODUCTION TO STRUCTURES

The Standard Specifications list the following as structures: bridges, culverts, catch basins, drop inlets, retaining walls, cribbing, manholes, endwalls, buildings, sewers, service pipes, underdrains, and foundation drains.

This course will be primarily concerned with the building of bridges of portland cement concrete. Those construction techniques which are unique to certain other structures, such as culverts, will also be discussed. The Inspector should be aware that many of the basic construction techniques which are utilized in bridge construction are also applicable to other structures built of portland cement concrete.

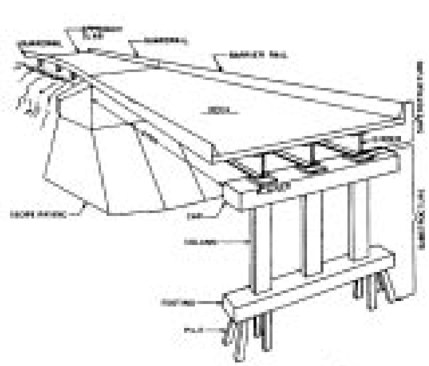
BRIDGE TERMS

In order to understand the operations involved in bridge construction, it is important to first recognize the parts that make up a bridge. The following is a list of bridge parts that will provide some familiarity with structural terminology.

1-5.
A-b
B-a
C-c

SUBSTRUCTURE AND SUPERSTRUCTURE

Bridges are divided into two distinct areas, termed the substructure and superstructure.
The substructure is the lower portion of the bridge from below the ground to the caps.
The structural members of the bridge above the caps form the superstructure.



BENT

A bent forms the basic support structure for a bridge. The bents compose the Substructure of a bridge. There are several different types of bents constructed in Georgia.

Fill in the blanks.

1-1 Bridges, culverts, and catch basins are types of ____________.

1-2 The lower portion of a bridge from below ground to the caps is termed the ______________.

1-3 The portion of a bridge above the caps is known as the _________________.

1-4 The substructure is composed of ___________________.

Pile Bent

A pile bent consists of piling driven into the ground and topped by a cap.

Column on Spread Footing

This type of bent consists of a cast-in-place concrete footing with cast-in-place concrete columns extending from the footing to the cap.

Column on Footing Supported by Pile

This type of bent is sometimes referred to as a pile footing bent. It is formed by driving support piling into the ground (pile foundation) and embedding them in a cast-in-place concrete footing. Cast-in-place concrete columns rise from the footing to the cap.

1-5 Match the bent types in the left column to the description in the right column.

A. Pile Bent	a.	concrete footing, columns, and cap
B. Column on Spread Footing	b.	pile foundation concrete footing, columns, and cap
C. Column on Footing Supported by Pile	c.	piling topped by a cap

1-7. Drilled Shaft Foundation

1-8. Pier

1-9. Sash and Sway Bracing

In the preceding bents have been described in terms of plies, footings, columns, and caps. The following will define these terms, as well as some others that are necessary for subsequent course discussion.

Pile

A pile is a long, slender structural element, which is embedded into the ground for the purpose of supporting a structure. Piles can be of precast concrete, steel, or timber.

Piles can be placed either straight up and down or at an angle (battered). Piles are battered in order to provide lateral stability for the structure.

Footing

A footing is that portion of a structure, which spreads and transmits the load directly to the piles or to the supporting soil. Footings are built of reinforcing steel and cast-in-place concrete.

Column

A column is a long, slender structural element that extends above the ground to provide support for a structure. Columns are constructed of cast-in-place concrete and reinforcing steel.

Although in a pile bent, piles act as columns, in general terms, it can be said that piles are driven and columns are poured (cast-in-place).

CAP

The cap is an essentially horizontal support member, which covers the tops of the columns or piling. The cap extends transversely across the entire bent with the tops of the columns or piles firmly embedded and anchored into the cap. Caps are made of concrete, either cast-in-place or precast.

RISERS

There are projections on the top of the cap on which girders, including bearing pads, are placed. These are called risers.

1-6 Match the terms in the left column to the definitions in the right column.

A. Pile	a. Covers the tops of columns
B. Footing	b. A long, slender, cast-in-place structural element
C. Column	c. A long, slender, structural element driven into the ground.
D. Cap	d. Element of a bridge that spreads the load to piling or supporting soil
E. Battered Piling	e. Projections on the top of the cap
F. Risers	f. Driven at an angle

DRILLED SHAFT FOUNDATION

Another type of bent constructed for bridges in Georgia is known as a drilled shaft foundation. There are two types of drilled shafts. The only difference in the two is the bellshaped footing that is excavated on one of them.

A drilled shaft is constructed by boring a hole into the ground with an auger. A special auger will be used to create the bell-shape at the bottom if the plans require it.

After the shaft has been drilled, a preformed cage of reinforcing steel is placed into the hole. Then the hole is filled with concrete.

Reinforcing steel for the column extending above the ground will be tied to the steel incorporated into the shaft.

1-1. Structures

1-2. Substructures

1-3. Superstructures

1-4. Bents

1-13.
A-c
B-b
C-a

Fill in the blank.

1-7 A bent constructed by boring a hole in the ground and filling it with reinforcing steel and concrete is called a ________________________________.

PIER

Another type of bent that may be encountered by the Inspector is a pier. A pier is a solid, concrete, vertical support member that forms a bent. A bent formed by a pier may or may not be topped by a cap. The use of a cap will depend entirely on the design of the individual pier.

SASH AND SWAY BRACING

Sash and sway bracing is used only with timber and steel piles. It is placed cross-wise between the piles to reinforce the vertical supports and to reduce the amount of sway that may occur from the pressure of wind or water against the piles.

Fill in the blanks.

1-8 A solid, concrete, vertical support that forms a bent is a _______________________.

1-9 Cross-wise bracing used as reinforcement with timber or steel piles is _____________________.

SUPERSTRUCTURE

The following will identify members that form the superstructure.

GIRDERS

Girders are the main supporting beams of the bridge deck. The ends of girders are placed on bearings on the risers of the caps and extend from bent to bent.

DECK

The deck is the roadway of the bridge.

BARRIER RAIL

The barrier rail extends the length of the bridge along the outside edge of the deck on both sides. It is there to keep cars from going over the side of the bridge in case of an accident.

Fill in the blanks.

1-10 The main supporting beams of the deck are called ______________________.

1-11 The roadway over the bridge is the ___________________________.

1-12 The rail extending the length of the bridge to prevent vehicles from leaving the bridge in an accident is the ________________________.

1-6.
A-c
B-d
C-b
D-a
E-f
F-e

MISCELLANEOUS TERMS

Besides the names of the structural elements of the substructure and superstructure, the Inspector should also be familiar with some other structural areas.

SPAN

The term span is used to identify the distance from one support point (bent centerline on cap) to another.

END ROLL

That part of the approach embankment that forms a transition in grade from the elevation of the roadway or ground line below to that of the bridge deck.

APPROACH SLAB

That part of the pavement, constructed on the approach embankment and paving rest, which provides a transition from the roadway to the bridge deck.

1-14.
A-c
B-a
C-b

1-13 Match the term in the left column to the definition in the right column.

A. Span
B. End Roll
C. Approach Slab

a. that part of the pavement that provides a transition from the roadway to the deck

b. that part of the embankment that provides a transition from roadway or ground line elevation below to deck elevation

c. the distance from one support point of a bridge to another

TYPES OF BRIDGES

There are several types of bridges that the Inspector may encounter. Bridges can be built of timber, concrete, steel, or combinations of these materials.

Bridges may be movable or fixed in place.

Concrete bridges may be constructed of precast members or may be cast-in-place.

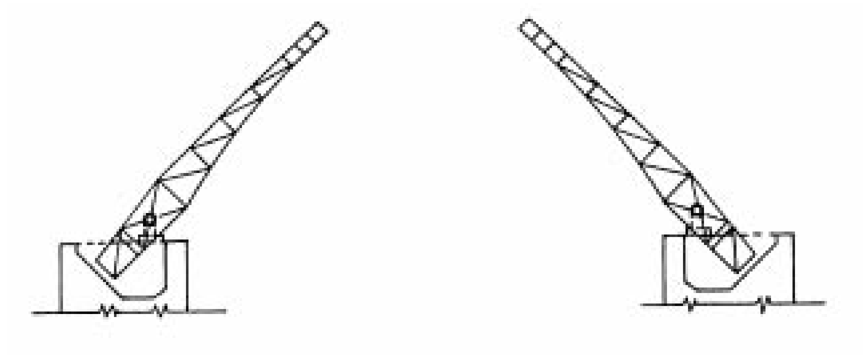
MOVABLE BRIDGES

There are many types of movable bridges. Three of the most common are:

Bascule
Lift Span
Swing Span

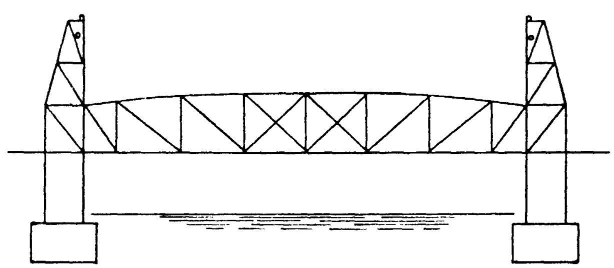
BASCULE

Each segment of a bascule bridge pivots, raising the center to create an opening through which channel traffic can pass.



LIFT SPAN

Lift span bridges are also referred to as vertical lift bridges. The entire span is lifted straight up, clearing the channel for river traffic.



1-10. Girders

1-11. Deck

1-12. Barrier Rail

1-17. Slab Span Bridge

1-18. Steel or Concrete Girders

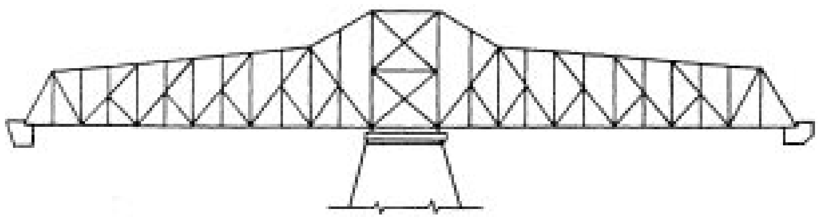
1-19. Through

1-20. Deck

1-21. c

SWING SPAN

Swing bridges are balanced on a pivot pier and swing open horizontally allowing channel traffic to pass.



Except for the machinery for their movable parts, movable bridges are built of the same materials as other bridges. For those basic areas of their construction (piers, columns, caps, deck, etc.) the same methods of construction and inspection will apply as for any other bridge.

1-14 Match the bridge type in the left column to the correct description in the right column.

A.	Bascule	a. entire deck lifts vertically
B.	Lift Span	b. deck pivots horizontally
C.	Swing Span	c. both ends pivot, opening center

NONMOVABLE BRIDGES

There are also several basic types of nonmovable bridges. Some are:

Slab Span
Girder Span
Truss Span

Besides these basic types of nonmovable bridges, the Inspector may also encounter some more specialized types of bridge construction. Some of these less common bridge types that have been built in Georgia are:

Cable Stayed Bridge - bridge deck is supported by cables attached to towers.

Segmental, Post-tensioned Box Girder - uses post-tensioned concrete box girder to support the deck.

Steel Box Girder - uses steel box girders to support the deck.

1-15 List three common types of movable bridges.

____

____

____

1-16 List three specialized types of nonmovable bridges.

____

____

____

SLAB SPAN BRIDGE

Concrete slab span bridges are also sometimes called flat deck or flat slab bridges. They are called flat deck bridges, because the deck has a 0.0 percent vertical grade. In slab span bridges, the deck rests directly on the sub-structure, without girders to help support the roadway. In such structures, the bents are usually no more than 25 feet apart.

GIRDER SPAN BRIDGE

In a girder span bridge, the deck rests on steel or concrete girders set on the substructure of the bridge.

TRUSS SPAN BRIDGE

Truss span bridges can essentially be divided into two types, through truss and deck truss. In a through truss, the truss (metal support structure) is primarily above the roadway, allowing traffic to pass through the truss. This type of truss is usually used for bridges over major rivers such as the Mississippi or Atchafalaya.

1-27. d

In a deck truss, the truss supports the bridge deck from below so that the roadway passes above the truss.

1-28. b

Fill in the blanks

1-17 The type of bridge that rests directly on the structure, without girders, is a ______________________.

1-29. d

1-18 In a girder span bridge, the deck rests on __________________________________.

1-30. a, c

1-19 If the metal support structure of a truss bridge is primarily above the roadway, it is a ________________________ truss.

1-20 If the metal support structure of a truss bridge supports the deck from beneath, it is a __________________ truss.

1-31. b

REVIEW QUESTIONS

Circle the letter next to the correct answer(s). Some questions in this section <u>may</u> have more than one answer.

1-21 Which terms are applied to that portion of a bridge from below ground to the caps?

a. superstructure
b. foundation
c. substructure
d. piling

1-22 Which of the following terms is applied to that portion of the bridge above the caps?

a. substructure
b. bent
c. superstructure
d. deck

1-23 Which of the following terms best describes the basic support structures of a bridge?

a. piling
b. girders
c. bents
d. superstructure

1-24 A bent, which consists of piling and a cap, is called which of the following?

a. pile bent
b. battered
c. footing and column
d. pile foundation

1-25 Piles that are driven at an angle are said to be which of the following?

a. battered
b. vertical
c. lateral
d. cast-in-place

1-26 Which of the following identifies that portion of the bent that transmits the load to sur rounding soils?

a. footing
b. column
c. pile
d. cap

1-15.
Slab Span
Girder Span
Truss Span

1-16.
Cable Stayed Bridge
Segmental, Post Tensioned Box Girder
Steel Box Girder

1-27 To be precise, you would say that girders rest on bearings, which rest on which of the following?

a. caps
b. columns
c. piles
d. risers

1-28 Which of the following terms applies to a bent constructed by boring a hole, then filling it with a cage of reinforcing steel and cast-in-place concrete?

a. pile bent
b. drilled shaft
c. column on spread footing
d. pile foundation

1-29 Which of the following is a solid, vertical support member of a bridge that forms a bent?

a. footing
b. pile
c. cap
d. pier

1-30 Sash and sway bracing is used with which of the following types of piles?

a. timber
b. concrete
c. steel
d. all of the above

1-31 The roadway over the bridge is known as which of the following?

a. approach slab
b. deck
c. rail
d. span

2-1.
Standard Specifications
Contract
Special Provisions
Supplemental Specifications
Bridge Foundation
Investigation Report
Shop Drawings

1-32 The distance between one support point of a deck and another is called which of the following?

a. girder
b. bent
c. deck
d. span

1-33 Which of the following is that part of the pavement that provides a transition from roadway bridge to deck ?

a. approach slab
b. end roll
c. barrier rail
d. embankment

1-34 Which of the following is not a movable bridge?

a. bascule
b. swing span
c. vertical lift
d. slab span

1-35 Which of the following bridges would not have girders?

a. girder span
b. slab span
c. steel box girder
d. all of the above

1-22. c

1-23. a, c

1-24. a

1-25. a

1-26. a

CHAPTER II: PROJECT PREPARATION

CONFERENCES AND DOCUMENTS

Before any operations are begun in the field, considerable preparation must be done. Preliminary plans are developed, which will indicate the proposed work. Persons from the offices of Design, Construction, Right-of-Way and Utilities will use these for an on-site review in order to discuss potential problems. Ideas or suggestions generated by this meeting are then incorporated into the plans and a “Final Field Plan Review” will be conducted to ensure that identified problems have been corrected. This meeting is instrumental in developing a final set of plans.

Once the final plans are made available, any copies of the preliminary drawings should be discarded. Preliminary plans, Preliminary Contracts or Proposals should only be used in the concept or development stages, not as actual construction documents.

2-6.
Finish Grade to Top of Girders

Top of Girders to Top of Cap

Plan Beam Seat or Rider

Elevations

Besides the final plans, the Inspector must also study the applicable portions of the Standard Specifications, the Contract, Special Provisions, Supplemental Specifications, Bridge Foundation Investigation (BFI) report and the Approved Shop Drawings.

Shop drawings are specific details, provided by the contractor, for special false-work, steel members and/or erection details, concrete beams, deck panels or other site specific bridge items.

2-1. List seven documents in addition to the plans with which an inspector should be familiar prior to the beginning of actual construction operations.

____________________ ____________________

____________________ ____________________

____________________ ____________________

____

Prior to construction, the Inspector should meet with the Contractor to discuss layout, clearing operations, construction procedures and silt/erosion control. All are important; however, the latter has become a critical concern. The Inspector must ensure that "Best Management Practices" are maintained according to the current specifications.

Whether this is to be a new installation or work on an existing structure, the Inspector should keep accurate records concerning all activities performed daily. This should be done in the contract diary. In the past, some Inspectors chose to keep a separate "Field Book" for this work; however, this is no longer necessary. If a "Field Book" is kept, it must be maintained as any other Contract Diary. Dates, weather, temperatures, equipment used, activities performed, etc., should be logged daily. Also, any field changes must be noted and an "As Built" set of plans must be maintained.

1-32. d

Circle T (True) or F (False).

2-2. T F Erosion control is not the Inspector's concern.

1-33. a

2-3. T F The "As Built" plans show changes made which reflect the actual construction..

1-34. d

2-4. T F All construction activities should be listed in the Contract Diary.

2-5. T F Each individual project requires its own project diary.

1-35. b

CHECKING PLANS

The plans are the document from which the structure will be built. Each section should be checked carefully to be certain there are no errors in the plans that will cause problems during construction. Elevations, dimensions, and estimated material quantities must be recalculated to be certain they are accurate.

ELEVATIONS

BASIC PROCEDURE

Elevations are recalculated by proceeding point by point through the critical elevations of the bridge. The same concept can be applied to all types of bridges and other structures.

Elevations for a bridge should be recalculated by checking dimensions from:

Finished Grade (elevation of the completed deck)
to
Top of Girders
to
Top of Bearings
to
Top of Risers or Beam Seats (top of cap)

And check against plan beam seat or riser elevations.

2-9. Sampling Plan

2-10. Project Engineer, Laboratory Representative

2-11. Materials Sampling Manual

2-12. Visual Inspection

2-6. List the sequence in which plan elevations for a bridge should be checked.

From: ________________________ to ______________________ to

________________________ to ______________________ and check against

_______________________.

In order to check these figures from the plans, the following computations should be followed. In performing these calculations, all dimensions must be converted to feet.

From finished grade, (above centerline girder and centerline bearing) subtract the thickness of the deck slab, then subtract the coping depth (distance from bottom of deck to girder), then subtract the depth of the girder.

This point should give you the elevation at the top of the bearing.

Subtract bearing pad thickness to figure the elevation of the top of a riser or beam seat (top of cap).

REINFORCING STEEL QUANTITIES AND INITIAL INSPECTION

The plans also include estimated quantities for each type of reinforcing steel that will be needed for the structure.

The lists should be checked against the details in the plans to be sure there are no discrepancies. Any errors should be corrected by marking through the error, leaving the original entry legible, then writing the correction clearly next to it.

Generally reinforcing steel will be delivered to the jobsite prior to the beginning of construction operations. A physical inventory should be made of the delivered steel to be certain that the correct amount of each type and size (as shown in the plans) is available.

All lengths and bends must be checked to be certain they are within the tolerances specified in the plans and/or specifications.

The clearance, height, and plastic tips of support chairs must also be checked for conformance to specifications.

The sampling method and frequency can be determined by referring to the Materials Sampling Manual and must also satisfy the sampling developed for the project.

All re-steel items must be approved prior to use.

Circle T (True) or F (False).

2-7. T F The reinforcing steel delivered to the jobsite must be the correct amount in size and type to meet the requirements of the plans.

2-8. T F No samples are ever taken to the district lab.

2-2. False

2-3. True

2-4. True

2-5. True

2-16. F

2-17. F

2-18. T

2-19. T

2-20. F

2-21. F

2-22. T

SAMPLING PLAN

As soon as the contract or plans for the job are made available, the Project Engineer and a representative from the Materials Lab should formulate the project-sampling plan.

The sampling plan is a schedule which outlines the minimal sampling and testing frequency for all materials used on the project. Additional sampling and testing may be performed if warranted by field conditions.

The sampling plan is developed by examining the contract, item by item, and listing the minimal sampling frequency for each material under each item. The minimal sampling frequency by section and material is delineated in the department's Materials Sampling Manual.

The sampling plan must include all materials which have specific sampling and testing requirements in plans or specifications. Minor materials for which sampling and testing procedures are not specified will be accepted on the basis of visual inspection by the engineer and listed on a Qualified Products List.

It is to be especially noted that although materials are accepted on the basis of tests on representative samples, all materials must be visually inspected prior to actual incorporation into the structure. Individual components which are found to be defective must be rejected.

Fill in the blanks.

2-9. The schedule outlining the minimal sampling and testing frequency for all materials used on a project is known as the _________________________.

2-10. The sampling plan for a project must be formulated by the ___________________________________.

2-11. The minimal sampling and testing frequency by item and material is delineated by the department in the ____________________________________.

2-12. Minor materials for which sampling and testing procedures are not specified are not normally included in the sampling plan, but are accepted on the basis of _____________________ by the Inspector.

2-13. Individual components of any material found to be defective by visual inspection must be ________________________________.

As equipment begins to arrive at the jobsite, it should be given a preliminary inspection for proper operation and safety features. Equipment such as hammers and cranes for pile driving operations and screeds must be of sufficient size to accomplish the work for which they are intended.

Any equipment which is defective must be repaired or replaced prior to its actually being used on the job.

Fill in the blanks.

2-14. Equipment should be given a preliminary inspection for proper ____________________and _________________ features.

2-15. Pile driving equipment such as __________________and ___________________ must be of sufficient size to accomplish the work for which it is intended.

2-7. T

LAYOUT-HORIZONTAL CONTROL

2-8. F

It is the responsibility of the contractor's personnel to provide alignment control for a project. The location of both the test piles and of the structure must be staked. While staking is usually done by a survey party, there should be close coordination between the survey group and the Project Inspector.

Since centerline stakes are destroyed once operations begin, the stakes at the offset line will provide permanent reference for the duration of the project. Stakes should mark the location of each bent and abutment. All stakes should be referenced to the centerline of either the bent or of the bridge. Stakes should also be marked with station location and bent numbers.

More information about layout and staking can be found in the Department's construction manuals and specifications.

Offset stakes should be placed far enough from the structure to preclude damage from construction activities. For more complicated structures, a system of double offsets should be used on each side of the structure if conditions allow. It is a good idea to place the second set of offsets at least 50 feet from the original offsets in order to minimize error in instrument sighting.

The contractor is to provide a sketch of all layout staking required.

Circle T (True) or F (False).

2-16. T F It is not necessary to stake the location of the test pile.

2-17. T F Stakes can be referenced either to centerline of bent or of joint.

2-18. T F Stakes must be marked with station location, bent number, and offset distance.

2-19. T F Complicated structures may require a double set of offsets on each side of the structure.

2-20. T F The double line of offsets, when used, should be placed a maximum of 25 feet apart.

2-21. T F The centerline of each pile and of each bent should not be marked.

2-22. T F Layout sketches should be required on all structures.

It is important to control the location of piles both within the bent transversely and from bent to bent longitudinally. This can be done using a tape for short distances, but for longer distances a distance meter may be used.

It will not be possible to locate bents in the middle of waterways by using an offset line. To locate a bent in a waterway, measurements are taken from the bent closest to shore to the plan location of the pile. These measurements are usually done during pile driving operations.

DISTANCE METER

A distance meter is an electronic device that measures distance with extreme accuracy by monitoring the frequency and amplitude of infrared light waves that are reflected by a prism target.

2-26. a

2-27. b

2-28. b

2-29. b

VERTICAL CONTROL

Grade control for bridges is based on permanent bench marks established far enough from the project not to be disturbed by construction activity. The bench marks might be an iron rod or a concrete pillar set securely into the ground.

While other bench marks may be established as control points for the structure, their elevations should all be referenced to permanent bench marks.

REVIEW QUESTIONS

Circle the letter next to the correct answer(s). Some questions in this section may have more than one answer.

2-23. For which of the following would the Project Engineer receive shop drawings?

a. falsework
b. concrete beams
c. steel erection
d. deck panels
e. all of the above

2-24. Which of the following books will generally not be required for a bridge project?

a. Standard Specifications
b. Supplemental Specifications
c. NADA Blue Book
d. Approved Contract

2-25. The ____________________ are the document from which the structure will be built.

a. plans
b. specifications
c. shop drawings
d. all of the above

2-13. Rejected

2-14. Operation, Safety

2-15. Hammers, Cranes

2-35. d

2-36. a

2-37. c

2-38. b

2-26. The elevations are recalculated by proceeding point by point through the ________________ elevations of the bridge.

a. critical
b. original
c. finished grade
d. gutterline elevation

2-27. Subtracting the thickness of the deck slab, girder and coping, and bearing pad from finish grade elevation would provide the elevation at which of the following points?

a. top of riser
b. top of cap
c. pile cut off
d. tip elevation

2-28. Which of the following procedures should be followed in correcting an error in elevation found on the plans?

a. Completely mark out the original figure on the plans so that it cannot be read by mistake and write in the corrected elevation.
b. Mark out the original figure on the plans, but leave it legible and write in the corrected elevation.
c. Make no corrections on the plans, but note the corrections in the proper field books.
d. None of the above

2-29. The estimated quantities for each type of reinforcing steel for a structure will be found in which of the following?

a. Standard Specifications
b. Plans
c. Materials Sampling Manual
d. Project Sampling Plan

2-30. Which of the following should be checked as soon as the reinforcing steel is delivered to the jobsite?

a. Correct amount of each type and size as per plans
b. Lengths and bends are within specification tolerances
c. Clearance, height, and plastic tips of chairs conform to specifications
d. all of the above

2-31. Which of the following is the schedule outlining the minimal sampling and testing frequency for all materials used on a specific project?

a. Materials Sampling Manual
b. Estimated Quantities Table
c. Sampling Plan
d. 2059 Review

2-32. The minimal sampling frequency by section and material is delineated by which of th following?

a. Standard Specifications
b. Construction Manual
c. Materials Sampling Manual
d. Project Contract

2-33. For which of the following reasons are preliminary equipment inspections conducted?

a. proper operation
b. safety features
c. adequate size to perform work
d. all of the above

2-34. Horizontal alignment control would include staking of ________________.

a. each bent location
b. each test pile location
c. each abutment location
d. all of the above

2-23. e

2-24. c

2-25. a

3-3. F

3-4. The type of piling to be driven

3-5. Energy Rating

2-35. Which of the following information is necessary on an offset stake for a bridge layout?

a. station location
b. offset distance
c. bent number
d. all of the above

2-36. To minimize errors in transit sighting, when a double system of offsets is used on each side of the bridge, the stakes should be placed approximately _____________ feet apart?

a. 50
b. 23
c. 10
d. 99

2-37. Which of the following would make a good permanent bench mark for a bridge project?

a. 60d nail in a chicken tree
b. guard rail post adjacent to an existing bridge
c. concrete pillar or iron rod embedded in natural ground
d. hub and tack on offset line

2-38. Sketches of both vertical and horizontal layout control should be provided by which of the following?

a. Inspector
b. Contractor
c. Steel Supplier
d. Area Engineer

CHAPTER III: PILE DRIVING OPERATIONS

BORING DATA

The minimum tip elevations shown on the plans and the Plan Driving objective are derived from test borings made at the site during the bridge foundation investigation.

A copy of the Bridge Foundation Investigation (BFI) is used in constructing foundations, especially when driving pile. The Plan Driving Objective, or P. D. O., should be followed precisely.

A typical P. D. O. may be as follows:

a) 55 tons bearing after a minimum tip elevation of 510.5 is achieved

or

b) 70 tons bearing after at least 15 feet of penetration is achieved

or

c) 90 tons bearing after a minimum tip elevation of 45 is achieved

The boring report included in the BFI shows the type of soil through which the pile can be expected to pass at a given elevation. The date and exact location of the boring are written at the top of the report.

Before driving either test or permanent piles, the conditions of underlying soil strata on the boring report should be checked to determine how the pile will drive or if special equipment will be required.

Fill in the blanks.

3-1 The type of soil through which a pile will pass at a given elevation can be found in the ______________________ in the Bridge Foundation Investigation.

3-2 Before driving piling, the boring report should be checked to determine ___________________________ or if _______________________________.

2-30. d

2-31. c

2-32. c

2-33. d

2-34. d

HAMMERS

There are four basic types of hammers that can be used to drive piling- steam, diesel, compressed air and gravity.

Gravity hammers are permitted for timber piles only. Steam, diesel or compressed air hammers may be used on timber, concrete, and steel piling.

More details about specific hammers and blow counts can be found in the Department's Bridge, Culvert, and Retaining Wall Construction Manual.

3-10. T

Circle T (True) or F (False)

3-3 T F Steam, air, diesel, and gravity hammers can all be used for any type of piling.

3-11. T

Before pile driving operations begin, the hammer must be inspected for proper working order and to be certain it is of adequate size for the type of piling to be driven. The contractor must provide the Inspector with the manufacturer's specifications for the hammer.

3-12. T

The Inspector should be certain that no modifications have been made to the hammer and should also check that the energy will not exceed the energy rating, which can be applied to the piling.

3-13. F

Weight and energy development for hammers applied to each pile type (timber, concrete, steel) are given in the pile driving chart supplied by the contractor and may be listed in the Bridge Manual.

Fill in the blanks.

3-4 Prior to beginning pile driving operations, the hammer must be inspected for proper working order and to be certain it is of adequate size for ___________________________.

3-5 The Inspector must check that the energy developed by the hammer does not exceed the _______________________ which can be applied to the piling.

3-6 Weight and energy development for hammers applied to specific pile types are found in the ________________________________.

PILE TYPES

There are several types of pile that are used in bridge construction.

These include: Metal Shell
Timber
Steel "H"
Pre-Stressed Concrete

METAL SHELL PILES

There are several types of cast-in-place concrete piles, including metal shells and steel pipe pile. These types of pile are driven closed end and filled with concrete. Another type of metal shell pile is called fluted steel shell pile. This type of pile is step tapered.

Metal shells are accepted by visual inspection before filling them with concrete.

Shell type piles have a high friction bearing and are often used in soils which have low bearing values, such as silt and clay.

Circle T (True) or F (False).

3-7 T F Shell type piles may be step-tapered.

3-8 T F Metal shell piles are often used in silt or clay.

3-9 T F Metal shell piles are filled with clean dirt after driving is completed.

3-1. Boring Report

3-2. How the pile will drive special equipment will be required

3-20. Footings, Bent

3-21. Delivery

3-22. Acceptance, Damage

3-23. Size, Type

3-24. Project Engineer

3-25. Puffs of white dust

TIMBER PILE

Timber piling for permanent structures must be pressure treated. Standard driving methods are used for timber piling; however, the top of the pile must be protected from direct hammer blows by a "follow block". The top of the timber pile should be cut and shaped to fit inside the block.

Timber piles are generally used as an alternate to other types of piling when the entire pile will be underground, as in footings, and when the borings indicate fairly soft soils. Timber piles are usually used for temporary detour bridges.

All timber piling must be stamped as acceptable to DOT specifications prior to incorporation into a structure. The DOT stamp and inspector's number will be found on the end of all approved piling.

Circle T (True) or F (False).

3-10	T	F	The top of timber piling must be protected during driving operations.
3-11	T	F	The top of a timber pile should be cut and shaped to fit inside the follow block.
3-12	T	F	The DOT stamp and inspector's number will be found on piling that meets Department Specifications.
3-13	T	F	Timber piles are often used in lieu of concrete piles.

STEEL PILING

Steel piles are usually H-beam shapes and are used for footing piles and pile bents.

Steel piles are often used when the bearing strata to be reached is rock or when the pile is to be driven through boulders or dense soil.

When a steel H-Beam pile is loaded, it should be laterally supported if the pile extends 15 feet or more above ground. Lateral support is need, because the stress of loading could cause the pile to bend.

Steel piles are able to absorb high driving forces. They can also be used for driving through dense materials such as shale or tight sands.

Fill in the blanks.

3-14 Steel piles are usually standard _________________________ shapes.

3-15 Steel piles are primarily used as _________________ piles.

3-16 Steel piles are able to absorb ______________________ forces.

3-17 Steel piles are often used when the bearing strata to be reached are ___________________________.

3-18 Because steel piles are able to absorb high driving forces, they can be used to drive through ____________________________ soils.

3-19 ______________________ piles should be supported laterally during loading operations, so that the stress of loading does not cause the pile to bend.

PRE-STRESSED CONCRETE PILES

Pre-stressed concrete piles are used for both footings and as bent piles.

Pre-stressed concrete piles are formed at a central manufacturing point. The steel tendons inside the piling are stressed to the proper tension during casting. All prestressed concrete piles are inspected, approved, and stamped prior to delivery to the jobsite.

The Inspector will receive a copy of the Certificate of Delivery with the piles. The piles must then be inspected for acceptance stamp and possible damage from shipping, including spalls and hairline cracks. They must also be checked to be certain they are the correct size and type called for by the plans, and that the piles correspond to the information on the Certificate of Delivery.

3-6. Pile driving chart supplied by the Contractor

3-7. T

3-8. T

3-9. F

3-34. Allows gas to escape from inside the pile

3-35. Test

3-36. Plans

3-37. Permanent

Spalls which do not structurally affect the member may be patched if the patching is approved by the Project Engineer. However, no patching shall be allowed within the stress area at the ends of the piles.

Pre-stressed concrete piles sometimes crack during driving. If puffs of white dust are seen coming from the pile during driving, that area should be carefully checked for damage.

If a prestressed concrete pile is slightly damaged during driving, it may be repaired. Other times however, the pile must be cut off and spliced or rejected. The Construction Office should be consulted regarding all damaged piles.

Extreme care must be exercised in handling pre-stressed piling. At no time shall a precast concrete pile be dragged along the ground or placed on the ground without proper support.

Fill in the blanks.

3-20 Pre-stressed concrete piles can be used for _______________ and/or ___________________ piles.

3-21 The Inspector will receive a copy of the Certificate of __________________________ for all pre-stressed piling.

3-22 The piles must be checked for _________________________ stamping and possible shipping _____________________________.

3-23 Piles received at the jobsite must be checked against the plans for correct _______________________ and __________________________.

3-24 Some spalls may be patched if the ____________________________ approves.

3-25 An indication that a pre-stressed concrete pile has cracked during driving would be _______________________ being emitted from the pile.

Note that the wooden blocks (called dunnage) are placed at designated points beneath each pile. The support points are clearly marked on each pile at the manufacturing site. Specifications allow the dunnage to be placed within approximately 1 foot of the marked pick up points; however, the blocks must be placed in a straight vertical line. Improper placement of the dunnage can cause damage to the piling.

Piling must also be supported at the pick up points during transport.

The support points marked on pre-stressed piling are also the designated pick-up points for the pilings. The plans will indicate by piling size and length whether two point pick-ups are required or if one point pick-ups can be used.

Most pre-stressed piling will be fitted with metal handling hooks at the designated pick-up points. The hooks should be used as much as possible when handling piles.

These handling hooks must be cut off before the pile is driven. They should be cut with a torch approximately ½" to 1" beneath the surface of the concrete. The area must then be filled with cement grout.

After the hooks have been removed, the precast piling should be handled by a sling to avoid overstressing the pile.

Circle T (True) or F (False)

3-26 T F Prestressed concrete piling should be laid flat on the ground whenever it is stockpiled at a jobsite.

3-27 T F Wooden blocks or other cushions should always be used to support pre-stressed concrete piles.

3-28 T F Support points are always located 1 foot from either end of a precast pile.

3-29 T F Improper placement of dunnage can cause damage to the piling.

3-30 T F The plans will designate if one point pick-ups are permissible for a specific pile.

3-31 T F Metal handling hooks on precast concrete piling must be cut ½" to 1" below the surface prior to driving.

3-32 T F Following removal of handling hooks, the holes left in the pile must be filled with portland cement concrete of the same mix design as that used in the original pile.

3-33 T F Once the handling hooks have been removed, pre-stressed piling should be handled by a sling to prevent over-stressed pile.

3-14. H-beam

3-15. Footing

3-16. High Driving

3-17. Rock

3-18. Dense

3-19. Steel Piles

Pre-stressed concrete piles can be either solid or hollow. When hollow piles are being driven, care must be taken that the vent holes not be blocked or cut off. Blocking the vent holes allows gas to accumulate in the pile and can result in an explosion.

Answer the following question.

3-34 What purpose do vent holes serve in hollow concrete piles?

3-43. Elastic Deformation

TEST PILES

The purpose of driving a test pile is to establish that the deep borings, on which pile data are based, represent the true soil profile and the necessary tip elevation to support design load.

3-44. T

Generally test piles are driven prior to other operations. The locations of test piles are included on the plans and have been chosen based on bent locations and the configuration of the underlying soil strata as indicated by boring reports.

3-45. F

Before driving test piles, the contractor's equipment should be inspected to insure that it meets the specifications for the intended piling. The Standard Specifications require that test piles be driven using the same type of hammer, the same energy, methods and procedures that will be used for permanent piles.

3-46. T

Based on the results of test pile operations, the Project Engineer will set the lengths of piles to be used for the entire project.

3-47. T

Fill in the blanks.

3-35 To check the accuracy of boring reports a _________________ pile is driven.

3-36 Locations of test piles are usually found in the __________________________.

3-37 Test piles are driven using the same energy, methods, and procedures that will be used for __________________________ piles.

All test piles should be driven their full length as shown in the plans.

If a test pile cannot be driven full length without possible damage to the pile, the Geotechnical Bureau or Construction Office should be consulted for recommendations.

Circumstances which could cause a pile not to reach plan tip elevation are the encountering of unexpected underground obstructions or soil strata that differ from those indicated on the boring report.

3-38 T F When a test pile is not driven full length, the Geotechnical Bureau should be consulted.

3-39 T F There are no circumstances that would cause the driving of a test pile to be stopped before tip elevation is reached.

The procedure for loading test piles is detailed in Subsection 520.03 D.2. of the Standard Specifications.

When a pile is loaded, the weight on the pile causes the pile to penetrate further into the earth. This is referred to as settlement. When the load is removed, the pile will again rise somewhat; this rising is termed rebound.

The weight applied to the pile during loading also causes the pile to compress, becoming slightly shorter and thicker than under normal conditions. This compression is known as the elastic deformation of the pile.

The amount of rebound that a pile exhibits when the load is removed is a combination of both a rise in elevation (due to elastic characteristics of the soil) and the return of the pile to its previous dimensions (due to the elasticity of the pile).

Fill in the blanks.

3-40 Approved methods and procedures for loading a test pile are outlined in the ______________________________.

3-41 The additional penetration of the pile into the earth during loading operations is known as ____________________________________.

3-42 The rising of the pile when the load is removed is called _____________________________.

3-26. F

3-27. T

3-28. F

3-29. T

3-30. T

3-31. T

3-32. F

3-33. T

3-43 The compression of the pile during loading is known as the ________________________ of the pile.

PERMANENT PILES

Permanent piles are piles which actually support the permanent structure.

Actual driving operations are essentially the same for both test piles and permanent piles. Hence, the procedures discussed in this section can basically be applied to test piles as well. Alignment control is more critical for permanent piles.

Two important criteria to observe during pile driving operations are the location of the pile and number of blows needed to drive the pile each foot into the ground. It is from the amount of penetration per blow that bearing capacity is calculated.

Piling must be held perpendicular to the horizontal plane (unless it is a battered pile), while it is being driven. There are several methods that can be used to hold the pile straight during driving operations. One means is to set the pile within a template that is strong enough to hold the pile in place.

When piles are driven in water, a rigid template will be attached to a barge or driven temporary piling and the proper location for each pile determined by use of surveying methods.

If a barge template is used, the barge is then securely anchored into the stream bed until all the pile have been driven.

Circle T (True) or F (False).

3-44 T F Pile location and blow count are the most important basic criteria to be observed during driving operations.

3-45 T F Bearing capacity is calculated from blow count.

3-46 T F A strong, rigid template can be used to hold the pile in place during driving.

3-47 T F The template can be affixed to a securely anchored barge when piles must be driven in midstream.

3-50. T

3-51. F

3-52. T

3-53. Jetting

3-54. On each side of the pile

3-55. Project Engineer

Even though rigid templates or leads must be used to insure that the pile is held in place and is properly aligned, its plumbness must be checked regularly during the driving process.

All piles should be placed as close as possible to the theoretical location. The Standard Specifications provide location tolerances for pile placement.

For tolerances for driving check the Specifications, Section 520.03.C.6

This section says: "Tolerance for Driving: Piling shall be driven to reasonable close conformity with the position shown on the Plans. Deviation in excess of 3 inches shall be corrected as directed."

No attempt should be made to pull piles which are out of tolerance back into position. The Project Engineer should submit a sketch of the actual and theoretical locations to the General Office Construction section, so that a determination of redesign can be made.

Another check on pile location which can be made during driving is to set reference points to the centerline and the edge of the pile and sight the edge of the pile with an instrument while it is being driven. If the pile edge does not remain in perfect alignment throughout driving, the Inspector will know that the pile has moved out of its intended location.

Answer the following questions.

3-48 How do you ascertain that a pile is being held perpendicular throughout driving operations?

3-49 What procedure should be followed if the final location of a permanent pile is not within tolerance?

During driving operations, adequate cushion material must be placed between the driving cap and the head of the pile in order to reduce stress on the pile.
The driving cap should fit loosely over the pile head and allow for a small amount of movement in order to prevent damage to the pile head.

Diesel hammers must be fitted with a gauge (generally a range pole), marked clearly in ½ foot increments so that observers can accurately measure the rebound of the hammer after it strikes the pile.

3-38. T

3-39. F

3-40. Standard Specifications

3-41. Settlement

3-42. Rebound

Circle T (True) or F (False).

3-50 T F Cushioning material must be placed between the driving cap and the head of the pile.

3-51 T F The driving cap should fit snugly over the pile head.

3-52 T F A range pole can be used to measure hammer rebound on diesel hammers.

Jetting Piles

When piles must be driven through extremely dense granular materials and it is not possible to drive the pile successfully to tip elevation without possible damage to the pile, it may be necessary to jet the pile.

3-58. d

Jetting a pile means using water at high pressure through long nozzles to soften the soil next to the pile location.

Jetting operations can be performed simultaneously with driving operations or they can precede actual driving. If the location is prejetted, only one nozzle (jet) is needed. However, if piles are jetted during driving operations, two nozzles with one placed on each side of the pile are used. The jetting must be done on each side of the pile equally to prevent the pile from moving out of position laterally.

3-59. b

Care must be exercised when jetting piles to be certain that the pile achieves bearing. Only under special circumstances and with authorization from the Project Engineer, can jetting operations be continued within the last 5 feet of tip elevation.

3-60. a

Jetting operations cannot be used where the water might undermine the integrity of an embankment.

Fill in the blanks.

3-53 Using water at high pressure to soften soil surrounding the location of a pile is called ______________________.

3-54 When piles are jetted simultaneously with driving operations, a jet must be placed _________________________.

3-55 For jetting operations to continue within 5 feet of tip elevation, permission must be granted by the ________________________.

PILOT HOLES

Occasionally, the hole into which the pile will be placed must be bored before the pile can be driven.

Piles are usually bored through embankments, so that driving does not begin until the pile is resting on natural ground. This prevents the pile from developing skin friction from embankment soils and increasing the blow count. Predrilling can also prevent damage to the pile by reducing hard driving through the densely compacted embankment.

When pilot holes are drilled, the maximum diameter of the holes will be the dimension of the pile diameter or as shown in the plans.

Fill in the blanks.

3-56 Pilot holes for piles are generally bored through ________________________________.

3-57 In general, the maximum diameter of the pilot hole will be the same dimension as the pile's ________________________________.

DETERMINATION OF BEARING CAPACITY

To determine the bearing capacity of a permanent pile, the amount of penetration achieved in 10 blows is recorded. The recorder marks the pile, counts ten blows, and marks the pile again. The distance between the marks is inserted into bearing charts for the pile hammer being used which have been developed from formulas provided in the Standard Specifications. Pile hammer manufacture's bearing charts may not be used unless they agree with the applicable formulas for Standard Specification 520.03.0.

DOCUMENTATION

It is extremely important that detailed records of all pile driving operations be maintained in field books, which are prepared before any pile driving activity begins. Areas of pile driving, which must be documented, are:

Blow counts and Load Bearing
Date and Time of Driving
Tip and Cut Off Elevations
Pile Placement (Location)
Gross Pile Length
Net Pay Length
As Built Plan Sheet
Data Pile
Test Pile
Jetting
Boring Pilot Holes
Splicing and Buildup
Extensions and Cutbacks

3-66. d

The Area Engineer can furnish examples of field books set up for pile driving operations. Blow counts for the last 5 feet of driving must be recorded.

3-67. a

REVIEW QUESTIONS

Circle the letter next to the correct answer(s). Some questions in this section may have more than one answer.

3-68. a

3-58 On which of the following pile types is it permissible to use a gravity hammer?

a. pre-cast concrete
b. steel
c. steel pipe pile
d. timber

3-69. b

3-59 Which of the following pile types are step-tapered?

3-70. d

a. steel piles
b. fluted steel shell pile
c. steel pipe pile
d. precast concrete

3-60 Which of the following is a characteristic of steel piling?

a. often used to reach deep lying bearing strata
b. must be creosote treated
c. puff of white dust indicates cracks during driving
d. stamped with DOT inspector's stamp

3-61 Which of the following will the project engineer receive with precast concrete piles?

a. Certificate of Analysis
b. Certificate of Compliance
c. Certificate of Delivery

3-62 Dunnage must be placed beneath precast piles in accordance with which of the following?

a. 1 foot of either end
b. 1 foot of marked pick up points
c. 1 foot either side of center
d. 1 foot either side of handling hooks

3-63 A pile's further penetration into the ground upon loading is termed _____________________.

a. rebound
b. driving
c. elastic deformation
d. settlement

3-64 A pile's rising somewhat in elevation when loading forces are removed is termed _____________________.

a. rebound
b. driving
c. elastic deformation
d. settlement

3-65 A pile's actual compression due to loading forces is known as

a. rebound
b. driving
c. elastic deformation
d. settlement

3-56. Embankments

3-57. Diameter

4-4. T

4-5. F

4-6. T

3-66 Templates are used during driving to accomplish which of the following?

a. proper alignment of pile
b. proper location of pile
c. that pile remains perpendicular during driving
d. all of the above

3-67 A range pole is affixed to a hammer during driving to measure ___________________________.

a. hammer rebound
b. penetration per blow
c. tip elevation
d. all of the above

3-68 Using water at high pressure to soften the ground next to the pile location is known as ___________________________.

a. jetting
b. boring
c. driving
d. none of the above

3-69 The usual method for getting piles through an embankment fill is ___________________.

a. jetting
b. boring
c. driving
d. none of the above

3-70 A field book for pile driving should include which of the following? (3-112)

a. Blow Count and Load Bearing
b. Tip and Cut Off Elevations
c. Pile Location
d. all of the above

CHAPTER IV: STRUCTURAL PREPARATION

FORMS AND FALSEWORK

To ensure that concrete will harden in the correct shape, it must be placed in a temporary structure or mold until it is strong enough to be self-supporting.
These molds are known as forms.

Forms and other parts of a bridge or other concrete structures must often be supported during construction activities. These temporary supports and braces are know as falsework.

3-61. c

FORMS GENERAL INFORMATION

3-62. b

Forms for concrete structures must be built in such a way that they can be easily dismantled after the concrete has set without causing damage to the still green concrete. However, they must still be strong and rigid enough to retain the freshly poured concrete in the proper shape until it has attained sufficient strength to support itself.

3-63. d

The form designs for bridge caps and decks must be given to the Inspector by the contractor well in advance of any actual field construction. When required, these designs must be approved by the Bridge Office and should be submitted to them at least two weeks prior to planned field activities. *See Standards and Supplemental Specifications.

3-64. a

Forms can be made of different types of materials. Although plywood is the most commonly used, metal and precast concrete are preferred in some situations.

3-65. c

Fill in the blanks.

4-1 Forms must be built so that after the concrete has set, they can be easily _____________________ without damage to the concrete.

4-2 Form designs for bridge _______________ and _______________ must be submitted to the Inspector well in advance of actual field construction.

4-3 Three materials, which can be used for forms, are __________________________, _____________________, and ________________________.

4-14. T

4-15. T

4-16. T

4-17. Oil or a form Release Agent

4-18. Steel, Girders

4-19.
Shape
Strength Retention
Surface Smoothness

Once forms are put together, the Inspector must be certain that their construction conforms to the approved designs.

Forms must also be checked to ensure that they are of the correct dimensions, that they are aligned properly, and that they are at the proper elevations. Forms for identical parts of a structure must be uniform.

To be certain that forms will be strong enough to retain their shape when filled with concrete, bracing may be necessary. When forms are braced, the braces should be inspected to be certain that they are placed properly to provide support at critical area, as well as being strong enough to furnish overall support for the forms.

When checking dimensions and grade on forms made of compressible materials such as wood, the Inspector must allow for the amount of deformation or settlement that will occur in the form when the weight of the concrete is placed in it. This is especially true for deck forms made of plywood or timber forms. Not only will these materials compress and settle under the weight of the concrete, but there may be minute voids between the layers of wooden forms which will fill with concrete or grout, compressing the forms further, and causing final grade or dimensions to vary from that of the unfilled form.

(See Bridge Culvert and Retaining Wall Construction Manual)

The amount of variance in grade or dimensions caused by this type of settlement is very small. Even this difference can be significant. In situations where form deflection under the concrete load can be expected, if the forms are set exactly to grade, the final grade will be low. If too much adjustment is built into the forms, either the final grade will be too high, or the slab will not be thick enough. Because of the importance of correctly estimating form deflection under load, decisions regarding allowances for settlement should be made jointly between the engineering staff and the contractor. The Inspector should consult the Project Engineer regarding settlement or dimensional allowances.

Circle T (True) or F (False).

4-4	T	F	Forms, once constructed, must be checked for conformance to approved designs.
4-5	T	F	Elevations or grade need not be checked on most forms.
4-6	T	F	The weight of the concrete can cause forms made of compressible materials, such as wood, to settle or deflect.

4-7 T F Plywood deck forms can be expected to compress and settle under a concrete load.

4-8 T F The amount of settlement that will occur in forms is usually small.

4-9 T F In decks where forms can be expected to settle when concrete is added, if the forms are set to exact grade, final deck grade will be too high.

4-10 T F Over compensation for form deflection in deck pours can cause problems with deck thickness.

Sometimes a miscalculation of the amount of settlement does not become apparent until during or after the initial pour when the deck's final grade or slab thickness is checked.

In this situation, adjustments may not be possible in the areas of the initial pour. The Project Engineer should be consulted to determine if any corrections are possible. The reason for the discrepancy should be isolated and adjustments made in forming for future pours.

Allowances for settlement must also be made when falsework is placed for support of forms during concrete pours. These allowances should be incorporated into the drawings of falsework submitted for approval.

All falsework used to support concrete forms must remain undisturbed until the concrete has cured sufficiently.

Circle T (True) of F (False).

4-11 T F If a discrepancy is found between the amount of settlement allowed in form structure and actual settlement during the initial pour, the pour should be stopped and adjustments made.

4-12 T F Allowances for settlement should also be incorporated into falsework used to support forms for concrete pours.

4-13 T F Falsework used to support forms can be removed as soon as the pour is com pleted.

It is important when building with portland cement concrete that exterior corners which form right angles be chamfered. The sharp edge formed by a right angle will prohibit any aggregate from being included in this area.

4-1. Dismantled

4-2. Caps, Decks

4-3. Plywood, Metal, Precast Concrete

4-20. Slings

4-21. Should not

4-22. In the same direction as

4-23. The same as

4-24. Handling Hooks

4-25. 4

4-26. 1 foot

Hence, that area of the structure would be a mixture of only cement and water and would be very weak.

To chamfer the corner of a form, place a triangular insert in the inside angle of the corner.

Circle T (True) or F (False).

4-14 T F Right angle corners in portland cement concrete cause a weak area because no aggregate is incorporated in the sharp angle.

4-15 T F All corners of forms used for structural portland cement concrete must be chamfered.

4-16 T F Chamfer strips are triangular in shape.

Except in the case of certain types of deck forms, which are designed to remain permanently in place, forms must be coated with oil or a form release agent after inspection. This coating will prevent the fresh concrete from adhering to the forms. The forms must be oiled prior to steel placement and care must be exercised not to get oil or form release agents on any steel or girders.

Forms may be re-used. However, any forms which are to be used more than once must be re-inspected to be certain that they are in acceptable condition. Forms must be checked for shape and strength retention, rigidity, water tightness, and surface smoothness. Forms which do not pass inspection on these points or which have been damaged in any way, may not be re-used.

Fill in the blanks.

4-17 Forms must be coated with ____ to prevent their bonding to the fresh concrete.

4-18 Oil must not be allowed to come into contact with the _________________________ or _____________________.

4-19 Three characteristics to be checked on forms which are to be re-used are:

____

____

____

PRECAST CONCRETE FORMS

Precast concrete forms must have the same care in handling as other precast structural members. These forms can be handled in stacks, supported by a sling. When precast deck forms are being handled in this way, a cushion of some sort, such as a rubber hose, should be used around the metal cable to prevent damage to the bottom slab.

Precast deck forms are also pre-stressed. Therefore, it is important when precast forms are being handled by a sling that the sling be placed parallel to the stress. The direction of the stress will be the same as the ribs (corrugations or rough tine finish).

Whenever these deck forms are handled individually, as during placement on girders, they should be lifted by the handling hooks embedded in the concrete for this purpose.

During storage or stockpiling, a minimum of four wooden blocks must be placed between each unit, within 1 foot of the edge of the panel. When units are transported by truck, additional support, such as longer lengths of wood, may be necessary to protect the members from damage.

4-7. T

4-8. T

4-9. F

4-10. T

4-11. F

4-12. T

4-13. F

4-27. F

4-28. T

4-29. F

4-30. T

4-31. F

Circle the correct words.

4-20 When precast deck forms are handled in stacks (handling hooks / slings) should be used.

4-21 A metal cable used as a sling to handle precast deck forms (should / should not) rest directly against the bottom form.

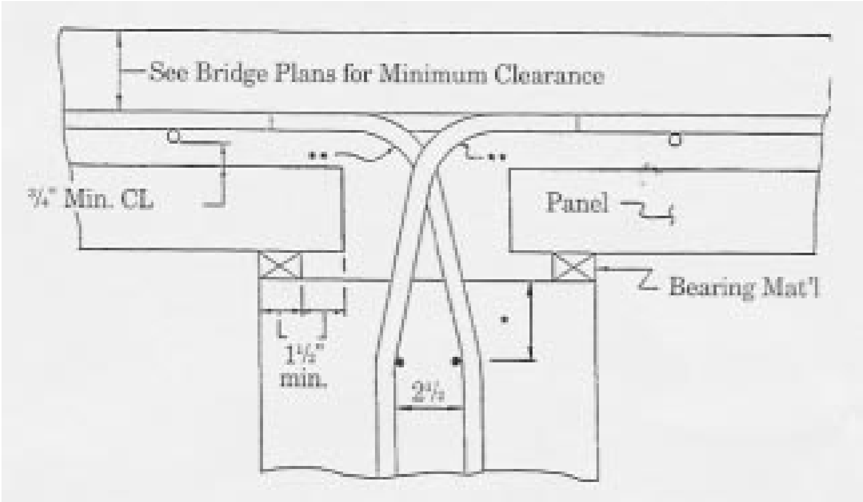
4-22 When precast, pre-stressed deck forms are handled by a sling, the cable should run (perpendicular to / in the same direction as) the stress.

4-23 The direction of the stress in a precast deck form will be (the same as / perpendicular to) the ribs.

4-24 When precast deck forms are handled individually (handling hooks / slings) should be used.

4-25 During storage or stockpiling, at least (4 / 2) wooded blocks must be placed between each unit.

4-26 The support blocks between stored precast deck forms must be placed within (1 foot/2 foot) of the edge of the form.



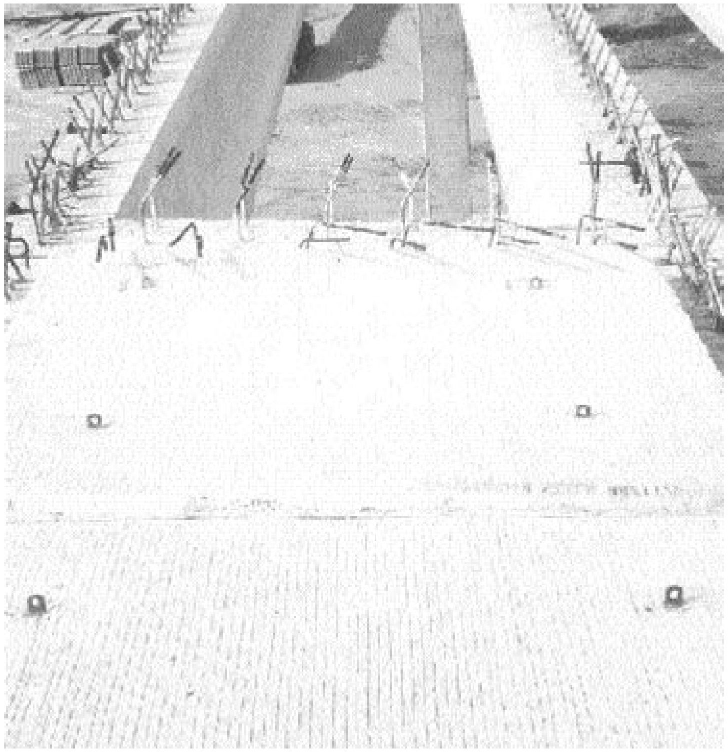
Prestressed concrete deck panels shall have a minimal bearing length of 1 ½ inches except as noted below. Panels shall overhang the bearing material by 1 ½ inches minimum. Panels shall be supported on the beams and end diaphragms by continuous layers of an approved mastic, fiber board or felt bearing material.

NOTE: See Special Provision 500.08F for type V beams.

Precast Concrete Deck Panels

Prior to the placement of precast concrete deck forms, a pad of fiber bearing material is set on the girder in the area on which the precast form will rest. This fiber pad is used to shim the form and to adjust the grade of the concrete deck forms. The thickness of the fiber material will be varied in order to ensure that the forms are at the correct grade. Thickness of the fiber material will be 1 inch minimum and 3 inch maximum.

Unlike wooden forms, precast concrete forms are not removed once the concrete deck has hardened. These forms remain in place as part of the deck's support structure. The roughened surface of the forms aids in bonding the poured deck to the precast panels.



4-37. F

4-38. T

4-39. T

4-40. F

4-41. T

Circle T (True) or F (False).

4-27 T F Precast concrete deck forms rest on the edges of the girders.

4-28 T F The amount of girder/form overlap will be shown on the plans.

4-29 T F Wooden shims are used between the girder and the precast deck forms to adjust the grade of the forms.

4-30 T F Precast concrete deck forms are not removed when the deck slab has hardened.

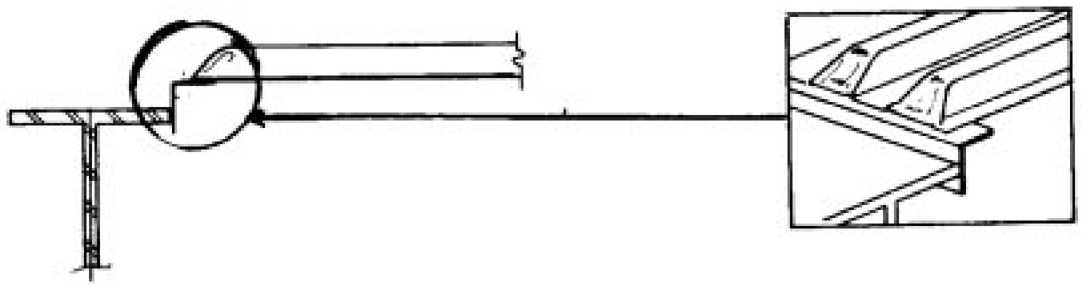
4-31 T F The roughened surface of the precast forms prevents the deck slab from bond ing to the form for easy removal.

CORRUGATED METAL FORMS

Another type of deck form that remains in place after the poured concrete has set is made of corrugated steel.

Unlike precast concrete panels, corrugated steel panels do not add to the structural strength of the deck. The re-steel will be placed on them in the same manner as it is for wooden deck forms. However, since the forms are not to be removed, they are never oiled prior to steel or concrete placement.

Unlike precast concrete deck forms, corrugated steel forms are designed to rest on steel angles which are attached to the top flange of the beams. Attachment of metal decking to beams is to be as shown on approved shop drawings.



The steel forms are designed to sit flush on the steel angles, tightly enough to prevent grout from the poured concrete from seeping through to the girder below. There is no need for fiber bearing material between the steel angle and the forms.

Circle T (True) or F (False).

4-32	T	F	Corrugated steel deck forms are designed for removal when the poured slab has set.
4-33	T	F	Corrugated steel deck forms become an integral part of the deck slab and add to its structural strength.
4-34	T	F	Corrugated steel deck forms are not oiled prior to steel or concrete placement.
4-35	T	F	Corrugated steel forms rest on steel angles.
4-36	T	F	Corrugated steel forms are designed to sit flush on the steel angles to help prevent grout seepage.

REINFORCING STEEL

Construction procedures and inspection of reinforcing steel are based on bridge deck operations. These procedures are essentially the same for all cast-in-place concrete structural members.

Whenever footing, columns, caps, barrier rails, etc., are to be poured, similar diagrams and tables will be provided for reinforcing steel layouts and quantities. These schematics and tables should also be checked for correctness.

4-44. T

Immediately prior to the placement of reinforcing steel into any area of a structure, the Inspector must visually inspect the steel. All steel incorporated into the structure must be clean and free of excessive rust or other deleterious material which could interfere with the concrete's bonding to the steel.

4-45. T

Information regarding steel layout in the form of charts and/or diagrams will be provided in the plans. The actual spacing, layout, and amount of Re-Bar utilized must be as delineated on the plans.

4-46. F

Some steel manufacturers provide shop drawings for the placement of the steel to be used in the bridge deck. The Inspector should compare these shop drawings to the Standard Specifications and special provisions to assure compliance.

4-47. T

Not all sets of plans identify bar types and quantities in the same manner. Therefore it is important to pay careful attention to the plans for a specific structure.

Circle T (True) or F (False).

4-48. F

4-37	T	F	Steel should be visually inspected when it is first delivered to the jobsite.
4-38	T	F	Any steel to be used in the structure must be clean so that it will bond to the concrete.
4-39	T	F	The actual spacing, layout, and amount of re-steel to be used in a structure will be delineated in the plans.
4-40	T	F	Charts showing design calculated quantities of reinforcing steel are included in the plans for pay purposes.
4-41	T	F	Plans should be checked to make sure that the estimated quantities of steel agree with the layout shown on the plans.

4-49. T

Whenever reinforcing steel or Re-Bar is placed, the Inspector must check that the bars are laid out in accordance with the plan design. The proper size bars must be at the same height, spacing, and location as shown in the plan layout.

The spacing of Re-Bar is given as "center to center" of bar. "Center to center" means that the distance indicated is measured from the center of one bar to the center of the next.

Information regarding spacing and height of Re-Bar is provided in the plans.
Fill in the blanks.

4-42 Re-bars must be at the same ____________________, _______________________, and _______________________ as shown in the plans.

4-43 When bar spacing is measured from the center of one bar to the center of the next, bars spacing is said to be ______________________________.

REINFORCEMENT SUPPORT

Since Re-Bar must be a specified distance from both the top and bottom of the finished concrete, it must be held securely in place.

The steel bars are placed on chairs, holders specially designed to keep the steel in place within the concrete at the dimensions shown on the plans, all directions considered.

Chairs are made of small steel bars, with a seat indented to hold the re-bars in place. Some chairs have plastic tips on the ends of the feet. The feet of the chairs rest directly on the forms. After the forms are removed the tips are exposed in the surface of the concrete. The plastic tips prevent the chairs from rusting from exposure to weather; therefore, it is important that the Inspector ascertain that all plastic tips are on the chair feet and are not cracked or broken. Plastic tips must be cast, not pressed on or they must be galvanized or epoxy coated.

Chairs come in varying sizes, heights and designs for their specific use in a structure. For the lower steel mat in a deck and the upper mat, the clearance is detailed on the plans.

Chairs are also used to support Re-Bar in caps, columns, or footings. They can also be turned sideways to support steel vertically in these areas.

4-32. F

4-33. F

4-34. T

4-35. T

4-36. T

Circle T (True) or F (False).

4-44 T F Chairs are holders specifically designed to keep Re-Bar at the proper level within the concrete.

4-45 T F The tips (feet) of chairs are exposed after the forms are removed.

4-46 T F The tips (feet) of the chairs are plastic coated to prevent the concrete from bonding to them.

4-47 T F Chairs can also be used to support Re-Bar vertically in columns, caps, and footings.

When reinforcing steel is placed in the bottoms of footings or box culverts, where no bottom forming is used, it is sometimes impractical to use chairs to hold the steel in place. The chairs would not balance properly on wet or uneven ground. Therefore, an alternate method of supporting the reinforcing steel must be devised.

Circle T (True) or F (False).

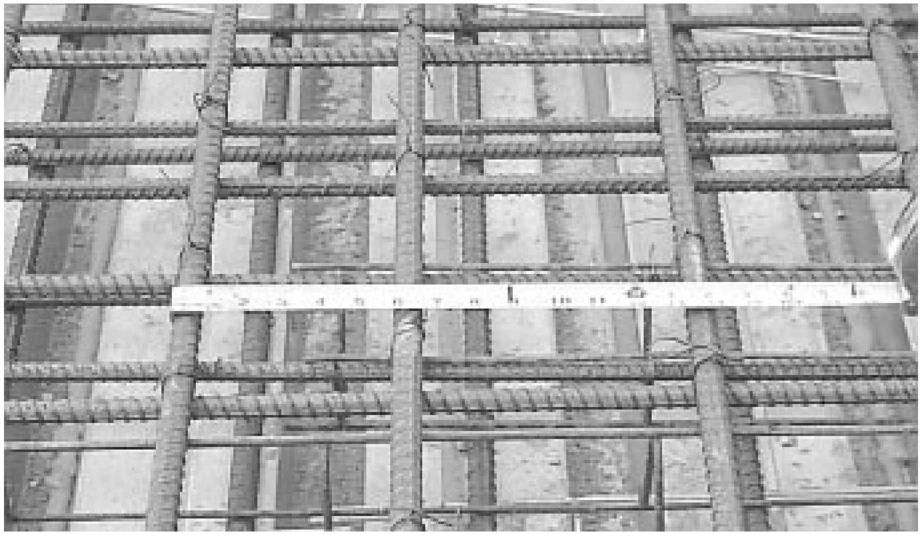
4-52. A splice

4-48 T F Chairs are always used to support re-bars in the bottom of footings or box culverts.

4-49 T F On wet or uneven ground, chairs may not balance properly; therefore, an alternate method may be needed to support re-steel.

TYING REINFORCING STEEL

In bridge decks there are often two mats of reinforcing steel. For each mat the re-bars are laid both longitudinally and transversely to the deck. All wire used for tying bar reinforcement steel shall be minimum diameter of No. 16 guage, black, soft iron wire. All bar ties shall be securely twisted a minimum of two full turns. Double bar ties may be required if single bar ties fail to securely maintain the position of the bar reinforcing steel under construction traffic.



Tied Reinforcing Steel Mats

The same requirements for tying re-bars must be adhered to in parts of the structures other than bridge decks, such as footings, caps, columns, barrier rails, and other cast-in-place structural elements.

Fill in the blanks.

4-50 In bridge decks re-bars must be laid both ________________________ and ____________________________ in each mat.

4-51 Re-bars must be tied with No. _____________ guage wire.

SPLICING REINFORCING STEEL

The Standard Specifications require that re-bars be furnished in the full lengths shown on the plans. However, re-bars must occasionally be spliced. Splices are often needed on long rows of re-steel.

Spliced means that two bars of Re-Bar are overlapped and tied securely together, so that the two act as one unit.

4-42. Height, Spacing, Location

4-43. Center to Center

The plans will establish requirements for the amount of overlap to be used for different types of re-bars.

The location of splices for Re-Bar will be shown on the plans. The Standard Specifications prohibit the ateration of this design without written approval. Should field conditions make it impossible to splice the re-bars as shown on the plans, the Project Engineer must be notified. It is the responsibility of the Project Engineer to notify the Construction Section of the problem and to obtain approval for any changes.

Fill in the blanks.

4-52 Overlapping and tying re-bars together so that the two act as one unit is known as ____________________________.

When columns or caps are formed and poured, they are secured to the footing or column by splicing the vertical bars of re-steel. The vertical bars from the column will rest on the concrete footing pad. Vertical bars will also protrude from the footing. The specified dimensions for splicing will determine the length of the re-bars that will extend upwards from the footing.

Circle T (True) or F (False)

4-53	T	F	Poured columns are attached to the footing by splicing vertical bars of reinforc ing steel.
4-54	T	F	Specification dimensions for splicing determine the length of the re-bars that will protrude above the footing pad.
4-55	T	F	A record of the estimate quantities of Re-Bar actually incorporated into the structure should be maintained on the As Built plans.

PLACEMENT INSPECTION

The placement of reinforcing steel should be inspected daily. The Inspector must visually observe the mat to be certain that all bars are straight. Any bars that are curved or improperly bent must be replaced. Critical dimensions should be checked by actual measurements.

4-50. Transversely, Longitudinally

The Inspector should walk across the mat to sight each line of steel bars. At the same time, he must check the spaces between the bars. The bars must be spaced according to the plans. The planned spaces between the bars will always be uniform and this same uniformity of spacing must be maintained in actual bar placement. If any spaces between bars are not as required in the plans, the bars must be moved and retied. The spacing of bars will be center to center.

4-51. 16

The distance from the ends of the steel bars to the side forms must also be measured. It must be the same as is indicated on the plans, so that the steel will be adequately covered with concrete. if the steel has been properly placed in general, the Inspector should be able to detect any out of line bars by sighting along the line of ends.

Lapped splices must be checked to be certain the requirements of the Standard Specifications and plans are met and that the bars are securely tied.

Measuring Bend of a Galloping Bar

The Inspector must also spot check the bend of the galloping or truss bars (bars specially bent to curve upwards over girders) and the distance between the bars that are tied at these points. The bend should be checked prior to the bar's incorporation into the structure. To check the bend of the galloping bars, set a straightedge on the top of the bar and measure from the straightedge down to the bottom bend and to the top of the bar tied to the bottom bend.

Measuring Linear Distance of Bend

The linear distance of the bend must also be measured to be certain it is in accordance with plan dimensions. To measure the linear distance of the bend, turn the bar on its side, place a straightedge against each point of the bend then measure the linear distance between them.

4-53. T

4-54. T

4-55. T

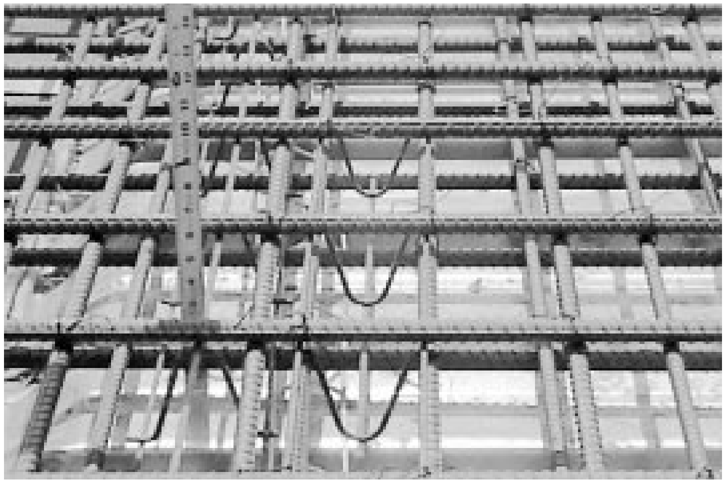
4-58. T

4-59. T

4-60. F

4-61. F

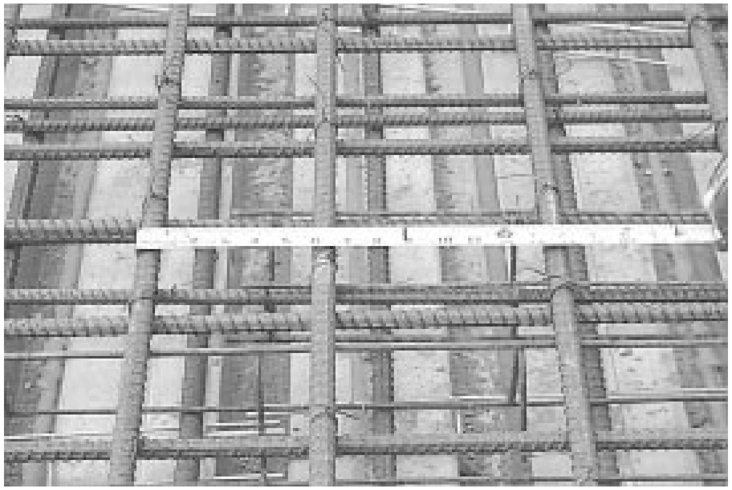
4-62. T



Vertical Distance

The vertical distances or clearances of the steel mats must also be checked. The clearance on bars of the bottom and top mat is detailed in the plans. To check this, measure the height of the steel from the deck flooring forms and subtract this measurement from plan deck thickness.

Measure the center to center distance of the bars to check the vertical distance of the top mat from the bottom mat.



Horizontal Distance

Measure the center to center horizontal distance between bars to check placement.

Fill in the blanks.

4-56. The distance from the side forms to the ____________________ of the steel re-bars must be measured.

4-57. If Re-Bar is basically aligned properly, the Inspector should be able to determine if any ends are not the proper distance from the side forms by _________________________________.

COLUMNS, CAPS, AND GIRDERS

COLUMNS

When columns are to be poured, the forms must be checked for dimensions, strength, and grade. Their alignment must also be checked. The offset lines established to determine bent location can be used as a reference for checking form alignment with a transit. Columns must be within the location tolerances established by the plans or specifications.

A plumb line should also be dropped from the top of the column form to a stable base to be certain that the forms are vertically straight. It is advisable to choose a time when there is little or no wind to use the plumb line, as wind will blow the plumb line out of place, making it impossible to check vertical alignment accurately.

Immediately after concrete placement and following form removal, the column's location and plumbness should be re-checked using the same methods. Should the forming have shifted during the pour, the finished column could be out of location tolerance and no longer vertically straight.

The location of forms for columns can be checked using the same methods as are used for pile locations. Measurements should be made bent to bent using a distance meter or surveyor's chain.

4-65. T

The finished columns should also be checked using be same methods.

Should a problem be discovered with the location or perpendicularity of a finished column, adjustments will have to be made. At this point, the Inspector should consult with the Project Engineer.

4-66. T

Circle T (True) or F (False).

4-58. T F The offset line established to determine bent location can also be used as a reference line for checking the alignment of column forms.

4-67. T

4-59. T F A plumb line can be used to check that the forming for a column is straight up and down.

4-68. T

4-60. T F Plumb lines can be used with accuracy on windy days.

4-61. T F If the forming for a column has been adequately checked prior to the concrete pour, it is not necessary to recheck the location, plumbness, or alignment of the finished column.

4-62. T F If a problem with perpendicularity or location tolerance is found with a finished column, the Project Engineer should be consulted.

CAPS

Forms for caps that are to be poured must be checked for location, grade, and alignment just as forms for all other parts of a structure.

Since the forms for caps must be placed on top of and around a set of columns, there is no solid base on which the cap forming can rest.

To provide support for the base of forms for caps, friction collars may be used. Friction collars are made of pieces of metal or wood bolted around the column. The formwork for the cap can then be attached to the collar. Another method is to place inserts into column, attach braces, and then place formwork for cap on braces.

Immediately prior to placing concrete in caps, friction collars should be checked to assure that they are fitted tightly and securely around the columns. Should the collars be too loose, they will fail to hold the form in place under the weight of the concrete.

When friction forms are used to support cap forms, the collars must be left in place at least seven days in accordance with section 509 B of the Standard Specifications or until the concrete in the cap has reached the specified compressive strength. Side forms can be removed earlier so that hand-finishing operations can begin.

Fill in the blanks.

4-63. Pieces of metal or wood bolted around columns and used to support forms for caps are called ________________________.

4-64. Friction collars must be left in place at least _____________________ days or until the concrete has reached the specified _______________________.

After caps have been poured and the forms removed, the horizontal and vertical alignment should be rechecked. Again, the offset line can be used. A carpenter's level should also be used to check the plumbness of the cap.

The grade of each riser should also be checked to be certain that the bearing for each girder will be at plan grade. The bearing for the girder is the actual location of the riser pad where the girder will rest.

The risers should be checked with a straight edge or carpenter's level to be certain that they are within tolerances. Exposed pieces of gravel or areas that are out of tolerance will require correction. The riser may have to be ground to within specified tolerances.

The centerline of the cap, of the bent, and of the structure must be scribed into the green concrete of the risers and/or cap after the forms are removed. These locations must be determined by measuring carefully from point to point and bent to bent. A tape, a distance meter, or a surveyor's chain can be used.

4-56. End

4-57. Sighting Along the Line of Ends

4-77. Center of bearing

4-78. Centerline of cap

4-79. Measured

4-80. Bearings

4-81. Project Engineer

4-82. Rejected

The bearing area for the girder must also be measured and marked on the riser. This will facilitate checking for correct placement of bearings on the riser.

Circle T (True) or F (False).

4-65. T F The offset line for bent location can be used to check the alignment of the cap.

4-66. T F The grade of each riser should be checked against plan grade.

4-67. T F Centerlines of cap, bent, and structure should be scribed clearly on the cap and/or risers.

4-68. T F The bearing area of the girder end should be marked on the riser.

GIRDERS

Girders will be of precast concrete or steel. The girders must be inspected to be certain they are in conformance with all plans and specifications.

Concrete girders will be stamped acceptable by a DOT inspector prior to delivery and a Certificate of Delivery must be sent to the Project Engineer.

All structural steel, including girders, will also be inspected at the point of fabrication. The steel member will be identified with a “piece mark” (e.g., IG-Right). This mark will be stenciled on the steel member. It identifies the location of the member in the structure.

The steel member will be accompanied by a Certificate of Analysis and a shipping statement will be sent to the Project Engineer. The Inspector must check the member for damage (welded areas) and must be certain to match the identifying piece mark on each member with the shipping report.

SETTING GIRDERS

Putting girders in place on caps is known as hanging or setting girders. When girders are being set, they must be handled with the same care needed during transport and storage.

Pre-cast concrete girders must be lifted into place using either the handling hooks embedded for this purpose, or slings placed under the marked pick up points. During placement, as at all other times, precast concrete girders must be supported at the marked pick up points. Lifting these girders at other points can cause the girder to crack.

While steel girders do not require such precise handling, they should generally be handled using two pick up points.

"Spreader bars" are often used to lift steel girders. The spreader bar is a steel beam, smaller than the girder, equipped with devices that lock it in place on the girder's flange. The spreader bar must be long enough to provide two stable pick up points when placed lengthwise slightly above the top of the girder.

Fill in the blanks.

4-69. Girders can be made of either ________________________ or ____________________.

4-70. Concrete girders will be accompanied by a Certificate of ________________________.

4-71. Steel girders will be identified by a ______________________________________.

4-72. For steel girders the project engineer will receive a ______________________________ and a Certificate of _________________________.

4-73. Putting girders in place on caps is termed _______________________________ girders.

4-74. Pre-cast concrete girders must be lifted by their ____________________________ or by slings placed under the ___________________________.

4-75. Steel girders are often lifted by ____________________________ in order to assure a two point pick up.

4-76. A spreader bar used to pick up a steel girder is equipped with devices to lock it onto the girder's ____.

The location of the ends of the girders placed on the risers must be closely inspected. The center of the girder must be correctly aligned over the center of bearing on the riser. The girder ends must be set symmetrically from

4-63. Friction Collars

4-64. Seven, Compressive Strength

the centerline of the cap both up and down station or as indicated in the plans.

The opening between the girder ends across the cap must be in accordance with the tolerances indicated on the plans. This space should be accurately measured with a ruler or tape. Since not all girders come out of casting in perfect tolerance, there may be some variations in girder lengths.

Pre-cast girders can be shortened by chipping the ends; the exposed ends of the pre-stressing strands must then be coated with an approved asphaltic material.

4-87. F

Steel girders cannot automatically be cut in the field. The type of steel and other factors must be taken into consideration.

4-88. T

Should any adjustments of girder length be required, the Inspector should consult the Project Engineer for his recommendation regarding appropriate action. The Bridge Construction section should also be notified of the problem.

4-89. T

If the girders are too short, it will be impossible to locate the bearings in the right place. This will cause the openings between the girders to be too large. Girders, which are too short, should be rejected.

4-90. T

Circle the correct words.

4-77. The center of the girder must be aligned over the (center of bearing / centerline of cap).

4-91. Grade

4-78. The girder ends must be set symmetrically from the (center of bearing / centerline of cap), both up and down station.

4-79. The opening across the cap between the girder ends should be carefully (estimated /measured).

4-92. Camber, Girder Elevations

4-80. If girders are too short, it will be impossible to locate the (bearings / flanges) in the right place.

4-81. Should any adjustments to girder length be needed, the inspector should consult the (contractor / project engineer).

4-82. Girders which are too short should be (adjusted / rejected).

It is essential that when girders are set on caps, the girder should be in total contact with the bearing pad. The

Inspector must visually observe how the girder actually rests on the bearing pad; no daylight should be visible between the riser and the pad or the pad and the girder.

Any deviation in the slope of the riser or bevel of the bearing pad can cause the girder to sit improperly. Should the girder not be in uniform contact with the bearing pad, adjustments must be made and the Project Engineer notified.

Once girders are in place, their camber must be checked to assure that it is in accordance with the plans. The camber will probably not be exact, but it should be very close. Camber is a slight upward curvature of the girder, designed to compensate for the anticipated deflection under load once the concrete is placed on the deck.

The plans will generally show the camber at midpoint and quarter points of the girder. Midpoint is at the center of the girder and quarter points are at one fourth the length of the girder from each end. The camber should be checked at these same points.

To check the camber of a girder, a tripod and level should be set up on the cap. Rod readings should then be taken at each of the points for which a camber dimension is given. Checking camber in this way is known as taking a profile of the girder.

If specific check points for camber are not given in the plans, checks should still be made at specific intervals along the girder.

The placement of steel girders is essentially the same as for concrete girders. Because steel girders usually have large web width with a comparatively narrow flange, they do not sit with as much stability as concrete girders. To prevent steel girders from turning over, it may be advisable to support them with lateral blocks until the diaphragms are placed. Lateral support is often also a good precaution to use with concrete girders.

Circle T (True) or F (False).

4-83. T F A slight gap should be evident between the ends of the girder and the bearing pad.

4-84. T F A deviation in the slope of the riser or bevel of the bearing pad can cause the girder to sit improperly.

4-85. T F A slight upward curvature of the girder, designed to compensate for the anticipated deflection under load is camber.

4-86. T F The plans will usually show camber at every quarter point along a girder.

4-69. Precast Concrete, Steel

4-70. Delivery

4-71. Piece Mark

4-72. Shipping Statement, Certificate of Analysis

4-73. Handing or Setting

4-74. Handling Hooks, Marked pick up points

4-75. Spreader Bars

4-76. Flange

4-93. T

4-94. T

4-95. F

4-96. T

4-97. F

4-98. T

4-87. T F A check of camber should be taken while the girders are stockpiled.

4-88. T F To check camber, a tripod and level should be set up on the cap and checks made at specific points along the girder.

4-89. T F Whenever camber check points are provided on the plans, an actual check of camber should be taken at these same points.

4-90. T F Steel girders may require lateral support to prevent their moving out of place.

Girders and Forms

The information regarding actual girder camber is used to set the forms for the deck slab at the proper grade. In order to be certain that the deck slab will be the right thickness and at the elevation set by the plans, the elevation of the forms must be based on actual camber and actual girder elevations.

After the profiles of the top flanges of the girders are determined, the information is used by the contractor for setting the bottom forms for the deck.

One method of providing the profile information by the contractor is to mark the actual elevation at that point on the side (haunch) of the girder (with camber added). The exact point where the reading was taken should also be indicated. This will establish the exact point where the bottom of the forms are to be placed against the girder. This point should also be marked.

Measuring actual camber and marking the form position on the girder takes into account any difference between actual and plan elevation. Adjustments in deck form placement at this point can correct minor discrepancies in grade and/or anticipated girder deflection, assuring correct deck grade and slab thickness.

Fill in the blanks.

4-91. The girder profile is used to set deck forms to proper ____________________.

4-92. The elevation of the deck forms must be based on actual girder ___________________ and ________________________________.

Torque Problems

Steel girders are more flexible than concrete girders. For this reason they are more prone to the problem of torque. When a girder torques, it twists on itself so that it no longer maintains the correct grade. This problem usually occurs only with outside girders.

The problem of torquing should be anticipated on bridges, which have extra-wide overhangs. The overhand is that part of the formwork, which extends beyond the outside edge of the girder. The overhangs generally support the rails upon which a transverse screed rides during deck pours. They also serve as a platform for workers. The overhangs are supported by braces, which in turn rest against the girder.

4-83. F

4-84. T

4-85. T

4-86. T

The pressure of the screed equipment and the weight of the concrete on the overhang pushes it against the bottom of the girder and out against its top flange at the same time. This could cause the girder to deform and the grade of the deck to be other than planned.

Whenever extra wide overhangs are used with steel girders or any other conditions exist which would indicate that this type of problem may occur, some provision should be made to brace the outside girders prior to the pour, to prevent their torquing. The bracing may consist of supporting struts placed between the webs of the exterior and adjacent interior girders at their bottom flanges.

Circle T (True) or F (False).

4-93. T F A girder that twists on itself under load has torqued.

4-94. T F Steel girders are more prone to torque problems than concrete girders, because steel girders are more flexible.

4-95. T F If a girder torques under the load of the concrete slab, the slab grade will be too high.

4-96. T F The problem of torquing can be expected on bridges with extra-wide overhangs.

4-97. T F Torquing usually occurs on inside girders.

4-98. T F If torque problems are anticipated, the outside girders should be braced prior to pouring the deck slab.

4-99.
A- c
B-a
C-d
D-b

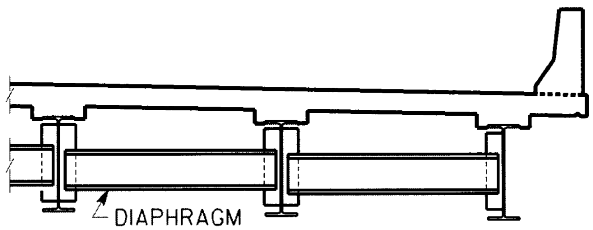
4-100. b

4-101. d

4-102. b

4-103. a

DIAPHRAGMS



The diaphragm, as shown in the sketch above, is located between the girders and acts as a transverse brace for the girders.

Diaphragms can be either steel or concrete. When steel girders are used, steel diaphragms are generally required. However, in some instances, concrete diaphragms may be used with steel girders. When concrete girders are called for, the diaphragms will also be concrete.

Diaphragms can be placed between girders both above caps and at points along the span. Those diaphragms that are located at points along the span between bents are known as intermediate diaphragms. Those located above the caps are called edge beams or edge walls if adjacent spans are continuous.

Steel diaphragms must be put in place before the deck slab is poured. Concrete intermediate diaphragms are also formed and poured prior to deck placement. Edge walls are poured at the same time the deck is poured.

Bridge decks are sometimes poured in continuous spans with no joints at the caps. When decks are poured in this manner, the end diaphragms are poured at the same time as the deck. These types of diaphragms are called edge walls.

4-108. d

4-109. c

4-110. d

4-111. d

4-99. Match the terms in the left column with those in the right.

A.	Diaphragm	a. placed between bents
B.	Intermediate diaphragm	b. poured in conjuction with bridge deck
C.	Edge beams	c. transverse girder brace
D.	Edge walls	d. placed above caps

REVIEW QUESTIONS

Circle the letter next to the correct answer(s). Some questions in this section may have more than one answer.

4-100. Which of the following is a basic characteristic of forms for concrete structures?

a. rigidity
b. strength
c. easily dismantled
d. all of the above

4-101. Which of the following materials can be used for concrete forms?

a. wood
b. metal
c. concrete
d. all of the above

4-102. Which of the following are points of inspection for concrete forms?

a. shape
b. dimensions
c. alignment
d. elevation
e. all of the above

4-103. Which of the following problems could be caused by form settlement or deflection under load?

a. finished grade is too low
b. finished grade is too high
c. concrete seeps through forms
d. finished deck is not thick enough

4-104. To be certain that all angles are composed of concrete, not just a cement and water paste, which of the following procedures should be followed?

a. build all corners on forms as right angles
b. chamfer all exterior corners on forms
c. make all corners on forms triangular
d. round all corners on the green concrete after the forms are removed

4-105. Which of the following times is the most appropriate to coat forms with oil or a form release agent?

a. coat form parts individually before assembly
b. before steel is placed
c. after steel is placed, but several days before pour is scheduled
d. immediately before the concrete is placed in the forms

4-106. Which of the following forms must be coated with oil or a form release agent?

a. precast concrete deck forms
b. corrugated metal deck forms
c. plywood forms
d. all of the above

4-107. Which of the following describes an improper method of handling precast deck forms?

a. handled in stacks, supported by cushioned sling
b. handled individually by handling hooks
c. handled in stacks, with support cable running transverse to the ribs
d. transported in stacks with at least four wooden blocks between the individual panels

4-117. a

4-118. c, d

4-119. b

4-120. c

4-121. a

4-108. On which of the following do precast concrete deck forms rest directly?

a. girders
b. plywood forms
c. reinforcing steel
d. fiber bearing material

4-109. On which of the following do corrugated steel deck forms rest?

a. girders
b. fiber bearing material
c. steel support angles
d. reinforcing steel

4-110. The distance measured between Re-Bar is usually measured?

a. out to out
b. in to in
c. center to center
d. end to end

4-111. Which of the following devices is used to hold reinforcing steel at the proper location within the concrete?

a. ribs
b. galloping bars
c. haunches
d. chairs

4-112. Two re-bars that are overlapped and tied together so that the two work as one unit are _______________________?

a. spliced
b. united
c. graded
d. staggered

4-113. Which of the following must be checked on steel mats in a bridge deck?

a. bars are not bent improperly
b. distance between bars
c. distance from bar ends to side forms
d. all of the above

4-114. A plumb line can be used to check which of the following standards for a column form?

a. elevation
b. grade
c. perpendicularity
d. strength

4-115. Which of the following devices are used to provide support for cap forms?

a. plumb line
b. precast concrete forms
c. friction collars
d. chairs

4-116. Precast concrete girders must be accompanied by which of the following?

a. Certificate of Delivery
b. Certificate of Conformance
c. Mill Test Reports and Heat Numbers
d. Certificate of Acceptance

4-104. b

4-105. d

4-106. c

4-107. c

5-1. T

5-2. F

4-117. Steel girders will be identified by which of the following?

a. piece mark
b. inspector's number
c. acceptance stamp
d. heat number

4-118. Steel girders will be accompanied by which of the following?

a. Certificate of Delivery
b. Certificate of Compliance
c. Certificate of Analysis
d. Shipping Statement

4-119. Hanging girders refers to which of the following?

a. marking girder location of riser's
b. placing girders on caps
c. profiling girders
d. using a spreader bar to handle a girder

4-120. Precast concrete girders are generally handled by which of the following?

a. flange
b. spreader bars
c. handling hooks
d. web

4-121. A slight upward curvature of a girder, designed to compensate for the anticipated deflection under load is which of the following?

a. camber
b. flexure

c. compression
d. profile

4-122. The profile of a girder is used for which of the following?

a. to place girder correctly on the riser
b. to adjust the elevation of the girder
c. to brace the girder
d. to set forms for the deck slab

4-123. In which of the following situations could girder torquing be anticipated?

a. steel girders under inner deck area
b. extra wide overhangs and concrete girders
c. narrow overhangs and concrete girders
d. outside girders of steel and extra wide overhangs

4-124. The transverse brace located between girders is known as which of the following?

a. diaphragm
b. continuity cable
c. riser pad
d. continuous span

4-125. Which of the following applies to an intermediate diaphragm?

a. located directly above the cap
b. located between bents
c. used between steel girders only
d. poured at the same time as the deck

4-112. a

4-113. d

4-114. c

4-115. c

4-116. a

CHAPTER V: CULVERTS

CONTRACTORS LAYOUT

The Contractor's layout of a culvert will include the following:

Checking and, if necessary, adjusting the plan skew and alignment of the culvert.
Checking and, if necessary, adjusting the plan flow line of the culvert.
Checking and, if necessary, adjusting the plan length of the culvert.
Gathering and recording original ground data for both the culvert and any necessary channel work.
Staking the culvert and any necessary channel excavation for construction.
Taking final cross-sections of the excavation.

SKEW AND ALIGNMENT

The station of the intersection of the centerline of the culvert and the survey centerline will be shown on the Plans. The skew of this intersection will also be given. The station of this intersection should be established and the skew angle turned. This establishes the plan alignment of the culvert.

In reviewing the plan alignment of a culvert the Inspector must use his knowledge and good judgement. The Engineer should ask, is this the best alignment? Do the ends of the culvert line up with the natural flow of the stream? If not, is it possible to line the culvert up with the natural flow of the stream? Are there conditions that render the plan alignment unsatisfactory? Before altering the plan alignment of a culvert approval by higher authority must be secured.

Circle T (True) or F (False)

5-1. T F The skew of the intersection of the centerline of the culvert and roadway will always be given.

5-2. T F The station of the intersection of the centerline of the culvert and roadway establishes the plan alignment of the culvert.

FLOW LINE

The establishment of the flow line of a culvert is very important. If the flow line is too low the culvert may silt up. If the flow line is too high, it may not carry enough flow. In most cases the plan flow line will be satisfactory. If, however, the plan alignment has been changed, the flow line may change.

The way to check or establish the flow line is to plot the original ground line profile along the centerline of the culvert and, using this visual data, set a flow line that bests fits the stream conditions. Basically, the end of the culvert on each end should fit the natural flow of the stream.

FILL IN THE BLANK

5-3. The way to ________________________ the flow line is to plot the ________________ ground line profile along the ___________________ of the culvert and set a flow line that best fits the stream conditions.

4-122. d

Culvert Length: The length of the culvert is best determined from a cross-section of the culvert alignment. The length of the culvert between parapets is the distance between the points of intersection of the roadway side slopes and the inside face of the parapet.

4-123. d

Circle T (True) or F (False)

4-124. a

5-4. T F The length of the culvert is determined from a cross-section plot along the culvert alignment.

4-125. b

ORIGINAL GROUND DATA

The centerline of the culvert should be stationed with the intersection of the culvert centerline and the upstream right of way line. Cross-sections that extend beyond the limits of excavation should be taken along the culvert centerline at the break points in the terrain. These cross-sections should be taken normal (perpendicular) to the centerline of the culvert. Any unusual conditions such as rock, muck, etc. should be noted on the cross-sections.

Circle T (True) or F (False)

5-5. T F Cross sections should be taken parallel to the centerline of the culvert.

STAKING FOR CONSTRUCTION

The culvert should be staked for construction by establishing offset lines along each side of the culvert outside the construction limits. These offset lines should be staked with hubs and tack points opposite one another except that the points for the parapets will be on the parapet line. The lines of the parapets will be parallel to the centerline of the roadway. If the roadway is on a curve, the parapet lines should be parallel to a tangent to the roadway at the station of the end of the culvert. All points on the offset lines should be referenced with respect to the centerline of the culvert and marked with cuts to the bottom of the excavation. Also points at each design change should be placed along the offset lines.

5-9. T

FINAL CROSS-SECTIONS

After the foundation, including all undercutting for foundation stabilization has been excavated and before the placement of the foundation backfill material is commenced, final cross-sections of the foundation should be made. Final cross-sections should be taken at any breaks in the final excavation caused by changes in the depth of the undercut.

5-10. F

5-11. F

CONSTRUCTION FOUNDATION

Though culverts are frequently considered minor structures their proper construction is of major importance to the serviceability of the roadway. Foundations must be carefully prepared. Decisions must be made as to the type and amount of foundation backfill material required.

5-12. d

REINFORCEMENT

5-13. b

Reinforcement steel placement is thoroughly discussed in section 511 of the Standard Specifications. A thorough review of this section should be done before this phase of construction. The Specifications call for specific types of supports for specific areas. All of the reinforcement must be checked before the pour is commenced. Tying of reinforcement steel shall be done before the concrete is placed. All wall steel or dowels must be placed and securely held in position.

Accurate placement of reinforcement steel is necessary if a reinforced concrete structure is to achieve its designed strength. Certain placement tolerances are given in the Specifications. These tolerances represent the maximum allowable deviation from plan location. Also the proper quantity of reinforcement steel is essential to the strength of a reinforced concrete structure. The spacing and type of bars should be checked against the plans. In checking the reinforcement particular attention must be paid to barrel steel at design changes. Spacing and sizes of bars can change at these points of design change.

FILL IN THE BLANKS

5-6. Tying of the reinforcement steel shall be done before the _________________ is placed.

5-7. Tolerances represent the _______________________ allowable deviation.

5-8. ____________________ and ______________________ of bars can change at design changes.

FORMING

The function of forms is to act as a structural unit in holding and supporting plastic concrete to the desired configuration until such time as the hardened concrete can support itself. The forms must be designed, supported, and tied together so that they will not sag, bulge, sway, or become misaligned. The forms must be set so that concrete of the proper configuration will be obtained.

The Inspector must also check the size of the formed footings, the depth of the forms, alignment of the forms, the height of the wall forms and all of the details necessary to produce the finished structure as detailed on the plans. Every dimension should be checked during the forming and again after the forms are complete before the pour is commenced. Special attention must be paid to the forming of cut-off walls. Weep hole locations must be carefully checked.

JOINTS IN BARREL

Transverse construction joints must be made in the barrel of the culvert at all locations indicated on the plans and at all design change locations. These must be full construction joints, constructed at an angle of 90° with the barrel. After the concrete has achieved its initial set in a floor or top slab pour, it is permissible to remove a header and pour the adjacent section. When this is done the concrete surface along the joint must be coated with curing compound to prevent bond of the two surfaces.

At all transverse construction joints outside the limits of the pavement width, reinforcement steel must not extend through the joint. Construction joints inside the limits of the pavement width should be avoided. However, if conditions require that such a joint be made, all longitudinal reinforcement steel must be extended through the joint, with no bond-breaking procedures implemented.

5-3. Establish, original, centerline

5-4. T

5-5. F

Circle T (True) or F (False)

5-9. T F Transverse construction joints must be made in the barrel of the culvert at all design changes.

5-10. T F Construction joints will be at an angle of 60° with the barrel.

5-11. T F Reinforcement must never extend through a construction joint.

CONCRETE

All placement equipment such as chutes, vibrators, tremies, etc. should be checked before placement commences.

BACKFILLING

In placing backfill material around the culvert care must be taken not to damage the culvert by loading one side more than the other. Backfilling must be done on both sides of the culvert so that the backfill on one side of the culvert will never be more than 3 feet higher than on the other side of the culvert.

REVIEW QUESTIONS

Circle the letter next to the correct answer(s). Some questions in this section may have more than one answer.

5-12. The Contractor's Layout of a culvert will include
a. skew and alignment
b. flow line
c. length
d. all of the above

5-13. In reviewing the plan alignment of a culvert, the engineer must use
a. knowledge and good judgement
b. mainline cross-sections
c. standards
d. construction details

5-14. When establishing the flow line the ends of the culvert on each end should fit __________.
a. the plan elevation
b. the plan skew
c. the natural flow of the stream
d. none of the above

5-15. The length of culvert is best determined from a cross-section plot ____________________.
a. of the roadway profile
b. along the culvert alignment
c. station before and after the culvert location
d. none of the above

5-16. When checking the placement of reinforcement you should check ______________.
a. type of support
b. type of bars
c. spacing
d. all of the above

5-17. The function of the form is __________________________.
a. keep soil from concrete
b. keep water from concrete
c. hold plastic concrete
d. support plastic concrete

5-18. The inspector should check the ______________________ of the formed structure.
a. size
b. alignment
c. location of weep holes
d. all of the above

5-19. At all transverse construction joints outside the pavement width, reinforcement steel ________________________ extend through the joint.
a. must
b. must not
c. may
d. may not

5-6. Concrete

5-7. Maximum

5-8. Spacing, sizes

CHAPTER VI: DECK POUR

DECK POUR

During the pour the Inspector must check each batch of concrete to see that it conforms to the requirements of the Specifications. Check the first truck for air content and slump before placing any concrete. Concrete plants are set up to be consistent. If the first truck is bad the odds are high that the second truck may be, too. The forms and reinforcing steel should be wet down in advance of the concreting. If the ground is muddy, workmen must not be allowed to track mud onto the forms, reinforcement steel or concrete. Workmen walking outside of the pour along the overhang bottom forms must not be allowed to walk on the overhang reinforcement steel. This will cause slight movements of these bars, which will destroy their bond. This steel can easily be bridged with a walkway.

The concrete placement operations must be observed, seeing that they conform to the requirements of the Specifications, paying particular attention that the rate of placement conditions are met. Many construction problems stem from a failure to meet the concrete placement rates required by the Specifications for bridge superstructure concrete. The failure to meet the required pour rate is critical primarily because it often prevents proper finishing of the concrete. This is especially true in the summer months. Bridges designed with structural steel beams having high dead load deflections present special problems, especially when a longitudinal screed is used. Rapid placement of the concrete is mandatory, as several beams must be loaded before the full deflection takes place and final screeding of the concrete can be accomplished. Finishing of the concrete must take place when the concrete is still in a plastic state. Non-deflecting structures such as those supported by falsework are less critical; but none-the-less, placement rates should meet the specifications to allow time for finishing.

6-5. c

6-6. a

A continual watch must be made over the reinforcement steel to see that it does not get displaced or if it does get displaced, it is relocated into its proper position. The forms must be inspected to see that they are holding, and the finishing operation must also be inspected.

The concrete supply must be regulated so that fresh concrete can be maintained along the leading edge of the pour at all times. This leading edge must also be placed uniformity along the full length or width of the pour.

As part of the "during the pour" inspection of the forms the Inspector should look for missing wedges, broken timbers, leaning struts, leaning joints, deflected pallets, leaks that would indicate the opening up of joints in the forms, etc. If any of these conditions are evident, or if the forms fail, the Contractor's attention must be called and investigations and/or repairs made immediately. Sometimes this repair will entail the removal of some of the fresh concrete.

The "Bridge Deck Construction Checklist" requires probing the slab during deck placement operations to verify plan dimensions. Probing of the deck must be made to check proper clearance over the top mat of steel and correct thickness of the deck. This inspection will allow the deficiencies to be corrected in a timely manner. Probes should be recorded.

Circle T (True) or F (False)

6-1. T F Check the first truck load for air content and slump

6-2. T F The forms and reinforcing steel do not have to be kept wet

5-14. c

6-3. T F The failure to meet the required pour rate is critical primarily because it often prevents proper finishing of the concrete.

5-15. b

6-4. T F Probing of the deck must be made to check proper clearance over the top mat of steel and correct thickness of the deck.

FINISHING AND CURING

5-16. d

After the final strike-off of the concrete and as close behind the final strike-off as practical, the surface shall be checked with a 10 foot straightedge. It is preferable that the straight edge be affixed to a broom-type handle for control and ease in using.

5-17. c, d

The gutters are usually hand finished with floats. This should be done between the screeding and final finishing operations. This way the final finish will cover the float marks and give the deck a more uniform texture. The floating and working of the gutters is necessary because the screed usually will not work well close to the rail steel. Also the area behind the curb steel has to be struck off and any slush or weak grout pushed up by the screed must be removed. The final gutter lines and grades must be such that the gutters will not pond water and the deck drains can operate.

5-18. d

5-19. b

The area, which will be covered by the barrier, should be patted down with a trowel to smooth the concrete. Any required keyways shall be constructed. The final finishing shall be accomplished with a street-type broom, burlap drag or belting. If grooving is required, it shall be done with mechanical equipment for grooving hardened concrete. The finish is begun as soon as the concrete has hardened sufficiently. The Specifications cover final finishing under strike-off and finish.

Poor joint finishing causes the majority of the deck finish problems. Transverse joints include the expansion joints at the ends of a span, construction joints between pours, and crack control joints within pours. They are either edged with an edging tool with a ¼ inch radius while the concrete is plastic, or ground to approximately that radius after the concrete has set. If finished while the concrete is plastic, the joints should be worked after the screeding is done and before the final finish is applied. Finishers, in edging the joint and in working it, very often will edge the joint either high or low. The only way for a finisher not to do this is to use a straight edge on the joint. This straight edging must be done as part of the joint finishing operation.

Curing is critical for deck concrete because of the large exposed area and shallow thickness of the decks. Curing requirements are covered in the Specifications. On large deck pours the curing of some areas will have to start before the last of the concrete is poured or finished. Oftentimes it is necessary to fog the fresh deck surface prior to final finishing and curing to minimize early moisture loss. Early loss of surface moisture can lead to excessive plastic shrinkage cracking. Care must be exercised in fogging the concrete. It is possible to over fog a concrete surface. If the excess water from over-fogging is worked into the concrete surface through the finishing process, a thin but weak layer of cement grout can form on top of the deck. Often a finishing crew is tempted to over fog because it aids them in finishing the concrete and many times creates a grout layer that will initially provide a good looking deck and a good ride. However, these looks may be deceptive as the long-term durability of the bridge deck could be significantly reduced resulting in future spalling and deterioration of the riding surface. Fogging should be limited prior to final strike-off or finishing, however, additional fogging is necessary when the water sheen begins to disappear from the concrete surface.

REVIEW QUESTIONS

Circle the letter next to the correct answer(s). Some questions in this section may have more than one answer.

6-5. Walking on the overhang reinforcement steel during concrete placement will cause slight movements of these bars, which will ___________________.

a. destroy their bond
b. cause screed to rise up
c. none of the above
d. all of the above

6-6. Finishing of the concrete must take place when the concrete ____________________.

a. is still in a plastic state
b. is still wet on the surface
c. is first placed in the form
d. none of the above

6-7. Probing of the deck during deck placement operations is required to ___________________.
a. check clearance for top mat of reinforcement
b. check depth of slabs
c. verify plan dimensions
d. all of the above

6-8. The floating and working of the ___________ with hand floats is necessary because the screed usually will not work well close to the rail reinforcement
a. deck
b. gutters
c. header
d. edge beam

6-1. T

6-2. F

6-3. T

6-4. T

GLOSSARY

Approach slab
That part of the pavement, constructed on the end roll, which provides a transition from the roadway to the bridge deck

As-built plans
The project plans on which all corrections and changes are indicated

Barrier rail
A concrete barrier extending the length of the bridge along the outside edge, designed to prevent vehicles from leaving the roadway

Bascule bridge
A movable bridge, which opens at the center, by each span's rotating about an axis

Batter
Driving a pile at an angle to widen the area of support

Bearing
The portion of the girder that rests on the cap

Bearing capacity
The maximum unit pressure which a structural member will withstand without failure or detrimental settlement

Bearing pad
Compressible material placed between the girder and the cap

Bench mark
A point of known or assumed elevation used as a reference in determining other elevations in topographical surveys

Bent
The basic support structure of a bridge

Bevel
The angle that one surface makes with another when they are not at right angles

Blow count
The number of hammer blows applied to a pile during a specified length of penetration

Box culvert
A cast-in-place or pre-cast drainage structure under a roadway or other facility which is generally rectangular in shape

Bridge
A structure built over a drainage channel or other obstruction and having a roadway surface or track for carrying traffic

Build up
A cast-in-place addition to a concrete pile or a cast-in-place repair for a damaged section of pile which has been removed

Camber
A slight, usually upward, curvature of a beam (girder) or form designed to compensate for anticipated deflection

Cap
Horizontal support member of a bridge, extending transversely across the entire bent with the tops of the columns or piles firmly embedded within

Cast-in-place
Concrete which is deposited in its final position as part of the structure, as opposed to pre-cast concrete

Catch basin
A concrete or brick and concrete lined depression, usually built into a curb, and designed to carry drainage water into an underground drainage system

Center-to-center
With reference to measuring the spacing

Centerline
The linear center of a roadway, lane or structure

Centroid
Center of mass

Chain
Surveyor's steel tape measure

Chair
Holders designed to keep reinforcing steel in place within concrete

Chamfer
To create a beveled edge

Column
A long, slender structural element that extends above the ground to provide support for a structure

Concrete
A mixture of portland or hydraulic cement, sand, coarse aggregate and water

Coping
Additional concrete over the beam necessary to insure that no part of beam extends into the slab thickness

Cross section
A representation of a roadway or structure drawn at a right angle through the structure

Cut off elevation
The grade of the top of the pile above ground

Deck
The roadway over the bridge

Deck truss
A metal support structure for a bridge deck which supports the deck from below

6-7. a, b

6-8. b

Deflection
The bending of a girder or form under a load

Design load
The amount of weight that is planned for a structure to sustain without damage or settlement

Diaphragm
A permanent transverse brace for girders contain plastic concrete

Distance meter
A device that measures distance by measuring the frequency and amplitude of infrared light waves

Down station
In the direction of decreasing station numbers of reinforcing steel, the distance is measured from the center of one bar to the center of the adjacent bar, as opposed to out-to-out

Drilled shaft foundation
A column which is cast-in-place into a hole, pre-drilled to the correct depth

Dunnage
Material used around a cargo to prevent damage

Elastic deformation
The compression of a pile under a load

Elevation
The distance above a certain point, usually sea level

End wall
A diaphragm located above the end bent cap

End roll
That part of the embankment that provides a transition in grade from the roadway to the bridge deck

Falsework
Temporary supports and braces used to support forms or other structural parts during construction activities

Flat deck bridge
A bridge in which the deck slab has 0.0 percent vertical grade and rests directly on the substructure, without girders; also called flat span bridge or slab span bridge

Flat span bridge
Refer to definition for flat deck bridge

Footing
That portion of a structure which spreads and transmits the load directly to the piles or to the supporting soil

Forms
Molds that are used to shape and is strong enough to be self-supporting

Friction collar
Pieces of metal or wood bolted around a column to support the formwork for a cap

Galloping bars
Bars which are specially bent to curve upwards over girders; also called truss bars

Girder
The main support beam of a bridge deck

Girder span bridge
A bridge in which the deck slab rests directly on steel or concrete girders

Grade
The slope of a road, bridge, waterway, etc.

Gross settlement
The amount of settlement or a pile under load prior to rebound

Guard rail
A barrier rail at the ends of a bridge, alongside the approach slab

Hanging girders
Putting girders in place on the cap

Heat of hydration
Heat generated by the chemical reaction between water and cement in concrete

Haunch
An area of a girder which is thickened for support purposes

Hydration
The chemical reaction that takes place in concrete between cement and water

Hydraulic cement
A product which hardens when mixed with water

Infrared light
Light waves lying outside the visible spectrum at its red end

Intermediate diaphragm
A diaphragm (transverse girder support) located at a point along the span other than over the cap

Initial set
The initial stiffening of concrete due to chemical reactions of its components

Jetting
Using water under pressure to soften soil through which a pile is being driven

Lift span bridge
A movable bridge in which the entire span is lifted determine straight up; also referred to as a vertical lift bridge

Net settlement
For pile loading operations, the amount the pile actually has penetrated into the ground after rebound

Offset
A line of reference points for alignment or grade established at a right angle to centerline

Overhang
That part of bridge deck formwork that extends beyond the outside edge of the girder

Permanent pile
Piles that provide support for the structure

Pier
A solid, concrete, vertical support member that forms a bent

Pile
A long, slender structural element which is embedded in the ground for the purpose of supporting a structure

Pile bent
Piling driven into the ground and topped by a cap

Portland cement
Hydraulic cement composed entirely of portland cement

Portland cement concrete
A mixture of portland cement, fine aggregate (sand), coarse aggregate, and water

Portland-pozzolan cement
Hydraulic cement in which pozzolans replace part of the portland cement

Pozzolan
Finely divided siliceous or siliceous and aluminous material that reacts

Pre-stressed
Precast concrete structural members in which the reinforcing strands have been tensioned prior to casting

Pile cup off
Elevation of top pile

Pile tip elevation
Elevation of bottom of pile

Pilot hole
A hole predrilled to neat tip elevation into which a pile is placed

Plan tip elevation
The elevation of the bottom of the pile shown on the plans

Plumb line
A stringline with weight attached used to vertical alignment

Prism
A transparent body with faceted faces that reflects light

PVI
Point of vertical intersection; point of intersection of vertical grade lines

PVT
Point of vertical tangency; that point leaving a vertical curve and connecting to the vertical grade line (end of the vertical curve)

Rebound
Amount a pile rises from gross settlement when load removed

Reinforcing steel
Steel bars embedded in concrete so that the steel and concrete act together to resist forces

Revetment
Cast-in-place concrete, stone, sacked concrete, cellular concrete blocks or riprap placed under bridges to protect the embankment from erosion

Riser
Projections on the top of the cap on which girders including bearing pads are placed

Sampling plan
The schedule which outlines the minimal sampling and testing frequency for all materials used on a project

Sash and sway bracing
Criss-crossed bracing used between timber or steel "H" piles to provide additional support

Scour line
The subsurface point to which it may be anticipated that the action of stream currents will erode soil on the stream bottom

Seal
A layer of concrete poured into a part of a structure, usually below the water line, in order to create a water free working area

Settlement
A pile's additional penetration into the ground during loading

Skin friction
The resistance of soils surrounding a pile to its movement

Slab span bridge
A bridge in which the deck slab has a 0.0 percent vertical grade and rests directly on the substructure, without girders; also called flat span bridge or flat deck bridge

Slope
The ratio of the inclination (rise or fall) of a surface to the number of horizontal units of measure covered

Span
The clear horizontal distance between structural supports

Span length
Same as span

Splicing
With reference to reinforcing steel, the overlapping of two bars, and tying them securely so that the two act as one unit

Spreader bar
A steel beam, smaller than the girder on which it is used, which is locked onto the girders flange and used to handle the girder

Substructure
Those structural members of a bridge that are below the bearings

Superstructure
Those structural elements of a bridge that are above the caps

Steel pipe pile
A thick walled steel casing driven into the ground to act as a permanent form for a cast-in-place concrete pile

Steel shell pile
A steel casing driven into the ground to act as a permanent form for a cast-in-place concrete pile

Step-tapered pile
A steel shell pile that is pointed at the lower end and is fabricated in sections of increasingly larger diameters

Swing span bridge
A movable bridge that is balanced on a pivot pier and swings open horizontally

Test pile
A pile driven to establish that the deep borings, on which pile data are based, represent the true soil profile and the necessary tip elevation to support design load

Through truss
A metal support structure for a deck which is primarily above the roadway

Tip elevation
The elevation of the bottom of the pile below ground

Topographical
Of or relating to the elevation points of natural ground

Torque
A turning or twisting force

Transit
An instrument used to determine alignment consisting of four principal parts; telescope; spirit level; vernier; tripod

Transverse slope
The ratio of rise or fall compared to horizontal units of measurement, measured across the roadway

Truss
A metal support structure for a bridge deck

Truss bars
Bars which are specially bent to curve upwards over girders; also called galloping bars

Vernier
An instrument used to measure vertical or horizontal angles

Vertical curve
Curves caused by changes in the grade of a roadway

Vertical lift span
A movable bridge in which the entire span is lifted straight up; also referred to as a lift span bridge

Wing wall
A wall that guides a water flow into a bridge opening, or culvert barrel