STRUCTURES INSPECTION
SELF STUDY
TRAINING COURSE

PART TWO

2005
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State Construction Training Engineer - Yvonne Collins
FOREWORD

Structures Inspection is a training course in two parts. The course covers most of the inspection activities that are necessary to ensure that proper quality assurance is performed during the construction of structures.

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

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

Part Two (superstructures) covers the following topics:

- Beams and Girders in General
- Erection of Steel Beams and Girders
- Erection of Precast Concrete Beams and Girders
- Deck Construction
- Barrier Walls
- Miscellaneous Construction
- Painting
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DIRECTIONS TO COURSE USERS

TRAINING TECHNIQUE

This course has been designed for self-instructional training:

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

PREREQUISITES

For Structures Inspection -- Part Two, you will need to successfully complete the following self study courses: Construction Mathematics and Contract Plan Reading. In addition, you should have completed two other training courses or know their subject matter thoroughly. These courses are: Portland Cement Concrete Testing, Placement and Control; and Structures Inspection -- Part One.
HOW TO USE THESE BOOKS

These are not ordinary books. You cannot read them from page to page as you do other books. These books give you some information and then ask a series of questions about that information. The questions are asked in such a way that you will have to think carefully and draw some conclusions for yourself. If you have difficulty answering the questions, review the sections that give you trouble before going on. Where applicable, on the right hand side of the page, of the lesson heading line, there will be a reference to the Florida Department of Transportation Standard Specifications (SS) and/or Special Provisions (SP) for Road and Bridge Construction section that applies to the lesson. For example: Grooving [SS 400]. If you want to find out more about the lesson you are working on, read the Standard Specification or Special Provision that is referenced.

The answers to the questions are found at the end of each chapter. The answers to the Review Quiz are at the end of the quiz.

EXAMINATION

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

The Exam contains questions and problems only -- no answers. To help you prepare for the Examinations, Review Quizzes are included at the end of each Part. If you do well on the Review Quizzes, the Examinations will present no problems.

Together, the two Examinations comprise the Examination for the whole course. But you must pass the Examination for each Part before you begin the next Part.
CHAPTER ONE

BEAMS AND GIRDER S IN GENERAL

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INTRODUCTION

The Contractor can begin the construction of the superstructure once the substructure of the bridge has met all strength and age requirements. The main elements of the superstructure include:

- The beams and girders, which transfer loads from the bridge deck to the substructure
- The bridge deck
- The barrier walls and railings

NOTE: The terms beams and girders may be used interchangeably. However, by definition, girders are larger, longer beams that are assembled by bolting or welding individual plates together instead of being rolled as one solid member (See Part 1, Chapter 1, for a review of bridge terminology).

As you know from Part 1, Chapter 1, the Department uses two beam material types: steel and concrete. The process of construction and erection of both beam material types is almost the same and the major phases are as follows:

- FABRICATION – Steel rolled beams are produced at a steel plant in standard sizes for use by any contractor that places an order. Steel girders, also called plate girders, are fabricated on a project by project basis from individual plates at a fabrication plant by welding or bolting plates together to form wide flange and box shaped members. After they are fabricated they are shipped to the project site. Concrete beams and girders are produced in a prestress concrete plant or yard by constructing forms for the required girder shape then placing and stressing prestress strands in the forms and finally pouring concrete into the forms. Once the concrete hardens, the strands are released and the beam receives final curing after which it is ready to be shipped to the project site.
DELIVERY AND STORAGE - Once the beams are delivered to the project site they must be stored properly and be inspected for fabrication defects and damage that may have occurred during transport to the project or as a result of handling at the site.

PLACEMENT AND ADJUSTMENT OF BEARINGS - The beam bearings are placed on the substructure elements (bent, pier or abutment cap) in preparation for beam erection. The position of the bearings may require adjustment for temperature just prior to placement of the beam.

GIRDER PLACEMENT - Steel rolled beams are lifted by crane and placed onto the bearings. Steel continuous plate girders are placed on the bearings and individual sections are bolted together while being suspended by a crane or while being supported on temporary towers. Simple concrete beams are placed onto bearings by crane. Individual sections of continuous concrete girders are placed on pier bearings and on temporary tower bearings. The concrete for the joints between concrete girder sections is poured.

FINAL BOLT TIGHTENING AND STRAND POST-TENSIONING - The bolts in steel girder splices receive final tightening. The steel strands for post-tensioned girders are stressed and anchored.

ASSEMBLY OF BRACING AND DIAPHRAGMS - Once at least two beams or girders are placed on their bearings, the members that connect one beam to another, called bracing (steel beams) or diaphragms (concrete beams), are installed. For steel, bracing is often installed between two beams prior to erection for better stability during handling. Diaphragms on concrete beams are poured after all beams in that span are placed. Temporary bracing is used to stabilize/secure beams until the diaphragms are poured. When all bracing and diaphragms are complete, the deck can be constructed.

In the lessons that follow, these beam/girder erection phases will be covered in more detail. The initial sections will cover phases that are the same for both steel and concrete beam/girder superstructures followed by sections that deal specifically with one or the other material.
**LOCATING BEARINGS**

The first step of bearing installation is locating the bearing areas on top of the substructure unit or cap. These areas are called pedestals or beam seats. Bearing areas on caps and abutments are located with survey methods from the original reference points outside the construction area. You should observe the Contractor's procedures for locating the bearing areas to be sure that the following things are done:

- The Contractor must not assume that the centerline of bearing is also the centerline of the cap. When beams from spans of different length bear on the same cap, the centerline of bearing is usually not at the centerline of the cap.

- Any deviations between the original survey and the actual structure location should be evaluated prior to the scribing of bearing areas. Scribing means marking the layout on a concrete surface.

- If any corrections are needed, you must check with the Project Administrator for the proper corrective methods. Then, you must be sure that the Contractor corrects any problems before beams are placed on the bearings.

- Elevations must be checked carefully.

- Bearing areas should be scribed onto the beam pedestals after being located and verified.

**QUIZ**

1) Bearings are placed on ______________ or ___________ ____________.

2) True or false: the centerline of bearing is always the same as the centerline of the cap.

3) In order to insure that the bearing is positioned properly what must be done to the pedestal?
ANCHOR BOLTS

Anchor bolts are used to hold the bearing assembly in place on top of the pedestal and to produce a fixed bearing, which will be explained in a following lesson. There are two methods of setting anchor bolts: drilled holes or formed holes. Details for anchor bolt placement will be found in the plans and shop drawings.

SETTING BOLTS IN DRILLED HOLES

In this method, which is the most commonly used, a vertical hole is drilled into the hardened concrete, the hole is thoroughly cleaned, grout is placed in the hole and the anchor bolt is pushed down through the grout. When this method is used, care should be taken to keep from cutting the reinforcing steel. To avoid hitting steel, and to make sure that the bolts will be placed properly, it is recommended that the Contractor use a bolt hole template. This method is usually more precise than the formed hole method since the final position of the anchor bolt is known and because the drilling takes place shortly before beams are placed.

Since the grout keeps the anchor bolt from pulling out of the cap concrete, it is very important that it be mixed and placed properly. The grout shall be a mixture of one part cement and one part clean fine sand that is wet enough to flow freely. The hole should be filled about two-thirds full of grout before the bolt is pushed into the hole and the grout rises to the top. After the bolt is in its final position, the grout is allowed to set. A recommended procedure for curing the grout is, simply, to brush curing compound on the area.

SETTING BOLTS IN FORMED HOLES

Holes that are 4 inches (100 mm) in diameter are formed in the concrete. This is accomplished by inserting a metal or plastic pipe, with an outside diameter of 4 inches (100 mm), into the fresh concrete then withdrawing it once the concrete is partially set. This leaves the correct size opening in the concrete for the anchor bolt. It is important that you make sure that the hole is at least 4 inches (100 mm) in diameter since it is usually formed long before the final position of the anchor bolts is determined. This hole diameter will allow extra room for establishing the anchor bolt’s final position. Once the concrete has hardened the grouting procedure is the same as with drilled holes.
This drawing shows a typical anchor bolt layout:

- **Anchor bolt**
- **Base plate**
- **Bearing pad**
- **Bridge seat**
- **Finished girder seat (bearing area)**

The bearing is skewed on the seat.

This plate was fabricated with slots for minor adjustments.
**QUIZ**

1) Where will you find details of anchor bolt placement?

2) Usually, anchor bolts are set into pier caps by ___________ holes for the bolts and ___________ them into place.

3) To make sure that the Contractor doesn't drill through rebars, it is recommended that a ___________ be used.

4) After a hole is drilled and cleaned, the next step is to fill it about ___________ full of grout.

**BEARING TYPES**

Steel and concrete beams use the same types of bearings and these fall into three major categories: non-composite neoprene bearings, composite neoprene bearing pads and multirotational bearings. Which type bearing is used, depends mostly on the length and curvature of the beam. Bearings function as either fixed or expansion. Fixed bearings permit rotation of the girder end but not lengthening (expansion) or shortening (contraction). Expansion bearings allow expansion and contraction as well as rotation.

The details of how to properly position the bearing on top of the pedestal will be discussed in a following lesson.

**NON-COMPOSITE NEOPRENE BEARINGS**

These type bearings are used primarily for Flat Slab bridges and are formed of pure neoprene. The pads are positioned between the bottom of the slab and the top of the cap and are usually continuous from one end of the cap to the other. You will need to make sure that they are positioned correctly and that all material requirements comply with the specifications.
COMPOSITE NEOPRENE BEARING PADS

Composite pads handle heavy loads from both steel and concrete beams/girders and this requires the pad to be manufactured with alternating layers of neoprene and steel (see illustration next page). The neoprene layers give the pad the flexibility needed to accommodate the expansion and contraction of the girders due to temperature variations as well as rotation of the end of the girder in the direction of the girder’s length. The steel plates provide stiffness to prevent the neoprene from bulging and cracking. Plain composite pads accommodate the beam movement by deforming or changing shape, since there are no sliding elements. Pads come in standard sizes when they are intended for use under standard beams such as AASHTO or Bulb-T beams, but they are also ordered in custom sizes where a standard pad will not work.

For all but the longest girders, the pad is used without sliding steel elements. The amount of girder expansion/contraction or movement the pad can accommodate is directly related to its height: the higher the pad the greater the movement that can be accommodated. There is a limit to how high the pad can get; however, and when it is exceeded, the top of the pad is fitted with a steel external plate having a non-stick surface similar to Teflon (TFE - polytetrafluoroethylene) (see illustration). To minimize friction between the girder and the bearing, a steel sole plate or bearing plate is attached to the bottom of the girder and is made of stainless steel with a polished surface. The stainless sole plate slides on the TFE surface, which allows the neoprene pad to accommodate more girder movement than it could by itself. Proper positioning of the pad is critical so you must observe how the Contractor does this very carefully. Remember, the pad must comply with all material specifications.
EXAMPLE COMPOSITE NEOPRENE BEARING PAD

Cross section through the center of a 10" wide by 20" long Pad

EXAMPLE COMPOSITE NEOPRENE BEARING PAD WITH TFE TOP SURFACE

Cross section through the center of a 10" wide by 20" long pad
MULTIROTATIONAL BEARINGS

These bearings are used for the longest girders and/or for curved girders. They can accommodate very large girder movements and rotation in any direction, not just in the direction of the girder’s length. They are used as fixed bearings also, in which case they allow rotation in any direction but not expansion or contraction. There are two main types of multirotational bearings used by the Department: Pot Bearings and Disc Bearings.

Pot Bearings (see the illustration to the right) are by far the most commonly used and function with a piston and cylinder (or pot) type mechanism. The pot contains a neoprene like material that is confined within it. When the piston is inserted into the pot, it floats on top of the neoprene material and this allows it to rotate in any direction.

The disc bearing functions very much like a bearing pad but is a much tougher material and is capable of withstanding much higher loads as well as rotations in any direction. It is also confined by steel plates. As with the bearing pads, you must be sure that positioning is done properly and that materials comply with the specifications. Both type bearings use a steel bearing or masonry plate with slotted holes for anchor bolts to go through, in order to permanently fasten the bearing assembly to the concrete pedestal.

Prior to installation, Pot Bearings must be protected from the elements. Sliding surfaces and bearing mechanisms can be affected greatly by corrosion and contaminants.
QUIZ

1) Name the three major types of bearings used by the Department.

2) Composite pads are made up of alternating layers of __________ for flexibility and __________ to prevent bulging.

3) True or false: fixed pot bearings can accommodate large expansion and contraction movements.

SETTING BEARINGS

CHECKING FABRICATION OF BEAMS

The way beams are fabricated is important. They must be checked against the shop drawings, as well as against actual field conditions. You should check for errors prior to construction in order to avoid unnecessary delays.

You should check the actual distances between the pier, bent or abutment pedestal centerlines and the distances between the bearing centerlines of the beam and the length of the beam while it is being stored. The shop drawings will show the centerline of bearing for the beams. When the beam ends are placed on the pedestals, the centerline of bearing for the beams must align as closely as possible to the centerline of bearing of the pedestals. For pedestals that have a bearing base plate on top, the centerline of bearing of the pedestal and base plate must be the same. For example, the diagram on the next page shows the various measurements that are used.

Bearing centerline spacing must be checked on each beam. This can be done upon delivery by matching the beams to the shop drawings. In most cases, the bearing centerlines are in the proper locations. But if they are not, major problems can arise. So be sure to check them.
CENTERLINE OF BEARING ADJUSTMENTS

If the locations of bearing centerlines on the beams are not within the tolerances noted on the shop drawings or standard specifications, the bearing areas on the pedestals may need to be adjusted to fit the bearing centerline spacing of the beams. If the beam bearing centerline locations are within the tolerances, the bearing areas on the pedestals need not be adjusted. The longer the beam the more critical is this process since the magnitude of the expansion and contraction increases with beam length. Also, the positioning of neoprene pads that do not have sliding plates is less precise, due to a much greater margin for error and the fact that they cannot be adjusted for temperature. For these type pads, the centerline of the pad just needs to coincide with the centerline of bearing of the pedestal.

This diagram shows the measurements you will need to determine the correct bearing locations.
In the diagram on the previous page, the distances between pier centerlines and beam bearing centerlines vary. To make the proper adjustments on the beam pedestals, you must:

1. Determine beam bearing centerline spacing at 70° F (21° C).

2. Compare spacing at 70° F (21° C) to pier, bent or abutment centerline spacing, by calculating the differences in the spacing.

3. Be sure that the proper corrections are made. We will discuss the options open to the Contractor in the text ahead.

Now, look at each step in detail, beginning below.

1) The following rule of thumb is used in determining the amount of expansion and contraction in steel. For concrete girders, consult your Project Administrator:

\[
\text{Expansion or contraction } = \frac{1}{8} \text{ inch (3 mm)} \text{ per 100 ft. (30.48 m) for each 15 degree F (8.33 degree C)}
\]

increment above or below 70° F (21° C). This is not the air temperature but the temperature of the steel or concrete girder as measured by a surface thermometer.

For instance, in our example, the distances between the beam bearing centerlines were taken at 55° F (13° C). To compute these distances at 70° F (21° C) or 15 degrees F (8.33 degrees C) warmer, we add 1/8 inch (3 mm) to each measurement:

\[
\begin{array}{cccccc}
1/8 \text{ inch (3 mm)} &=& 0.0104' \text{ rounded to 0.01'} & \text{or} & 0.003 \text{ m} \\
89.99' (27.429 \text{ m}) & +0.01' & (0.003 \text{ m}) & 90.00' (27.432 \text{ m}) \\
59.98' (18.282 \text{ m}) & +0.01' & (0.003 \text{ m}) & 59.99' (18.285 \text{ m}) \\
100.02' (30.486 \text{ m}) & +0.01' & (0.003 \text{ m}) & 100.03' (30.489 \text{ m}) \\
74.99' (22.857 \text{ m}) & +0.01' & (0.003 \text{ m}) & 75.00' (22.860 \text{ m})
\end{array}
\]

Notice that we used 0.01 ft. (3 mm) for each span, even though the span lengths varied. This is because we are using a "rule of thumb" and it would be difficult to work with a greater degree of accuracy at this point.

2) Compare the distances between the beam bearing centerlines at 70° F (21° C) to the actual as-built distances between pier pedestal centerlines measured in the field. To do this, you begin at the fixed
bearing pedestal, P1, and work toward the expansion bearings (A1, P2, P3, A2) - adding the differences as you progress. For example:

Start at the fixed bearing and work toward the expansion bearings and remember that a positive value for the difference means that a beam bearing centerline is up station from a pedestal centerline of bearing. A negative value difference is down station.

![Diagram of bearing pedestals and expansion bearings]

Actual Pier Measurement:

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<th>100.01'</th>
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<td>(m)</td>
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<td>18.285</td>
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<td>22.866</td>
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- Beam Bearing Spacing (70°F)

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<th>100.03'</th>
<th>75.00'</th>
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<tbody>
<tr>
<td>(m)</td>
<td>27.432</td>
<td>18.285</td>
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Difference:

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<th>+ 0.02'</th>
<th>0.00'</th>
<th>- 0.02'</th>
<th>+ 0.02'</th>
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<tbody>
<tr>
<td>(m)</td>
<td>+ 0.006</td>
<td>0.000</td>
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Cumulative difference:

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<tr>
<td>(m)</td>
<td>+ 0.006</td>
<td>0.000</td>
<td>- 0.006</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Work in two directions. Cumulate the differences in the directions of the expansion.
Here's what the diagram on the previous page means:

- Beams should be set at the fixed bearing first so an adjustment for temperature should never be needed; however, an adjustment for an out of tolerance cap location may be needed. For this example, the fixed bearing is set first so the centerline of bearing for the beam aligns exactly with the centerline of bearing for the pedestal or base plate.

- The beam bearing centerline at Abutment #1 will be up station by 0.02 ft. (6 mm) from the abutment pedestal bearing centerline.

- The beam bearing centerline at Pier #2 aligns exactly with the pier #2 pedestal centerline of bearing.

- The beam bearing centerline at Pier #3 is down station by 0.02 ft (6 mm.) from the pier #3 pedestal centerline of bearing.

- The beam bearing centerline at Abutment #2 will align exactly with the Abutment #2 pedestal centerline of bearing, because the spacing difference between P3 and A2, which is +0.02 ft. (+6 mm), cancels out the difference between P2 and P3 which is -0.02 ft. (-6 mm).

3) Now we must be sure that proper corrections are made. For all but neoprene bearings, the base plate, also called the masonry plate, has slotted holes that will allow the plate to be shifted as much as one inch. This is usually enough to get exact alignment of the beam bearing centerline and the centerline of the base plate. If the slotted holes do not allow enough adjustment, then the anchor bolts have to be repositioned.
1) In order to correct differences between fabricated beam bearing centerlines and actual as-built pier, bent and abutment pedestal locations, you must follow three steps. The last step is to be sure that corrections are made. What are the first two steps?

1. ____________________________________________
2. ____________________________________________

2) True or false: bearing alignment corrections of less than 1 inch (25 mm) can easily be made because of the slotted holes in base plates.

3) How should you check bearing centerline spacing of beams delivered to the project site?

4) The bearing centerline spacing on a girder is 80.91ft. (24.661 m), at 84° F (31° C), but the actual field measurement between the bearing centerlines of the pedestals is 81.00 ft. (24.689 m). If the anchor bolts have not been installed, which of the following courses of action probably should be taken?

A. Erect girder, no corrections needed.
B. Adjust bearing centerlines on the pedestals by drilling anchor bolt holes so that the base plate centerlines will match the girder bearing centerlines.
C. Move the centerline of bearing plates on steel girders by rewelding.
D. Shift base plates on the pedestals to match the girder centerline of bearing by using slotted holes.

5) If the anchor bolts had been set already in the problem above, which course of action would probably be taken?

__________________________
ANSWERS TO QUESTIONS

Page 1-4, Locating Bearings
1) pedestals, beam seats
2) false
3) It must be scribed

Page 1-7, Anchor Bolts
1) In the plans and shop drawings
2) drilling, grouting
3) template
4) 2/3

Page 1-11, Bearing Types
1) non-composite bearings, composite neoprene bearing pads, multirotational bearings
2) neoprene, steel
3) false: fixed bearings do not allow the girder to expand or contract

Page 1-16, Setting Bearings
1) 1. Determine bearing plate spacing at 70° F (21° C)
2. Compare spacing at 70° F (21° C) to pier, bent or abutment pedestal centerline spacing, by calculating the differences in the spacing.
2) true
3) Measure spacing and match to shop drawings.
4) B
5) D
CHAPTER TWO

ERECION OF STEEL BEAMS AND GIRDER

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As you know from chapter one, the erection of beams and girders is pretty much the same whether the material is steel or concrete. However, there are some aspects of steel girder or beam erection that are unique and these will be discussed in detail in this lesson. Steel girders require bolting and welding both of which are very critical with regard to the quality of the final product. Bolting requires rigorous procedures to ensure that critical joints and connections are assembled and joined correctly. Welding is so important that welders must be qualified and this requires them to be tested to confirm that their skills and abilities are acceptable.

You must pay close attention to the girder framing configuration that is covered in detail in the plans and shop drawings. The framing plans will show all the information needed to ensure that the right girder goes in the right location and in the proper direction. These plans will also show where the bracing is located. Certain simple clues will give you the girder’s proper orientation into a frame. Attached tags, paint, or approved low stress die stamped match marks on frame members indicate which components go together. Also, with experience, you can look at copings on sloped beams and determine which end goes where (e.g. sloped transverse members used to achieve cross-slope, and sloped longitudinal members used to achieve vertical profiles).

Once the girders are in their proper location, the cross bracing is installed in order to ensure the lateral stability of the superstructure prior to deck placement and to ensure that vehicular traffic loads are shared by multiple girders once the bridge is in service.

Steel girders also have shear connectors that are vertical steel studs welded to the top flange in specific locations. The shear connectors ensure that the deck and girders act together to carry the loads by preventing the deck from slipping on top of the girders when the girders deflect. You must make sure that the shear connectors are fastened to the top flange properly and they are in the proper locations and are proper sizes according the shop drawings and plans. Standard Specification 502, covers the inspection requirements for shear connectors and you must be thoroughly familiar with this specification in order to perform a proper shear connector inspection.
INSPECTING FOR DEFECTS BEFORE ERECTION

When they arrive at the project site, examine the beams/girders carefully for the following defects and report significant ones to the Project Administrator:

- **KINKS**: Sharp bends in flange or web plates that do not reveal warps. Kinks are occasionally required by the design so check the plans before you report a kink as a defect.

- **WARPS**: Wavy sections in flange or web plates that are an indication of buckling or excessive temperature effects caused by welding.

- **BENDS**: Gradual curves in plates that are not indicated as being part of the design.

- **CRACKS**: These are very serious defects when in a steel beam because they can grow and eventually cause sudden failure of a plate, which can cause collapse of the beam or even the entire superstructure.

- **PLUMBNESS**: Using a Plumb Bob or square, check to see that flange plates are perpendicular to the web plate and that stiffener plates are perpendicular to top and bottom flange plates.

- **WELDED AND BOLTED CONNECTIONS**: Examine all welds that join plates together, such as flange to web connections, for obvious welding defects and make sure that any bolted connections are properly assembled and that bolts appear to be snug. A loose bolt can be revealed by the sound it makes when lightly taped with a hammer.

HANDLING AND STORAGE

When the beams/girders arrive at the project site very often they are lifted from a truck or barge and are placed directly in their permanent position. You must make sure that the proper lifting devices are used and placed at the proper locations so that lifting stresses will not cause damage to the girder. These devices are usually special clamps that attach to the top flange. If they are used improperly, there can be damage structurally or to the beam’s protective coating. Pay particular attention to box girders and curved girders since they can be larger, heavier, or far more unstable than single straight beams and are; therefore, more difficult to handle properly.
If the beams/girders are placed in a temporary storage site prior to permanent placement, they must be supported at least at the points of bearing shown in the plans and they must be high enough off the ground to avoid being submerged in, or being splashed by, water. The beams should also be kept free of dirt, oil, or any other detrimental contaminant.

**BOLTING**

**GENERAL REQUIREMENTS**

As an Inspector, you will be responsible for inspecting field bolting. Bolting is done with high-strength bolts, nuts and hardened-steel washers.

Here are some general requirements for bolting:

- The combination of fastener elements, which include a bolt, nut, DTI (Direct Tensioning Indicator) and washer/s, is referred to as a fastener assembly. Torque tests - which will be explained later - are performed on a representative fastener assembly that is made up of elements from specific production lots. Once a production lot for each element of an assembly is established, it must not be changed unless a new set of torque tests are conducted on the assembly.

- Bolted connections must be used only as indicated on the plans or in the Special Provisions.

- For bolted girder splices, all bolts required by the plans must be installed and fully tightened prior to the removal of falsework or any other temporary support. Failure to have a fully completed splice could result in severe damage to the joint and girder or even collapse.

- The materials quality of the fastener assembly and the accuracy of the bolt tightening process are extremely critical to the integrity of a bolted connection or joint. It is your job to verify that accurate tracking and documentation of the assembled materials are being done by the Contractor and that correct torquing procedures are being consistently followed.
FASTENER ASSEMBLY MATERIALS

The plans specify the type of bolts to be used, but you should be able to identify them to see that the Contractor uses the specified kinds of bolts. Different high-strength bolts are distinguished by the markings on their heads. Be sure that these markings match the type of bolts required by the plans. On the left is a table of the different types of bolts and their individual markings, which will help you to identify them. These marks do not appear on temporary erection bolts. Temporary erection bolts are often used for short periods of time until replaced by permanent high strength bolts.

<table>
<thead>
<tr>
<th>Type</th>
<th>Markings</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A-325M) - Type 1 Bolt</td>
<td>Manufacturer’s Identification (AB325M) 3 raised radial lines 120 degrees apart</td>
</tr>
<tr>
<td>(A-325M) - Type 2 Bolt</td>
<td>Manufacturer’s Identification (AB325M) 3 raised radial lines 60 degrees apart</td>
</tr>
<tr>
<td>(A-325M) - Type 3 Bolt</td>
<td>Manufacturer’s Identification (AB325M)</td>
</tr>
<tr>
<td>Nuts for use with (AB325M) bolts</td>
<td>Marked on one face with 3 similar circumferential markings 120 degrees apart or alternatively with: C, 2, D, 2H or DH</td>
</tr>
<tr>
<td>(A-490) Bolt</td>
<td>Manufacturer’s Identification (AB490)</td>
</tr>
<tr>
<td>Nuts for use with (AB490) bolts</td>
<td>Marked on one face with 3 similar circumferential markings 120 degrees apart or alternatively with 2H or DH</td>
</tr>
</tbody>
</table>

The Contractor is required to submit to the Department certified test reports that confirm the physical properties of the fastener assemble elements (bolts, nuts, DTI’s and washers). You must check these reports to see that the information required by the specification is complete and accurate. In addition, other tests are required by the specification such as the rotational capacity test, which confirms the bolt assemblies meet the performance and strength criteria required by the specification. You must verify that these tests are in order. The Rotational

NOTE: The "E" is the manufacturer's trademark.
Capacity Test must also be performed in the field and you will need to consult the Project Administrator for the detailed procedure covering this test.

Fastener elements are manufactured hundreds or thousands at a time from a single source of steel. All the elements from a single source are said to come from the same LOT. The physical properties of elements from different LOTs can differ a great deal so it is very critical that once the LOTs of a fastener assembly are established, that they not be changed. Torque tests performed on a small sample of assemblies each day at the project site, are based on using the same LOTs for all the assemblies installed that day. If LOTs are mixed the torque tests will not be valid and the assemblies will not perform as expected. The Contractor is required to establish a procedure for making sure that LOTs are identified properly and that elements of different LOTs are not mixed together. You must make sure the Contractor follows the procedure for maintaining integrity of the LOTs.

Other materials related issues you will need to monitor include type and quality of bolt lubricants, packaging of the fastener elements during shipping, and storage and protection of the elements prior to installation. All these issues are governed by comprehensive specifications that you must be thoroughly familiar with.

**INSTALLATION**

There are two types of bolted connections: Friction and Shear (also called “Bearing”). For the Friction type, the bolts are tightened to a degree that friction between the steel plates that the bolts are holding together, will prevent slippage of the plates when they are loaded. For Shear type connections, the plates may slip which can allow them to come to bear on the bolt shafts. For structural steel connections of bridges, shear type connections are not permitted. For friction connections, you need to be sure that contact surfaces of joint or connection plates referred to as the “Faying Surfaces” are free of the following: dirt and loose scale (except tight mill scale), burrs, pits, oil, paint and lacquer, galvanizing, and any other thing that would prevent a completely tight joint.

The faying surfaces of bolted connections must be in full contact when assembled and must not be separated by gaskets or any other compressible material. You must check that bolt holes are at least 1/16 inch (2 mm) larger then the diameter of the bolt shaft, but not greater then 2/16 inch (4mm). Greater then 2/16 inch requires the use of a special washer or can even require the use of a larger bolt. Where one side of a connection is protected from the weather, the threaded ends of bolts should be placed on the protected side if possible.
Before bolting begins, the plates are usually held together by drift pins and temporary erection bolts. Plates that are to be bolted together must be held in their correct positions so that the joint can be aligned properly. Drift pins of the proper size usually are installed first in a few sets of holes, in order to bring the plates into their proper relative positions and to keep the holes in alignment. Temporary bolts of the specified size are put into other sets of holes and are tightened in order to hold the pieces in contact until the permanent bolts are installed. Eventually the drift pins and temporary bolts are removed, and the joint is fully bolted using the permanent fasteners.

Bolts must be tightened in a required order or sequence to ensure that the faying surfaces of the plates being bolted are pulled into full contact and that all bolts have approximately the same final tension. If the proper sequence is not followed, some of the initially tightened bolts may loosen and allow plates that were previously in contact, to pull apart.

On the right, is an example of the required bolting sequence. The bolt to be tightened first is numbered with a “1”, the bolt to be tightened next with a “2”, and so on, until the last bolt, number “60”, is tightened.

Tightening should be symmetrical, starting from the most rigid parts of the joint at the center and working outward. This eliminates warps in the plates by pushing them to the free ends. As you can see, the order starts with the two top half center columns of bolts and works upward, back and forth, between columns until the two center columns are completely tightened for the top half of the plate. Then the sequence again starts at the center of the plate and
goes up the outside top half column until it is complete, followed by the opposite outside top half column. The order is the same for the bottom half of the plate. Regardless of the shape of the plate or the number of bolts, this general order must be followed.

Be sure the Contractor has replaced all temporary drift pins or temporary erections bolts with permanent bolts. You can tell the difference by the identification markings on the permanent bolt heads.

Usually, bolting is done with impact wrenches. If so, impact wrenches should have adequate capacities and be sufficiently supplied with air to perform the required tightening in approximately 10 seconds. If limited clearance will prevent the nut from being turned, then tightening may be done by turning the bolt while the nut is prevented from rotating. In this case a washer must be used under the bolt head and lubricant must be used on the bolt face. When bolts are not perpendicular to the plate, a beveled washer may be required.

The plans will specify the minimum bolt tension to be obtained for each bolt. The Department's required bolt tensions are shown in the table on the next page. Try the quiz beginning on the next page, and then we will discuss how bolts are tightened.
### MINIMUM REQUIRED BOLT TENSION*

*English units in lbs. and Metric units in kN

<table>
<thead>
<tr>
<th>Bolt Size (inch)</th>
<th>Type Bolt: ASTM A 325</th>
<th>Type Bolt: ASTM A 490</th>
<th>Bolt Size (mm)</th>
<th>Type Bolt: ASTM A 325</th>
<th>Type Bolt: ASTM A 490</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>12,050</td>
<td>14,900</td>
<td>M16</td>
<td>94.2</td>
<td>130</td>
</tr>
<tr>
<td>5/8</td>
<td>19,200</td>
<td>23,700</td>
<td>M20</td>
<td>147</td>
<td>203</td>
</tr>
<tr>
<td>3/4</td>
<td>28,400</td>
<td>35,100</td>
<td>M22</td>
<td>182</td>
<td>251</td>
</tr>
<tr>
<td>7/8</td>
<td>39,250</td>
<td>48,500</td>
<td>M24</td>
<td>212</td>
<td>293</td>
</tr>
<tr>
<td>1</td>
<td>51,500</td>
<td>63,600</td>
<td>M27</td>
<td>275</td>
<td>381</td>
</tr>
<tr>
<td>1 1/8</td>
<td>56,450</td>
<td>80,100</td>
<td>M30</td>
<td>337</td>
<td>466</td>
</tr>
<tr>
<td>1 1/4</td>
<td>71,700</td>
<td>101,800</td>
<td>M36</td>
<td>490</td>
<td>678</td>
</tr>
<tr>
<td>1 3/8</td>
<td>85,450</td>
<td>121,300</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 1/2</td>
<td>104,000</td>
<td>147,500</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
QUIZ

1) How can you identify high-strength bolts?

2) What must the contractor submit to the Department to confirm the physical properties of the fastener assembly elements?

3) Who is responsible for establishing a procedure for properly identifying LOTs?

4) Why must bolts and the surfaces they contact be free of galvanized zinc, oil and paint?

5) Besides the three things named above, what else should you watch for on joint surfaces?

6) Why are temporary erection bolts used?

7) Tightening should begin at the ______________________________ of a joint.

8) True or false: once installed, the threaded end of the bolt should be protected from weather if possible.

9) When drift pins are used in splicing, what is the construction sequence?
   a. ______________________________
   b. ______________________________
   c. ______________________________
BOLT TIGHTENING

Bolts are tightened until the tension force (measured in pounds or kN) in the bolt reaches a minimum level, which applies the required clamping or compression force to the plates being joined. There are two methods for ensuring that the bolt is tightened to at least the minimum tension. One method uses a Direct Tension Indicator (DTI) and the other method, referred to as the Turn-Of-Nut (TON) method, establishes how much torque or nut rotation will produce the minimum tension. Refer to the contract documents to determine which method must be used. Both may be permitted, so find out from the Contractor which method he intends to use.

Inspecting the TON method requires the use of an inspecting wrench, which may be either a calibrated torque wrench or a calibrated power wrench. Inspecting the DTI method requires the use of a feeler gauge. A calibrated torque wrench is equipped with a dial gage that measures and displays the torque while tightening a bolt. A construction worker supplies the tightening force. Power wrenches are calibrated to stall or cutout at the desired level of tension. Wrenches are referred to as calibrated when their measuring device or gage is certified to be accurate by an independent laboratory or vendor who adjusts the mechanism so that it performs to the required level of accuracy.

Direct Tension Indicator Method

For the DTI method, a device that looks like a washer with bumps or protrusions on it (see illustration) is placed between the bolt head (when the nut is turned) and the plate before tightening begins. When the bolt head has to be turned, the DTI is placed under the nut. As the protrusions are flattened during tightening, the tension in the bolt increases. When the protrusions are flattened to a gap, less then a specified amount, between the washer surface of the DTI and the bolt head - typically 0.005" (0.13mm) - the bolt will have the minimum required tension. As can be seen in the illustration, a feeler gage is used to determine when the proper gap has been achieved and the gage must be placed at a number of locations on the DTI. Not all the gaps between protrusions must be less then 0.005" (0.13mm) to approve the bolt as fully tensioned. For example, if the DTI has five gaps between protrusions, 3 gaps must be refused by the gage for the bolt tension to be approved. The specification will have a table that will indicate the number of gap refusals required for a given size DTI and you will need to be familiar with this table. The gap can also vary if the DTI is galvanized.
The illustration below shows a DTI before and after it is flattened to the required minimum gap. During the tightening process, the construction worker should go through a first round of tightening in which every DTI in the joint is flattened to more than the minimum gap. This should produce a snug tight condition for the joint. What is meant by snug tight will be explained later in this lesson. Then, during the second round, the worker should flatten every DTI to the final required minimum gap. If only one round of tightening is used, there is a high probability that bolts tightened during the start of the round will loosen because steel plate warps in those locations are eliminated as more bolts are tightened. The bolting sequence explained in the installation section above, must be used.

**DIRECT TENSION INDICATORS BEFORE AND AFTER TIGHTENING**

Note: Protrusions are always against the bolt head or nut
QUIZ

1) What are the two methods for ensuring that bolts are tightened to the required tension?
   a. 
   b. 

2) Inspection of the turn-of-nut method requires the use of a calibrated __________ wench or a calibrated____________ wench.

3) True or false: a DTI must be placed under the bolt head if the bolt head is turned.

4) What device is used to measure the gap between the DTI and the bolt head or nut?

5) Should every DTI be flattened to the minimum required gap during the first round of tightening?

Turn-Of-Nut Method (TON)

For the TON method, each bolt is tightened to a “snug tight” condition by turning the nut while holding the bolt head stationary. After the snug tight condition is achieved, the nut is turned another 1/3 to 3/3 of a turn depending on the length of the bolt and the bolted parts orientation to the bolt axis - thus the name Turn-Of-Nut. The longer the bolt is, the greater the required turn. The snug tight torque plus the torque that is produced by the “turn” - the additional 1/3 to 3/3 turn - must result in a bolt that has 1.05 times the minimum required tension shown in the table of the Installation Lesson above. In addition, once all bolts are snug tight, which must happen before any nuts are turned, all faying surfaces of the joint plates must be in full contact and have no gaps showing. If this cannot be achieved, excessive plate warping may exist and you should notify the Project Administrator immediately for a special tightening procedure or other remedial action.

The Contractor must establish a snug tight torque value for bolts at the start of each day that bolts are installed and this torque is referred to as the “job inspection torque”. The job inspection torque must be determined each day because the torque will vary from day to day depending on the temperature, humidity, degree of lubrication,
and finish of the assembly elements. The snug tight torque is determined by tightening the bolt to a trial torque, that is the Contractor’s best guess, then turning the nut the required amount and measuring the bolt tension. The bolt is placed in a special device called a Skidmore-Wilhelm calibrator, or just Skidmore, that measures and displays the amount of bolt tension. If the tension is equal to or greater than 1.05 times the required minimum, then the trial torque is acceptable. This procedure is performed five times for each combination of fastener assembly and three of the five values are averaged since the high and low values are not used. This average torque value is the snug tight torque that is used for that day or the job inspection torque. The job inspection torque plus the torque produced by the turn will produce 1.05 times the minimum required tension and; therefore, the torque versus tension relationship is established. Note: this relationship does not need to be established when DTIs are used because the DTI confirms the required bolt tension directly when the gap closes to the specified opening.

You should watch the bolting procedure to be sure a proper bolting sequence is followed. Normally a bolt is tightened by turning the nut, but sometimes it is not possible to get a wrench onto the nut because of an obstruction. Then it is necessary to turn the bolt head while holding the nut to prevent its turning. The hardened washer must be placed under the bolt head when tightening and the surface between the washer and bolt head should be lubricated.

You must observe the installation and tightening of bolts to determine if the selected tightening procedure is properly used. You must also determine that all bolts are tightened. The following procedure must be followed when you inspect the bolt installation and tightening of a joint or any connection.

- After the Contractor has installed all the permanent bolts, he will start the snugging process. Using the job inspection torque, the Contractor will install all the bolts of the connection. If this process is done correctly you must confirm that the faying surfaces will be in full contact and there will be no gaps between plates.

- You must also confirm that the snugging is acceptable by checking to see that the job inspection torque has been developed. This is done with a torque wrench by checking a representative sample of not less than 3 bolts or ten percent of all the bolts in the joint, whichever is larger. If all the sample bolts have the full job inspection torque, then the snugging is considered to be acceptable and the turn-of-nut process can begin. If you find that even one sample bolt fails to develop the required torque, then it must be tightened to the full torque and all the bolts in the joint must then be torque tested by the Contractor while you observe. Any other loose bolts must be tightened.
Once you accept the joint as being in snug tight condition, the Contractor can begin the turn-of-nut process. To do this he must place a mark (vertical straight line) on the flat end of the bolt shaft and on the nut so that the line on the bolt end and on the nut are visually aligned, which is referred to as matchmarking. This will allow you to confirm that the required turn, say 1/3 rotation or 120 degrees, is fully completed since you will be able to observe the mark on the nut relative to the mark on the bolt thread. The plate must also be matchmarked because you will be able to tell if the bolt moved during the turn, which is not permitted. If the bolt rotates during the turning process, then the nut must be completely loosened and snugged again before the turn can be reapplied.

**Q U I Z**

1) The_______ ________ _______ plus the torque that is produced by the “turn” must result in a bolt that has 1.05 times the minimum required tension.

2) True or false: a joint is considered to be snug tight if the faying surfaces have gaps of not more than 1/100 inch.

3) The job inspection torque must be determined each day because the torque will vary from day to day depending on the ___________, _________, __________, and __________.

4) As measured by the Skidmore, a bolt must develop a capacity ______ times the minimum required to be acceptable.

5) How many fastener assemblies of each combination per lot per day are required to be Skidmore tested in order to establish the job inspection torque?

6) How many bolts make up a representative torque checking sample for snug tight acceptance?

7) List the three locations where matchmarks must appear.
ALLOWABLE BOLTING ADJUSTMENTS

One more point can be made about bolting. Steel plates should fit together with little distortion or strain. The need for slight adjustments using drift pins is to be expected. However, if the holes are too far out of place, do not allow workmen to force the parts into position with drift pins. The improper use of drift pins may damage the material around the holes and will overstress the plates. Also, do not allow a member to be struck with a heavy sledgehammer.

In most structures, a reasonable amount of reaming and drilling to match up holes is allowable. However, no reaming should be allowed in a connection in a main tension member of a truss, unless specific permission is obtained from the Project Administrator.

Any error which cannot be corrected by light drifting, a moderate amount of reaming and drilling, or slight chipping and cutting, should be reported to the Project Administrator. Approval of the proposed method of correcting the fault must be obtained before the method is used.

Checks and any necessary corrections should be made as the work progresses. Also, before the parts are connected permanently, you should check the work once more to be sure that all members are aligned properly and are set so as to give the required camber. This final checking is necessary to prevent poor alignment from being built into the final structure.

Q U I Z

1) Why must you not allow workmen to force steel parts into position during construction?
2) Where can reaming be done?
3) If light drifting or a moderate amount of reaming or drilling does not correct errors, what should you do?
4) Before final connecting is done, you must make a final check of the steel parts for _____ and ______.
WELDING

Welding is done in two places -- in the shop and in the field. Shop welding is done on structural steel components such as girders and beams. Almost all field welding is done in order to splice steel piles. As an Inspector, you will be concerned with field welds and you should be able to recognize incorrect or poor quality welds on any steel member that shows up on your project. Any questionable weld must be reported to the Project Administrator. You should have a basic understanding of the standard welding symbols shown on the plans. The Standard Symbols can be reviewed by studying the American Institute of Steel Construction chart on the next page. You are not responsible for knowing how to weld, but you should be able to distinguish between good and bad welds. You also will be responsible for checking to see that the welder’s qualification documents are in order before welding begins. Only qualified welders are permitted to make steel pile splices.

In the remainder of this section we will discuss welder qualification, types and positions of welds and weld defects.

WELDER QUALIFICATION

Only welders who are qualified can be allowed to weld structural members and it is your responsibility to verify this is the case. Qualification is based on tests and inspections given by private testers. The qualification requirements that apply will be determined by the latest welding code governing the work and the code most commonly used by the Department is the American Association of State Highway and Transportation Officials Bridge Welding Code. Consult with your Project Administrator about the details of verifying welder qualifications and to obtain a copy of the latest welding code.
WELDED JOINTS
Standard symbols

BASIC WELD SYMBOLS

<table>
<thead>
<tr>
<th>BACK</th>
<th>FILLET</th>
<th>PLUG OR SLOT</th>
<th>SQUARE</th>
<th>V</th>
<th>BEVEL</th>
<th>U</th>
<th>J</th>
<th>FLARE V</th>
<th>FLARE BEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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</tbody>
</table>

SUPPLEMENTARY WELD SYMBOLS

<table>
<thead>
<tr>
<th>BACKING</th>
<th>SPACER</th>
<th>WELD ALL AROUND</th>
<th>FIELD WELD</th>
<th>CONTOUR</th>
<th>FLUSH</th>
<th>CONVEX</th>
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</thead>
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</tr>
</tbody>
</table>

For other basic and supplementary weld symbols, see AWS A2.4-86

STANDARD LOCATION OF ELEMENTS OF A WELDING SYMBOL

Finish symbol
Contour symbol
Root opening; depth of fillet for plug and slot welds
Effective throat
Depth of preparation; size or strength for certain welds
Reference line
Specification, process or other reference
Tail (omitted when reference is not used)
Basic weld symbol or detail reference

Note:

Size, weld symbol, length of weld and spacing must read in that order from left to right along the reference line. Neither orientation of reference line nor location of the arrow alters this rule.

The perpendicular leg of D, V, J, V weld symbols must be at left.

Arrow and Other Side welds are of the same size unless otherwise shown. Dimensions of fillet welds must be shown on both the Arrow Side and the Other Side Symbol.

Flag of field-weld symbol shall be placed above and at right angle to reference line of junction with the arrow.

Symbols apply between abrupt changes in direction of welding unless governed by the “all around” symbol or otherwise dimensioned.

These symbols do not explicitly provide for the case that frequently occurs in structural work, where duplicate material (such as stiffeners) occurs on the far side of a web or gusset plate. The fabricating industry has adopted this convention: that when the billing of the detail material discloses the existence of a member on the far side as well as on the near side, the welding shown for the near side shall be duplicated on the far side.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION
QUIZ

1) Most field welding is done in order to ____________________________________________________.

2) Briefly list your responsibilities in regard to welding.

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

3) Look at the welding symbol shown below. Then answer the following questions.

What size and type weld will this be? ____________________________________________

What does the ☺ indicate? ____________________________________________

0.25” (6.35 mm)
TYPES AND POSITIONS OF WELDS

You should be able to recognize at least two types of welds: fillet welds and groove welds. Fillet welds are shown below:

- Tee joint
- Lap joint
- Corner joint

Groove welds are used on the butt joints shown below:

- Square groove
- Vee groove
Welds are made in four basic positions -- flat, horizontal, vertical and overhead. The diagrams below show these positions and their designations (in parentheses).

- **Flat position fillet weld (1 F)**
- **Flat position groove weld (1 G)**
- **Horizontal position fillet weld (2 F)**
- **Horizontal position groove weld (2 G)**
Vertical position fillet weld (3 F)

Vertical position groove weld (3 G)

Overhead position fillet weld (4 F)

Overhead position groove weld (4 G)
QUIZ

1) What kind of joint is shown at right? _________________________

2) What kind of weld? ________________________________

3) Butt joints should be joined with ____________________ welds.

4) List the four basic welding positions:
   ______________________________________________________
   ______________________________________________________
   ______________________________________________________
   ______________________________________________________

5) What does the designation 3 G indicate? _________________
WELD DEFECTS

During your inspection, all bad weld defects should be reported to the Project Administrator. The defects shown below are typical of poor field welding techniques. The steel in the parts joined together by welding is referred to as the base metal.

Undercuts

As can be seen in the diagram at right, undercutting causes a reduction in base metal thickness. Adding more material at the undercut points repairs this condition.

Overlaps

This diagram shows a weld with considerable overlap. Overlap is an overflow of weld materials onto the base metal. The weld material does not fuse with the base metal. Overlaps should be removed and the base metals should be rewelded.
Porosity

Gas bubbles trapped in the weld material cause porosity. This condition causes a weak weld. You will recognize this by the large number of small holes in the weld material. Removing the defective weld and rewelding the joint, correct this condition.

Cracks

Cracks are very serious welding defects that must be repaired. You should be sure the cracks are removed and the joints are rewelded.

Spatter

Spatter is not a serious welding defect because it does not affect the strength of the weld. However, spatter should be removed because paint will not adhere to it well and it gives an undesirable appearance. Wire brushing and chipping will remove spatter.

As an Inspector, you should inspect each weld after the slag (weld residue) has been removed. Welded surfaces should be bright and clean. Your responsibility ends with a visual inspection -- any further inspection will be done by a private testing laboratory that is under contract to the Department.
Q U I Z

1) Does undercutting cause a reduction or an overflow of base metal thickness?
2) What causes porosity?
3) How should overlaps be corrected?
4) Must cracks in welds be corrected?
ANSWERS TO QUESTIONS

Page 2-10, Fastener Assembly Mtrls. and Installation

1) By markings on their heads.
2) certified test reports
3) Contractor
4) They would prevent a tight joint.
5) dirt, loose scale, burrs, pits, lacquer
6) To hold connections together until permanent bolts are installed.
7) most rigid part
8) true
9) a. Drift pins placed in the first few sets of holes.
   b. Temporary bolts are put into other sets of holes and tightened
   c. Permanent bolts placed in other holes and tightened
   d. Drift pins removed and connection completed with remaining permanent bolts

Page 2-13, Bolt Tightening and DTI method

1) DTI, Turn-Of-Nut
2) torque, power
3) false
4) feeler gage
5) no

Page 2-15, Turn-Of-Nut Method

1) snug tight torque
2) false, surfaces must be in full contact
3) temperature, humidity, lubrication, finish of the assembly elements.
4) 1.05
5) 5
6) larger of 3 bolts or 10% of the total bolts
7) bolt threads, nut, plate
Page 2-16,  Allowable Bolting Adjustments

1) Strain will damage parts and over stress the steel.
2) Any parts other than main tension members.
3) Contact the Project Administrator.
4) alignment, camber

Page 2-19,  Welding Symbols

1) splice piles
2) Understand standard welding symbols. Distinguish between good and bad welds. Check welder's qualifications.
3) weld size: 0.25 inch (6.35 mm), type weld: fillet
4) weld all around

Page 2-23,  Types and Positions of Welds

1) corner
2) fillet
3) groove
4) flat, horizontal, vertical, overhead
5) vertical position groove weld

Page 2-26,  Weld Defects

1) reduction
2) Gas bubbles trapped in the weld material
3) Remove them and reweld base metals
4) yes
5) no
CHAPTER THREE

ERECTION OF PRECAST CONCRETE BEAMS AND GIRDERS

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As you will remember from Part 1, Chapter 1, there are two main types of precast beams: Prestressed or Post-tensioned; however, sometimes both types are used in the same beam. Their method of fabrication is discussed in detail in Part 1, Chapter 1 along with a description of the different shapes they come in: AASHTO, Bulb-T, U-Beam, Double-Tee, Inverted-Tee. Both types are fabricated and prestressed at a precast plant but the Post-tensioned girders are also post-tensioned together at the project because spans are so long that more than one girder segment is required to complete a span. The Department conducts quality assurance inspections at the precast plant unless the plant is located out-of-state in which case the inspections are provided by a testing lab approved by, and under contract to, the DOT. The Department plant Inspector makes sure that beams are constructed according to the contract documents and the Producer stamps them, just before they are shipped from the plant, with the Producer’s official approval stamp to indicate compliance with Department specifications. When the beams arrive at the construction site, your job will be to inspect them to be sure that there are no defects missed by the Producer, that no damage has occurred due to mishandling or improper storage and to make sure the beam has the Producer’s approval stamp. Do not allow beams and girders to be used on the project if they have no approval stamp.

INSPECTING FOR DEFECTS BEFORE ERECTION

When the beams arrive at the project site, look for any cracks. Small hairline cracks are usually due to shrinkage and are not critical to the strength of the beams. However, large cracks may indicate that the beams were mishandled or that more serious structural defects exist. If you notice that a beam has significant chips, spalls, or fragments that have broken off, the beams were probably damaged during transport from the plant to the project site.

Also check the reinforcing steel that extends out of the top flange of the beam. These rebars, referred to as stirrups, will be used to tie the beams and the deck slab together, and serve the same purpose as the shear connectors on steel beams. Stirrups should not be broken or badly bent (see illustration, next page).

If you find any damage, notify your Project Administrator.
STORAGE

The Contractor must store prestressed concrete beams in an upright position. This is important because pretensioned cables are located in the bottoms of the beams. This makes a beam resistant to compressive stress in the top flange and tension stress in the bottom flange caused by the loads applied to the top of the beam.

If the beams tip over or are stored upside down, they will crack. This is because the prestress strands in a beam are designed to only work when the beam is in its permanent upright position with the top flange at the top. To design a beam that could be placed upside down or on its side would be excessively expensive and inefficient.

STIRRUP REBARS EXTEND FROM THE TOP FLANGE

Beams should be stored off the ground. The supports used during storage, should be placed under the ends of the beam at approximately the same location, as will the permanent supports.
HANDLING

Beams should be picked up and supported only at the designated pick-up points, unless the plans state otherwise. These pick-up points are loops extending out of the tops of the beams (one near each end).

The pick-up cable should maintain a safe slope. A safe maximum amount would be 1:1.5. If a flatter slope is used, the beam may be damaged. Contractors will sometimes use two cranes, which create no problems. If he uses only one crane, be sure that the cables are long enough. The cables also must be the same length, for proper balance.

The illustration to the right is for an AASHTO beam, so you will have to review the plans for the pickup point locations and lifting method for other beam shapes such as U-Beams or Double-Tees.
QUIZ

1) Pieces broken off a concrete beam usually indicate that the beam was__________________________.

2) Concrete beams must be stored in an_____________________________ position.

3) If the Contractor decides to use one crane to pick up a concrete beam, he must be sure the cables are _________________ and _________________.

4) Who will stamp the beams as approved before they arrive at the construction site?

5) Beams should be picked up only at designated_______________________________.

ERECTION

PRESTRESSED BEAMS

Prestressed concrete beams are erected according to framing plans included in the plans and according to the shop drawings. Framing plans show a plan view of the beams with their markings. Concrete beams will have erection marks painted or stamped on them to show where each beam is to be placed. It is important for you to verify that the right beam is placed on the right pedestal and bearing. More often than not beams look identical; however, looks are deceiving since the rebars and prestress stands can be very different from beam to beam.

When prestressed beams are lifted into place and lowered onto their bearings, you must verify that the centerline of bearing of the beam coincides with the centerline of bearing for the bearing on the pier. U-Beams and Double-Tee beams often have multiple bearings and these can be more difficult to seat properly, so pay particular attention to whether or not these beams are in full contact with all bearings. The above issues and concerns apply as well to post-tensioned girders.
POST-TENSIONED GIRDERS

Since post-tensioned girders - which are usually Bulb-T girders - come to the project site in segments, their erection is far more complex than for prestressed beams. In the photograph on the next page, the erection of a three span post-tensioned bridge is underway. As can be seen, the three spans require five girder segments that are supported on two temporary steel pile bents. The first girder segments (pier segments) placed, are #2 and #4 followed by segments #1 and #5 (side segments) and finally segment #3 (center or “drop in” segment) is placed.

A pier segment is supported at its center by a permanent pier and at one end by the temporary bent. Its other end is unsupported and extends out over the water, which is called a cantilever. The side segments are supported on one end by a permanent pier and the other end is suspended from the pier segment by steel rods. Both ends of the drop in segment are suspended from the cantilever ends of the pier segments by steel rods. You should verify that the girder segments are sway braced adequately since they are very unstable by themselves and that bracing is installed immediately after segment placement. Verification of the suspension hardware at segment ends is also important and you should review the shop drawings for the details as well as consulting with the Project Administrator.

Once the segments are in their permanent positions, the open joints between the segments are fitted with post-tensioning ducts and other reinforcement. The joints are then filled with concrete, which permanently connect the girder segments. When the joint concrete is adequately cured, the post-tensioning tendons (groups of steel strands or cables) are threaded through ducts that were cast into the girders at the precast plant. Each tendon runs through all five segments and is stretched or tensioned with a hydraulic jack and the ends are anchored while still stretched. The anchors are located at the outside ends of the side girder segments. When the jack is released, the stretched tendon tries to return to its original un-stretched length, but cannot, because it is anchored to the girder ends and; therefore, highly squeezes or compresses the girder. The compression force the tendon applies to the girder is what holds the segments together and prevents the girder from bending excessively under vehicle loads.

During the post-tensioning phase of erection, you must be involved in assuring that the ducts are properly cleaned prior to the threading of the tendons, that tendons are free of corrosion and other surface contaminants, and that the tendons are stressed properly. You must consult with the Project Administrator about the complex procedures and record keeping involved in proper tendon stressing. You will be required to keep records of tendon elongation, which is the distance a tendon stretches during jacking. You will also be involved in verifying that duct and tendon materials and post-tensioning hardware are certified as required by the specification.
Erection of a Concrete Precast Post-tensioned Girder
Soon after the tendons are anchored, the tendon ducts are filled with grout. This is done by pumping the grout under pressure through a pipe connected to the duct. You will need to make sure the contractor is mixing the grout properly, is using an approved grout, that the correct amount of grout discharges at vents along the duct and that CTQP (Construction Training and Qualification Program) Qualified Grouting Technicians (foreman must be Level II, workers Level I) are performing the grouting. This assures that the duct is completely full and that tendons are completely encased in grout. The grouting process is very important because the grout protects the tendon from corrosion and poor grouting can cause accelerated deterioration of the tendon. The specification requires that grouting be completed within a specific time limit - usually 7 days after the tendons are stressed - and you must make sure that this limit is complied with by the Contractor. If grouting is delayed the tendon can begin to corrode since it is unprotected.

Finally, after grouting is complete, the anchorage areas must be properly sealed to prevent corrosion of the steel in the anchorages. The plans will indicate how this is to be done and it is also very critical that anchorages be properly protected from corrosion. For detailed information about proper grouting methods and procedures refer to the State of Florida DOT training manual, Grouting of Bridge Post-Tensioning Tendons.

The temporary bents must remain in place until the deck is constructed and fully cured and after other post-tensioning tendons are installed from the deck and that also go through the girders.

**DIAPHRAGM CONSTRUCTION**

After the concrete beams are erected, forms for diaphragms are built and concrete is placed in the forms. The diaphragms will stabilize the beams prior to completion of the deck and will prevent the beams from swaying sideways due to lateral forces applied to the beams such as high wind.

On the same plan sheet as the framing plan, you will find instructions for when and where the diaphragms should be constructed. You will also find more information about diaphragms by consulting the deck plan sheets that are included in the plans. All specification requirements that apply to cast-in-place concrete (SS 346) apply to the diaphragms, so you will need to do your inspection with this in mind.
QUIZ

1) During erection, how does the Contractor tell which beams go where?

2) True or false: beams that are the same size and length have the same load carrying capacity.

3) Other than using the right girder in the right position, what is the most important item you must check about the placement of beams and girders?

4) What do you need to verify in order to ensure that girders are stable prior to deck construction?

5) Is it acceptable for the surface of tendons to be rusty before they are threaded into the bridge?

6) What materials involved in the post-tensioning of the bridge must you check? ______, ______,______.

7) Tendons must be grouted within ____days of their being stressed.

8) Diaphragms stabilize beams prior to deck construction and prevent them from _______ permanently

Chapters One, Two and Three had a lot of information in them. To check yourself, go back and try a couple of the quizzes. If you miss many questions, go back and review these sections. If you do well, take a break before going on to Chapter Four.
ANSWERS TO QUESTIONS

Page 3-5, General and Handling

1) damaged during transport from the plant to the project site
2) upright
3) long enough, the same length
4) Producer
5) pick-up points

Page 3-9, Erection and Diaphragms

1) Each beam is marked for correct location as shown on the framing plan.
2) false, rebars and prestress steel can vary a great deal for a given size and length beam
3) The centerline of bearing for the beam must coincide with the centerline of the bearing on the pier.
4) bracing
5) no
6) ducts, tendon steel and other hardware
7) 7
8) swaying
# CHAPTER FOUR

## DECK CONSTRUCTION

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INTRODUCTION

The Contractor will place the bridge deck after the beams/girders have been erected. The deck construction work has a number of phases and in this chapter we will cover all phases of deck construction from preparation to curing. Other chapters will cover construction of barrier walls and painting. Your involvement in the construction of decks is especially important since decks require more complex and time dependent processes than other concrete placements. The equipment, such as screeds and pumps, is more complicated which increases the possibility for breakdowns and delays. Requirements for concrete placement, finishing and curing are also more stringent and temperature and weather conditions are far more critical.

PREPARATION

PRE-OPERATIONS MEETING

Before the deck construction operation begins a pre-operations meeting must be conducted to discuss all aspects of the upcoming work. There can be one meeting at which all phases of deck construction are discussed or there can be several meetings that take place just before each phase is due to begin. The meetings should be conducted by the Project Administrator and should be attended by the Contractor’s Project Manager, Superintendent, work crew chief or foreman, work crew members if possible and the Department’s Senior Inspector and inspectors assigned to the operation. At the meeting, the Department’s guidelist for bridge decks or other detailed guidelist should be given to the contractor and all guidelist items should be discussed. Summary minutes should be kept of the meeting and should cover, at a minimum, contingency plans, interpretations of contract documents and unresolved questions that require followup. The following topics should always be discussed at the pre-operations meeting:

- If required, changes to the original Concrete Quality Control Plan that are unique to the deck construction operation and a review of the plan with regard to concrete transport and delivery and who will be responsible for coordination of these issues by the Contractor during construction.

- Review of the approved forming system plan.
Locations for concrete sampling and testing as well as concrete cylinder storage arrangements.

Review of concrete placement sequence, equipment - such as vibrators - and the number of workers that will be involved in the operation.

Method of placing, finishing and curing concrete.

Use of tattletales if required - which will be discussed later in this lesson.

Other precautions, requirements and “What Ifs” or contingency plans. For example: the use of emergency bulkheads; the Contractor’s plans for protecting the fresh concrete from the rain; the various curing requirements and time limits in the different parts of the structure; procedures for keeping the concrete within specified temperature ranges; and minimum required concrete placement rates.

CAMBER OF GIRDERS

Both steel and concrete girders are fabricated with an arched shape referred to as “Camber”. All girders bend or deflect downward when dead load such as a deck is placed on them but when this results in a sag it is aesthetically undesirable. Camber is used to prevent a beam’s final deflected shape from being a sag. In the illustration on the next page, you can see that the girder that is not cambered sags when the slab is placed but the girder that is cambered bends to a level position under the slab load. In steel girders, the camber is produced by cutting the web plate in the shape of an arch. The designer determines exactly how much camber will be needed to produce a beam that will deflect to the required profile grade without sagging.

In prestressed concrete beams, camber is automatically produced by the prestressing process and can only be estimated by the designer since many variable factors such as humidity and age affect the magnitude of the final camber. In most cases even with all dead loads applied to the girder there is still some camber remaining. As a result, the deck slab directly over the beam flange is usually the minimum required thickness at the center of the span and then gets thicker the closer it gets to the supports. These thicker slab sections over the beams are referred to as “Buildups”. The Contractor is required to monitor the amount of camber for each beam from the time it is fabricated to the time it is shipped to the project. If the camber is larger or smaller than a predetermined amount, the Contractor must compensate for this by adjusting the profile grade of the deck or by
adjusting the elevation of the substructure if it has not been completed. You will need to verify that the Contractor is monitoring camber and if adjustments are needed, that they are carried out properly.

**A LEVEL GIRDER - WHEN PLACED ON SUPPORTS AND LOADED - WILL SAG**

![Diagram of a level girder sagging](image)

**A GIRDER THAT IS CAMBERED – WHEN PLACED ON SUPPORTS AND LOADED – WILL REST IN A LEVEL POSITION**

![Diagram of a cambered girder resting level](image)
QUIZ

1) True or false: the pre-operations meeting should be attended only by the Project Administrator and the Contractor’s Superintendent.

2) At the pre-operations meeting, the Department’s __________ for bridge decks should be given to the contractor.

3) Should the Contractor's contingency plans be discussed at the pre-operations meeting?

4) Both steel and concrete girders are fabricated with an arched shape referred to as _________.

5) In steel girders the camber is developed by cutting the _______ _________ in the shape of an arch.

6) True or false: the designer can determine the exact amount of camber in prestressed girders.

FORMING

EXPANSION JOINTS

Expansion joint hardware is placed during the form setting process for short bridges and either during form setting or after acceptance of the deck surface for long bridges. Openings between superstructure spans or open joints are used in order to allow the superstructure to expand and contract without damage. When the superstructure expands the open joint is wide enough to prevent the faces of adjacent beams and decks from coming into contact thus preventing damage. However, the open joint allows undesirable drainage water to leak through the deck and when the openings are very wide, vehicle safety and ride quality become unacceptable. These problems are prevented by installing expansion joint seals, which prevent drainage water from leaking through the deck and, for wide joints, provide for the safe and smooth passage of vehicles across the joint.
In general, expansion joint seals will be installed according to the plans and specifications. You should consult the contract plans for the installation requirements, but also be sure that such things as temperature and construction sequence are considered for installation. Expansion joint hardware is placed with temporarily tack welds or bolts that prevent the joint from moving vertically. This assures that proper vertical alignment is maintained across the joint opening until adjacent decks are satisfactorily cured and are up to full strength. The joint opening is referenced to 70 degrees F (21 degrees C) in order to ensure the proper opening width will be provided.

One more point: you must be sure that metal joint hardware or armor is set properly. This will ensure that the exposed lines of the joint are straight. You must also make sure that the Contractor installs the joint according to the manufacturer's instructions and that all the joint materials comply with the specifications.

**FORM PLACEMENT**

**Forming system plan**

The Contractor must submit a forming system plan to the Department for review and approval if the Contractor uses Stay-In-Place (SIP) forms, or for review only, if removable forms. The plan will contain drawings and material specifications for the forms that the Contractor intends to use. You will need to review the plan once it is approved (SIP forms) or reviewed (removable) to be sure that the Contractor adheres to the submitted plan. Pay particular attention to the connection details for connecting the form panels to the beam hardware in the case of SIP forms, and stringer hanger details for removable forms.

With both SIP and removable forms, you will need to monitor that elevations of form panels are correct. Pay particular attention to the thickness of buildups. If buildup depths are too thick - the distance from the top of the girder flange to the top of the form panel - this could indicate that there is an error in locating the finished grade elevation or that girder cambers are too large. If the top of the form panel is below the top of the girder flange, which means that the flange will penetrate into the deck slab, this is a serious problem. For both situations, the Project Administrator should be consulted immediately. You must also monitor the stability of the forms once in place. They should be stable and firm when walked on since they will be supporting hundreds of pounds of wet concrete. If there is any significant instability, consult the Project Administrator immediately.

In addition to your observation of the buildups, the Project Administrator or Senior Inspector will usually do a
rough check of the contractor’s form elevations from time to time during the form setting operation.

**Removable Forms**

Removable forming systems can either be wood, metal or a combination of both. Since removable forms are used over and over again, they wear out and are damaged. You must monitor the condition of the form materials and request of the Contractor that damaged or worn out panels and other components be replaced. Also make sure that the form materials comply with the forming system plan and the specifications for form materials quality. Metal hanger hardware that will be left in the slab after form removal must be located so that it can be cut back at least one inch to prevent corrosion after patching. Finally, carefully monitor any welding operations - hanger straps often require welding - that take place on adjoining steel girder surfaces. The significance of this issue is explained more fully in the next section.

**Stay-In-Place Forms**

SIP forming systems are almost always made of heavy gage galvanized steel sheet metal. It is very important that the Contractor conform to the approved forming system plan since this system will become a permanent part of the finished bridge. The Project Administrator must approve any deviation from the plan. As with removable forms, the quality of the forming materials must meet the specifications. You must make sure that welding operations, which may deposit weld spatter and have other damaging effects on girder steel associated with SIP form installation, do not come in contact with the permanent steel girder. These operations must be separated from the girder steel by heat proof materials. If this is not possible, then the welding must not take place in the vicinity of the girder steel. This is a very important issue since serious damage to the girder can occur if welding operations are done carelessly, so contact the Project Administrator immediately if the Contractor violates the welding procedures.

When the deck concrete has fully hardened, the Contractor must sound the bottom surface of the SIP forms with a hammer or other appropriate device to check for the existence of flaws. If the deck concrete has flaws or voids the sound the hammer makes when the panel is struck will be different than will solid areas. You must be present during this process. If flaws are found, the SIP form material must be removed in order to determine the extent of the flaws and method of correction.
1) Openings between superstructure spans or open joints are used in order to allow the superstructure to ________ and ________ without damage.

2) What is the function of expansion joint seals?

3) What must the Contractor submit to the Department for approval before forming begins?

4) A buildup that is too thick could indicate that girder camber is too __________.

5) True or false: for removable forms, a small amount of form instability is OK since forms do not become part of the permanent deck.

6) Are wooden forms tough enough to withstand repeated use without wearing out before the job is over?

7) __________ __________ hardware that will be left in the slab after form removal, must be located so that it can be cut back at least one inch to prevent corrosion after patching.

8) True or false: welding spatter associated with SIP form straps can come in contact with girder steel without harm.

9) What must be done if sounding of SIP forms reveals flaws?
As with any concrete member, the placement of rebars is critical. The issues you will be concerned about include size, length, spacing, support, ties, grade and quantity. You must verify the following:

- Rebars must be stored properly until placed and be free of foreign matter. A light coating of corrosion is acceptable but a heavier coating must be cleaned off and if advanced corrosion exists the bar must be replaced. Hot bending, welding or flame cutting of rebars is not allowed.

- Rebars shall be tied within 1" (25.4 mm) of plan position and splices shall be securely clamped or tied with at least the minimum lap splice length. Outside clearance or cover tolerance must be ¼" (6 mm) or less.

- Rebar mats must be tied with a double strand single tie used at every intersection on the periphery, and for non-periphery locations, every third intersection.

- Mortar block and bolster materials and placement must meet numerous specification requirements, with which you must be completely familiar. For top rebar mats, two rows of continuous high chairs shall be used between beams and shall be spaced 6" (152 mm) from the coping. If individual high chairs are used, they shall be spaced as are continuous ones, but longitudinal spacing shall not exceed 4’ (1.22 m). For bottom rebar mats, when bolsters are used, at least two rows must be placed between beams and the spacing between rows must not exceed 4’ (1.22 m). One bolster row shall be placed 6" (152 mm) from the coping.

- Metal rebar supports in contact with SIP forms, or that bear on removable forms, must be protected from corrosion by a plastic coating that extends up support legs at least ½” (13 mm) from the point of contact with the form. Supports made of non-corrosive material may also be used and are required for substructures in extremely aggressive environments, and must be in conformance with material requirements in the specification.
**QUIZ**

1) Rebars can be out of position by no more than how much?

2) The periphery of rebar mats must be tied with a _______ _______ _______ tie.

3) Are the legs of metal bar supports required to be protected from corrosion?

**SCREED PREPARATION**

With rare exception, the Contractor will use a screeding machine with the following characteristics (see illustration below):

- It will ride on tracks, called rails, which are set on top of or outside of the deck side forms and that can be adjusted vertically by using a threaded rod or adjusting screw that can be rotated to change the rail height.

- It can be adjusted for different crowns and elevations.

- It has guide tracks from which the strike-off device is suspended.

- The strike-off device (see illustration on next page) consists of two steel drums that rotate and which do the actual strike-off and smoothing of the concrete; an auger that pushes excess concrete ahead of the drums; vibrating drums (Rollatamp) with fins on the surface that push the large aggregate down into the concrete which causes the cement paste to rise to the surface (these drums are optional and are not always used); and a drag, which is usually a burlap covered metal pan that adds smoothness and texture to the surface of the screeded concrete.
TYPICAL SCREEDING MACHINE

BRIDGE DECK FINISHING MACHINE

Rail  Guide track  Strike-off device  Rail adjusting screw
TYPICAL DUAL DRUM ROLLER STRIKE-OFF DEVICE
Contractors also occasionally use simple straight edge type screeds which consist of a straight screed bar suspended from a light truss that is pulled forward through the concrete and which vibrates. These type screeds are used for small or irregular placements.

**SETTING THE SCREED RAIL ELEVATIONS**

While the rebars are being placed, the Contractor will begin placing and adjusting the rails on which the screeding machine will ride. Once all rebars have been placed and checked, the screed will be positioned on its rails in preparation for the concrete placement operation. At this point, the Contractor will test the screed in order to make sure that it operates properly and that it will strike-off the concrete so that the required slab thickness will be achieved as well as the minimum concrete cover over the top rebar mat. This process is referred to as a “Dry Run”.

During the dry run you will need to take periodic measurements of the expected slab thickness as well as the cover thickness (see illustration). The measurements should be taken approximately every 10 feet (3 m) longitudinally and transversely over the forms at each beam flange end and at the slab edges. Attaching a wood plank or steel plate to the bottom of the screed drums that spans across the two drums can do this. This will provide a true and level surface from which to measure. At each check location a ruler, held in a plumb position, can be used to verify that the slab thickness is the minimum thickness, usually 8” (203 mm) or 8.5” (216 mm), and the concrete cover is the minimum over the top mat, usually 2”(51mm) or 2.5” (64 mm). Based on your measurements, the Contractor will adjust the screed rails to provide the required dimensions. If the dimension deviations cannot be adjusted out, you must notify the Project Administrator who will address this issue with the Contractor.

During the dry run process you must verify that both bulkheads at the ends of the slab, match the crowns and top of deck surface profile of the adjacent slabs. Also, the smoothness of the transition from adjacent finished slabs to the slab being placed should be checked by extending half the length of a straight edge from the adjacent slab over the slab to be placed. The screed should be at the end of the span for this check and the drums should have a true alignment with the straight edge to ensure a smooth ride for vehicles.

Finally, be sure the deck finishing machine operates on the bridge centerline without regard for skew, as shown on the next page.
TAKING DRY RUN MEASUREMENTS

Top mat of reinforcement must be checked from the screed during the inspection dry run, in addition to checking the deck thickness.

SCREED MUST BE PARALLEL TO BRIDGE CENTERLINE

Finishing machine and screed are parallel to bridge centerline -- not the skew. This way the machine will be over all the checkpoints at the same time.
QUIZ

1) Screed rail elevations are adjusted by using what?

2) The strike-off device has _______ _______ _______ that strike-off and smooth the concrete.

3) Name the two dimensions you will be measuring during the dry run.

4) True or false: it is not critical that the crown of the adjacent finished slab match the slab being placed.

5) Should the direction of screed advancement be parallel to the bridge centerline?

CONCRETE PLACEMENT AND SCREEDING

Once the rebars are placed and the screed is checked out to make sure proper cover and slab thickness will be achieved, it is time to place the concrete. As mentioned previously, deck concrete placement is complex and time dependent. Because of the relatively small thickness of the slab and large exposed surface area, the concrete sets up quickly and is very susceptible to accelerated drying due to wind, low humidity and high heat which are often the conditions during deck placements in Florida. This makes it very important for the concrete to be placed as quickly as possible and the specification requires a minimum production rate of 20 cubic yards/hour (15 cubic meters/hour) for placements of 50 cubic yards (40 cubic meters) or less and 30 cubic yards/hour (23 cubic meters/hour) for placements of more than 50 cubic yards (40 cubic meters).

You must monitor the placement rate and the weather conditions. If the weather is excessively windy, dry, or hot, or it is very likely to rain, you should notify the Project Administrator who may want to suggest to the Contractor that the placement be delayed until weather conditions are more favorable. Also, you should make sure that the Contractor has a rain protection system immediately available, that has been demonstrated to be
effective and that can be installed quickly. The Contractor must also estimate the rate that moisture evaporates off the surface of the deck (evaporation rate) during concrete placement by using temperature, humidity and wind speed instruments on site and/or by checking with the local weather bureau. If the estimated evaporation rate during the concrete placement will exceed 0.2 lb/ft²/hr (1.0 kg/m²/hr) then evaporation counter measures must be used or the placement must be postponed until more favorable weather conditions exist. Counter measures could include the use of a chemical evaporation retarder, continuous water fogging or cooling of the concrete during batching. The evaporation rate is computed by using a special nomograph that you must know how the read and which will be provided by the Project Administrator so that you can verify the Contractor’s evaporation rate estimate.

Another very important issue that must be verified is the concrete placement sequence. For simple spans, the entire deck is usually placed in one continuous operation; however, occasionally only part of the deck is placed. You must review the plans, which will indicate in what order each part of the deck must be placed. For continuous spans - no expansion joint between spans - the concrete placements must be in sections and cannot be placed in one continuous operation. Again, the plans will have the order of concrete placements and this order must be followed precisely or serious damage can occur to the new deck slab. If the order is incorrect, a newly placed deck section could be subjected to high tension stresses before it has developed adequate strength, which will cause severe cracking. Concrete must not be placed until the Project Administrator has approved the concrete placement sequence. For simple span beams with continuous decks, a best practice is to always start the concrete placement at the end opposite an existing completed deck slab thus ending the concrete placement at a cold joint with the hardened concrete. This procedure reduces the possibility of deck cracks that form during or immediately after concrete placement.

**PLACING CONCRETE**

Just prior to the start of concrete placement, the forms must be sprayed with cool fresh water. This prevents wooden forms from drawing excessive amounts of water out of the concrete, which is undesirable, and also helps prevent the concrete from sticking to the forms.

There are several approved methods for moving concrete from the concrete delivery vehicle - which can be a concrete truck, barge hopper, etc. - to the point of placement in the forms. Two of these methods are the most commonly used: 1) crane and bucket, or 2) concrete pump.
For the crane and bucket method, concrete is discharged from the delivery vehicle into a large bucket that is suspended from a crane and that has a door that can be opened by the worker to allow discharge. The crane will swing the bucket into position over the area where the concrete is deposited. This cycle is repeated numerous times until the delivery vehicle is empty.

The Contractor's workmen at the point of placement will release the concrete by opening the door of the bucket as the crane suspends the bucket above the deck. This operation is critical, since the concrete must be deposited as close as possible to its final resting place. In tight areas such as corners, the workmen may need to hand shovel the concrete. In general, precise placement is difficult with a bucket and; therefore, concrete is often placed in mounds that must be leveled out before the screed passes. You should try to encourage the workers to avoid mounds and instead attempt to distribute the concrete more uniformly over the surface of the forms. Also, the concrete must not be dropped more than 5' (1.5 m) from the bucket or pump discharge end.

For the concrete pump method, the delivery vehicle discharges into a pump truck which pumps the concrete through a hose directly to the point of placement. The discharge hose is almost always suspended above the placement area and this allows the worker to easily move it to any location over the forms. As a result, placement is more uniform and can be done more quickly because the pump discharges continuously until the delivery vehicle is empty. In recent years concrete pumps have become more popular and are usually used on large projects.

Regardless of placement method, the concrete delivered to the deck must be uniform in composition, workability and consistency. Wet or dry loads should not be placed, since they may cause unevenness in portions of the surface after it has been struck off. The concrete should be leveled by workers to a degree that the screed will have only a small amount of concrete to push out of the way as the strike-off proceeds. The specifications require that external hand held vibrators be used to consolidate the concrete around the reinforcing steel and in the corners of the forms.
CONSOLIDATION

As soon as the concrete is placed, it should be consolidated with portable hand held vibrators having an approved size and frequency. Due to the large number of rebars used in deck construction, vibrators must be used at close intervals. Keep your eye on this operation to be sure that the workmen do not use the vibrators to spread concrete into corners or low spots. As you previously learned, spreading concrete with vibrators will result in segregation. Immediately around the vibrator head, the surface of the concrete will display the effects of the vibrator with a wavy appearance and this is referred to as the circle of vibrator influence. The vibrator should be placed in the concrete often enough so that the circles of influence overlap, which will assure that the entire volume of concrete is fully consolidated. Also, the vibrator head should be kept as vertical as possible the entire time it is in the concrete and should penetrate down to the bottom of the slab.

SCREEDING

After placement and consolidation of the concrete is underway for a short time, the screed begins to operate. The screeding machine strikes off and smoothes the concrete surface as it moves back and forth across the deck and it ensures that the top of the slab is at the correct elevation or grade.

Screeding also helps to consolidate the surface. The trailing ends of the rotating drums are usually set about 1/8-inch (3 mm) higher than the leading end so that ridges in the concrete surface will not be left by the screed. To get the best job of strike-off, the concrete layer just in front of the screed must be higher than the final slab surface will be, by a small amount - in the 2” (50 mm) range. Be sure that the workmen maintain this layer in the correct thickness range. If they do not, a low spot can get filled with cement paste only, which is not as strong or as durable as the concrete; or a layer that is too thick will lift the screed machine, creating high spots.

During deck placing operations, you should be sure that the screed is operated in the following manner:

- The overlapping of screed passes should be governed by the workability of the concrete and the closing or smoothing of the concrete surface behind the finishing machine. Each pass of the drums should overlap the previous pass so that they can cut off any excess that might have rolled under on the previous pass. Usually the screed is advanced 3 to 6 inches (76 to 152 mm) but not more than 12 inches (305 mm) into the new concrete during each pass.

- Excess concrete at the gutter line must be removed and disposed of properly.
Sometimes screed rail supports will bear on a beam. In this case, immediately after screeding is completed, the screed rails and their supports must be removed without disturbing the screeded concrete. Holes left after support removal must be filled with fresh concrete, not with mortar or concrete screeded off the surface.

The rate of placement is critical. If operations slow down, you must be sure that the Contractor is trying to correct the situation. If the situation is not corrected, you should consult with the Project Administrator.

Check the slab after it has been screeded and while the concrete is still fluid for minimum thickness and for minimum rebar cover. The concrete must be checked at random locations with a marked probe approximately every 500 square feet (46 square meters) of deck. The results must be kept in a permanent field book and the detailed requirements for recording the data are specified in Section 10.3 of the Department’s Construction Project Administration Manual. It is important that you follow the instructions for recording this data very carefully.

The best way to locate the places you want to check on the bridge is to:

- Mark the screed machine’s bridge with keel (chalk) at the places where the thickness checks were made. This will allow you to measure how far the check point is from the edge of the bridge.

- Tie ribbon to the barrier steel at places along the deck where checks were made. This will help determine the survey station of the check point.

- The rebar cover check can be checked at the same location as the slab depth. This is done best with a thin metal plate at least 4” (100 mm) high and 8” (200 mm) long attached to a rod. When the long edge of the plate is pushed into the plastic concrete it will come to rest on the top mat of rebars. If the plate is marked at ¼” (6 mm) intervals, the thickness of the cover concrete can easily be determined. More sophisticated devices are also available for this type of measuring, so consult your Project Administrator for more information.

CHECKING TATTLETales
During the placement of concrete, you must check the tattletales for deflection if the Project Administrator requires their use. Tattletales are attached to the beams and deck finishing machine rails to register the amounts of deflection during concrete placement. As the first 10 ft. (3.0 m) of deck concrete is placed, you should check the tattletales below the deck. If they are dropping more than anticipated, then you should contact the Project Administrator and Contractor and be sure that corrections are made in the lengths of the rail adjusting screws.

The diagram below shows how the tattletales are used.

A method of documenting tattletale results is shown below.
Note

Dry Run High Rail set 0.02' (6.1 mm) above finish grade
Dry Run Low Rail set 0.03' (9.14 mm) above finish grade

2.69' (0.820 m) SPAN 1 2.22' (0.677 m) 3.51' (1.070 m) SPAN 2 2.66' (0.811 m)

<table>
<thead>
<tr>
<th>Rail</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.02' (6.1 mm) High Rail</td>
<td>0.01 (3.04)</td>
<td>0.01 (3.04)</td>
<td>0.00 (0.000)</td>
<td>0.01 (3.04)</td>
<td>0.005 (1.52)</td>
<td>0.01 (3.04)</td>
</tr>
<tr>
<td>0.03' (9.14 mm) Low Rail</td>
<td>0.015 (4.51)</td>
<td>0.02 (6.10)</td>
<td>0.05 (15.24)</td>
<td>0.02 (6.10)</td>
<td>0.01 (3.04)</td>
<td>0.01 (3.04)</td>
</tr>
</tbody>
</table>

Deflection units in feet (mm)

Note that tattletale results for each span are recorded three times:

1. when the weight of the machine and concrete are over the tattletales
2. when the weight of the machine and concrete are over the pier
3. when the weight of the machine and concrete are over the bulkhead

These results will be useful in the future, but are not used to correct the deck being placed.
QUIZ

1) What is the minimum production rate for deck concrete placements of more than 50 cubic yards (40 cubic meters)?

2) True or false: the likelihood of deck cracking is greatly affected by weather conditions.

3) For continuous spans, the concrete placements must be in ________ and cannot be placed in one continuous operation.

4) The two most common concrete placement methods are?

5) Spreading concrete with vibrators will result in______________________.

6) Name two things that are wrong with the consolidation shown below:

---

[Image of consolidation diagram]
QUIZ, continued

7) What should be done to fill a large gap between piles of concrete?

  _ A. Finish the concrete as is, leaving a small depression.
  _ B. Place more concrete in the gap.
  _ C. Move concrete from the previously placed piles, to fill the gap.

8) Usually the screed is advanced ___ to ___ inches (___ to ___ mm) into the new concrete during each pass.

9) The concrete must be checked behind the screed at random locations with a marked probe approximately every ___ square feet (___ square meters) of deck.

10) When should you first check tattletales for deflection?

11) After this initial check, you should check when concrete is placed over __________, ___________ and ____________________ .

12) If the last section of a deck is being placed, but the tattletales show that the grade is not being reached, how will the concrete and reinforcing steel be affected?

FINISHING

The quality of the bridge deck finish is important because it affects the skid resistance as well as the smoothness and uniformity of the ride for motorists.

The first opportunity the Contractor will have to check the flatness of the deck for short bridges is right after completing consolidation, strike-off, and screeding of the concrete, but while it is still plastic. This requires the Contractor to
furnish and employ an accurate straightedge having a minimum length of 10 ft. (3.048 m). You should verify that the straightedge is true before the Contractor uses it.

The 10 ft. straightedge should be placed on the deck surface for short bridges at 5 ft. (1.5 m) intervals, also called half-lapping, and must be aligned and advanced in the direction of traffic. The entire deck must be checked, so the straightedge should be advanced across the deck as well, at approximately 5 ft. (1.5 m) intervals. A surface depression with a gap beneath the straightedge of deeper than 1/8 in. (3 mm), should be immediately filled with freshly mixed concrete, struck off, consolidated and refloated. Areas greater than 1/8

th inch must be lowered and refloated. The straightedge checking and refloating should continue until the entire deck surface is found to be free of deviations from the straightedge and has the required grade and contour. Your role during this process is to check that straightedge intervals are followed and deviations are corrected properly.

After the high and low areas of the deck are corrected, the surface must be finished to a uniform texture by the use of a burlap drag, fine bristle broom or float. The surface should not have flaws greater than 1/16

th inch deep after the texture is applied.

For long bridges, floating and texturing of the concrete surface behind the screed is prohibited with some exceptions and; therefore, straightedging is not required. This is because a minimum of ¼” (6 mm) of deck surface is required to be removed by a grinding or planing machine at some time after the concrete is fully cured. The grinding or planing process insures that the deck will ride smoothly and eliminates the need to have a highly finished surface immediately after concrete placement. This also eliminates the need to add water to the deck to facilitate floating and texturing operations.
QUIZ

1) The Initial straightedge check should be performed while the concrete is still ________________.

2) The straightedge is half-lapped every ____ feet ____ (meters) in the direction of travel.

3) True or False: low areas in plastic concrete can fail the straightedge by ½ in. (13 mm) before they must be corrected.

4) For short bridges, flaws greater than what depth require correction?

CURING [SS 400]

Curing of the deck, perhaps more then any other component of the bridge is very critical. This is true because the deck is directly and continuously exposed to the deteriorating effects of vehicular traffic and extreme weather conditions. If deck curing is done poorly, cracks will form early in the life of the deck and these will cause the concrete to wear out far earlier than for a properly cured deck. Sometimes Contractors do not take curing as seriously as they should, and so you must encourage them to be as conscientious as possible about this critical operation.

As soon as the Contractor has completed the deck finishing operation, curing compound must be applied to all exposed surfaces, including surfaces that will be covered by barrier walls. Compound must be applied to the surface as soon as it dries to a damp condition or within 120 minutes whichever comes first. The compound must be applied without delay because during the period following finishing, rapid drying of the concrete is taking place, and this can cause severe cracking. The Contractor must apply Type 2 membrane curing compound at a rate of at least 1 gallon to every 150 square feet (1 Liter to every 3.75 square meters) and in accordance with Standard Specification 925. The Contractor is required to report to the Project Administrator how the spread rate will be determined prior to application and once compound application is complete for a given deck placement, the quantity used must be reported to the inspector for verification. A rule of thumb for visually determining if the spread rate is adequate is “All White is Right”. So if the surface is completely white without the gray deck color showing through then the spread rate is probably adequate but remember, the Contractor is still required to
report the spread rate for every concrete placement.

Once the deck concrete is hard enough, curing blankets must be placed on all exposed surfaces that are not formed with the exception of the areas beneath future barrier walls. The curing blankets as approved by the Project Administrator must be overlapping sufficiently to form an effective moisture seal. The blankets must be in good condition and you should check to see that blanket materials conform to the detailed requirements in the specification. The blankets must be kept wet immediately after satisfactorily placing them and be maintained in a saturated condition throughout the seven-day curing period. There must be a sufficient quantity of fresh water at the job site for wetting the blankets. You must be very vigilant about checking that wetting is continuously maintained, since Contractors can do a poor job of managing this operation and it is very critical that the blankets stay wet at all times.

Where a bridge deck slab is to be subjected to walking, wheeling, or other approved construction traffic within the seven day curing period, the blankets and deck must be protected from damage by placing wooden sheeting, plywood or other approved protective material in the traveled areas. When the ends of the curing blankets are rolled back to permit screeding of adjacent bridge deck slabs, the exposed surfaces must be kept wet by spraying water throughout the period of exposure.

As you can see, the deck curing requirements are very detailed and comprehensive and so it is especially important that you make sure the Contractor addresses them properly.

**FORM REMOVAL**

Generally the forms on the underside of the deck must be kept in place for seven days. The specifications do allow removal of the forms after 72 hours but in order to do so, the Contractor must break cylinders to demonstrate that minimum concrete strengths have been achieved. You must be completely familiar with the detailed specifications for establishing the proper cylinder break procedure, which is governed by temperature and curing conditions and you must witness the cylinder breaks. Regardless of the procedure used, forms must not be removed until authorized by the Project Administrator. If forms are removed prior to the seven-day limit, curing compound must be applied to the exposed slab surfaces within two hours of form removal. The minimum curing compound spread rate is the same as that which is required for the top of deck surface.

Remember that once forms are removed, the Contractor must remove all form system components including
embedded metal hardware, which must be cut back at least one inch into the slab. Cut back holes must be patched as well as other minor voids or flaws. Large flaws must be brought to the attention of the Project Administrator so the best method for correction can be determined. As mentioned previously stay-in-place forms must be sounded for flaws.

**QUIZ**

1) Proper deck curing is especially important because the deck is directly exposed to ____________ ____________ ____________ ____________ ____________ ____________.

2) True or false: curing compound must not be applied sooner than 2 hours after finishing is complete.

3) The minimum application rate for curing compound is 1 gallon to every ____ square feet (1 Liter to every ___ square meters).

4) How many days must curing blankets remain in place before they can be removed?

5) What must be continually maintained for the deck not to form cracks?

**SMOOTHNESS EVALUATION**

Once the deck is fully cured and hard, surface flaws must be corrected based on whether the bridge is categorized as short or long. A bridge is considered to be “Short” if the combined length of deck and approach slabs is less than or equal to 100 ft. (30.5 m). Long bridges have a combined length of greater than 100 ft. (30.5 m). It is your job to make sure the Contractor corrects all unacceptable flaws.
SHORT BRIDGES

For short bridges, a final straightedge check must be performed using the same positioning procedure as described previously in the Deck Finishing section. High spots of 3/16 inch (5 mm) or greater must be ground down to 1/8 inch (3 mm) or less. Significant depressions or low spots must be brought to the attention of the Project Administrator who will determine a method of correction. Make sure the grinding operation results in a smooth uniform surface.

LONG BRIDGES

The degree of smoothness must be determined by using a special machine called a Profilograph. This machine is a rolling straightedge that automatically records (electronically and with paper printout) the variations in the surface smoothness through use of a computer. The Prime Contractor must hire a subcontractor approved by the Department to supply and operate the profilograph and to report the results. The subcontractor must be independent, which means there must be no ownership or partnership connection with the Prime Contractor. The profilograph must be calibrated by the Department and you will need to verify that the subcontractor and equipment is approved. For a fee and when available, the Contractor may also use the profilograph services of the Department’s State Materials Office.

The profilograph must be operated in all traveled lanes including future lanes. Before the profilograph is used, the bridge deck must be as clean as possible to assure the accuracy of the check and the right and left wheel line of each traveled lane must be checked with the profilograph. Two variances are checked by the profilograph: overall smoothness, which must not exceed 10 inches/mile (158 mm/kilometer), and isolated high and low points which must not exceed 0.3 in. (7.6 mm) per 25 ft. (7.62 m). Both variances are displayed on the profilograph printout. The Contractor may also be required by the Project Administrator to perform a manual straightedge check across the deck or in the transverse direction, if the smoothness in this direction looks like it is a problem. If this is required, the variance must not exceed ¼ in. per 10 ft. (6 mm per 3.048 m).

The Contractor is required to grind at least ¼” (6 mm) of deck surface off regardless of the initial profilograph results; however, the initial profilograph results are intended to help the subcontractor that performs the grinding to determine the best settings for the grinding machine prior to the start of the grinding operation. After the initial ¼” or more is removed another profilograph pass must be performed. If your review of the profilograph printout shows more than 10 inches/mile (158 m/kilometer) for the overall variance, notify the Project Administrator of
your findings. After his review of the data, he will probably require the Contractor to again grind or plane the entire deck. Variances of more than 0.3 in. (7.6 mm) per 25 ft. (7.62 m) for isolated high points will only require spot grinding by the Contractor if the overall variance is within tolerance. Isolated low points must be brought to the attention of the Project Administrator who will determine a method of correction. If the overall variance is still out of tolerance after the second pass, planing may be required again and the entire cycle of profilograph and planing must be repeated until the variance is within tolerance. However, the maximum allowable total concrete removal during planing is ½ inch (13 mm) and it is important that you make sure that the Contractor is aware of this. The deck is constructed with an extra ½ inch (13 mm) of cover to compensate for removal by planing so if the removal exceeds this amount, the concrete cover that protects the rebars is reduced.

**QUIZ**

1) Deck high spots on short bridges must be ground down to no more then what dimension?

2) True or false: the inspector must verify that the planing subcontractor and his equipment are approved.

3) For long bridges, overall smoothness variance must not exceed ____________ and isolated high points must not exceed ____________.

4) Smoothness variance in the transverse direction must not exceed what dimension per 10 ft. (3.048 m)?

5) The maximum concrete removal during planing is ____________.

**GROOVING**

In order to improve the skid resistance and reduce hydroplaning - the tendency of vehicle tires to float on top of the rain water at high speeds - of the deck surface, the Contractor must cut grooves into the surface transverse to the direction of travel. This is only done after the smoothness evaluation is complete and accepted. The grooves
are cut by using a mechanical device that will leave grooves nominally 1/8th inch (3 mm) wide and 3/16 inch (5 mm) deep. The groove spacing varies, as covered in the specification, and the sequence repeats every 7 spaces. The specification also establishes tolerances for groove widths, depths and spacing.

The grooves are cut continuously across the deck or approach slab to within 18 inches (450 mm) of gutter lines at the barrier wall, curb line and median divider. The specification has spacing requirements for grooves adjacent to metal expansion joints, armored joints, gutter lines, curb lines and median barriers. You must make sure that the Contractor is familiar with all the spacing and dimension requirements before grooving begins and also verify that actual cutting is done as required.

Q U I Z

1) Why are decks grooved?

2) True or false: grooves should be nominally ½ in (13 mm) wide.

3) Grooves are cut continuously across the deck to within _________ of gutter lines at the barrier wall.
### ANSWERS TO QUESTIONS

**Page 4-6, Preparation**

1) False
2) guidelist
3) Yes
4) cambered
5) web plate
6) False

**Page 4-9, Forming**

1) expand, contract
2) prevent drainage water from leaking through the deck and provide for the safe and smooth passage of vehicles across the joint
3) forming system plan
4) large
5) False
6) No
7) Metal hanger
8) False
9) SIP form material must be removed in order to determine the extent of the flaws and method of correction

**Page 4-11, Rebar Placement**

1) 1 inch (25 mm)
2) double strand single
3) Yes

**Page 4-17, Screed Preparation**

1) adjusting screws
2) dual rotating drums
3) minimum slab thickness, minimum concrete cover over the top mat of rebars
4) False
5) Yes

**Page 4-23, Concrete Placement and Screeding**

1) 30 cubic yards/hour (23 cubic meters/hour)
2) True
3) sections
4) crane and bucket, concrete pump
5) segregation
6) vibrator head is not vertical, vibrator head is not penetrating to the underlying layer
7) C
8) 3 to 6 inches (76 to 152 mm)
9) 500 square feet (46 square meters)
10) After the first 10’ (3 m) of deck concrete has been placed.
11) tattletales, piers, bulkheads
12) slab thickness and cover will be increased

Page 4-26, Finishing
1) Plastic
2) 5 feet (1.5 m)
3) False
4) 1/16th inch (1.6 mm)

Page 4-28, Curing
1) vehicular traffic, extreme weather conditions
2) False
3) 150, 3.75
4) 7
5) wetting

Page 4-30, Smoothness Evaluation
1) 1/8 inch (3 mm)
2) True
3) 10 inches/mile (158 mm/kilometer), 0.3 in. (7.6 mm) per 25 ft. (7.62 m)
4) ¼ in. (6 mm)
5) ½ inch (13 mm)

Page 4-31, Grooving
1) improve skid resistance and reduce hydroplaning
2) False
3) 18 inches (450 mm)
**BARRIER WALLS**

Barrier walls are constructed after the deck is placed and, along with the deck, are the most visible elements of the bridge to motorists. Because of this, the surface finish and alignment of the walls are very important. There is usually no maximum time limit on the age of the deck before barrier walls are placed. However, there may be a minimum time or strength limit on the age of the deck. You will find these limits in the Standard Specifications or Special Provisions as well as detailed information about barrier walls in Specification 521. Be sure that no work is begun prior to the minimum allowable specified time shown in the specification or contract documents.

There are two barrier wall forming methods: stationary forming and slip forming. For the stationary forming method, metal or wooden forms that are the shape of the vertical barrier wall surfaces are firmly set in place on top of the deck. Concrete is placed in the forms and cured and then the forms are removed and reused for the next section of wall.

For the slip forming method, a machine guided by a string line, slowly moves along the deck while it covers the barrier wall rebars with a steel form in the shape of the barrier. Very stiff concrete is continuously fed into the machine, which automatically shapes and forms the barrier wall as it passes over the rebars. The concrete is stiff enough to stand up by itself once the machine moves forward thus leaving a correctly shaped wall that only requires final finishing and curing. Slip forming machines can routinely produce as much as 1500 feet (457 m) of wall per day. On all but the smallest projects, barrier walls are usually slip formed because this method is much less expensive and far quicker than the stationary form method.
WHAT TO CHECK BEFORE CONCRETE PLACEMENT

As the inspector, you will need to check a number of items before the Contractor places any barrier wall concrete and the most important of these are as follows:

- Make sure the deck surface under where the barrier will be placed has a rough texture and that any loose concrete fragments or other debris have been removed before concrete is placed. This will ensure that there will be a good connection or bond between the barrier and the deck concrete.

- Check to see that rebars are the right grade, size, shape and length; that they are fastened with the right tie wire style and interval and that the tie wires do not protrude into the concrete cover zone; that the rebars are free of any coatings (concrete, curing compound, etc.) and significant corrosion; and that they are spaced and located properly and have the minimum concrete cover.

- Check on whether utility embedments such as conduits, pipes and junction boxes are located properly and that they are not in contact with rebars which would prevent concrete from flowing between the embedment and the rebars.

- For the slip form method, verify that the Project Administrator has approved the Contractor’s slip forming machine and operations plan; that the slip forming machine is operating properly, particularly with regard to vibrators; and that the deck ahead of the machine is clean and level. Also, make sure that the shape and dimensions of the slip form are correct and that the string line used to guide the machine has been checked for correct line and grade.

- For the stationary form method, verify that forms are set on the correct line and grade and sight along the top of the forms to determine whether or not there is a smooth and true alignment. Forms must not have a horizontal deviation greater than 3/8 inch (10 mm) as measured from the midpoint of a 10 feet (3.048 m) straightedge. Regardless of elevation variations in the deck surface, the barrier forms should be adjusted to produce a true, top of barrier, alignment. Also, make sure that shape and dimensions of the forms are correct and that form material is an approved metal or wood material. See diagram that follows.
1. Check the alignment of the barrier wall on the deck slab as shown on the right.

2. Check the break points in the forms also shown on the right.

3. Check the alignment as the concrete is being poured and have the Contractor make any necessary adjustments.

- Be sure that expansion joints are located properly and according to the plans.

- Anchor bolts that extend from the top surface of the barrier wall for connecting bridge railings, may be required. Be sure that the Contractor sets them accurately and firmly secures them in place. They must be securely attached to the rebar cage to prevent the weight of the fresh concrete from moving them during placement.
WHAT TO CHECK DURING CONCRETE PLACEMENT

When the concrete is delivered to the site and is placed in the stationary forms or is poured into the slip forming machine, the items that follow must be checked to ensure that the wall will be sound and properly aligned:

- Before concrete is placed, interior surfaces of stationary forms and the surface of the deck must be wet. Consolidation of concrete must be thorough and this can be accomplished by a hand operated vibrator, and the edges or faces of the forms should be tapped or rodded to eliminate any entrapped air.

- When the forms for a barrier wall have been filled nearly to the top, all water and contaminated concrete should be removed, and the form should then be overfilled with fresh concrete. After the concrete has shrunk, the surface should be screeded off slightly above the desired final grade and should be given the final finish as soon as the concrete attains the proper set.

- For the slip form method, verify horizontal alignment behind the machine as the wall is placed by checking to see if there is a horizontal deviation greater that 3/8 inch (10 mm) as measured from the midpoint of a 10 feet (3.048 m) straightedge. The Contractor must correct any deviations greater than 3/8 inch while the concrete is still moldable. Also, verify rebar clearances just in front of the machine as it progresses.

WHAT TO CHECK AFTER CONCRETE PLACEMENT

Once the concrete is placed, you must make sure that the proper form stripping, concrete curing and joint cutting procedures are followed by the Contractor. Here are some of the more important ones:

- For the stationary form method, forms can not be removed for at least 12 hours after placement and once they are removed the proper curing method must be used which can be found in Specification 400.

- Contraction joints must be sawed at intervals as specified in the plans and not later then 12 hours after concrete placement.

- For the slip form method: cure according to Specification 400 and see that all pinholes, pockmarks and blemishes are patched with mortar. Curing compound must be applied to all concrete surfaces within 30 minutes after the slip form machine passes or when the surface dries to a damp condition whichever comes first. The curing compound spread rate and procedure for measuring the spread rate is the same as it is for deck construction.
QUIZ

1) The appearance of a barrier’s surface and alignment are very important because they are the ___________ __________ elements to __________.

2) The deck surface below where the barrier will be placed must be free of _______ ______ and other ______.

3) Which of the following items should be checked about rebars before concrete is placed:
   a) Size, length, shape and grade
   b) Approval of the rebar manufacturer
   c) Location and spacing
   d) Qualifications of the ironworker setting rebars
   e) Correct style and interval of tie wires

4) The Project Administrator must approve the Contractor’s _______ _______ machine and __________ plan.

5) Forms must not have a horizontal deviation greater than ____inch (___ mm) as measured from the midpoint of a ____ foot (_____ m) straightedge.

6) True or false: before concrete is placed, the interior surfaces of stationary forms and the surface of the deck must be thoroughly dry.

7) For the stationary form method, the forms cannot be removed for at least ___ hours after placement and once they are removed the proper curing method must be used which can be found in Specification ____.

8) True or false: contraction joints must be sawed not later then 12 hours after concrete placement.
ANSWERS TO QUESTIONS - PAGE 5 - 6

1) most visible, motorists
2) concrete fragments, debris
3) a, c, e
4) slip forming, operations
5) 3/8, 10, 10, 3.048
6) False: they must be wet
7) 12, 400
8) True
CHAPTER SIX

MISCELLANEOUS CONSTRUCTION

CONTENTS

BRIDGE DRAINAGE ................................................................................................................................. 6-2

SLOPE PROTECTION ............................................................................................................................... 6-2

ANSWERS TO QUESTIONS ...................................................................................................................... 6-9
BRIDGE DRAINAGE

The collecting and disposing of rainwater on bridge decks is accomplished by use of a “Drainage System” which is shown in the plans for each individual structure. In most cases the drainage system consists of openings in the deck, referred to as scuppers, which are located at the gutter line just in front of the barrier wall or curb. Rainwater drains off the deck surface to the scuppers and then free falls into a body of water below the bridge. You must make sure that the scuppers are the correct size and are located properly.

When rainwater cannot be discharged directly onto the ground or into a body of water because of pollution restrictions, a closed drainage system is required, much like your plumbing system at home. A closed system, which includes piping, inlets and outlets, collects the water and discharges it into a sewer system or into a retention or detention pond. You must verify that correct drainage system materials are used, that they are the specified size and that they are placed correctly in the forms prior to placement of concrete. Improper drainage system installation can result in improper or inadequate drainage as well as water leaks that can eventually cause corrosion of structural steel and/or rebars.

SLOPE PROTECTION

In order to prevent rainwater runoff from eroding embankment slopes at the ends of bridges, the slopes are stabilized in one of three ways. The first method, see illustrations on pages 6-4 and 6-5, which uses concrete slabs or slope pavement to cover the slope, is used when the bridge spans a roadway. The second method (see illustration on page 6-6) uses rubble riprap or large stones to cover the slope and is used when the bridge spans a body of water. The third method (see illustration on page 6-7) uses sand cement riprap or bags of cement and sand mixture and is used when the bridge spans a railroad. Details for construction of slope protection, similar to the illustrations in this chapter, are shown in the plans for each structure.
Before construction of slope protection begins, be sure to carefully study the requirements in the plans. Some important facts that you should know are as follows.

- Slope protection must withstand water pressure from beneath it caused by water seeping through the earth. If the pressure is not released by allowing the excess water to escape, the slope protection will eventually be damaged. For this reason, openings called “Weep Holes” are built into the protection system, at regular intervals. The soil end of the weep hole is in contact with stone aggregates and covered with a wire mesh, to prevent soil from being washed through the weep holes.

- Sand-cement slope protection doesn't require weep holes because there are small gaps between the bags to allow seepage water to drain.

- If sand-cement slope protection is used, the sand must be natural silica sand.

Refer to the illustrations on the following pages and study the slope protection details. You must make sure that the Contractor installs the slope protection according to details in the plans.
CONCRETE SLOPE PAVEMENT PROTECTION ADJACENT TO ROAD

Note: This is not a complete drawing.

Outline of End Bent

900 mm Min. Berm

End of Wingwall

1,200 m on the outside
450 mm Berm

Limits of Concrete Slope-Pavement

Toe of Fill Slope

150

75

45°

900 mm Min. Berm

Filter Fabric

SECTION B-B

Note: Vertical Joints shall be sealed.

* See Detail A

SECTION A-A

Drain Hole formed with 100 mm Ø Pipe
@ 2,400 m centers (staggered)

Hat Poured Sealer

DRAIN DETAIL

Clean free-draining sand
(< 5% passing 0.075 mm sieve)

Galvanized Wire Mesh:
200 x 320 x 6 mm opening,
(centered at drain)

#57 Aggregate

600

13 mm Premolded Expansion Joint Material

DETAIL A

Note: The filter Fabric shall be Type D-6 in accordance with
Index 199 of Roadway and Traffic Design Standards.
Cost of Holes, Wire Mesh, Aggregate, Filter Fabric and
Sand shall be included in the Cost for Slope Pavement.
CONCRETE SLOPE PAVEMENT PROTECTION BETWEEN DUAL GRADE SEPARATION BRIDGES

Note: This is not a complete drawing.

1,200 m on the outside of the berm

End of Wingwall

Outline of End Bent

300

900 mm Min. Berm

Toe of Fill Slope

PARTIAL PLAN

NOTE: Vertical Joints shall be sealed.

Wrap around embankment continuously to edges of concrete pavement (typ.)

SECTION A-A

Hot Poured Sealer

Filter Fabric

#5 Aggregate

Drain Hole formed with 100 mm Ø Pipe @ 2,400 m centers (staggered).

Clean free-draining sand (< 5% passing 0.075 mm sieve)

Galvanized Wire Mesh 200 x 320 x 6 mm opening, centered at drain

DETAIL A

DETAIL B

See Detail A

13 mm Premolded Expansion Joint Material

See Detail B

Slope to Drain Away from Slope Pavement (Level)

NOTE: The Filter Fabric shall be Type D-6 in accordance with Index 199 of Roadway and Traffic Design Standards. Cost of Holes, Wire Mesh, Aggregate, Filter Fabric and Sand shall be included in the Cost for Slope Pavement.
RUBBLE RIPRAP PROTECTION ADJACENT TO STREAM

SECTION C-C

SECTION A-A

SECTION B-B

Notes: The filter Fabric shall be Type D-2 in accordance with Index 99 of Roadway and Traffic Design Standards.
Note: This is not a complete drawing.

Limits of Sand-Cement Riprap

Outline of End Bent

900 mm Min. Berm

Vertical Joints shall be staggered

PARTIAL PLAN

* If forward slope is 1 to 1/2, transition to 1 to 2 within the indicated limits.

End Bent

900 mm Min. Berm

#57 Aggregate

Filter Fabric

SECTION A-A

Note: A standard filled bag shall be 150 x 300 x 450 mm in nominal dimensions.

SECTION B-B

Filter Fabric

Note: The filter fabric shall be Type D-4 in accordance with Index 199 of Roadway and Traffic Design Standards.

SAND-CEMENT RIPRAP PROTECTION ADJACENT TO RAILROAD TRACK
QUIZ

1) The most common type of drainage system uses openings in the deck called what?

2) Drainage system leaks can cause corrosion of _______ _______ and/or _______ .

3) How thick is the slope pavement shown in the illustration on page 6-4?

4) How thick is the toe wall on page 6-4?

5) True or false: rubble riprap is used to protect slopes of bridges that span railroads.
ANSWERS TO QUESTIONS

Page 6-8,  Bridge Drainage and Slope Protection

1) scuppers
2) structural steel, rebars
3) 100 mm
4) 200mm
5) False, sand-cement riprap is used
# CHAPTER SEVEN

## STRUCTURAL STEEL PAINTING

### CONTENTS

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**COMPLIANCE OF PAINT MATERIALS WITH SPECIFICATIONS** ......................................................... 7-2

**PREPARATION OF THE SURFACE TO BE PAINTED** ....................................................................................... 7-4
  - New Construction Jobs .................................................................................................................................. 7-4
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GENERAL

There are two types of structural steel painting operations: first time or new construction paint jobs and repaint or maintenance paint jobs. New members usually receive a first coat or prime coat of paint after they are fabricated and are still in the fabrication plant or shop. This coat is sometimes referred to as the shop coat. The member is painted again in the field - one or two more coats - and these are referred to as field coats. Maintenance paint jobs can be as simple as painting over (over-coating) a deteriorated but intact topcoat or as complex as complete removal and repainting of all coats.

Concerns associated with painting operations include worker safety, air and water pollution, control of overspray and disposal of contaminated waste. These concerns can have a major impact on public safety and so you must be familiar with all the specifications and regulations that govern these issues. You must bring violations to the attention of the Project Administrator immediately since they can result in serious injury or death of project personnel or the public.

COMPLIANCE OF PAINT MATERIALS WITH SPECIFICATIONS [SS 560 and 971]

Prior to the start of any paint application you must verify that paint materials are in compliance with the specification and this includes checking packaging and labeling; verifying the condition of paint in the container; and taking samples for testing.

Paint material cannot be used by the Contractor unless it is on the Department’s Qualified Products List (QPL). Products on the QPL have been thoroughly tested at the Department’s State Materials Office and are the only products approved for use. Once you confirm that the product is on the QPL, you will need to make sure packaging and labeling are per the specifications. The container must be marked with the following information: weight in pounds per gallon (kilograms per liter), total amount contained in gallons (liters), color, user information, date of manufacture, LOT, batch and DOT code number and other information required by specification 971. If any of the information is missing the product should not be accepted but the Project Administrator should be notified for a final decision on acceptance.
You should inspect the contents of all containers when opened for the first time or if reopened after an extended period of time, to make sure the paint has not hardened, gelled or formed a solid film referred to as livering. When the paint is mixed it must have a smooth, uniform consistency or it should be rejected. The paint should be remixed periodically when the container is open for an extended period of time. Mechanical mixers are required for containers in excess of 5 gallons (20 liters). If pigment, thinner or paste is mixed into the paint, it must be done according to the specification. Also, verify that the material storage life date, shown on the label, has not been exceeded.

The paint will need to be sampled, so consult the Job Guide Schedule to find out what sampling frequency and procedure you will need to follow. Samples will need to be sent to the designated Department Lab for testing.

**QUIZ**

1) **True or False:** only the topcoat of paint needs to be on the QPL.

2) If labeling information is missing, who should make the final decision about acceptance of the material?

3) When the volume of paint exceeds ____gallons (____liters) a mechanical mixer is required.
PREPARATION OF THE SURFACE TO BE PAINTED

NEW CONSTRUCTION JOBS

If the project is a first time paint job, the steel members will be delivered to the construction site with the prime coat applied. When steel members arrive at the site, they need to be inspected to see if there was damage of the prime coat during shipment. Damaged places must be touched up prior to the application of any other coats. You must verify that touch-up paint is the same paint that was used in the shop.

Before the application of other coats, make sure any dust, dirt, oil, grease or other foreign materials are removed from the surface of the prime coat to insure the next coat will adhere properly. Pay particular attention to horizontal surfaces or surfaces that can collect debris including airborne material generated by dusty construction operations. These surfaces are usually not visible from the ground and are easily missed during the cleaning process.

MAINTENANCE JOBS

For maintenance paint jobs, preparation procedures are usually complex and difficult, since existing coats of paint usually have to be removed. Removal can employ a variety of methods as simple as hand held power tools and as complex as large-scale sand or shot blasting machines. The removed paint material must be contained as completely as possible and be disposed of in an appropriate manner. Methods of containment and disposal are specified in Society for Protective Coatings (SSPC) Guide 6, "Containment of Debris During Paint Removal Operations" and Guide 7, "Disposal of Lead-Contaminated Surface Preparation Debris". In order to contain all material generated during removal, the site of the work must be completely enclosed in a temporary tent. If the removed material is hazardous or toxic then the enclosure must also be airtight and workers must use a purified and sealed air supply much like that of underwater divers.

The handling of the waste material must be done in the strictest manner and according to very detailed procedures. Your job will be to become knowledgeable about the proper procedures for containment, waste disposal and worker safety. The Department does not enforce these requirements but you must be knowledgeable enough to recognize violations when they occur so you can report them to the Project
Administrator for appropriate action. Your Project Administrator will know what procedures and laws govern any particular removal operation and you will be able to obtain copies from him in order to familiarize yourself with the requirements.

These procedures and laws deal with worker safety, which also applies to you since you may have to inspect areas that have hazardous or toxic waste or dangerous air quality. In addition, special procedures that deal with the handling of worker clothing and washing may apply and these must be followed very carefully to insure that the health of workers is safeguarded.

The actual surface preparation and cleaning procedure must be done in accordance with SSPC Surface Preparation Specifications. You must be thoroughly familiar with these procedures. These specifications define the condition and texture of surfaces after cleaning. Use, "SSPC-VIS 1: Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning and SSPC-VIS 3: Guide and Reference Photographs for Steel Surfaces Prepared by Hand and Power Tool Cleaning, to verify the Contractor has achieved the specified surface preparation. These standards provide photographs of what surfaces should look like so that you will have a guide to judge the quality of the actual work.

**QUIZ**

1) Members must arrive at the site with the ________ coat already applied.

2) True or false: damaged prime coat must be touched up with intermediate coat paint.

3) What type of surface debris is the most easily overlooked?

4) Must all removed material be contained and disposed of properly?

5) Even though the Department is not responsible for enforcement, why must you be familiar with proper procedures for containment, waste disposal and safety?

6) Actual surface preparation and cleaning procedures must be in accordance with what organization's specifications?
PROTECTION OF ADJACENT PROPERTY AND WORKER SAFETY

Before any painting begins, the Contractor must provide a method for protecting buildings, houses, vehicles, boats, bodies of water and any other property in the immediate vicinity of the painting operation from being sprayed by paint. Very often, paint is applied at high elevations where the wind is always blowing so that any excess paint spray, referred to as “Overspray”, can be picked up by the wind and be deposited on property adjacent to the job site.

The Contractor must provide screens, enclosures or any other means available to contain overspray. If the Contractor uses non-spray application methods like brushes or rollers, drips and excess paint can still fall on vehicles, boats or in the water or objects below and; therefore, protection must still be provided.

You must monitor the protection requirement carefully because inadequate protection of adjacent property can result in damage to public and private property, which can generate very negative public relations for the Department and Contractor as well as costly lawsuits.

As discussed in the Maintenance Paint Job section, procedures and laws related to worker safety are very important and apply to the application of paint just as they do to the removal of paint. You must monitor violations of the procedures and laws that cover worker safety for the paint application operation.

Immediately report inadequate protection systems and violations of worker safety procedures to the Project Administrator.

FIELD PAINTING

The type paint to be used and the number of coats required is usually determined on a project by project basis; therefore, with regard to type paint and number of coats, the Standard Specifications will usually not govern. Instead, the contract documents package or the plans will usually contain Special Provisions or notes that identify the type of paint to be used and the number of coats along with other paint application requirements that
are unique to your paint project. You must be thoroughly familiar with these special provisions in order to ensure the Contractor uses the correct paint and applies the correct number of coats as well as other considerations such as required minimum time between coats and thickness of coats. Plural component paints have a limited time period to be used once mixed, this is called “pot life”. Ensure the Contractor does not exceed the manufacturer’s recommended pot life.

One of the most important inspection tasks you must perform during a painting project is measuring the paint coat thickness. The measuring is done with “Dry Film Thickness Magnetic Gage” and there are two types. You will be able to obtain one of these gages from your Project Administrator who will instruct you in their proper use.

Some points to keep in mind when checking paint coat thickness are as follows:

- Required paint coat thickness always refers to the thickness after the paint has dried in accordance with SSPC PA-2, "Measurement of Dry Coating Thickness with Magnetic Gages".

- Coat thickness measurements should be taken at the average rate of one every 25 square feet (2.25 square meters) of painted area. If thickness is deficient, increase the measurement rate as needed.

- The total thickness of the complete paint system must not be less than the minimum required thickness of each individual coat added together.

**BRUSH PAINTING**

When using a brush, paint should be worked into all crevices and corners whenever possible. Any runs or sags should be immediately brushed out. Hard-to-reach places may be painted by using sheepskins or daubers.

Thorough mixing of the paint before it is applied is essential. A mechanical mixer should be used for stirring the paint when required.
SPRAY PAINTING

Sprayers must be clean and in good working order. Clean sprayers will prevent dirt and dried paint from contaminating the paint finish. Paint should be sprayed in even layers to prevent uneven build-up. Any hard-to-reach places may be painted by using sheepskins or daubers. Runs or sags should be brushed out immediately.

The pattern to be followed in applying the paint should make it possible to get a uniform thickness not less than the thickness specified. There must be some overlapping at the edges of strips covered on successive strokes of the spray gun. The spray gun should be held at right angles to the surface being painted and at the correct distance away from it. All small cracks and cavities, such as those in back of crimped stiffeners and ground splice plates, which were not sealed watertight by the first coats of paint, must be caulked with an approved caulking compound. This caulking compound must be dry before the next coat of paint is applied.

QUIZ

1) What is the excess spray paint called that gets picked up by the wind and can be deposited on adjacent property?

2) True or false: the Contractor has to contain overspray but not drips if a brush application is used.

3) Should you report violations of safety procedures related to paint application to the Project Administrator?

4) The type of paint to be used and the number of coats will be covered in the ________ ________ of the contract documents or in the ________.

5) Should you measure the paint coat thickness before the coat is dry?

6) A spray gun should be held at _______ _______ to the surface being painted.
Painting should not take place if the paint or steel temperature is below 40 degrees F (4 degrees C). The Contractor must adhere to the manufacturer’s temperature restrictions if they are warmer than the conditions specified in the Contract Documents.

Paint must not be applied if it is raining, excessively windy, foggy, or misty. In addition, paint must not be applied if moisture will condense - referred to as dew -- on steel surfaces. At a given combination of temperature and humidity, dew will form on steel surfaces when the temperature of the steel is a predictable value and this is referred to as the “Dew Point” temperature. The Contractor must not apply paint unless the steel surface temperature is at or above the dew point temperature. The tables that follow will assist you in determining the dew point temperature. In the first table, for example, if you follow the 70 degrees F ambient air temperature column down and follow the 65% relative humidity row across, where they intersect gives the dew point temperature of 57 degrees F. This means that as long as the temperature and humidity do not change, the Contractor must not apply paint if the steel surface temperature is below 57 degrees F. If the temperature or humidity change then a new dew point must be determined.

If paint is applied under cover in damp or cold weather, it must remain covered until it is dry or until weather conditions permit exposure to the open air. Be sure the Contractor observes these requirements.

**Q U I Z**

1) If the manufacturer’s temperature restrictions are warmer than the contract documents, should they govern?

2) True or false: paint may be applied if the steel surface temperature is below the dew point temperature.

3) What is the dew point temperature if the relative humidity is 35% and the air temperature is 50° F?
# DEW POINT CALCULATION TABLES

## DEGREES FAHRENHEIT

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<th>RELATIVE HUMIDITY %</th>
<th>AMBIENT AIR TEMPERATURE IN DEGREES FAHRENHEIT</th>
<th>DEW POINT --- SURFACE TEMPERATURE OF STEEL AT WHICH CONDENSATION OCCURS</th>
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## DEGREES CELSIUS

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</table>
ANSWERS TO QUESTIONS

Page 7-3, Compliance Of Paint Materials With Specifications
1) False, all coats must be on the QPL
2) Project Administrator
3) 5 gallons (20 liters)

Page 7-5, Preparation Of The Surface To Be Painted
1) prime
2) False, the same as used in the shop
3) horizontal or those that collect debris
4) yes
5) to report violations to the Project Administrator
6) SSPC

Page 7-8, Paint Application
1) overspray
2) False
3) yes
4) special provisions, plans
5) no
6) right angles

Page 7-9, Weather and Temperature Limitations
1) yes
2) False
3) 23 degrees F
CHAPTER EIGHT

REVIEW QUIZ

The lessons you have learned in this course are going to help you do a better job as an Inspector. This Review Quiz is intended to help you determine how much you have learned. It will also help you prepare for the Examination.

Here are some instructions on how to take the quiz.

1. Do not take this quiz immediately after you finish Part Two of the course.

2. Remember, the objective is not to test your memory. The objective is to help you evaluate how well you have learned the material and how well you can think through your everyday work problems.

3. When you take this quiz, make sure that you will not be disturbed for about an hour.

4. Attempt all questions.

5. You may refer to the course material if you get stuck on a question. But first try to reason out the problem.

6. Finally, keep track of your answers. Instructions on how to grade the Review Quiz follow. If you score less than 90% on the quiz, do not be disappointed. Go back and study the course materials once again and reattempt the questions with which you had difficulty.
1) Any deviations between the original survey and the actual structure location should be evaluated prior to the________ of bearing areas.

2) True or false: it is acceptable to cut one rebar during the process of drilling holes for anchor bolts.

3) Pot bearings can accommodate ______ ______ movements and ________ in any direction, not just in the direction of the girder’s length.

4) For a fixed bearing, is it acceptable for the centerline of bearing of the beam to be misaligned with the centerline of bearing of the pedestal, by a ¼ inch?

5) What is the rule of thumb used in determining the amount of expansion and contraction in steel?

6) For bolted girder splices, all bolts required by the plans must be installed and fully tightened prior to the removal of _________ or any other _________ _________.

7) True or false: the Contractor is required to establish a procedure for making sure that fastener assembly LOTs are identified properly and that elements of different LOTs are not mixed together.

8) The contact surfaces of joint or connection plates are referred to as what?

9) Tightening of a bolted connection should be symmetrical, starting from the ________ rigid parts of the joint at the _______ and working _________.

10) What is the minimum required bolt tension for a 1¼ “ diameter ASTM A 490 bolt?

11) The typical minimum gap required for proper DTI use is _____ inches.

12) True or false: for the turn-of-nut method, the longer the bolt is, the greater the required turn.
13) If you find that even one sample bolt fails to develop the required torque when the torque test is performed, must the Contractor torque test all the bolts?

14) In most structures, a _________ amount of reaming and drilling to match up holes in steel plate connections is allowable.

15) The stirrups in the top of prestressed beams are used for what?

16) Beams should be picked up and supported only at the _________ pickup points, unless the plans state otherwise.

17) Why are post-tensioning tendons grouted?

18) Which issues and concerns below should be discussed with the Contractor at the pre-operations meeting that takes place before deck construction begins?

   A) Changes to the original Level I or II Concrete Quality Control Plan that are unique to the deck construction operation and a review of the Level II plan with regard to concrete transport and delivery and who will be responsible for coordination of these issues by the Contractor during construction.

   B) Review of the approved forming system plan.

   C) Locations for concrete sampling and testing as well as concrete cylinder storage arrangements.

   D) Review of concrete placement sequence, equipment - such as vibrators - and the number of workers that will be involved in the operation.

   E) Method of placing, finishing and curing concrete.

   F) Use of tattletales if required.
G) Other precautions, requirements and “What Ifs” or contingency plans. For example: the use of emergency bulkheads; the Contractor’s plans for protecting the fresh concrete from the rain; the various curing requirements and time limits in the different parts of the structure; procedures for keeping the concrete within specified temperature ranges; and minimum required concrete placement rates.

19) The thicker slab sections over the beam flanges are referred to as what?

20) Expansion joint openings are referenced to ___ degrees F (___degrees C) in order to ensure the proper opening widths will be provided.

21) True or false: if buildup depths are too thick, it could indicate there is an error in locating the finished grade elevation or that girder cambers are too large.

22) Is hot bending, welding or flame cutting of rebars allowed?

23) Screeding machines must be adjustable to account for the different _______ and _______.

24) During the screed dry run, measurements should be taken approximately every __ feet (_ m) longitudinally and transversely over the forms at each beam flange end and at the slab edges.

25) What is the minimum production rate for placing deck concrete when placements are 50 cubic yards (40 cubic meters) or less?

26) The vibrator should be placed in the concrete often enough so that the circles of influence _______, which will assure that the entire volume of concrete is fully consolidated.

27) What is your role during the straight edging process?

28) True or false: for the deck surface for long bridges, variances of more than 0.6 in. (15 mm) per 25 ft. (7.62 m) for isolated high points will only require spot grinding by the Contractor if the overall variance is within tolerance.
29) Can grooving be performed before the smoothness evaluation is complete and accepted?

30) Before a barrier wall is placed, the deck surface under where the barrier will be placed must have a _______ texture and any _______ concrete fragments or other debris must be removed before concrete is placed.

31) For the slip form method of barrier wall placement, deviations of horizontal alignment behind the machine should not be greater than how much as measured from the midpoint of a 10 feet (3.048 m) straightedge?

32) For the slip form method, all barrier wall surface _______ , _______ and _______ must be patched with mortar.

33) A closed drainage system collects the deck water and discharges it into a ______ _______ or into a _______ or _______ pond.

34) What is the purpose of slope protection?

35) Is the purpose of a weep hole to allow water to enter the ground beneath the slope pavement so it stays moist?

36) True or false: only paint top coats are required to be on the QPL.

37) When steel members arrive at the job site, what coat of paint must have already been applied?

38) When property adjacent to painting operations is poorly protected, this can result in what undesirable outcomes?

39) For painting jobs, can the top or finish coat be applied before all previously applied coats are at full thickness?

40) If the relative humidity is 70% and the air temperature is 90 degrees: above what steel temperature is it OK to paint?
COMPUTING YOUR GRADE

Count your incorrect answers and if there are four or less, you got 90% or more correct which means you understood the lessons well. If you got more then four incorrect, thoroughly review the lessons that covered your incorrect answers before you attempt the final examination.

ANSWERS TO QUESTIONS

1) scribing
2) False, rebars must never be cut
3) very large, rotation
4) No, the alignment must be exact
5) Expansion or contraction = 1/8 inch (3 mm) per 100 ft. (30.48 m) for each 15 degree F (8.33 degree C) increment above or below 70° F (21° C).
6) falsework, temporary support
7) True
8) faying surfaces
9) most, center, outward
10) 101,800 lbs.
11) 0.005
12) True
13) Yes
14) reasonable
15) To tie the beams and the deck slab together.
16) designated
17) To prevent corrosion of the tendon.
18) A, B, C, D, E, F, G
19) buildups
20) 70, 21
21) True
22) No
23) crowns, elevations
24) 10, 3
25) 20 cubic yards/hour (15 cubic meters/hour)
26) overlap
27) To check that straightedge intervals are followed and deviations are corrected properly.
28) False, 0.3 inches (15 mm)
29) No
30) rough, loose
31) 2 inch (51 mm)
32) pinholes, pockmarks, blemishes
33) sewer system, retention, detention
34) To prevent erosion of slopes.
35) No
36) False, all coats
37) prime or shop
38) negative public relations and lawsuits
39) No
40) 78 degrees F