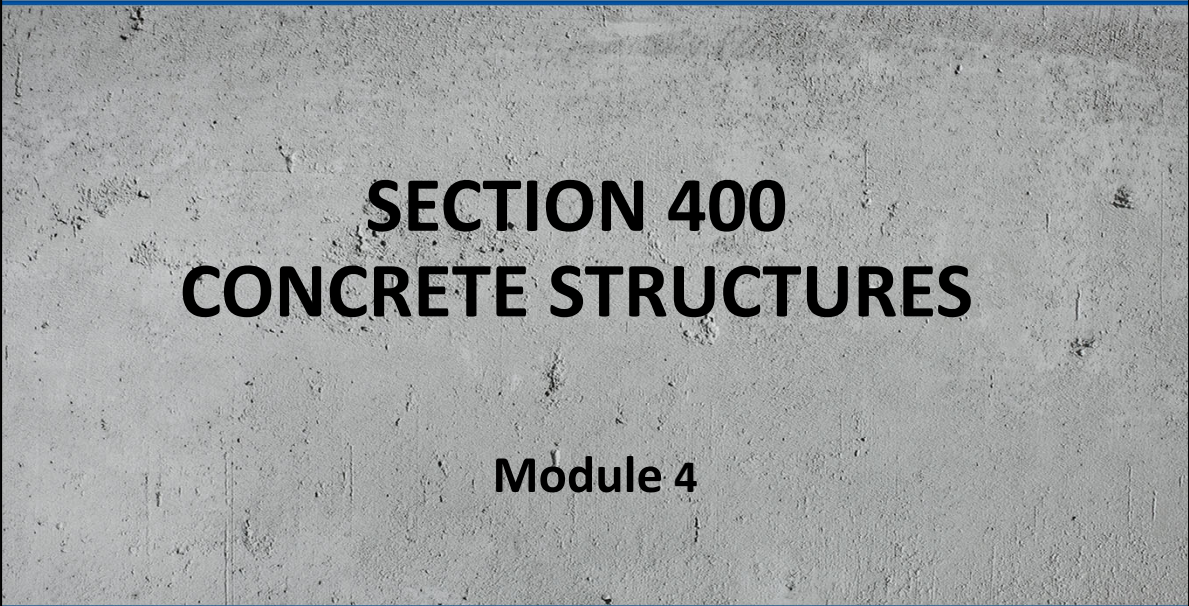




Florida Department of
TRANSPORTATION



Construction
Training Qualification Program



SECTION 400
CONCRETE STRUCTURES

Module 4

October 2021

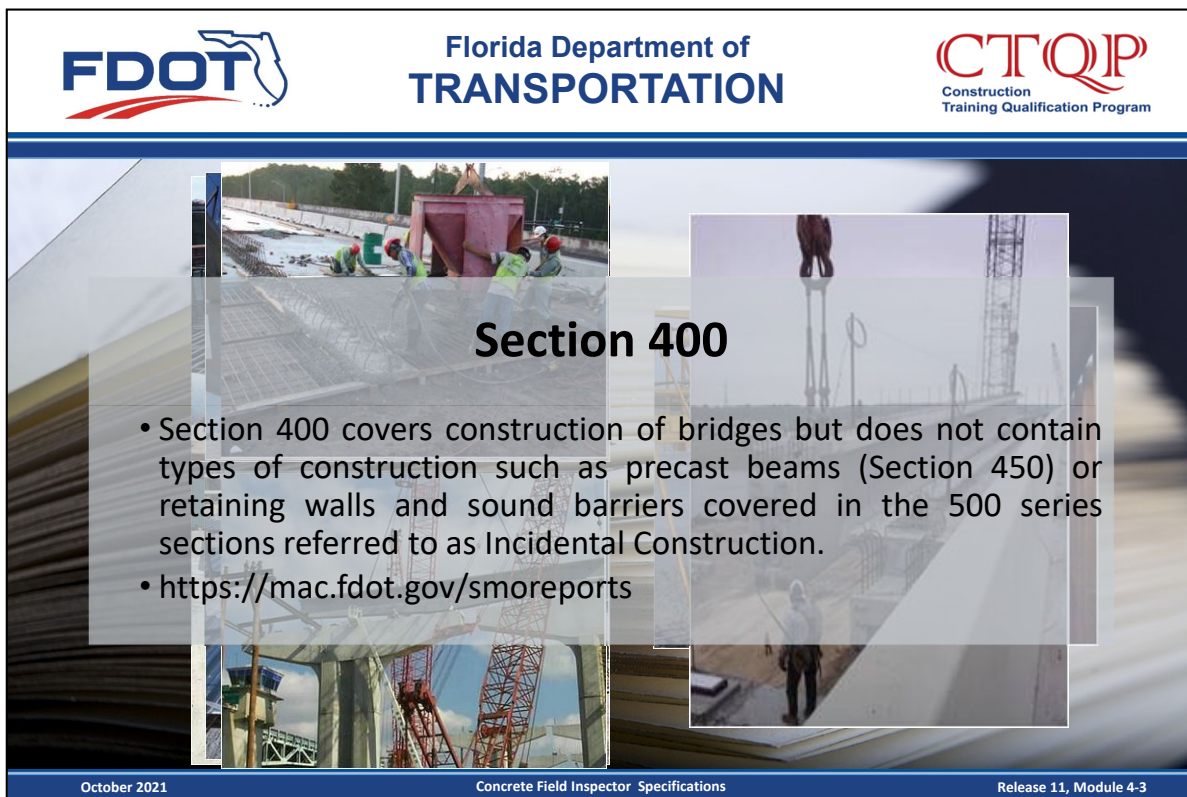
Concrete Field Inspector Specifications

Release 11, Module 4-1



Photographs of the aqueducts in Spain.

These structures, in Spain, have lasted hundreds of years. Concrete done right lasts.



The slide features the Florida Department of Transportation (FDOT) logo on the left and the Construction Training Qualification Program (CTQP) logo on the right. The title 'Section 400' is centered in a large, bold font. Below the title, a bulleted list provides details about the section's scope and a website link. The background of the slide is a collage of construction-related images, including workers on a bridge deck, a crane lifting a large concrete structure, and a view of a bridge under construction.

Section 400

- Section 400 covers construction of bridges but does not contain types of construction such as precast beams (Section 450) or retaining walls and sound barriers covered in the 500 series sections referred to as Incidental Construction.
- <https://mac.fdot.gov/smreports>

October 2021 Concrete Field Inspector Specifications Release 11, Module 4-3

Section 400 covers the construction of concrete structures which is the predominant material for the construction of bridges in Florida since footings are concrete as are almost all columns and pier/bent caps, decks and barrier walls. The list of producers with acceptable QC Programs such as prestressed concrete producers and precast concrete producers, can be found on the Production Facility Listing (MAC) on the state materials office (SMO) website.

400-1 Description.

Construct concrete structures and other concrete members, with the exception of pavement and incidental concrete construction (which are specified in other Sections).

Refer to Section 450 for prestressed construction requirements additional to the requirements of this Section.

For precast concrete structures meet the requirements of Section 450 for inserts and lifting devices, handling, storage, shipping, and erection.

Obtain incidental precast products from a plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.



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**Prestressed Concrete Products Production Facility
Listing**

FDOT State Materials Office, 5007 N.E. 39th Avenue, Gainesville, FL 32609 (352) 955-6600

Production Facility ID and Description	Contact Information	Physical Address	Mailing Address	Status Date of Action	Company
PCP10-010 CORESLAB STRUCTURES	ANDRE ROBERTS aroberts@coreslab.com (813) 626-1141	6301 N 56TH STREET TAMPA, FLORIDA 33610	6301 N 56TH STREET TAMPA, FLORIDA 33610	QC Plan Inactivated for Prestressed Concrete Products [2/16/2018] 6/23/2015	Coreslab Structures, Inc.
PCP10-011 STANDARD CONCRETE PRODUCTS, INC.	Klaus Barna klausbarna@standar dconcrete.org (813) 831-9520	5801 WEST COMMERCE STREET TAMPA, FLORIDA 33616	P.O. BOX 19449 TAMPA, FLORIDA 33686	QC Plan Accepted for Prestressed Concrete Products [3/3/2021] 6/23/2015	Standard Concrete Products, Inc.
PCP10-012 CDS MANUFACTURING INC. - TAMPA	SHAWN LOUNSBURY shawnl@cdsmanufac turing.net (850) 933-8255	5411 W Tyson Ave Tampa, FLORIDA 33611	5411 W Tyson Ave Tampa, FLORIDA 33611	QC Plan Accepted for Prestressed Concrete Products [9/25/2020] 7/8/2020	CDS Manufacturing, Inc.
PCP11-013 DURA-STRESS, INC.	G. KENT FULLER gkfuller@durastress. com (352) 787-1422	11325 CR 44 EAST LEESBURG, FLORIDA 34788	P.O. BOX 490779 LEESBURG, FLORIDA 34749	QC Plan Accepted for Prestressed Concrete Products [7/7/2015] 6/23/2015	Dura-Stress, Inc.

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400-2 Materials

- Materials mentioned in Section 400 are covered in detail in many other specification sections including 346 (Portland Cement Concrete), 415 (Reinforcing for Concrete), numerous 900 series and others
- It is important for inspectors to know about and be familiar with these other sections
- Some materials are required to be on the Approved Products List (APL) which is available on the Dept.'s Program Management Website

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The APL is displayed on the department's specifications office website which lists materials in order of specification number so to find an item on the APL one needs to know the spec number in which the item is called for.

400-2 Materials.

Meet the following requirements:

Concrete	Sections 346 and 347
Penetrant Sealer	Section 413
High Molecular Weight Methacrylate (HMWM)**	Section 413
Reinforcing for Concrete	Section 415
Water	Section 923
Curing Materials*	Section 925
Epoxy Bonding Compounds**	Sections 926 and 937
Joint Materials**	Section 932
Bearing Pads	Section 932
Non-Shrink Grout**	Section 934
Class 5 Applied Finish Coatings**	Section 975
Galvanizing Compound**	Section 562
Dowel Bar Assembly**	Section 931
Filter Fabric	Section 985

*The Engineer will allow clean sand and sawdust for certain curing, when and as specified.

**Use products listed on the Department's Approved Products List (APL).



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PATH

Home

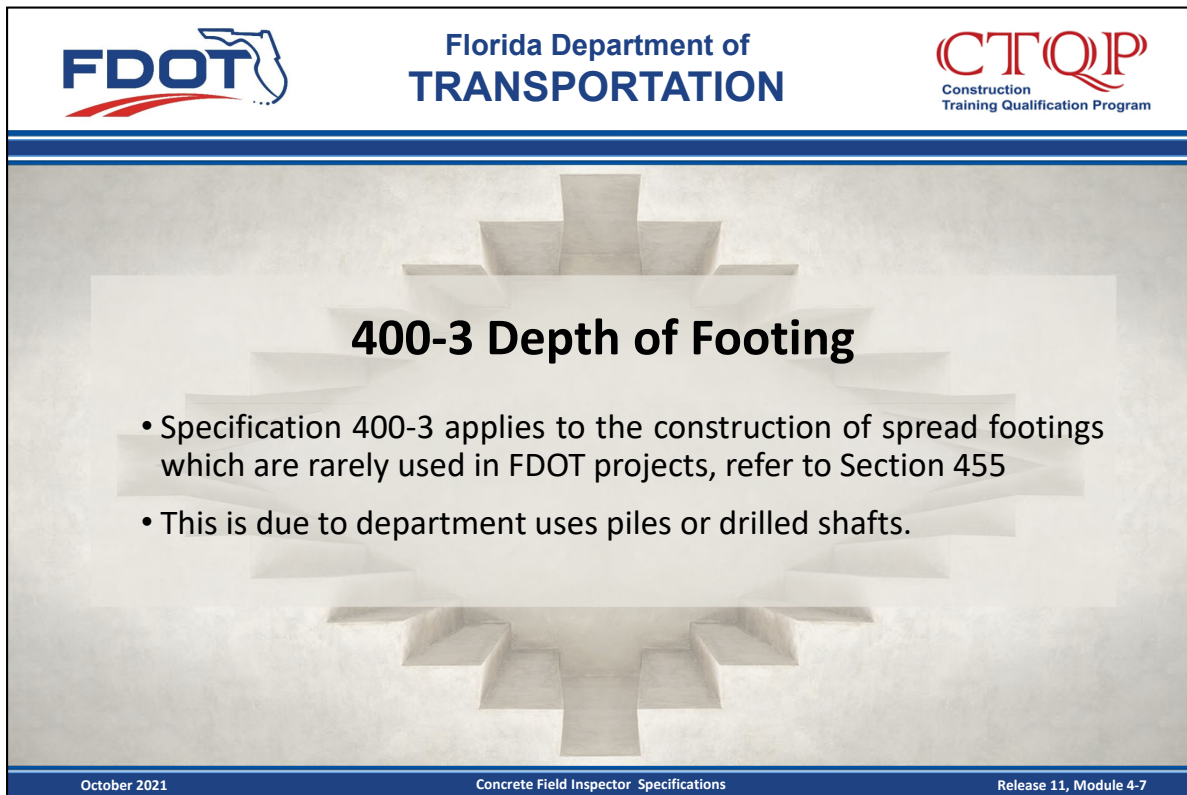
Go
APL IPL Other Manufacturers

Specifications

Filter by Range: 100-199 400-499 500-599 600-699 700-799 900-999

Specification Number	Resource Links	Product Types
400 - Concrete Structures	Resource Links: - FDOT Standard Specifications for Road and Bridge Construction - Roadway Design Bulletin/Memorandum	Class 5 Applied Finish Coatings
413 - Sealing Cracks and Concrete Structure Surfaces	Resource Links: FDOT Standard Specifications for Road and Bridge Construction	High Molecular Weight Methacrylate (HMW)
415 - Reinforcing for Concrete	Resource Links: FDOT Standard Specifications for Road and Bridge Construction	- Mechanical Rebar Splice - Plastic Chair and Bolster
455 - Structures Foundations	Resource Links: FDOT Standard Plans for Road and Bridge Construction	Pile Splices System
458 - Bridge Deck Joints		Strip Seal Joint System
462 - Post-Tensioning	Resource Links: FDOT Standard Specifications for Road and Bridge Construction	Elastomeric Coating System

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The slide features a background image of a concrete footing with a central vertical shaft and several horizontal steps or tiers. The text is overlaid on this image. At the top, there are three logos: FDOT (Florida Department of Transportation) on the left, the full name 'Florida Department of TRANSPORTATION' in the center, and CTQP (Construction Training Qualification Program) on the right. The main title '400-3 Depth of Footing' is centered in a large, bold font. Below the title, there are two bullet points. At the bottom of the slide, there is a blue footer bar with three pieces of text: 'October 2021' on the left, 'Concrete Field Inspector Specifications' in the center, and 'Release 11, Module 4-7' on the right.

FDOT Florida Department of **TRANSPORTATION** **CTQP**
Construction Training Qualification Program

400-3 Depth of Footing

- Specification 400-3 applies to the construction of spread footings which are rarely used in FDOT projects, refer to Section 455
- This is due to department uses piles or drilled shafts.

October 2021 Concrete Field Inspector Specifications Release 11, Module 4-7

Spread footings are very rarely used on department projects since piles or drilled shafts are almost always used. However, if spread footings are used, the firmness of the underlying soil layer can be quite variable and therefore, the elevations for bottom of footing shown in the plans may need to be adjusted in the field.

400-3 Depth of Footing.

Refer to Section 455, “D. SPREAD FOOTINGS”.



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400-4 Falsework

- Falsework includes any temporary construction work used to support the permanent structure until it becomes self supporting (Definition in Spec. 5-1.4.1)
- Contractor responsible for design and construction of falsework
- Falsework shall be adjustable and able to support without appreciable settlement or deformation
- The lower contact point of deck overhang falsework supporting screed rails shall be within 6 inches above the bottom flange. (Steel Girders)



Falsework

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Although the contractor is responsible for design and construction of falsework, inspectors should verify whether or not the contractor is constructing the falsework according to the plans. If something about the falsework appears to be questionable or unsafe it should be brought to the attention of the Engineer immediately.

400-4 Falsework.

400-4.1 Plans: At the Engineer's request, furnish detailed plans for falsework or centering to the Department. The Contractor is responsible for results obtained by using these plans.

400-4.2 Design and Erection: Design and construct all falsework to provide the necessary rigidity and to support the loads without appreciable settlement or deformation. Use screw jacks or hardwood wedges to take up any settlement in the framework, either before or during the placing of concrete. If any weakness develops and the centering shows undue settlement or distortion, stop the work, remove any affected concrete, and strengthen the falsework before resuming work. Support falsework which cannot be founded on a satisfactory footing on piling. Space, drive, and remove the piling in an approved manner.

400-4.3 Camber: Provide camber to correct for settlement and deflection of falsework. Give bridges permanent camber only when shown in the plans.

400-4.4 Bridge Deck Overhang Falsework for Steel I-Girders: Locate the lower contact point of bridge deck overhang falsework supporting screed rails within 6 inches above the bottom flange. If the lower contact point of the overhang falsework bears more than 6 inches above the bottom flange and/or if the deck overhang is 4 feet or greater, submit shop drawings

and calculations to the Engineer in accordance with Section 5 and Chapter 11 of the Structures Design Guidelines (SDG). The deck overhang is measured from the centerline of the girder supporting the overhang falsework to the outside edge of the concrete deck.



400-5 Forms

- Forms shall be wood or metal
- Forms shall contain the concrete without changing shape even when vibrated
- Form liners shall be used when Class 3 finish is specified
- The same form system for a type of work shall be used throughout
- Form removal shall not damage concrete surfaces

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Inspectors shall verify that the form bracing is substantial and unyielding and if there is a question about this it should be brought to the attention of the Engineer immediately.

400-5 Forms.

400-5.1 General: Provide forms, either of wood or metal, that are as follows: externally secured and braced where feasible; substantial and unyielding; of adequate strength to contain the concrete without bulging between supports and without apparent deviation from the neat lines, contours, and shapes shown in the Plans. Design forms to withstand the additional forces of vibration without apparent deviation from the desired shape or position. Assemble forms to be mortar-tight. If using lumber forms, construct them of dressed wood of uniform thickness. Use form liners on wooden forms where Class 3 surface finish is specified. Construct assembled forms to render a concrete surface of smooth, uniform finish. Make provisions to remove forms without injury to concrete surfaces. Remove blocks and bracing with the forms, and do not leave any portion of the forms in the concrete. Use the same form system for a type of work throughout.



Different pictures of forms. The one in the lower right corner is from an overhang bracket for supporting of a removal form on a bridge deck.



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400-5.2 Inspection and Approval

- Forms, ties and bracing shall be inspected and approved by the Engineer prior to concrete placement
- Stop and correct defects to the satisfaction of the Engineer if unsatisfactory
- Ties and bracing are critical for satisfactory performance
- No warping or bulging



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The ties and braces that stabilize and strengthen forms are critical to the successful performance of the forms. If inspectors suspect that these are inadequate prior to concrete placement then this should be reported to the Engineer for immediate action.

400-5.2 Inspection and Approval: Do not place concrete in a form until the form has been inspected and approved. Although the Engineer inspects and approves the forms, the Contractor is responsible for obtaining satisfactory concrete surfaces, free from warping, bulging, or other objectionable defects. Pay special attention to the ties and bracing. Where the forms appear to be insufficiently braced or unsatisfactorily built, stop and correct defects to the satisfaction of the Engineer.



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400-5.3 Non-metallic Form Materials

- Lumber shall not be less than ¾" in thickness
- Plywood shall not be less than 5/8" thick
- Form liners cannot have patches and shall produce smooth uniform surface
- The Engineer shall approve layout of form liner sheets






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Form liners can produce a variety of pleasing textures in concrete and when the textures are deep, extra concrete is added to the exterior surfaces by the designer so that the dimensions needed for structural strength are not diminished. Some of the textures can be vertical or horizontal grooves, geometric shaped patterns or imitation stone, rope or brick patterns. In order to obtain the best possible appearance, the inspector should verify that the alignment of texture patterns are correct particularly through construction joints and form breaks.

400-5.3 Non-metallic Form Materials:

400-5.3.1 Lumber: For all surfaces, use lumber that is not less than 3/4 inch in thickness, dressed, and free of knot holes, loose knots, cracks, splits, warps, and other defects. Proportion the spacing of studs, joists, and wales to exclude warps and bulges and to produce true and accurate concrete surfaces. Only use structurally sound lumber.

400-5.3.2 Form Liners: Use form liners of durable, abrasion resistant materials that are unaffected by water. Use liners with a hard surface texture capable of rendering concrete surfaces of a smooth, uniform texture, without grain marks, patterns, or blemishes. Use form liner material of sufficient thickness to eliminate the reflection of irregularities, undesirable patterns, and marks from the forms to the surfaces. Replace liners as necessary to produce a consistent concrete surface texture. Use form liners in large sheets and with true, tight-fitted joints which are logically located. Obtain the Engineer's approval of the layout of sheets. Do not use liners which have been patched. Use liner material of the same stock throughout.

400-5.3.3 Plywood: The Contractor may use plywood of not less than 5/8 inch in thickness manufactured with waterproof glue or protected with an approved impervious coating. Do not use pieces with bulged plies or raveled, untrue edges.



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400-5.4 Special Requirements

- Filleted forms shall be used for reentrant angles
- Chamfered forms shall be used for exterior corners
- Chamfers and fillets shall be $\frac{3}{4}" \times \frac{3}{4}"$
- Handrails & Parapets - Recheck the alignment immediately after placing concrete
- End-bent cap forms shall not be placed until the embankment is within 12" of bottom of cap



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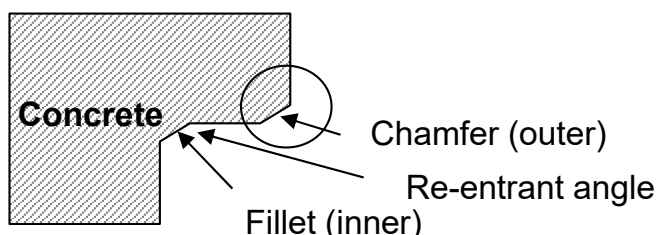
Chamfers and fillets are important because they eliminate the fragile sharp edges of concrete members which can easily be chipped or damaged. Members with chamfers and fillets also have a more pleasing appearance.

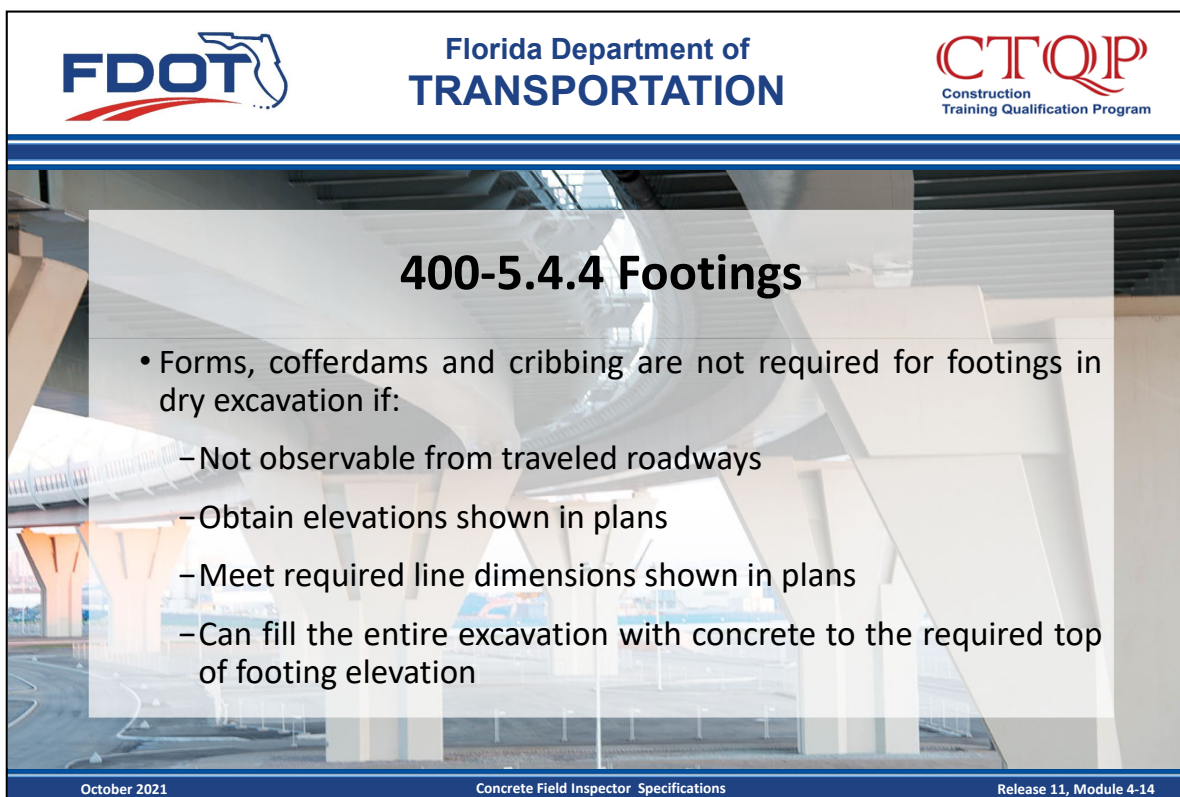
400-5.4 Special Requirements:

400-5.4.1 Re-entrant Angles: Use chamfered forms for exterior concrete corners and filleted forms for interior concrete corners. Use chamfers and fillets that are $\frac{3}{4}$ by $\frac{3}{4}$ inch and are mill-dressed on all sides to uniform dimensions. The Contractor may use plastic or metal chamfers and fillets provided they perform satisfactorily in producing uniform, smooth concrete corner surfaces without honeycomb.

400-5.4.2 Handrails and Parapets: Construct barriers and parapets in accordance with Section 521.

400-5.4.3 End-bent Caps: Do not place forms for end-bent caps until the embankment has been constructed to within 12 inches of the bottom of the cap. Place a mass of embankment that is sufficient to produce the subsidence, displacement, and settlement which may result from the construction of the total embankment.





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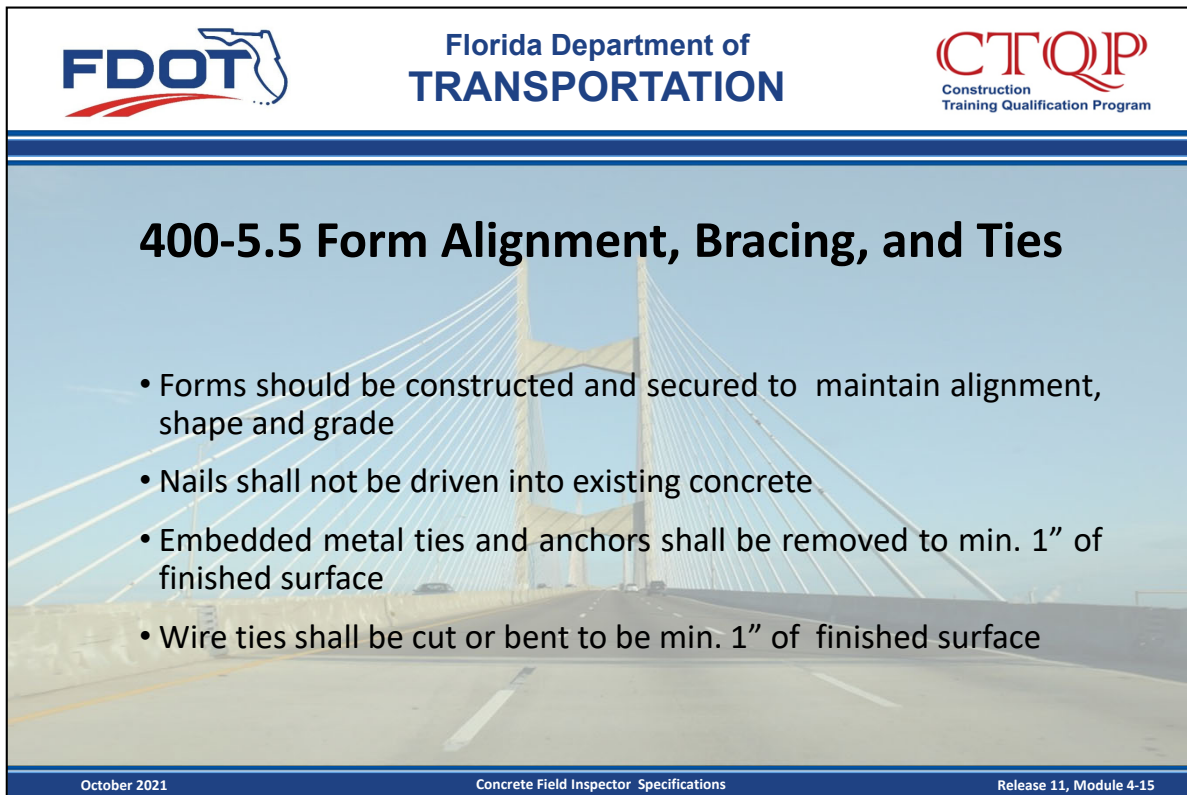
400-5.4.4 Footings

- Forms, cofferdams and cribbing are not required for footings in dry excavation if:
 - Not observable from traveled roadways
 - Obtain elevations shown in plans
 - Meet required line dimensions shown in plans
 - Can fill the entire excavation with concrete to the required top of footing elevation

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400-5.4.4 Footings: Where footing concrete can be placed in dry excavation, the Contractor may omit cribs, cofferdams, and forms, subject to compliance with the following limitations and conditions:

1. Use this procedure only in locations not exposed to view from traveled roadways.
2. Obtain required elevations shown in the Plans.
3. Obtain neat line dimensions shown in the Plans.
4. Fill the entire excavation with concrete to the required elevation of the top of the footing.
5. The Engineer will determine the volume of footing concrete to be paid for from the neat line dimensions shown in the Plans.



The slide features a background image of a large cable-stayed bridge with multiple white cables fanning out from a central pylon. The bridge deck is visible in the foreground, and the sky is a clear blue. The slide is framed by a blue border. At the top, there are three logos: the FDOT logo on the left, the Florida Department of Transportation text in the center, and the CTQP logo on the right. The title '400-5.5 Form Alignment, Bracing, and Ties' is prominently displayed in the center. Below the title, there is a bulleted list of four items. At the bottom of the slide, there is a blue bar containing the date 'October 2021', the text 'Concrete Field Inspector Specifications', and 'Release 11, Module 4-15'.

FDOT Florida Department of **TRANSPORTATION** **CTQP** Construction Training Qualification Program

400-5.5 Form Alignment, Bracing, and Ties

- Forms should be constructed and secured to maintain alignment, shape and grade
- Nails shall not be driven into existing concrete
- Embedded metal ties and anchors shall be removed to min. 1" of finished surface
- Wire ties shall be cut or bent to be min. 1" of finished surface

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Embedded metal items shall be cut back to 1" or less because if they are left close to the concrete surface, eventually they will rust which will produce unsightly stains or even cause damage to the concrete structure.

400-5.5 Form Alignment, Bracing, and Ties: Construct forms in such manner that they may be adequately secured for alignment, shape, and grade. Use bracing systems, ties, and anchorages that are substantial and sufficient to ensure against apparent deviation from shape, alignment, and grade. Do not drive nails into existing concrete. Do not use bracing systems, ties, and anchorages which unnecessarily deface or mark, or have an injurious or undesirable effect on surfaces that will be a part of the finished surface.

If metal ties and anchorages are to remain in the concrete, construct them so as to permit the removal of metal to at least 1 inch beneath the finished surface of concrete. Use accessories for metal ties and anchorages that allow the removal of metal to the prescribed depth while leaving the smallest possible repairable cavity.

When using wire ties, cut or bend them back from the finished surface of the concrete a minimum of 1 inch. Do not use internal ties of wire when forming surfaces that are exposed to view.



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400-5.6 Preparation and Cleaning

- Prior to concrete placement
 - Forms shall be cleaned of all concrete laitance from previous use and all dirt, sawdust, shavings, loose wire ties and other debris
 - Forms shall be treated with an approved form-release agent
 - All inspection and clean-out holes shall be closed and secured



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The proper application of form oil, which prevents the forms from sticking to the concrete when they are removed, is very important and inspectors should verify that the form oil is effective and correct for the application.

400-5.6 Preparation and Cleaning: Meet the following requirements for the condition of forms at the time of beginning concrete casting:

1. Treat all forms with an approved form-release agent before placing concrete. Do not use material which adheres to or discolors the concrete.
2. Clean forms of all concrete laitance from previous use and all dirt, sawdust, shavings, loose wire ties and other debris.
3. Close and secure all inspection and cleanout holes.



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400-5.7 Stay-In-Place Metal Forms

- Stay-in-place (SIP) forms may be used when called for in the Plans
- Flutes may be filled with concrete or polystyrene foam
- If foam is used, completely fill flute, and protect foam during concrete placement
- Forms may be used in moderately and extremely aggressive environments if polymer sheeting is used to protect exposed surfaces



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The specification allows stay-in-place forms to be used in moderately and extremely aggressive environments. This change was possible because a polymer coating is now available which protects metal panel and angle surfaces from corrosion when used in moderately and extremely aggressive environments such as over bodies of salt water. Instead of one SIP form system as before there are now three additional systems that require use of polymer coatings as described below.

- 1) Galvanized form components with polymer coating on the form top only: this system - see accompanying photo - allows Styrofoam to be used for slightly aggressive environments in form panel flutes as a replacement for concrete which reduces deck weight significantly.
- 2) However, unlike concrete which will absorb water that leaks into the flutes after the deck is in service, Styrofoam will not. A corrosion environment may develop if the water combines with certain other elements and this can cause premature panel deterioration and eventual failure. Therefore, if Styrofoam is used then the form top components shall be polymer coated.

400-5.7 Stay-In-Place Metal Forms:

400-5.7.1 General: Utilization of stay-in-place metal forms is permitted in lieu of removable forms to form concrete bridge decks between beams and between the webs of individual box girders when designated in the plans. Stay-in-place metal forms may be of the cellular, non-cellular or non-cellular with top cover sheet type. The flutes of non-cellular stay-in-place metal forms may be filled with polystyrene foam or concrete. When polystyrene foam is used to fill the forms, fill form flutes completely; do not allow any portion of the polystyrene foam to extend beyond the limits of the flutes. Ensure that the polystyrene foam remains in its required position within flutes during the entire concrete placement process. Do not use reinforcing steel supports or other accessories in such a manner as to cause damage to the polystyrene foam. Replace all damaged polystyrene foam to the satisfaction of the engineer.

Apply polymer sheeting to stay-in-place metal forms in accordance with the requirements in the following table. Apply polymer sheeting to all faces and edges (including sheared edges) of support angles used on bridges with Moderately and Extremely Aggressive Superstructure Environmental Classifications (as shown in the Plans). No polymer sheeting is required for beam attachment straps or clips partially embedded in concrete, and for support angles used on bridges with a Slightly Aggressive Superstructure Environmental Classification. Use polymer sheeting materials and application methods as described herein.



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400-5.7 Stay-In-Place Metal Forms

- Plans and calculations for form usage shall be approved prior to placement
- Use of forms shall not change finished deck dimension in plans
- Welding of SIP metal form supports and connections to structural steel components is not permitted
- Attachments are permitted by welds, bolts, clips, screws or other approved means except that welding is not permitted to polymer coated components
- Electrical grounding to steel reinforcing or fiber reinforced polymer (FRP) reinforcing is prohibited



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2) Galvanized form components with polymer coating on the form bottom

only: this system does not allow the use of Styrofoam in form panel flutes but does allow the SIP form system to be used in moderately or extremely aggressive environments. This system requires polymer coating on all form system components but the panels are only required to be coated on the bottom: see accompanying photo. The coating protects the panel surfaces directly exposed to corrosive elements, such as salt spray from the ocean, from premature deterioration.

400-5.7 Stay-In-Place Metal Forms:

400-5.7.1 General (continued): Prior to using stay-in-place metal forms, submit detailed plans for approval of the forming system, including method of support and attachment and method of protecting the supporting structural steel components from welding effects. Submit design calculations for the forming system, which have been signed and sealed by the Specialty Engineer. Detail stay-in-place metal forms such that they in no way infringe upon the concrete outline of the slab shown on the plans. Use stay-in-place metal forms that provide and maintain the dimensions and configuration of the original slab in regards to thickness and slope.

Do not weld stay-in-place metal form supports and connections to the structural steel components. Do not connect polymer coated angles or other hardware that support polymer coated metal forms to the beam attachment straps or clips by welding. Electrical grounding to steel reinforcing or fiber reinforced polymer (FRP) reinforcing is prohibited.



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400-5.7 Stay-In-Place Metal Forms

- Structural steel components shall be protected from damage by using a shield to guard against weld splatter, weld over-run, arc strikes, or other damaging effects of the welding process.
- For coated steel, the vertical sides of steel beam top flanges shall be painted in accordance with specification 560 Coating Structural Steel
- All welded areas of supports and accessories, cut from galvanized sheets, which are not embedded in concrete shall be zinc coated

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400-5.7.1 General (continued): Protect structural steel components from damage by using a shield to guard against weld splatter, weld overrun, arc strikes, or other damaging effects of the welding process. Upon completion of welding, rest the metal form support flush on the supporting steel component. Should any weld spatter, weld overrun, arc strike, or other effects of the welding process be evident or occur to the structural steel component, immediately stop in-place welding of the metal form supports for the remainder of the work. In this event, weld all metal form supports off of the structure and erect the forms after prefabrication, or use an alternate approved method of attaching the form supports. Remove improper weldment, repair the supporting steel component for any improper welding. Perform all required verification and testing at no expense to the Department and to the satisfaction of the Engineer.

Do not use stay-in-place metal forms until the forming system has been approved by the Engineer. The Contractor is responsible for the performance of the stay-in-place forms.

For all structures utilizing structural steel supporting components, paint the vertical sides of the top flange prior to installation of the stay-in-place metal forms in accordance with Section 560.

For non-polymer sheeting form surfaces, use zinc paint coating in accordance with Section 562 to all accessories cut from galvanized sheets, which are not embedded in concrete.

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Table 400-1 Polymer Sheeting Usage Requirements					
Form Type		Superstructure Environmental Classification (as shown in Plans)			
		Slightly Aggressive	Moderately Aggressive	Extremely Aggressive	
Non-cellular form with concrete filled flutes		No polymer sheeting required	Polymer sheeting required on bottom side ²	Polymer sheeting required on bottom side ²	
Non-cellular form with polystyrene foam filled flutes		Polymer sheeting required on top side ¹	Polymer sheeting required on both sides ^{1,2}	Polymer sheeting required on both sides ^{1,2}	
Non-cellular form with Top Cover Sheet	Top Cover Sheet	Polymer sheeting required on bottom side	Polymer sheeting required on bottom side	Polymer sheeting required on bottom side	
	Non-cellular form	Polymer sheeting required on top side	Polymer sheeting required on both sides ²	Polymer sheeting required on both sides ²	
Cellular form		No polymer sheeting allowed or required	Cellular form not permitted	Cellular form not permitted	
¹ Polymer sheeting not required on top side of form when foam filled flutes are used only at interior supports on continuous decks and the remainder of the flutes are concrete filled. ² Polymer sheeting not required on bottom side of form located within box girders and U-beams.					

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Concrete Field Inspector Specifications

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3) Galvanized form components with polymer coating on form top and bottom: This system may be used in moderately and extremely aggressive environments with Styrofoam in the flutes and all system components shall be polymer coated.

Left photos shows stay-in-place forms spanning between steel beams.

Right photos shows steel sheet metal straps on top of the top flange of a steel beam allowing stay-in-place forms to be attached to the beam.





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400-5.7.4 Construction

- Form sheets should not rest directly on top of the stringer of floor beam flanges
- Minimum bearing length at end of forms = 1"
- Damaged galvanized coating, on permanent exposed steel, shall be cleaned and coated per Section 562 Repair of Galvanized Surfaces
- All areas of deficient or damaged polymer coating shall be repaired with an approved liquid polymer
- Apply 2 coats of liquid polymer such that the dry film thickness of the two coats is at least 6 mils



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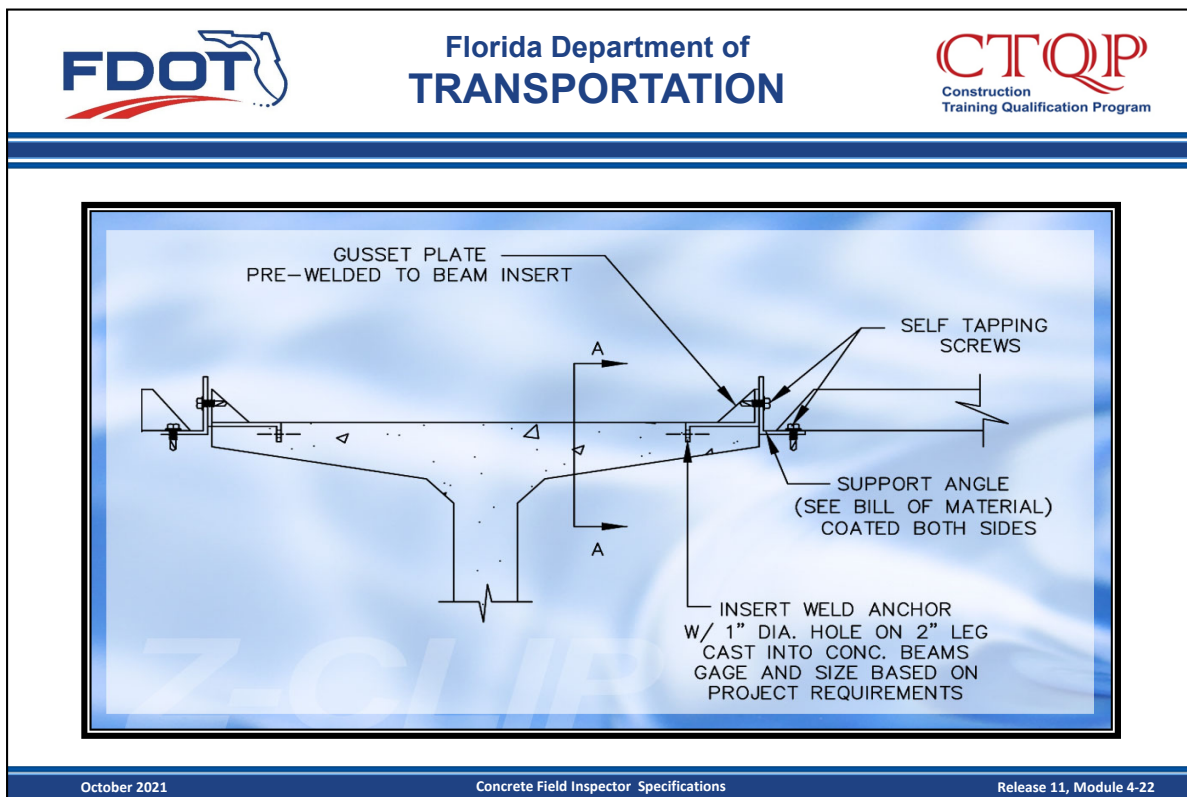
Release 11, Module 4-21

Panels are delivered to the project in large stacks and individual panels are taken off the top of the stack and are usually placed without inspecting the bottom surface of the panel. Inspectors should mention to the contractor prior to the start of panel placement that coating imperfections do occur so it is important to inspect top and bottom surfaces prior to placing panels. Panels with minor imperfections may be field coated with approval of the engineer but panels with significant coating imperfections should be rejected.

400-5.7.4 Construction: Install all forms in accordance with approved fabrication and erection plans.

Do not rest form sheets directly on the top of the stringer of floor beam flanges. Fasten sheets securely to form supports, and maintain a minimum bearing length of 1 inch at each end for metal forms. Place form supports in direct contact with the flange of the stringer or floor beam. Make all attachments for coated metal forms by bolts, clips, screws, or other approved means.

400-5.7.4.1 Form Galvanizing Repairs: For any permanent exposed steel where the galvanized coating has been damaged, thoroughly clean, wire brush, and paint it with two coats of galvanizing compound in accordance with Section 562 to the satisfaction of the Engineer. Do not touch up minor heat discoloration in areas of welds.



The Contractor shall provide a method for verifying that the mil thickness of the coating that is used to recoat a damaged area is at least 6 mils thick and the inspector shall verify that the method is accurate and that the coating thickness is in full compliance with the Specifications. The accompanying beam cross-section details show how the coated sip forms are assembled with screws instead of with tack welds since welding would damage the polymer coating.

400-5.7.4.2 Polymer Sheeting Repairs: Inspect and identify areas for damage to the polymer sheeting and repair with liquid polymer coating similar and compatible with respect to durability, adhesion and appearance in accordance with ASTM A762, as furnished by the stay-in-place form manufacturer. Ensure that the inspection includes checking the polymer sheeting for cuts, tears, cracking, surface pits, peeling, dirt, grease, oil, stains, rust or bare areas. Reject any panels that show coating blistering, peeling or cracking. Repair all polymer sheeting damage according to the following:

1. Surface Preparation: Ensure that all surfaces to be repaired are clean and free of any deleterious substances. Remove all traces of dirt, soil, oil deposits, greases, and other surface contaminants in accordance with the polymer sheeting and coating manufacturer's written specifications prior to touch-up and recoating.

2. Application Procedures: Ensure that the liquid polymer repair coating is applied to a clean dry surface and in accordance with the manufacturer's written specifications. Apply the repair coating using a suitable paintbrush or other means acceptable to the Engineer. Apply a first coat of product to the surface at 2-4 mils in thickness. Let the first coat air dry. Apply a second coat to form a complete layer and increase the thickness, immediately after verifying the first coat is dry to the touch (15 - 25 minutes depending on the local air drying temperature and atmospheric conditions). Apply the second coat at the same coating thickness as the first at 2-4 mils. Ensure that the total dry film thickness of the two coats is not less than 6 mils. Apply additional coats in this same manner until desired coating thickness is achieved.



400-5.7.5 Placing of Concrete

400-5.7.6 Inspection

- Concrete shall be vibrated to avoid honeycomb and voids
- Approved pouring sequences shall be used
- Based on observations by inspectors during concrete placement, the Engineer may require the sounding of the SIP form bottoms to check for voids or defects
- If voids are found, the panels will be removed to determine what, if any, corrective action will be required

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400-5.7.5 Placing of Concrete: Vibrate concrete to avoid honeycomb and voids, especially at construction joints, expansion joints, valleys and ends of form sheets. Use approved pouring sequences. Do not use calcium chloride or any other admixture containing chloride salts in the concrete.

Inspectors shall be observant during deck concrete placement operations and if for any reason the inspector thinks that there may be voids in contact with the bottom surface of the deck forms then this should be brought to the attention of the Engineer immediately after the pour. The Engineer may decide to require the contractor to sound the forms for voids in the presence of the inspector once the initial curing period is complete. If voids are detected then the forms shall be removed in order to perform a visual inspection of the concrete and if the deficiency is serious enough, a repair may be needed.

400-5.7.6 Inspection: The Engineer will observe the Contractor's method of construction during all phases of the construction of the bridge deck slab, including the installation of the metal form system; location and fastening of the reinforcement; composition of concrete items; mixing procedures, concrete placement, and vibration; and finishing of the bridge deck. Should the Engineer determine that the procedures used during the placement of the concrete warrant inspection of the underside of the deck, remove at least one section of the metal forms in each span for this purpose. Do this as soon after placing the concrete as practicable in order to provide visual evidence that the concrete mix and the procedures are obtaining the desired results. Remove an additional section in any span if the Engineer determines that there has been any change in the concrete mix or in the procedures warranting additional inspection.

If, in the Engineer's judgment, inspection is needed to check for defects in the bottom of the deck or to verify soundness, sound the metal forms with a hammer as directed by the Engineer after the deck concrete has been in place a minimum of two days. If sounding discloses areas of doubtful soundness to the Engineer, remove the metal forms from such areas for visual inspection after the concrete has attained adequate strength. Remove metal bridge deck forms at no expense to the Department.



400-6 Underdrain and Weep Holes

- Weep holes shall be provided in all abutments and retaining walls
- Weep Holes: Min. 3-inch diameter; Max 10 feet spacing
- Cover the exterior opening of all weep holes with galvanized wire mesh and a minimum of 2 cubic feet of clean, broken stone or gravel wrapped in Type D 3 filter fabric.
- A continuous underdrain shall be provided for box culverts

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Weep holes are very important because they allow excess water that builds up behind walls and slope pavements to drain instead of accumulating. Without weep holes the fluid pressure could reach a level that can force the element to be dislodged or fail.

400-6 Underdrain and Weep Holes.

Provide weep holes in all abutments and retaining walls.

Provide a continuous underdrain for box culverts in accordance with Standard Plans, Index 400-289. Provide weep holes that are at least 3 inches in diameter and not more than 10 feet apart. Place the outlet ends of the weep holes just above the ground line in front of abutments and retaining walls. Cover the exterior openings of all weep holes with galvanized wire mesh and a minimum of 2 cubic feet of clean, broken stone or gravel wrapped in Type D 3 filter fabric, to allow free drainage but prevent the fill from washing through.



400-7.1.1 Concreting in Cold Weather

- Concrete shall not be placed when air temperature is below **40° F**
- Meet the air temperature requirements for mixing and placing concrete in cold weather as specified in Section 346.
- In cold weather, enclose the concrete and cure as specified in 400-7.1.1

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400-7 Placing Concrete.

400-7.1 Weather Restrictions:

400-7.1.1 Concreting in Cold Weather: Do not place concrete when the air temperature at placement is below 40°F.

Meet the air temperature requirements for mixing and placing concrete in cold weather as specified in Section 346. During the curing period, if NOAA predicts the ambient temperature to fall below 35°F for 12 hours or more or to fall below 30°F for more than 4 hours, enclose the structure in such a way that the air temperature within the enclosure can be kept above 50°F for a period of 3 days after placing the concrete or until the concrete reaches a minimum compressive strength of 1,500 psi.

Assume all risks connected with the placing and curing of concrete. Although the Engineer may give permission to place concrete, the Contractor is responsible for satisfactory results. If the placed concrete is determined to be unsatisfactory, remove, dispose of, and replace the concrete at no expense to the Department.



400-7.1.2 Concreting in Hot Weather

- Requirements for mixing and placing concrete in hot weather as specified in Section 346 shall be met
- Reinforcing bars and metal forms shall be sprayed with cool fresh water just prior to placing the concrete in a method approved by the Engineer

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When the wind velocity exceeds 15 mph, rapid drying of concrete surfaces or excessive evaporation of surface moisture in the concrete cannot be controlled effectively using common practices such as applying an evaporation retarder or using a water fogger. If evaporation is not controlled, excessive drying is likely to cause cracking that is referred to as “plastic shrinkage cracking” since cracks form prior to initial set of the concrete while the concrete is still plastic.

400-7.1.2 Concreting in Hot Weather: Meet the temperature requirements and special measures for mixing and placing concrete in hot weather as specified in Section 346.

Spray reinforcing bars and metal forms with cool fresh water just prior to placing the concrete in a method approved by the Engineer.

Assume all risks connected with the placing and curing of concrete. Although the Engineer may give permission to place concrete, the Contractor is responsible for satisfactory results. If the placed concrete is determined to be unsatisfactory, remove, dispose of, and replace the concrete at no expense to the Department.



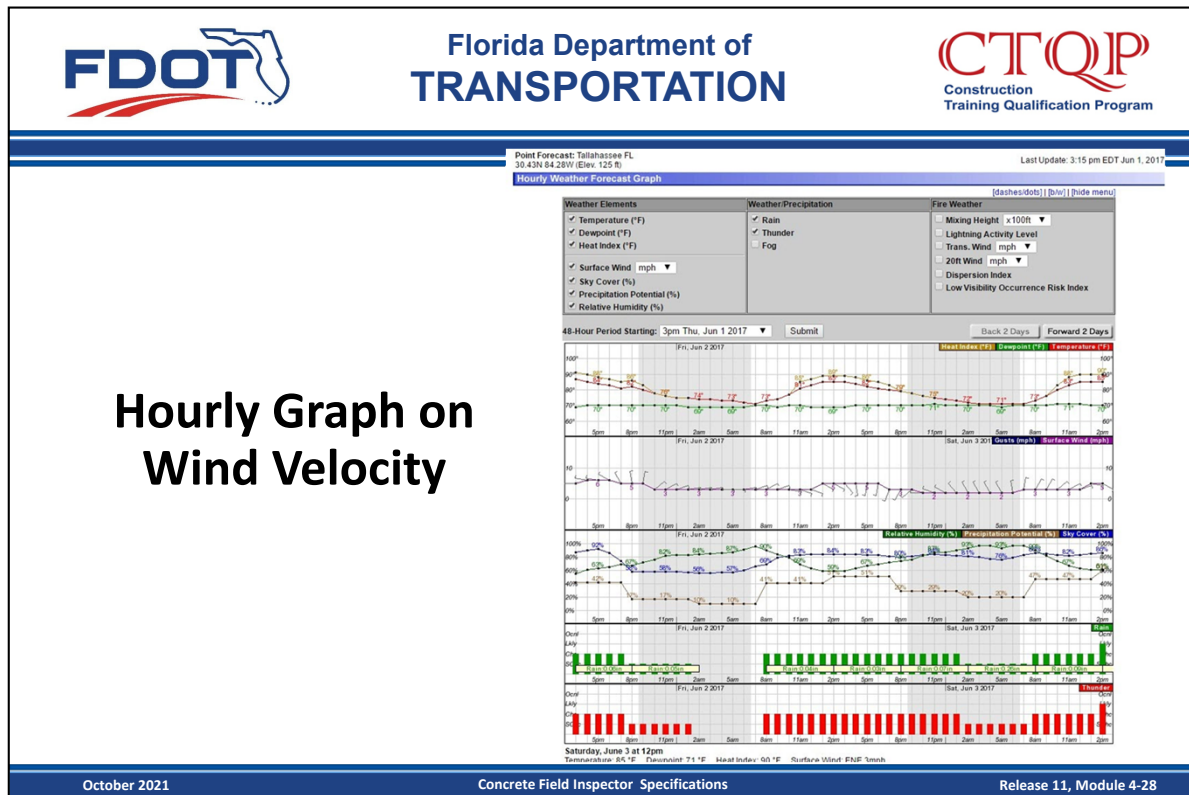
400-7.1.3 Wind Velocity Restrictions

- Do not place bridge deck concrete if the **forecast** average wind velocity exceeds 15 mph as determined from the National Weather Service, Hourly Weather Graph
- Consideration of the wind velocity forecast needs to be given when planning deck placements



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400-7.1.3 Wind Velocity Restrictions: Do not place concrete for bridge decks if the forecast of average wind velocity at any time during the planned hours of concrete placement exceeds 15 mph. Obtain weather forecasts from the National Weather Service “Hourly Weather Graph” for the city closest to the project site.



Hourly Graph on Wind Velocity

This specification requires contractors to consult the national weather service (NWS), hourly weather graph, for wind velocity forecasts prior to a planned placement in order to determine if wind velocity will be a postponing factor. Inspectors should also check the NWS website in order to verify that the contractor has satisfied the specification requirement properly. On the NWS home page, input the name of the city closest to the project site. Select “hourly weather forecast” which will display weather forecast data including wind velocity 48 hours in advance of the input time.



400-7.2 Lighting Requirements

- An approved lighting plan must be provided for night time concrete placement operations

400-7.3 Inspections before Placing Concrete

- Reinforcement must be inspected and approved by the Engineer before concrete is placed

400-7.4 Exposure to Water

- Concrete must not be exposed to salt or brackish water for 7 days



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The inspector should verify the effectiveness of lighting systems prior to concrete operations, if practical. All work areas and surfaces should be illuminated in accordance with the approved lighting plan submitted at the pre-construction meeting. Inspectors should report inadequate lighting to the Engineer immediately since safety and work quality may be seriously compromised if lighting is poor. Inspectors should confirm that the rebar placement includes an item by item check of the reinforcing steel schedule in the plans. The contractor's technician and when time permits, the inspector, must make sure that all rebars called for in the schedule, are not only placed in the member, but are also placed in the correct position and within tolerances.

400-7.2 Lighting Requirements: Provide adequate lighting for all concrete operations conducted at night. Obtain approval of the lighting system prior to starting the concrete operations.

400-7.3 Inspections before Placing Concrete: Do not place concrete until the depth and character of the foundation and the adequacy of the forms and falsework have been approved by the Engineer. Do not deposit any concrete until all reinforcement is in place and has been inspected and approved by the Engineer.

400-7.4 Exposure to Water: Do not expose concrete other than seal concrete in cofferdams to the action of water before final setting. Do not expose such concrete to the action of salt or brackish water for a period of seven days after placing the concrete. Protect the concrete during this period by keeping salt or brackish water pumped out of cofferdams.



400-7.5 General Requirements for Placing Concrete

- Concrete must be deposited as nearly as possible to its final position
- Concrete must not be moved by using a vibrator and should not receive excessive racking or pushing to relocate
- Rebars must not be pushed out of position during concrete placement
- Aluminum troughs or chutes for ready mixed concrete trucks may be used if they are less than 20' long
- Concrete must not be dropped more than 5 feet and chutes greater than 30 feet long must be approved by the Engineer
- The surface of forms or soil must be moist when fresh concrete is placed against it

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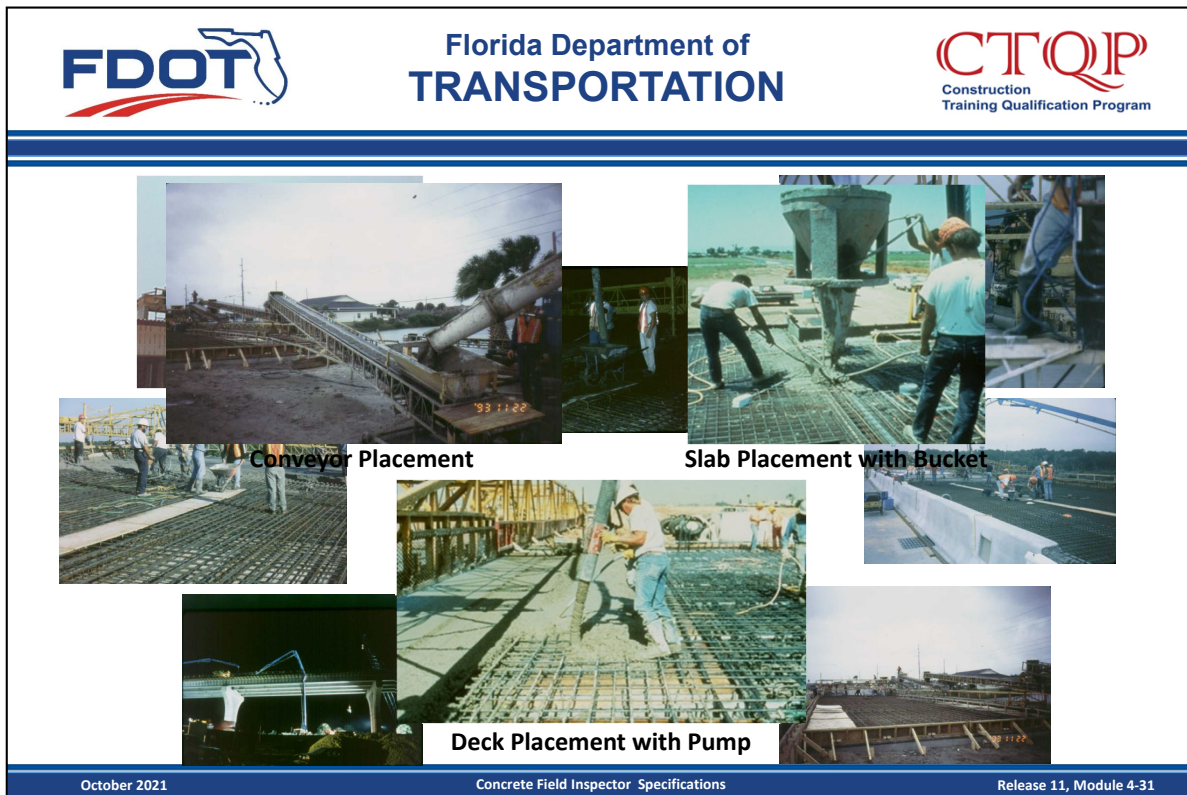
If concrete is dropped further than 5' then it may cause segregation of the aggregates because the force of the drop will cause the large aggregates to sink further into the concrete mass than the small aggregates thus causing the separation of large and small aggregates which is known as segregation.

400-7.5 General Requirements for Placing Concrete: Deposit concrete as nearly as possible in its final position. Do not deposit large quantities at one point and then run or work it along the forms. Take special care to fill each part of the forms, to work coarse aggregate back from the face, and to force concrete under and around reinforcing bars without displacing them.

Use a method and manner of placing concrete that avoids the possibility of segregation or separation of aggregates. If the Engineer determines that the quality of concrete as it reaches its final position is unsatisfactory, remove it and discontinue or adjust the method of placing until the Engineer determines that the quality of the concrete as placed is satisfactory.

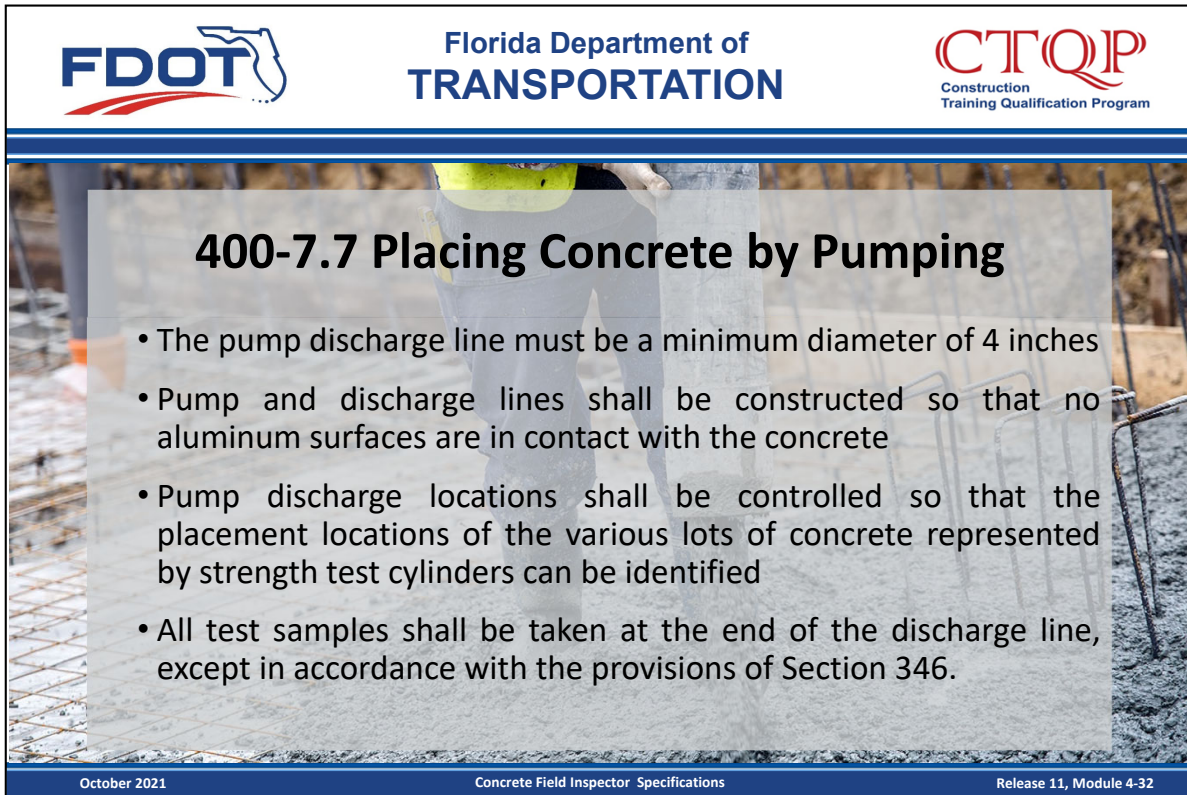
Use metal or metal-lined open troughs or chutes with no aluminum parts in contact with the concrete. As an exception, chutes made of aluminum for ready mixed concrete trucks, no longer than 20 feet, may be used. This exception does not apply to any other means of concrete conveyance. Where steep slopes are required, use chutes that are equipped with baffles or are in short lengths that reverse the direction of movement. Where placing operations would involve dropping the concrete freely more than 5 feet, deposit it through pipes, troughs, or chutes of sheet metal or other approved material. Use troughs, chutes, or pipes with a combined length of more than 30 feet only with the Department's authorization. Keep all troughs, chutes, and pipes clean and free from coatings of hardened concrete by thoroughly flushing them with water after each run or more often if necessary.

Place concrete against supporting material that is moist at the time of concrete placement. If additional water is required, uniformly apply it ahead of the concrete placement as directed by the Engineer. Do not place concrete on supporting material that is frozen. The Contractor may use a moisture barrier in lieu of controlling the foundation grade moisture when approved by the Engineer.



1. Concrete being pumped into a pier cap
2. Deck Concrete being vibrated
3. Concrete sample being pumped into a wheel barrow
4. Concrete being pumped into a bridge deck with testing in the foreground
5. Concrete sample being pumped into a wheel barrow
6. Concrete being placed by conveyor belt
7. Concrete being pumped into a deck from below at night
8. Concrete sample being pumped into a wheel barrow





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400-7.7 Placing Concrete by Pumping

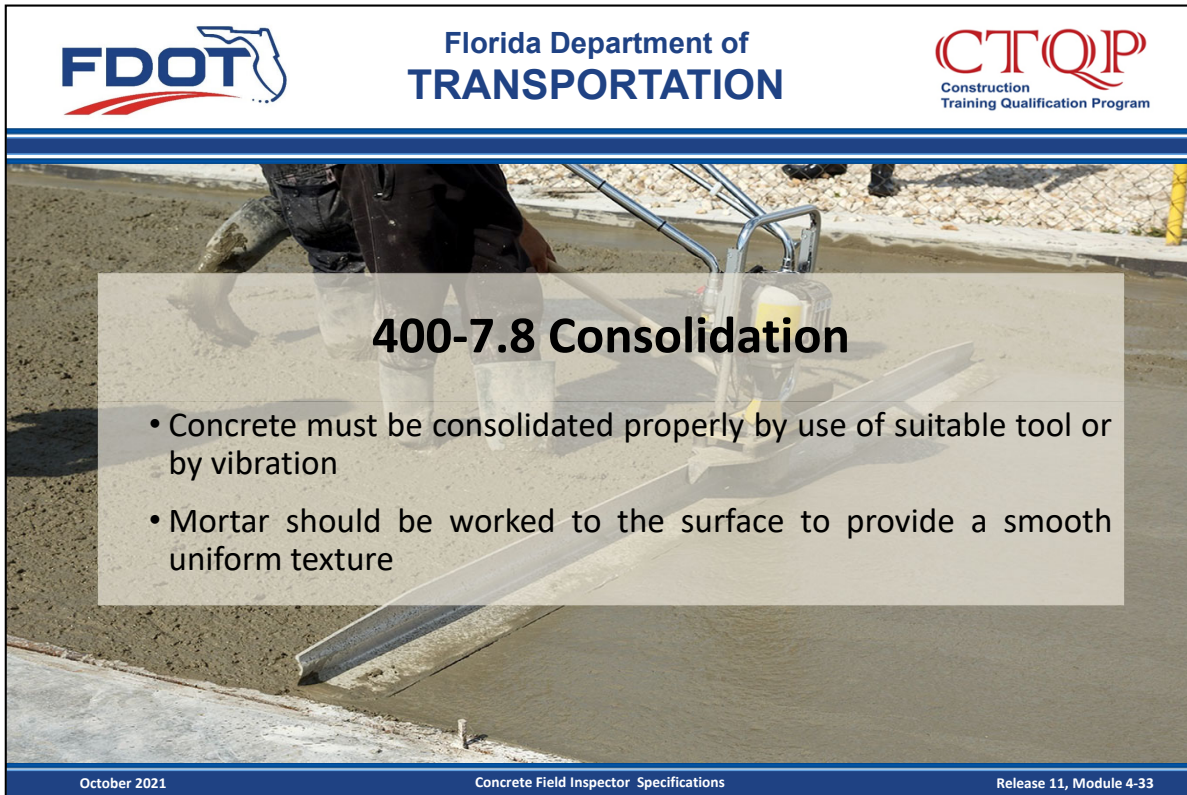
- The pump discharge line must be a minimum diameter of 4 inches
- Pump and discharge lines shall be constructed so that no aluminum surfaces are in contact with the concrete
- Pump discharge locations shall be controlled so that the placement locations of the various lots of concrete represented by strength test cylinders can be identified
- All test samples shall be taken at the end of the discharge line, except in accordance with the provisions of Section 346.

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When using a pump, initial and acceptance samples must be taken from the discharge end of the pump. As an exception, a correlation test may be performed by the contractor establishing how much the slump changes when the pump is used. For example, a sample is taken from the back of the truck and another sample of the same load is taken from the end of the pump hose. The slump of both samples is determined and the end of pump sample has $\frac{1}{2}$ " less slump than the back of the truck sample. If this same difference is repeated on a number of samples over a period of time then a consistent pattern or correlation of $\frac{1}{2}$ " inch loss due to pumping can be established. Thereafter, samples may be taken from the back of the truck as long as the recorded slump value is adjusted down by $\frac{1}{2}$ ". However, if conditions change (average ambient air temperature changes by 15 degrees, pumping distance changes significantly, type of pump truck changes) then a new correlation test must be performed. Correlations may also be established when buckets are used to allow the concrete to be sampled at the back of the truck instead of at the point of discharge of the bucket.

400-7.7 Placing Concrete by Pumping: In general, use concrete pumping equipment that is suitable in kind and adequate in capacity for the work proposed. Use a pump discharge line that has a minimum diameter of 4 inches. Use a pump and discharge lines that are constructed so that no aluminum surfaces are in contact with the concrete being pumped. Operate the pump to produce a continuous stream of concrete, without air pockets.

When using cement slurry or similar material to lubricate the discharge line when pumping begins, collect such material at the point of discharge. Dispose of the collected slurry in areas provided by the Contractor. Control the pump discharge locations so that the placement locations of the various LOTs of concrete represented by strength test cylinders can be identified in the event the test cylinders indicate deficient strength. When concrete is placed by pumping, take all test samples of concrete at the end of the discharge line, except in accordance with the provisions of Section 346.

A photograph showing a construction worker in a dark shirt and pants using a long-handled vibration tool on a freshly poured concrete surface. The worker is positioned on the left, and the tool is being used on the right side of the frame. The concrete is a light gray color and appears to be in the process of being finished. The background shows a construction site with some gravel and a yellow safety cone.

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400-7.8 Consolidation

- Concrete must be consolidated properly by use of suitable tool or by vibration
- Mortar should be worked to the surface to provide a smooth uniform texture

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400-7.8 Consolidation: Consolidate the concrete by continuous working with a suitable tool in an acceptable manner, or by vibrating as set forth in 400-7.11. When not using vibrators, thoroughly work and compact all thin-section work with a steel slicing rod. Spade all faces, and flush the mortar to the surface by continuously working with a concrete spading implement.



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400-7.9 Obstructions

- Forms may have to be vibrated in order to produce proper consolidation
- Produce vibrations by striking the outside surfaces of the forms with wooden mallets or by other satisfactory means
- Care must be taken to not jar the concrete after initial set



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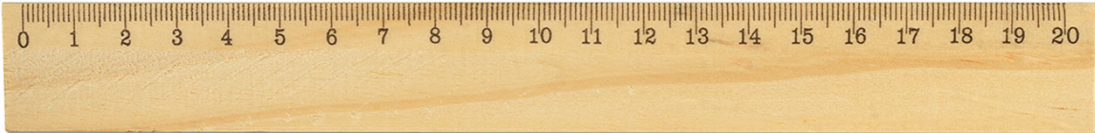
400-7.9 Obstructions: In cases where, because of obstructions, difficulty is encountered in puddling the concrete adjacent to the forms, bring the mortar content of the mix into contact with the interior surfaces by vibrating the forms. Produce the vibrations by striking the outside surfaces of the forms with wooden mallets or by other satisfactory means. In placing concrete

around steel shapes place it only on one side of the shape until it flushes up over the bottom flange of the shape on the opposite side, after which place it on both sides to completion. After the concrete has taken its initial set, exercise care to avoid jarring the forms or placing any strain on the ends of projecting reinforcing bars.



400-7.10 Requirements for Successive Layers

- When placing in successive layers:
 - Concrete shall be placed in 20" thick layers
 - Vibrators must be inserted through the top most layer well into the underlying layer to mix the concrete at the joint between the two layers



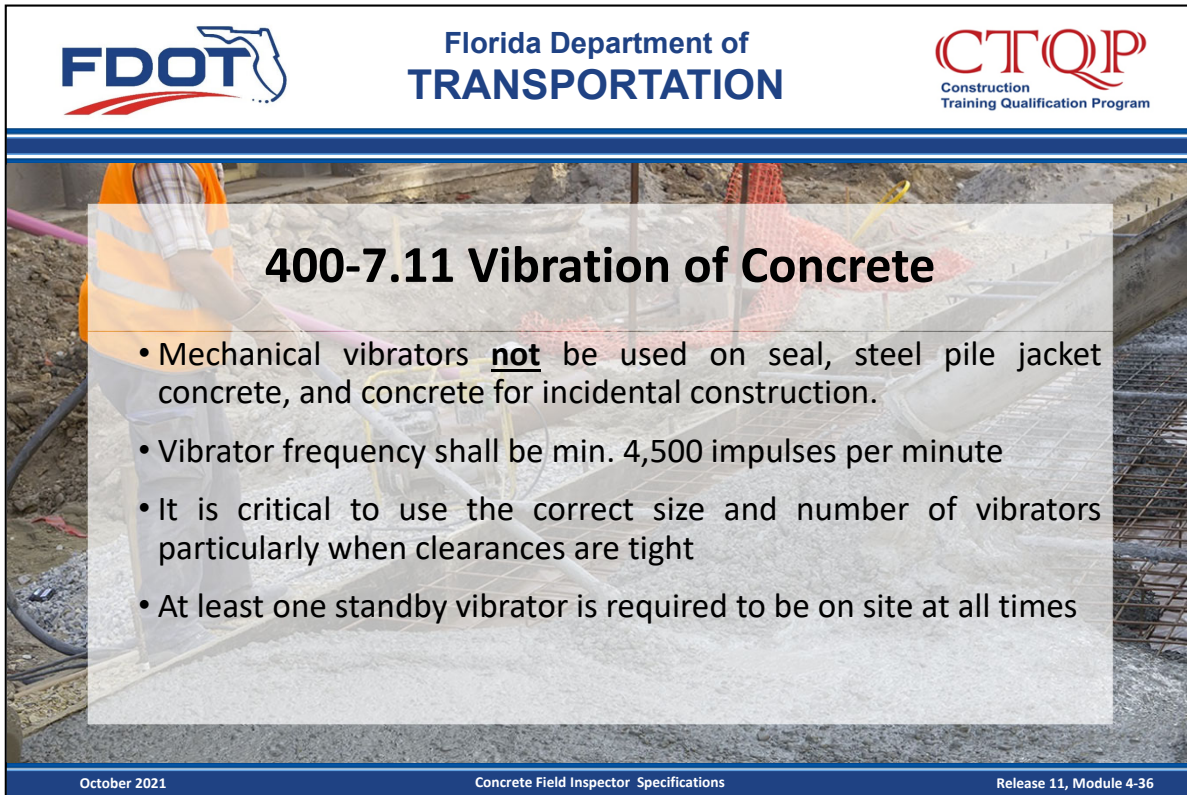
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This specification requires horizontal layers of concrete, commonly referred to as lifts, to be approximately 20 inches thick or less. For example, a 4 foot thick footing should be placed using (2) 20" lifts and (1) 8" lift. Lifts that are too stiff will not allow a vibrator to penetrate them from the lift above. If the vibrator cannot penetrate then the interface between lifts will form a permanent cold joint. The component is designed to perform without cold joints and; therefore, cold joints become a design issue that has to be resolved by a formal review process that can result in expensive corrective measures or even removal. The inspector should discuss this Specification requirement with the contractor at the pre-operations meeting prior to starting any concrete placement requiring multiple lifts and should confirm compliance with the Specification during the actual placement.

400-7.10 Requirements for Successive Layers: Place concrete in continuous horizontal layers, approximately 20 inches thick. To avoid obtaining a plane of separation or a cold joint between layers, vibrate the concrete in accordance with 400-7.11.



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400-7.11 Vibration of Concrete

- Mechanical vibrators **not** be used on seal, steel pile jacket concrete, and concrete for incidental construction.
- Vibrator frequency shall be min. 4,500 impulses per minute
- It is critical to use the correct size and number of vibrators particularly when clearances are tight
- At least one standby vibrator is required to be on site at all times

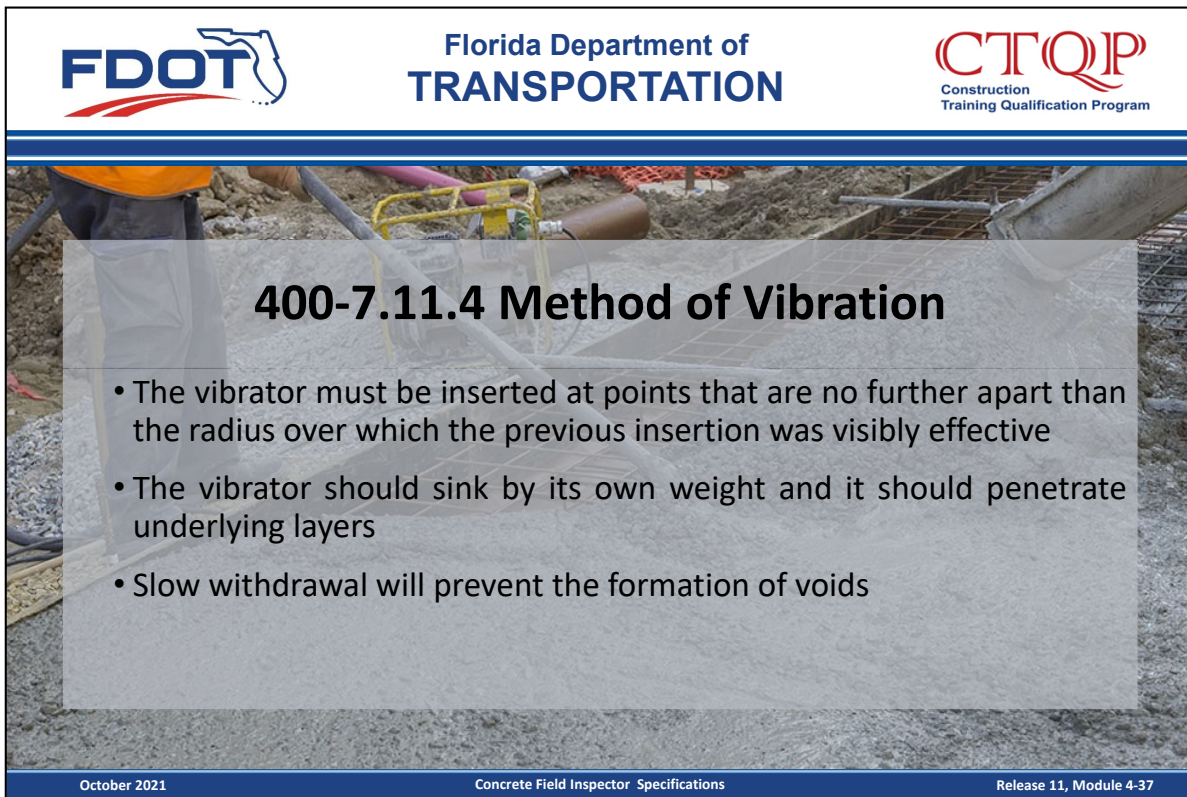
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As soon as the concrete is placed, it should be consolidated with portable hand-held vibrators having an approved size and frequency per Specification 400-7.11. Due to the large number of rebars used in deck construction, vibrators must be used at close intervals. Inspectors should keep an eye on this operation to be sure that the workmen do not use the vibrators to spread concrete into corners or low spots. 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, known 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 member. Vibrators can be checked using a device, such as a vibra-tech, which simply measures the pulses per minute.

400-7.11 Vibration of Concrete:

400-7.11.1 General: Consolidate all concrete except seal, steel pile jackets, and concrete for incidental construction by the use of mechanical vibrators.

400-7.11.2 Vibrators: Provide adequate vibrators on the project that are approved by the Engineer before beginning concrete work. Generally, provide vibrators of the internal type. For thin sections, where the forms are especially designed to resist vibration, the Contractor may use external vibrators. Use a vibrator with a minimum frequency of 4,500 impulses per minute with sufficient intensity and duration to cause complete consolidation of the concrete without causing segregation of the materials. For vibrating thin, heavily reinforced sections, use heads of such size to secure proper vibration of the concrete without disturbance of either the reinforcing bars or the forms.



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400-7.11.4 Method of Vibration

- The vibrator must be inserted at points that are no further apart than the radius over which the previous insertion was visibly effective
- The vibrator should sink by its own weight and it should penetrate underlying layers
- Slow withdrawal will prevent the formation of voids

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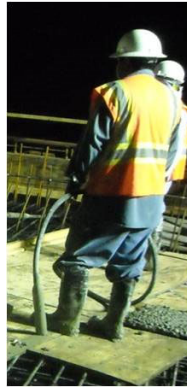
400-7.11.3 Number of Vibrators Required: Use a sufficient number of vibrators to secure the compaction of each batch before the next batch is delivered, without delaying the delivery. In order to avoid delays due to breakdowns, provide at least one stand-by vibrator, with an appropriate power source.

400-7.11.4 Method of Vibration: Use vibrators to consolidate properly placed concrete. Do not use them to move concrete about in the forms. Insert the vibrators in the surface of concrete at points spaced to ensure uniform vibration of the entire mass of the concrete. Insert the vibrator at points that are no further apart than the radius over which the vibrator is visibly effective. Allow the vibrator to sink into the concrete by its own weight, and allow it to penetrate into the underlying layer sufficiently so that the two layers are thoroughly consolidated together. After thoroughly consolidating the concrete, withdraw the vibrator slowly to avoid formation of holes.

400-7.11.5 Hand Spading: When necessary in order to secure well-filled forms, free from aggregate pockets, honeycomb, bubbles, etc., spade the concrete by hand, along the surfaces of the forms and in all corners, following the vibration.



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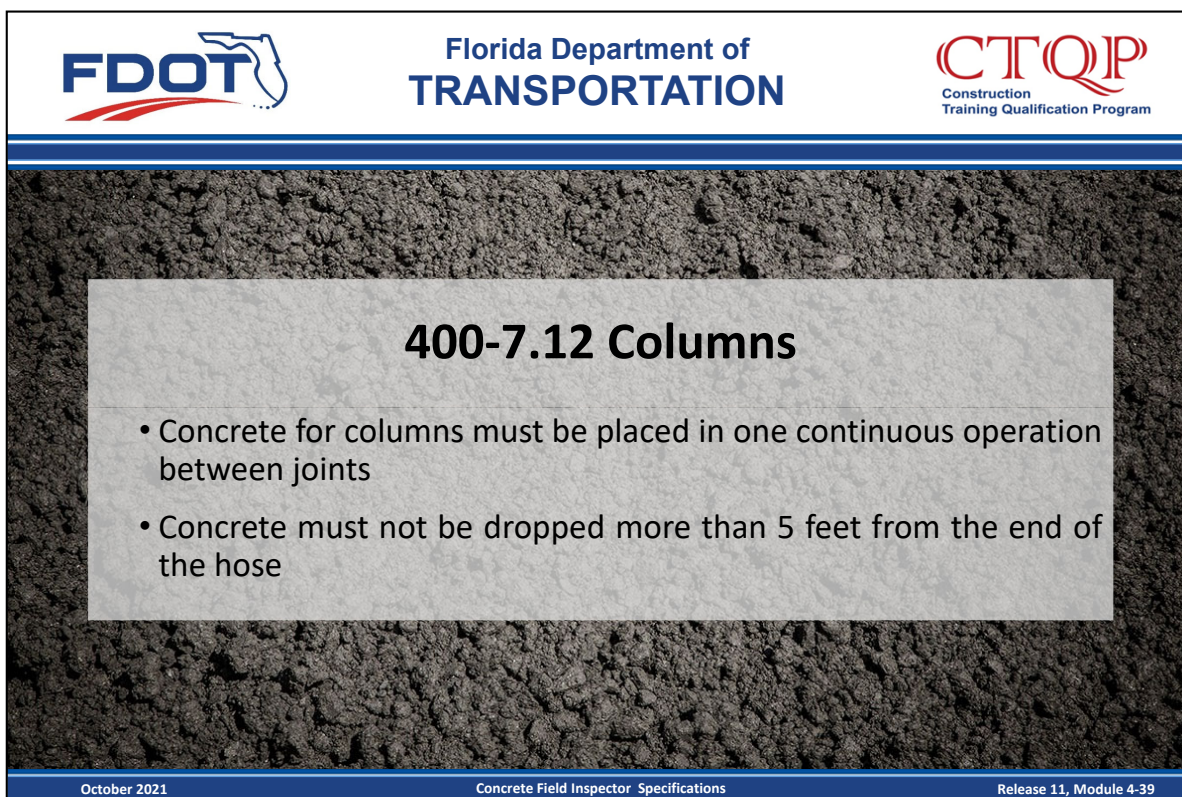


Vibrators being used during Placement

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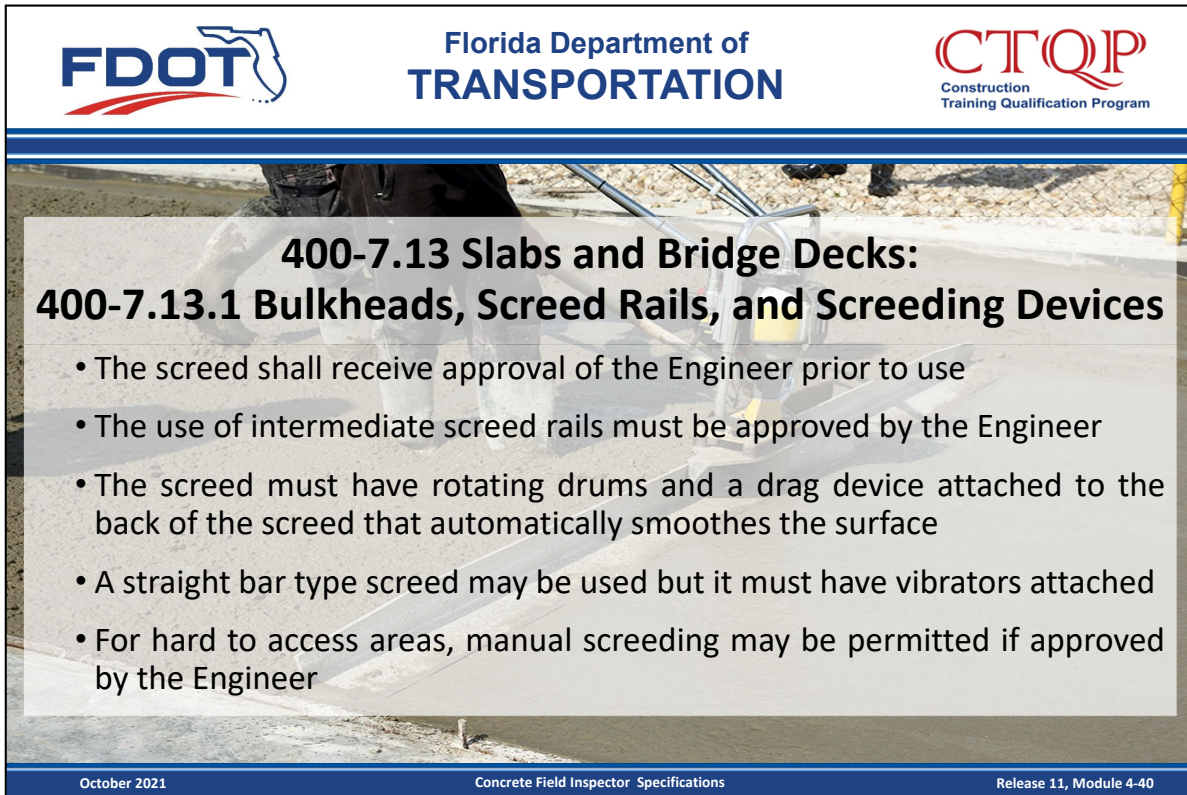
400-7.12 Columns

- Concrete for columns must be placed in one continuous operation between joints
- Concrete must not be dropped more than 5 feet from the end of the hose

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Concrete placed in a column can produce very high fluid pressures in the bottom sections of the column and this can result in failure of the forms or what is referred to as a form blowout. Concrete column forms must be secured per the manufacturer's instructions for the fluid pressures the forms are designed to resist. inspectors should verify that the contractor is following the manufacturer's instructions. When placed in columns, the concrete should not have a high slump which increases fluid pressures and should not be placed too rapidly: continuous placement as stated in the specification does not mean "all at once."

400-7.12 Columns: Place concrete in columns in one continuous operation for each lift as shown in the plans.



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400-7.13 Slabs and Bridge Decks:

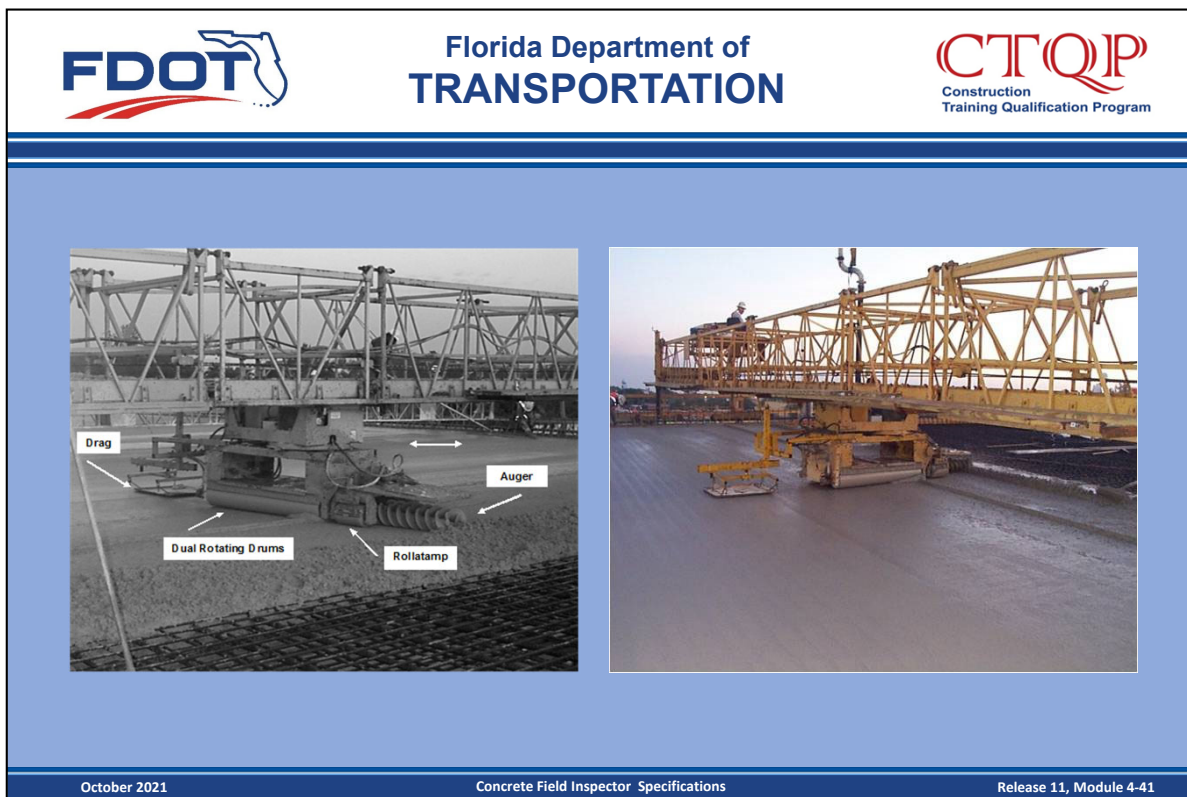
400-7.13.1 Bulkheads, Screed Rails, and Screeding Devices

- The screed shall receive approval of the Engineer prior to use
- The use of intermediate screed rails must be approved by the Engineer
- The screed must have rotating drums and a drag device attached to the back of the screed that automatically smooths the surface
- A straight bar type screed may be used but it must have vibrators attached
- For hard to access areas, manual screeding may be permitted if approved by the Engineer

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400-7.13 Slabs and Bridge Decks:

400-7.13.1 Bulkheads, Screed Rails, and Screeding Devices: Strike-off the concrete using an approved metal screed operating on rails or bulkheads. Use devices which do not contain aluminum parts. Prior to placing concrete, provide an approved screed capable of striking-off and screeding the surface of the slab or deck to the required shape. Set all necessary bulkheads and screed rails to the required grade. Use bulkheads, screed rails, and screeding devices that permit vertical profile adjustment to the grade, satisfactory for providing straight transverse slopes, differing transverse slopes broken as shown in the Plans and/or transverse slopes with changing grade along the longitudinal length of slab or deck. Locate the screed rails so the entire placement surface can be screeded to grade without using intermediate screed rails, unless approved otherwise by the Engineer.



The screed's main elements are shown in the accompanying photo and the device labeled rollatamp, which is a drum with gear like teeth, is used to push the large aggregate down into the concrete so that the cement more easily accumulates at the surface which helps the screed to be more effective and produces a more uniform surface texture.

400-7.13 Slabs and Bridge Decks:

400-7.13.1 Bulkheads, Screed Rails, and Screeding Devices (cont.): Use a screed consisting of a truss or heavy beams that will retain it's shape under all working conditions, and a set of rotating drums with a diameter sufficient to carry a 2 inch mortar roll in front of and parallel to the axis of the drums, while making an initial pass. Adjust the drums to prevent mortar buildup forming behind the trailing edges of the drums. For long bridges, as defined in 400-15.2.5.1, provide a device that automatically smooths the concrete surface to an untextured finish and that is attached to, and is moved by, the rolling drum screed. As an alternate to the drum type screed, a mechanical screed with a metal strike-off may be used. Equip the mechanical screed with mechanical vibrators to provide continuous uniform vibration to the entire length unless otherwise authorized by the Engineer. Small and irregularly shaped areas that cannot be mechanically screeded may be screeded in a manner approved by the Engineer.



400-7.13.2 Screed Demonstration

- The screed must be demonstrated prior to concrete placement to show that the required finished grades can be achieved
- The demonstration must take place over the entire length and width of the span
- Check
 - Rebar clearance
 - Grades and elevations
 - Motors and overall operation

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For bridges that are categorized as “long” (structure length in excess of 100’) application of water to the deck during placement and after screeding, while the concrete is plastic, is no longer permitted unless authorized by the engineer. This is because decks of long bridges are planed (surface is ground off) for improved ride quality after curing which removes $\frac{1}{4}$ to $\frac{1}{2}$ inch of the deck surface. This means that the concrete surface of the deck does not need to be floated or broomed after screeding since this surface will be planed off later; therefore, there is no need to add water to improve workability during floating or finishing. Inspectors should discuss this issue with the contractor at the pre-operations meeting prior to the first deck placement.

400-7.13.2 Screed Demonstration: Subsequent to the placement of all reinforcing bars and prior to placing any slab or deck concrete, demonstrate that the proposed equipment and methods can finish the concrete to the specified grades while maintaining the specified cover over the reinforcement. Provide the demonstration over the entire length and width of the spans to be placed.



400-7.13.3 Screeding Operations

- The concrete in front of the screed should be placed as near as possible to finished grade to prevent the screed from lifting off the rails
- If the Engineer allows water to be applied to the concrete surface, use a fog mist generated by a power sprayer
- The deck surface of bridges over 100 feet long shall not be floated or broomed after screeding
- The concrete must not take initial set before all deck concrete has been placed

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The rate of placement is very important because if it is too slow the concrete placed at the start of the pour may take initial set before the pour is complete and this can cause cracks in the deck that already has initial set since it has very low strength at this stage of curing. Prior to large placements, the inspector should discuss the concrete placement plan with the contractor. The number of trucks provided for the placement, and the batch, transit and discharge times needed to maintain the required placement rate should be discussed.

400-7.13.3 Screeding Operations: Perform concrete placement and screeding as independently controlled mechanical operations. Ensure that the passing of the screed and forward movement of the screeding equipment are independent of the movement of concrete placement equipment.

Level the concrete in front of the screed as near to the finished grade as possible to prevent the screed from rising off the rail and forming uneven ridges behind the screed. Pass the screed over the slab or deck as many times as necessary to obtain a satisfactory surface and provide a concrete surface true to grade and crown, and free of irregularities.

Do not add water to the concrete surface to assist in finishing operations unless specifically authorized by the Engineer. If the Engineer permits the addition of water, apply only a fog mist, above the concrete surface, by means of approved power driven spray equipment.

For long bridges, as defined in 400-15.2.5.1, do not manually or mechanically float the concrete surface or apply a texture by broom or any other device to the concrete surface produced by the screeding process. Correct isolated surface irregularities in accordance with 400-15.2.5.3.



400-7.13.4 Placing Operations

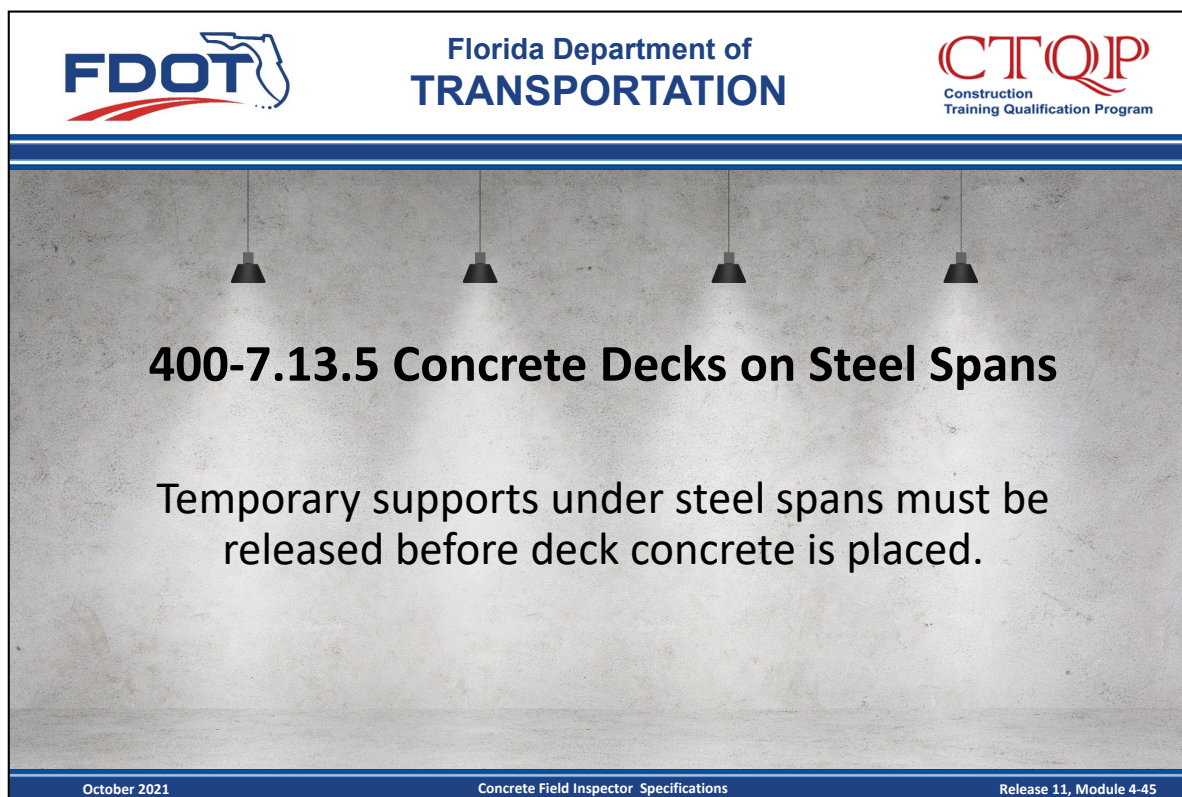


- Concrete must be placed at a rate of 20 cy/hr. if 50 cy or less of concrete are placed
- For placements greater than 50 cy, the minimum placement rate is 30 cy/hr.

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400-7.13.4 Placing Operations: Select an approved concrete design mix which ensures complete placement of all slab or deck concrete between construction joints before initial set begins in the plastic concrete. On placements of 50 yd³ or less, the minimum placement rate is 20 yd³/h. On placements of greater than 50 yd³, the minimum placement rate is 30 yd³/h.

The Engineer will not permit slab or deck placements until an acceptable plan for meeting the minimum placement rate is approved.



The slide features a header with the FDOT logo (Florida Department of Transportation) on the left, the text 'Florida Department of TRANSPORTATION' in the center, and the CTQP logo (Construction Training Qualification Program) on the right. The background is a grayscale image of a concrete wall with four pendant lights hanging from the ceiling. The main title '400-7.13.5 Concrete Decks on Steel Spans' is centered in a large, bold, black font. Below the title, the text 'Temporary supports under steel spans must be released before deck concrete is placed.' is centered in a smaller black font. At the bottom of the slide, there is a blue footer bar containing the text 'October 2021' on the left, 'Concrete Field Inspector Specifications' in the center, and 'Release 11, Module 4-45' on the right.

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400-7.13.5 Concrete Decks on Steel Spans

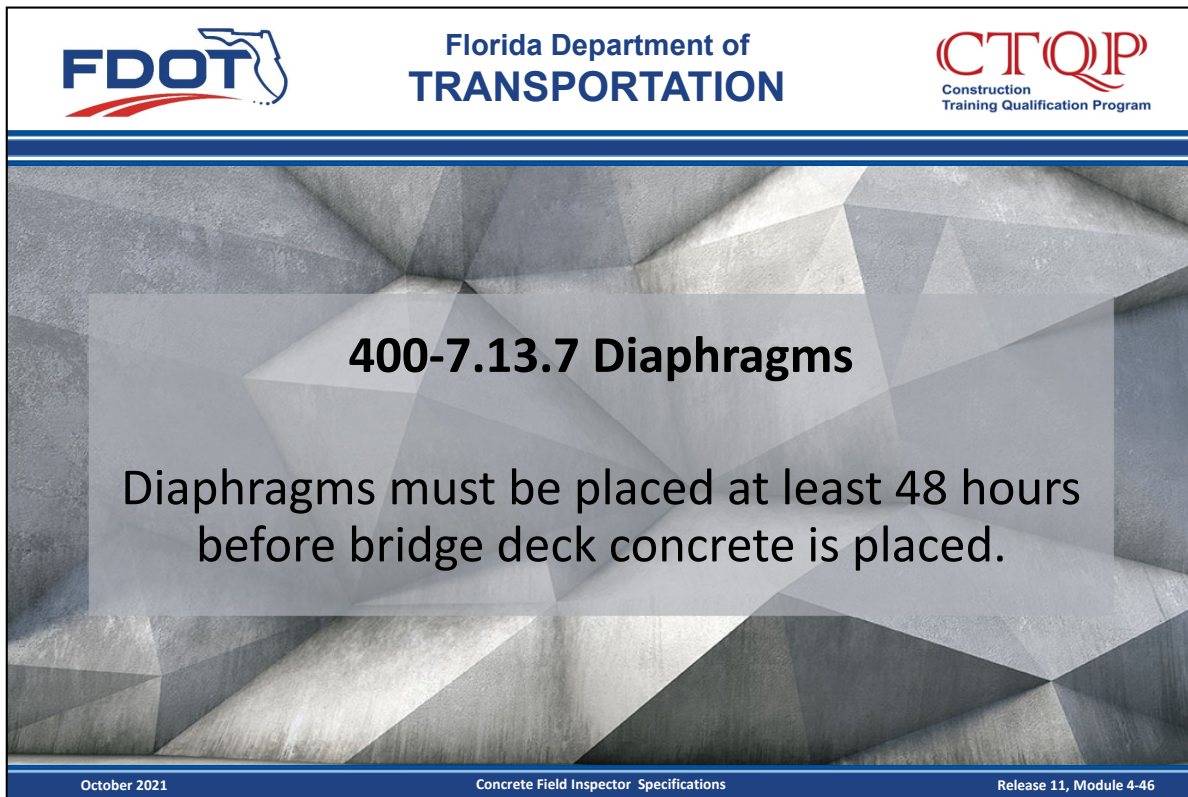
Temporary supports under steel spans must be released before deck concrete is placed.

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Temporary supports must be released because the beams that support the deck are designed to deflect from the load of the slab concrete to an elevation that is the correct finished grade. If they continue to be supported and can't deflect before the concrete is placed then the finished grade will be too high.

400-7.13.5 Concrete Decks on Steel Spans: Where concrete decks are placed on steel spans, release the temporary supports under the bridge before placing any concrete.

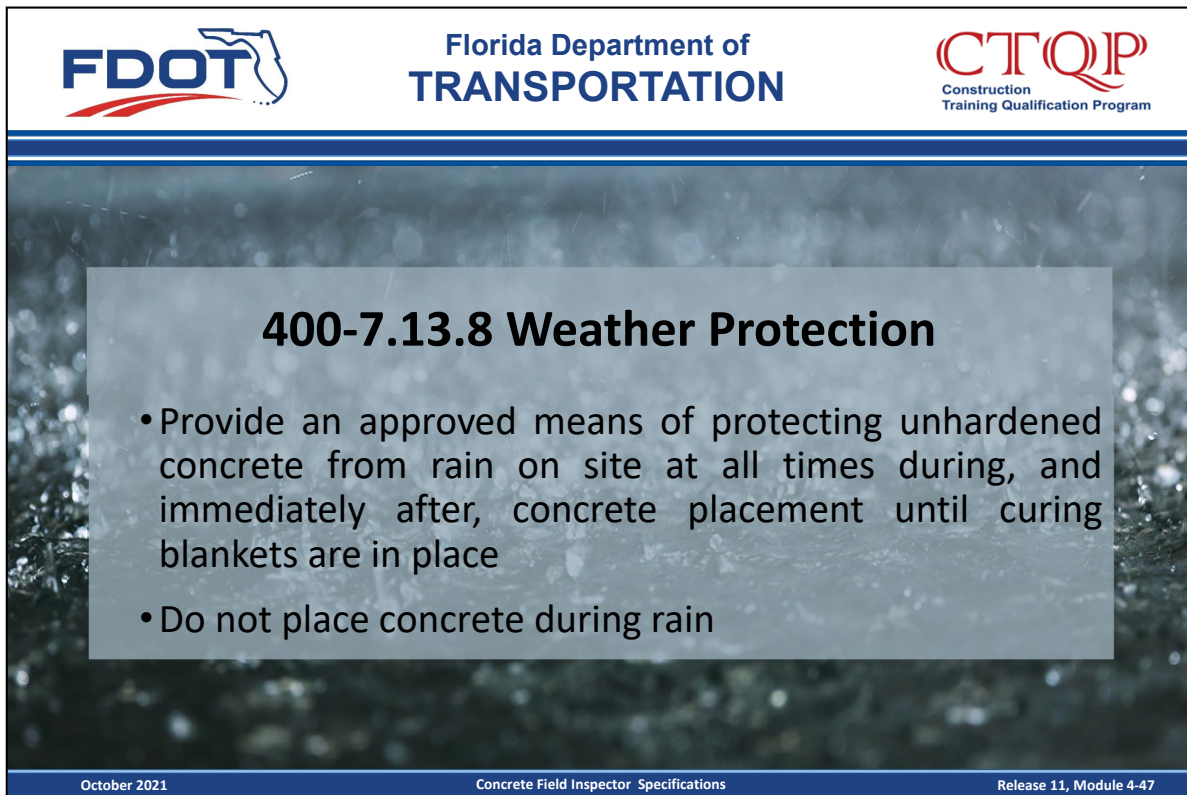
400-7.13.6 Concrete Decks on T-Beams: For cast-in-place T-beam construction, cast the slabs and beams in one continuous operation. As an exception, where special shear anchorage or keys are provided for in the Plans or approved by the Engineer, the beams and slabs may be constructed in successive placements.



400-7.13.7 Diaphragms: Place concrete diaphragms at least 48 hours before the bridge deck slabs are placed unless otherwise indicated in the Plans.

400-7.13.8 Weather Protection: Provide an approved means of protecting unhardened concrete from rain. Position the protection system to shield the concrete from rain and running water. Provide a shield impervious to water over the slab or deck concrete, of sufficient size to protect all areas of slab or deck concrete subject to water damage, and include a means of intercepting and diverting water away from freshly placed concrete. Arrange the equipment so that the weather protection system can be erected over unhardened concrete. When there is a possibility of rain during concrete placement operations, place the weather protection system in stand-by readiness, capable of being deployed in a timely manner. Use the weather protection immediately when rain begins so that slab or deck concrete damage will not occur. Do not place concrete during rain.

Assume responsibility for damage to the slab or deck in the case of failure of the weather protection system



The slide features a dark, textured background with a central light gray box containing the title and bullet points. At the top, there are three logos: FDOT (Florida Department of Transportation) on the left, the text 'Florida Department of TRANSPORTATION' in the center, and CTQP (Construction Training Qualification Program) on the right. The bottom of the slide has a dark blue footer with white text.

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400-7.13.8 Weather Protection

- Provide an approved means of protecting unhardened concrete from rain on site at all times during, and immediately after, concrete placement until curing blankets are in place
- Do not place concrete during rain

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400-7.13.8 Weather Protection: Provide an approved means of protecting unhardened concrete from rain. Position the protection system to shield the concrete from rain and running water. Provide a shield impervious to water over the slab or deck concrete, of sufficient size to protect all areas of slab or deck concrete subject to water damage, and include a means of intercepting and diverting water away from freshly placed concrete. Arrange the equipment so that the weather protection system can be erected over unhardened concrete. When there is a possibility of rain during concrete placement operations, place the weather protection system in stand-by readiness, capable of being deployed in a timely manner. Use the weather protection immediately when rain begins so that slab or deck concrete damage will not occur. Do not place concrete during rain.

Assume responsibility for damage to the slab or deck in the case of failure of the weather protection system



400-7.14 Concrete Box Culverts

- The base slab or footing of concrete box culverts, shall be placed and allowed to set before constructing the remainder of the culvert
- Transverse construction joints must be placed at right angles to the culvert barrel with keys
- Where the height of the box culvert walls exceeds 6 feet, the concrete in the walls shall be placed and allowed to set at least 12 hours before placing the top slab concrete.
- The edge of the beveled material forming the key shall not be less than 1 1/2 inches from the edge of the concrete
- Horizontal wingwall construction joints must not be visible in the exposed face above ground

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400-7.14 Concrete Box Culverts: In general, place the base slab or footing of concrete box culverts, and allow them to set before constructing the remainder of the culvert. In this case, make suitable provision for longitudinal keys. Construct bottom slabs, footings, and apron walls as a monolith if practicable. Where transverse construction joints are necessary, place them at right angles to the culvert barrel, and make suitable provision for keys.

In the construction of box culverts having walls 6 feet or less in height, the sidewalls and top slab may be constructed as a monolith or may place the concrete in the walls and allow it to set before placing the top slab concrete.

Where the height of the box culvert walls exceed 6 feet, place the walls, and allow the concrete to set at least 12 hours before placing the top slab concrete. In such cases, form keys in the sidewalls.

When casting the walls and top slabs of box culverts as a monolith, ensure that any necessary construction joints are vertical. Design all construction joints with formed keys. Provide keys that are beveled as shown in the Plans or as directed, but do not allow the edge of the beveled material forming the key to be less than 1 1/2 inches from the edge of the concrete.

Construct each wingwall, if possible, as a monolith. Ensure that construction joints, where unavoidable, are horizontal and so located that no joints will be visible in the exposed face of the wing above the ground line.

Precast box culvert sections may be used in lieu of cast-in-place box culvert construction provided the provisions in Section 410 are satisfied.



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400-8 Seals

- Seals are needed in order to produce a dry enclosure for the construction of cast-in-place components by forming a concrete floor to which forms can be attached
- The seal acts as a barrier to the flow of water into the enclosure and makes it possible to dewater the enclosure with the aid of continuous pumping
- Method of Placement - Tremie - Min. ID of 10"
- The bottom of the tremie pipe must be kept submerged in the concrete mass at all times to avoid trapping pockets of water that can weaken the concrete and lead to leaks later
- Seal concrete shall be poured in one continuous placement
- Seal concrete shall not be placed in running water
- Seal concrete shall not be disturbed after placement - no dewatering for min. 72 hours after placement

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Seals allow the cofferdam or form enclosure to be dewatered; however, there are always leaks and these must be minimized before footing concrete is placed. It is very important that the inspector tell the contractor that the floor of the enclosure is to be free of standing water and active flows across the surface and that the flow of leaks must be under full control before concrete placement. There must be an adequate backup pump immediately available if the primary pump fails.

400-8 Seals.

400-8.1 General: Wherever practicable, dewater all foundation excavations, and deposit the concrete in the dry as defined in 455-15.2. Where conditions are encountered which render it impracticable to dewater the foundation before placing concrete, the Engineer may authorize the construction of a concrete foundation seal of the required size. Then, dewater the foundation, and place the balance of the concrete in the dry.

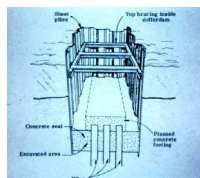
When required to place seal concrete, the Contractor is responsible for the satisfactory performance of the seal in providing a watertight excavation for placing structural concrete. The Department will provide and pay for the seal concrete as an aid to the construction of the structure. Repair seal concrete as necessary to perform its required function at no expense to the Department.

400-8.2 Method of Placing: Carefully place concrete deposited under water in the space in which it is to remain by means of a tremie, a closed-bottom dump bucket of not less than 1 cubic yard capacity, or other approved method. Do not disturb the concrete after depositing it. Deposit all seal concrete in one continuous placement. Do not place any concrete in running water, and ensure that all form work designed to retain concrete under water is watertight.

400-8.3 Use of Tremie: Use a tremie consisting of a tube having a minimum inside diameter of 10 inches, constructed in sections having water-tight joints. Do not allow any aluminum parts to have contact with the concrete. Ensure that the discharge end is entirely seated at all times, and keep the tremie tube full to the bottom of the hopper. When dumping a batch into the hopper, keep the tremie slightly raised (but not out of the concrete at the bottom) until the batch discharges to the bottom of the hopper. Stop the flow by lowering the tremie. Support the tremie such as to permit the free movement of the discharge end over the entire top surface of the work and to permit its being lowered rapidly when necessary to choke off or retard the flow.

Provide a continuous, uninterrupted flow until completing the work. Exercise special care to maintain still water at the point of deposit.

400-8.4 Time of Beginning Pumping: Do not commence pumping to dewater a sealed cofferdam until the seal has set sufficiently to withstand the hydrostatic pressure, and in no case earlier than 72 hours after placement of the concrete.

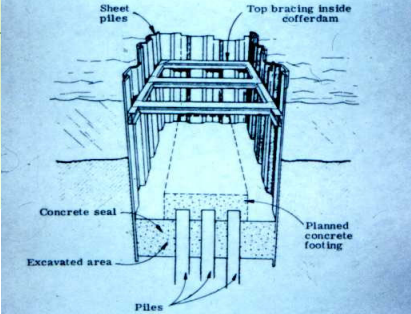
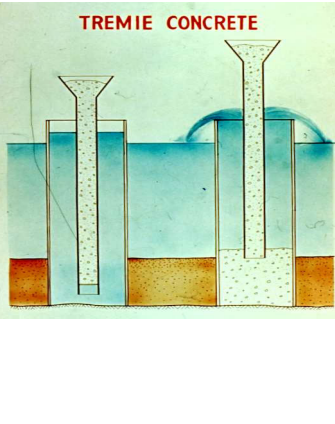




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400-9 Construction Joints

- Hardened concrete should be “roughened” and thoroughly cleaned and saturated prior to placement of new concrete
- Concrete shall be placed continuously from joint to joint
- No construction joints permitted in sea or brackish water between:
 - 2’ below mean low water elevation
 - 6’ above mean high water elevation
- No less than 30’ spacing for vertical construction joints on Long Box culverts
- When crack control grooves are required, a tooled “V” groove must be used or the groove can be cut using an early entry dry cut saw

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Saw cutting the crack control grooves must be done as soon as the concrete has hardened enough to permit standing on the surface, to prevent uncontrolled cracks. The inspector should discuss this with the contractor prior to the concrete placement and the appropriate equipment must be in advance of this work.

400-9 Construction Joints.

400-9.1 Location: Make construction joints only at locations shown in the Plans or in the placement schedule, unless otherwise approved in writing. If not detailed in the Plans or placement schedule, or in case of emergency, place construction joints as directed.

400-9.2 Provisions for Bond and Transmission of Shear: Use shear key reinforcement where necessary to transmit shear or to bond the two sections together.

400-9.3 Preparations of Surfaces: Before depositing new concrete on or against concrete which has hardened, re-tighten the forms. Roughen the surface of the hardened concrete in a manner that will not leave loosened particles, aggregate, or damaged concrete at the surface. Thoroughly clean the surface of foreign matter and laitance, and saturate it with water.

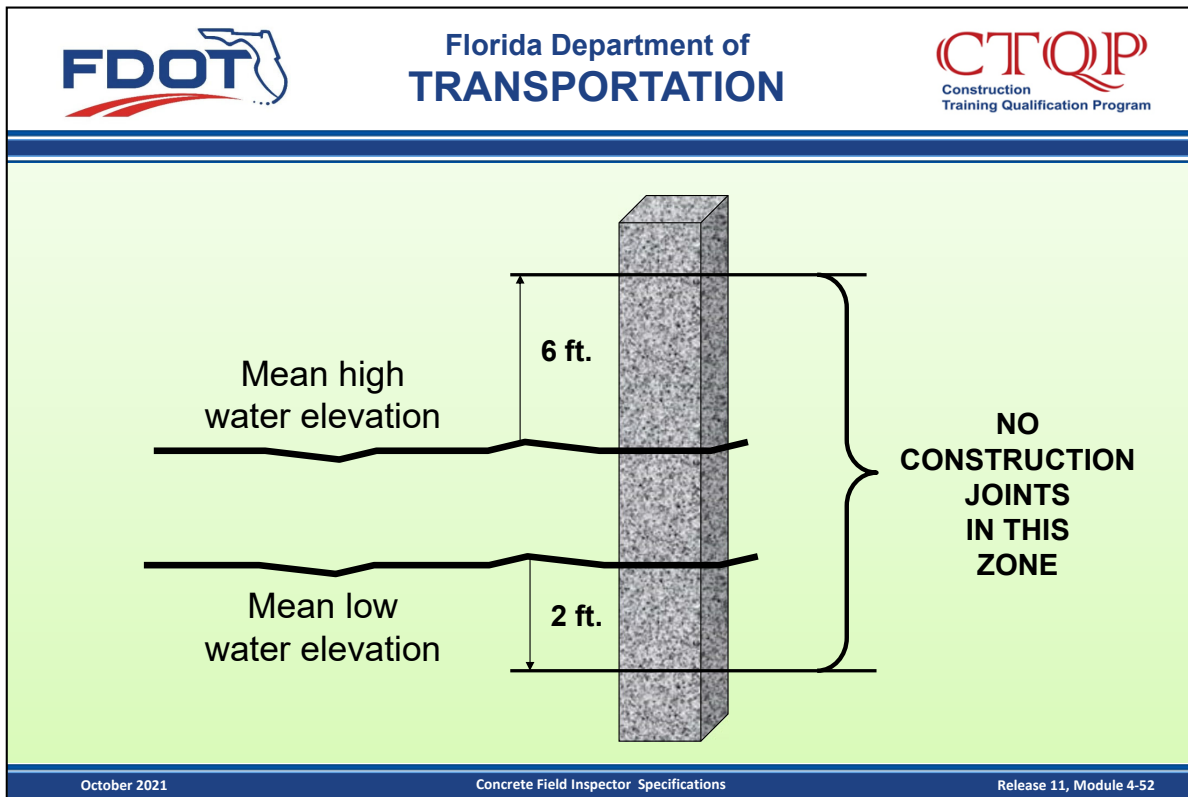
400-9.4 Placing Concrete: Continuously place concrete from joint to joint. Carefully finish the face edges of all joints which are exposed to view true to line and elevation.

400-9.5 Joints in Sea Water or Brackish Water: For concrete placed in sea water or brackish water, do not place any construction joints between points 2 feet below the mean low water elevation and 6 feet above the mean high water elevation.

400-9.6 Joints in Long Box Culverts: For long concrete box culverts, vertical construction joints may be placed at a spacing not less than 30 feet. When using transverse construction joints, ensure that longitudinal reinforcing is continuous through the joint and that the joint is vertical.

400-9.7 Crack Control Grooves in Concrete Bridge Decks: When the Plans require crack control grooves in the top surface of decks, either install a tooled “V” groove prior to initial concrete set or saw a groove using an early entry dry cut saw. When using an early entry dry cut saw, operate in accordance with the manufacturer’s recommendations. Commence sawing as soon as the concrete has hardened enough to permit standing on the surface without leaving visible tracks or impressions and before uncontrolled concrete cracks occur.







400-10 Expansion Joints

- After the smoothness criteria in 400-15 has been met, the expansion joints may be installed
- The joints are to be filled with preformed joint filler with as few pieces as possible
- The joint sealer must be installed according to the manufacturer's recommendations
- Joints installed after deck planing must not be installed higher than the deck surface or more than 1/4 inch below
- Joints installed before deck planing must be 3/8 inch low plus or minus 1/16 inch

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Since at least 1/4" of deck surface is removed during planing for long bridges, the elevation of the expansion joints must take into account how much deck concrete will be removed. If the joints are installed before planing and if they are installed not more than 3/8" below unplanned grade then if only a 1/4" of concrete is removed during planing the joint will still have a 1/8" recess. Even if planing removes the maximum 1/2" allowed, the joint will only be 1/8" high which has a negligible effect on ride quality. If the joint is installed after planing, in which case the final deck grade is known, then the elevation of the joint must always be at or below the that grade but not more than 1/4" below since that might affect ride quality.

400-10 Expansion Joints.

400-10.1 General: After meeting the smoothness criteria in 400-15, construct expansion joints to permit absolute freedom of movement. Carefully remove all loose or thin shells of mortar likely to cause a spall with movement at a joint from all expansion joints as soon as possible.

400-10.2 Sealed Joints: Fill expansion joints with a preformed joint filler. Cut the filler to conform to the cross-section of the structure, and furnish it in as few pieces as practicable, using only a single piece in each curb section. Do not use small pieces that would tend to come loose. Prepare joints to be sealed and apply the sealer in accordance with approved manufacturer's directions.

400-10.3 Joint System Installation: Install expansion joints before or after the deck planing required by 400-15.2.5.5 following the manufacturer's instructions. When installed after deck planing, install the edge rail assemblies in the blockouts on a profile tangent between the ends of the deck and/or approach slab to within a plus 0 and minus 1/4 inch variation.

When installed before deck planing, install the edge rail assemblies 3/8 inch, plus or minus 1/16 inch, below the top surface of the deck or approach slab to compensate for concrete removal during planing.



400-11 Contact and Bearing Surfaces

- ASTM D6380 Class S, Type III organic felt must be used to separate contact and bearing surfaces
- The concrete bearing surface for neoprene pads must have a rough texture
- Small concrete surface depressions must be filled for high load bearings
- The trueness of the bearing surface must be checked with a straightedge

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Bearings are made to work in the plane for which they were designed: any deviation from that plane may cause premature stress related failures. Bearing areas must be constructed within the specified tolerances.

400-11 Contact and Bearing Surfaces.

400-11.1 Separation of Surfaces: In general, separate all contact surfaces between superstructure and substructure or end walls and between adjacent superstructure sections by a layer of ASTM D6380 Class S, Type III organic felt. When an organic felt bond breaker is specified for other structures, use either one layer of ASTM D6380 Class I, Type III or two layers of ASTM D226 Type II organic felt.

400-11.2 Finishing of Bearing Surfaces: Construct bearing surfaces (areas) to the tolerances as specified herein and in the other parts of the Contract Documents. When using neoprene bearing pads, finish the concrete surface to a uniform 'rough' texture using a burlap drag, fine bristle broom or float. For metal or high load rotational bearings, fill minor depressions, 1/8 inch maximum, caused by finishing, bush hammering, or grinding with a low-viscosity epoxy meeting the requirements of 926-1, Type F-2, applied by the use of a squeegee.

Bearing surfaces may be ground to final position with carborundum. Check all bearing surfaces with a metallic straightedge prior to setting bearings or neoprene pads.

400-11.2.1 Deviation from Specified Elevations for Steel Beam Superstructures: Construct to the elevation shown on the Plans plus or minus 0.01 feet and do not exceed a 0.01 feet difference between specified elevations of bearing areas of adjacent bearings measured between the centerlines of bearing areas.

400-11.2.2 Deviation from Specified Elevations for Concrete Beam Superstructures: Construct to the elevation shown on the Plans plus or minus 0.02 feet.

400-11.2.3 Projecting Irregularities: Projecting irregularities will not exceed 1/16 inch.

400-11.2.4 Variations in Flatness for Neoprene Pads: In any direction, the pad is to be flat to within 1/16 inch. Pads designated to be sloped are not to deviate from the theoretical slope by the same amount.

400-11.2.5 Variations in Flatness for Metal or High Load Rotational Bearings: Construct the bearing area to the tolerance indicated for the measured length along the orthogonal axes.

Bearing area length up to 30 inches long to plus or minus 1/16 inch.

Bearing area length over 30 inches up to 45 inches long to plus or minus 3/32 inch.

Bearing area length over 45 inches long to plus or minus 1/8 inch.



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400-11 Contact and Bearing Surfaces

- Bearing area elevations must not deviate more than 0.01 feet from plan for steel and 0.02 for concrete beams
- Projecting irregularities must not exceed 1/16 inch
- For high load rotational bearings, levelness tolerances must be met

Bearing Area Length	Levelness Tolerance
Up to 30 inches	$\pm 1/16''$
$> 30 \leq 45$ inches	$\pm 3/32''$
> 45 inches	$\pm 1/8''$

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Bearings are made to work in the plane for which they were designed: any deviation from that plane may cause premature stress related failures. Bearing areas must be constructed within the specified tolerances.

400-11 Contact and Bearing Surfaces.

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400-11.2 Finishing of Bearing Surfaces: Construct bearing surfaces (areas) to the tolerances as specified herein and in the other parts of the Contract Documents. When using neoprene bearing pads, finish the concrete surface to a uniform 'rough' texture using a burlap drag, fine bristle broom or float. For metal or high load rotational bearings, fill minor depressions, 1/8 inch maximum, caused by finishing, bush hammering, or grinding with a low-viscosity epoxy meeting the requirements of 926-1, Type F-2, applied by the use of a squeegee.

Bearing surfaces may be ground to final position with carborundum. Check all bearing surfaces with a metallic straightedge prior to setting bearings or neoprene pads.

400-11.2.1 Deviation from Specified Elevations for Steel Beam Superstructures: Construct to the elevation shown on the Plans plus or minus 0.01 feet and do not exceed a 0.01 feet difference between specified elevations of bearing areas of adjacent bearings measured between the centerlines of bearing areas.

400-11.2.2 Deviation from Specified Elevations for Concrete Beam Superstructures: Construct to the elevation shown on the Plans plus or minus 0.02 feet.

400-11.2.3 Projecting Irregularities: Projecting irregularities will not exceed 1/16 inch.

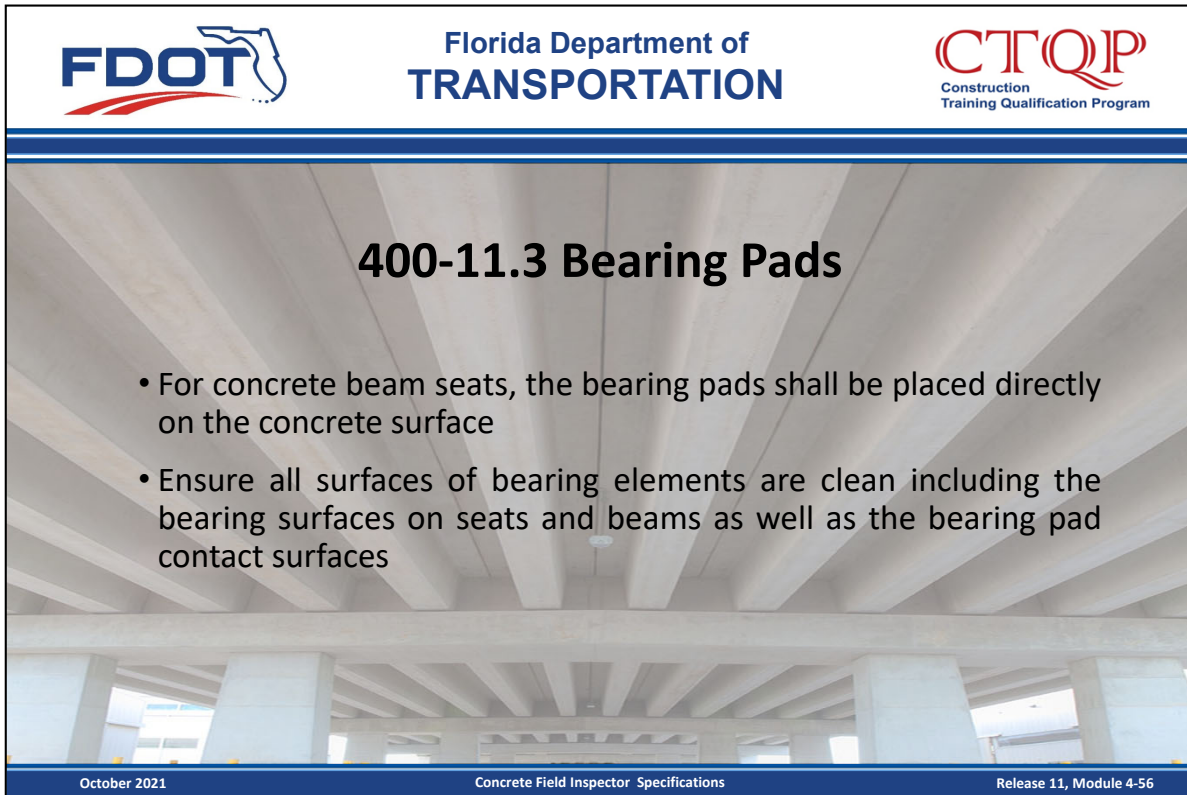
400-11.2.4 Variations in Flatness for Neoprene Pads: In any direction, the pad is to be flat to within 1/16 inch. Pads designated to be sloped are not to deviate from the theoretical slope by the same amount.

400-11.2.5 Variations in Flatness for Metal or High Load Rotational Bearings: Construct the bearing area to the tolerance indicated for the measured length along the orthogonal axes.

Bearing area length up to 30 inches long to plus or minus 1/16 inch.

Bearing area length over 30 inches up to 45 inches long to plus or minus 3/32 inch.

Bearing area length over 45 inches long to plus or minus 1/8 inch.



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400-11.3 Bearing Pads

- For concrete beam seats, the bearing pads shall be placed directly on the concrete surface
- Ensure all surfaces of bearing elements are clean including the bearing surfaces on seats and beams as well as the bearing pad contact surfaces

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400-11.3 Bearing Pads: Use bearing pads for seating bridge shoes, ends of beams, and slabs of the types specified or required in the Plans.

Furnish and install neoprene pads as detailed in the Plans. Place neoprene pads, where specified or required, directly on concrete surfaces finished in accordance with the requirements of this Article. Ensure that pads, bearing areas of bridge seats, and metal bearing plates are thoroughly cleaned and free from oil, grease, and other foreign materials.

Exercise care in fabrication of related metal parts to avoid producing conditions detrimental to the performance of the pads, such as uneven bearing, excessive bulging, etc.

The Engineer will evaluate the degree of deformation and condition of bearing pads in the completed bridge on or before the final inspection required by 5-10 or when requested by the Contractor. As directed by the Engineer, correct horizontal bearing pad deformations that at the time of inspection exceed 50% of the bearing pad thickness or that the Engineer predicts will exceed 50% of the bearing pad thickness during future high or low temperature periods.

Payment for this correction effort will be considered extra work in accordance with 4-3.



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400-12 Anchor Bolts and Dowels

- Anchor bolts and dowels must be set in accordance with Section 460
 - Structural Steel and Miscellaneous Metals
- Galvanizing of anchor bolts must be in accordance with Section 962
 - Details for Metal Items



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Setting of anchor bolts that secure a bearing to the pier or bent cap must be done precisely. The most common method for facilitating the setting of anchor bolts is by forming a cylindrical void (blockout) in the cap during concrete placement. Later, the anchor bolt is positioned in the void and then grouted in once its proper position is confirmed. This method works well if the blockout is securely fastened to the rebar cage prior to concrete placement and cannot move while the concrete is fluid. When significant misalignment of a blockout occurs, a new void may have to be provided by core drilling. Drilling must not begin without the Engineer's approval which may also require a recommendation from the EOR. If drilling is done improperly then critical pier/bent cap rebars may be damaged or completely severed which may not be discovered until performance or durability is compromised at a much later date. The inspector must make sure that the contractor is fully aware that drilling is not permitted until approved by the engineer.

400-12 Anchor Bolts and Dowels.

Set anchor bolts and dowels as specified in Section 460.

Galvanize all anchor bolts as specified in Section 962.

400-13 Epoxy Bonding Compounds.

Where epoxy bonding compounds for bonding concrete are specified or required, apply the epoxy bonding materials only to clean, dry, structurally sound concrete surfaces. Provide surface preparation, application, and curing of epoxy bonding compound in strict accordance with the manufacturer's recommendations for each particular application. Use an epoxy bonding compound listed on the Department's APL. Photos show steel bearing pad assembly placement.

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400-13 Epoxy Bonding Compounds

Epoxy bonding compounds which improve adhesion of fresh concrete to hardened concrete must be applied in accordance with the manufacturer's recommendations and the product must be on the APL

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Setting of anchor bolts that secure a bearing to the pier or bent cap must be done precisely. The most common method for facilitating the setting of anchor bolts is by forming a cylindrical void (blockout) in the cap during concrete placement. Later, the anchor bolt is positioned in the void and then grouted in once its proper position is confirmed. This method works well if the blockout is securely fastened to the rebar cage prior to concrete placement and cannot move while the concrete is fluid. When significant misalignment of a blockout occurs, a new void may have to be provided by core drilling. Drilling must not begin without the Engineer's approval which may also require a recommendation from the EOR. If drilling is done improperly then critical pier/bent cap rebars may be damaged or completely severed which may not be discovered until performance or durability is compromised at a much later date. The inspector must make sure that the contractor is fully aware that drilling is not permitted until approved by the engineer.

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	Florida Department of TRANSPORTATION	 Construction Training Qualification Program
400-14 Removal of Forms Table		
Table 400-2		
Location of Concrete Placement	Minimum Time for Form Removal for any Strength Concrete*	Minimum (%) of 28-day Compressive Strength for Form Removal
(1) Deck slabs, top slabs of culverts and bottom of caps, forms under sidewalks, and safety curb overhangs extending more than 2 feet		
(a) Class II Bridge Deck	7 days**	75**
(b) Class II (Other than Bridge Deck)	7 days	75
(c) Class III	7 days	70
(d) Class IV	7 days	60
(e) Class V	7 days	50
(2) Walls, piers, columns, sides of beams and other vertical surfaces	24 hours***	50***
(3) Front face form of curbs	6 hours	70
* For mass concrete, remove forms in accordance with 346-3.3		
** Reference 400-16.4		
***Do not place additional load on the section until 70% of the specified 28-day concrete strength is attained. Also, refer to 400-7.4.		
October 2021	Concrete Field Inspector Specifications	Release 11, Module 4-59

400-14 Removal of Forms.

Use the table below as the criterion for minimum time or compressive strength required before removal of forms or supports.

When using the time period criterion, include in the time period all days except days in which the temperature falls below 40°F.

Use the specified 28-day minimum compressive strength value as stated in 346-3.1 for each Class of Concrete utilized.

When using the percent of required strength, cast test cylinders for each mix for compressive strength determination, develop a curing concrete strength versus time curve (S/T Curve) or a strength-maturity curve. Either curve may be used in lieu of multiple test cylinders to determine when the percent of required strength has been met.

Prior to curve use; obtain the Engineer's approval of the S/T Curve and its supporting data. An approved testing laboratory may be used to provide this information with approval of the Engineer. Plot S/T Curves using at least three different elapsed times that begin once test cylinders are cast; however, one of the elapsed times must be prior to the Contractor's intended form removal. Each elapsed time plotted must have a corresponding compressive strength computed by averaging the compressive strength of two test cylinders.

Cure such test cylinders as nearly as practical in the same manner as the concrete in the corresponding structural component, and test them in accordance with ASTM C39 and ASTM C31. Perform cylinder casting, curing, and testing at no expense to the Department and under the observation of the Engineer. When the S/T Curve indicates a compressive strength equal to or greater than the percentage of specified strength shown in the table above for form removal, the Contractor may remove the forms.

Prior to using the strength-maturity method, obtain the Engineer's approval of the strength-maturity curve and its supporting data. Estimate the strength development of concrete using the strength-maturity method in accordance with ASTM C1074. An approved testing laboratory may be used to provide this information with approval of the Engineer. Develop the strength-maturity curve at no expense to the Department.

When the ambient air temperature falls 15°F or more below the ambient air temperature that existed during development of a S/T Curve, use a S/T Curve that corresponds to the lower temperature and that is developed in accordance with this section.

Do not remove forms at any time without the consent of the Engineer. Even when the Engineer provides consent to remove the forms, the Contractor is responsible for the work.



400-14 Removal of Forms

- If the Contractor chooses minimum time for form removal, then Table in 400-2 must be used
- If the Contractor chooses strength, then the minimum allowed percent of 28-day strength must be used as specified in 400-2
- Forms must not be removed without the Engineer's consent
- If deck forms are removed before 7 days, then curing compound must be applied

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Concrete Field Inspector Specifications

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The contractor should recognize that cylinders cast for acceptance cannot be used for determining compressive strength for early form removal. Extra cylinders will need to be cast for this purpose.



400-15 Finishing Concrete

- A general finish is required for all surfaces
- Metal ties, conduits, etc. to be cut back 1" from finished surface
- Joint filler must be exposed for its full length and have clean edges
- All imperfections in the concrete surface must be patched with a mortar blended from the mix ingredients of the existing concrete and cured using a curing blanket or Type 1 clear curing compound

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400-15 Finishing Concrete.

400-15.1 General Surface Finish (Required for All Surfaces): After placing and consolidating the concrete, strike-off all exposed surfaces to the lines and grades indicated in the Plans in a manner that will leave a surface of uniform texture free of undesirable surface irregularities, cavities, and other defects. Cut back metal ties supporting reinforcement, conduit, and other appurtenances a minimum of 1 inch from finished surface. After removing excess mortar and concrete and while the concrete is still in a workable state, carefully tool all construction and expansion joints. Leave joint filler exposed for its full length with clean edges. Ensure that finished work in addition to that specified above is compatible and complementary to the class of surface finish required.

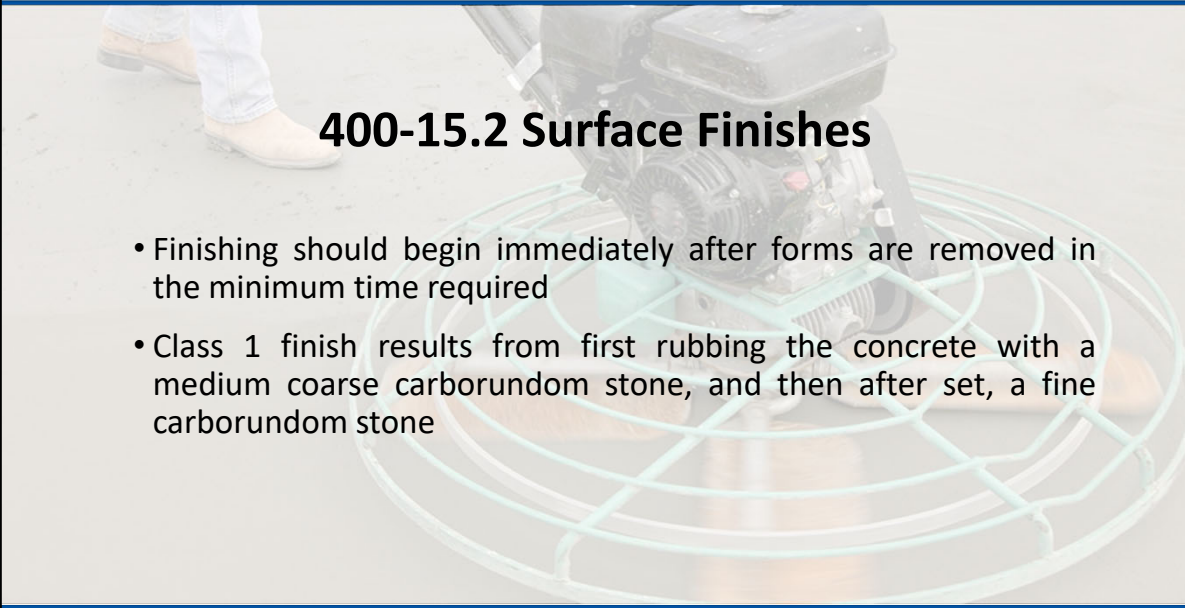
Remove all laitance, loose material, form oil and curing compound from exposed surfaces that do not require forming and from exposed surfaces requiring forming, after form removal. Remove fins and irregular projections flush with the surface. Clean, saturate with water, and fill all holes, tie cavities, honeycomb, chips and spalls. Prior to filling, prepare the surface to ensure that patching mortar will bond to the existing concrete. Exercise care during the roughening process to prevent excessive defacement and damage to the surface of the existing concrete. Use patching mortar blended from the mix ingredients of the existing concrete. Ensure the patching mortar closely matches the color of the existing concrete when fully cured. As an alternative, mortar consisting of the following materials may be used: 4 parts of ordinary gray portland cement, 1/2 part of white portland cement, 1 part of fly ash and 2 to 4 parts of sand. The blended mortar must closely match the color of the filled element once fully cured and the proportion of white portland cement may be adjusted to achieve as close a match as possible.

Regardless of the type patching mortar used, provide a mortar surface closely resembling the existing surface.

Cure the newly placed mortar using a curing blanket or a Type I clear curing compound at a uniform coverage as recommended by the manufacturer, but not less than 0.06 gallon per square yard.

In the event unsatisfactory surfaces are obtained, repair these surfaces by methods approved by the Engineer or the affected concrete will be rejected. Repair any surface or remove rejected concrete at no expense to the Department.





400-15.2 Surface Finishes

- Finishing should begin immediately after forms are removed in the minimum time required
- Class 1 finish results from first rubbing the concrete with a medium coarse carborundum stone, and then after set, a fine carborundum stone

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400-15.2 Surface Finishes:

400-15.2.1 General: In addition to the general surface work specified for all exposed concrete surfaces, the Engineer may require one of the classes of surface finish listed below. For all such exposed surfaces, begin finish work for the applicable class specified, along with the general finish work, immediately after removal of the forms. In order to further ensure the required quality of the finish, remove forms no later than the minimum time specified for the forms to remain in place. Satisfactorily repair finished concrete surfaces which are subsequently disfigured or discolored at no expense to the Department.

Provide the required class of surface finish for the various items of structural concrete as shown in the Plans.

400-15.2.2 Class 1 Surface Finish: As soon as the pointing has sufficiently set, thoroughly saturate the exposed surfaces with water, and rub them with a medium coarse carborundum stone. Continue rubbing until the surface has been ground to a paste and remove all form marks, irregularities, and projections. In this process, do not introduce any additive material other than water. After the rubbing has produced a smooth surface of uniform color, allow the material which has been ground to a paste to reset under proper curing conditions. Subsequently, as a second operation, re-saturate the concrete surfaces with water, and thoroughly rub them with a fine carborundum stone. Continue this rubbing until the surface has a smooth, fine grain texture of uniform color.

The Contractor may substitute a Class 5 applied finish coating in accordance with 400-15.2.6 as an alternate surface finish on all areas where Class 1 surface finish is specified.



400-15.2 Surface Finishes

- Class 2 is similar to Class 1 except that rubbing is only done once and then a brush texture is applied
- Class 3 requires the use of a form liner that produces an architectural surface treatment and No. 89 coarse aggregate may be required

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Concrete Field Inspector Specifications

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400-15.2.3 Class 2 Surface Finish: As soon as pointing has sufficiently set, thoroughly saturate the exposed concrete surfaces with water and rub them with a medium coarse carborundum stone. Continue rubbing until the surface has been ground to a paste and remove all form marks, irregularities, and projections. In this process, do not introduce any additive material other than water.

After rubbing has produced a smooth surface finish, of uniform color, carefully brush the material which has been ground to a paste to a uniform texture, and allow it to reset under proper curing conditions. Carefully protect these surfaces from disfigurement and discoloration during subsequent construction operations.

400-15.2.4 Class 3 Surface Finish: Where this surface finish is specified, use forms with a form liner. Where specified or required on the Plans, use No. 89 coarse aggregate for concrete.

After concrete has been placed in the forms and compacted, finish all exposed surfaces which are not contained by the forms to produce a surface texture as nearly equal to that produced by the form as practicable. Generally, finish unformed surfaces to a smooth, dense surface with a steel trowel.

Perform all work, including general surface finish work, in a manner that will preserve the same surface texture and color produced by the form liner. Pointed areas may be rubbed with a dry carborundum stone.



400-15.2.5 Class 4 Deck Finish

- Class 4 finish is used for bridge decks and has two categories: short bridges (length of 100 feet or less) and long bridges (length of greater than 100 feet)
- Deck finish requirements for bridge widenings are covered in the plans and not in the specs
- Regardless of length, a deck with less than 2-1/2 inch top cover is considered short for finish purposes
- Short bridge smoothness is checked during concrete placement with a 10 foot straightedge while the concrete is plastic and defects greater than 1/8 inch high or 1/16 inch low must be corrected
- The decks of long bridges must not be externally moistened, manually floated or textured and flaws that will not be removed by planing, must be corrected

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400-15.2.5 Class 4 Deck Finish:

400-15.2.5.1 General: Apply a Class 4 finish on bridge decks and concrete approach slabs. On Short Bridges (bridges having a length less than or equal to 100 ft), and on Miscellaneous Bridges (Pedestrian, Trail and Movable Spans) regardless of length, meet the finish and smoothness requirements of 400-15.2.5.2 and 400-15.2.5.4. On Long Bridges (bridges having a length greater than 100 ft) meet the finish and smoothness requirements of 400-15.2.5.3 and 400-15.2.5.5. When an existing bridge deck is widened, see the plans for the finish and smoothness requirements of the existing bridge deck and its new widened section. After meeting the screeding requirements of 400-7.13 and curing requirements of 400-16 and the smoothness requirements, herein, groove the bridge deck and approach slabs.

Regardless of bridge length, finish decks with less than 2 1/2 inches of top cover in accordance with the requirements for Short Bridges.

400-15.2.5.2 Plastic Surface Finish for Short and Miscellaneous Bridges: After screeding is completed, check the surface of the plastic concrete with a 10 foot straightedge, positioning and half-lapping the straightedge parallel to the centerline to cover the entire surface. Immediately correct deficiencies of more than 1/8 inch, measured as an ordinate between the surface and the straightedge.

Finish the concrete surface to a uniform texture using a burlap drag, fine bristle broom or float. Finish the deck to a smooth surface having a sandy texture without blemishes, marks or scratches deeper than 1/16 inch.

400-15.2.5.3 Plastic Surface Finish for Long Bridges: Do not moisten, manually float or apply texture to the concrete surface after the screed, with attached smoothing device, has passed unless correction of isolated surface irregularities is warranted and this should be done as soon as possible after screeding while the concrete is plastic. Correct all flaws such as cavities, blemishes, marks, or scratches that will not be removed by planing.

If the Engineer permits the addition of water when correcting flaws, apply moisture to the concrete surface only if required and only in the immediate vicinity of the isolated irregularity. Apply a quantity of moisture not greater than what is needed to facilitate correction of the irregularity and apply only a fog mist, above the concrete surface, by power driven spray equipment approved by the Engineer



400-15.2.5.5 Class 4 Deck Finishes

- Moisture may be applied with a fog mist for the correction of isolated flawed areas
- For short bridges prior to planing, the smoothness of the final deck surface must be evaluated with a 10 foot straightedge and defects greater than 3/16 inch must be corrected
- For long bridges, the smoothness must be evaluated with a calibrated profilograph machine that is provided by an independent provider
- Prior to profilograph use, the deck surface must be completely clean

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400-15.2.5.4 Smoothness Requirements for Short Bridges and Miscellaneous Bridges (including approach slabs): Perform a final straightedge check with a 10 foot straightedge, positioning and half-lapping the straightedge parallel to the centerline, approximately 5 feet apart to cover the entire surface. Correct all irregularities greater than 3/16 inch measured as an ordinate to the straightedge, by grinding. Perform grinding by the abrasive method using hand or power tools or by machine, to leave a smooth surface within a 1/8 inch tolerance.

400-15.2.5.5 Smoothness Evaluation and Concrete Surface Planing, Long Bridges (including approach slabs): Prior to planing, provide a smoothness evaluation of the completed bridge deck and exposed concrete surfaces of approach slabs by a computerized Cox California-type profilograph in accordance with the criteria herein and FM 5-558E. Furnish this evaluation through an independent provider approved by the Engineer, using equipment calibrated by the Engineer. All bridge deck and concrete approach slab surfaces to within 2 feet of gutter lines are subject to this smoothness evaluation.

Prior to initial profilograph testing, complete work on the bridge deck and approach slabs. Thoroughly clean and clear the bridge deck and approach slab areas to be evaluated for smoothness of all obstructions and provide the smoothness evaluation. Ensure that no radio transmissions or other activities that might disrupt the automated profilograph equipment are allowed during the evaluation.



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400-15.2.5.5 Class 4 Deck Finishes

- The maximum smoothness value is 10 inches/mile using a 0.2 inch blanking band
- The minimum evaluation distance is 100 feet
- Isolated high areas exceeding 0.3 inches must be ground to grade
- The Engineer may require a straightedge check in the transverse direction

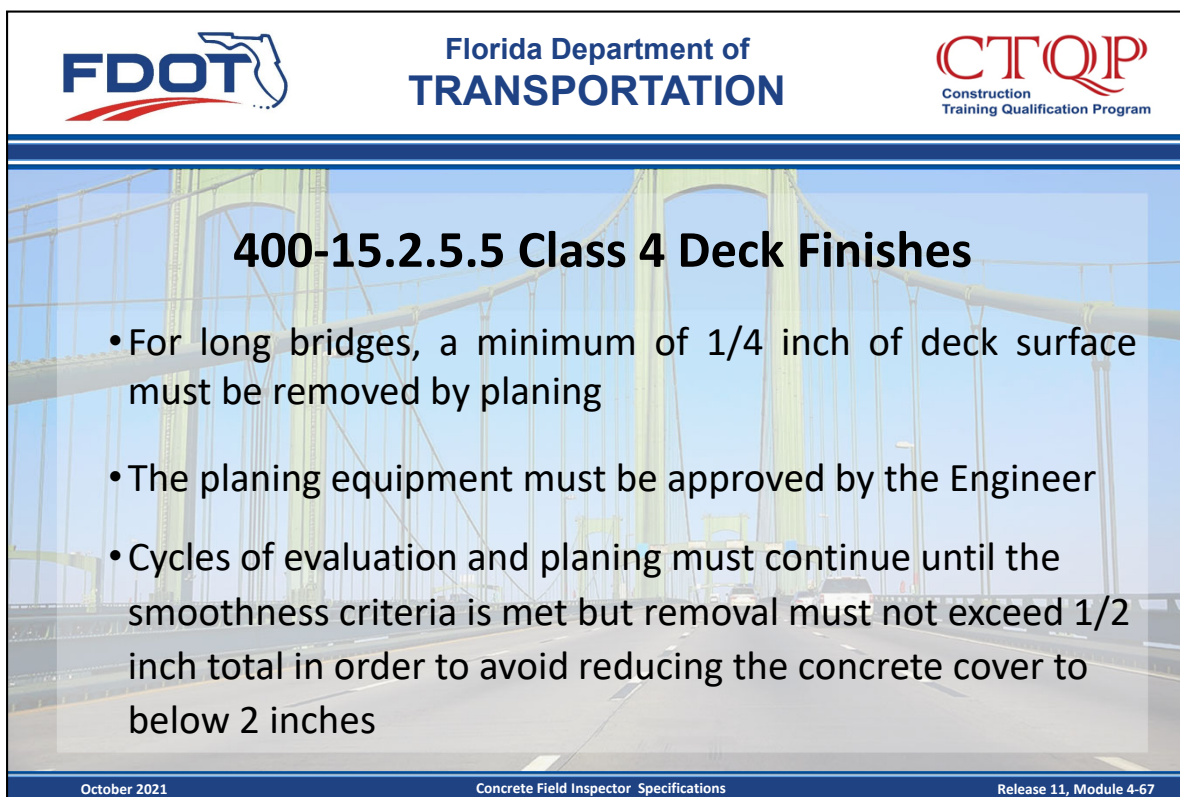


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400-15.2.5.5 Smoothness Evaluation and Concrete Surface Planing, Long Bridges (including approach slabs) (continued): Average the Profile Index Value for the bridge deck, including the exposed concrete surfaces of the approach slabs, for the left and right wheel path of each lane. The maximum allowable Profile Index Value for acceptable smoothness is 10 inches per mile utilizing the 0.2 inch blanking band. Apply these criteria to a minimum of 100 feet of each lane. Additionally, correct individual bumps or depressions exceeding a cutoff height of 0.3 inch from a chord of 25 feet (see ASTM E1274) on the profilograph trace. Ensure that the surface meets a 1/4 inch in 10 feet straightedge check made transversely across the deck and approach slabs if determined necessary by the Engineer. Provide additional profilograph testing as necessary following longitudinal planing and any other actions taken to improve smoothness, until a profile meeting the acceptance criteria is obtained.



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400-15.2.5.5 Class 4 Deck Finishes

- For long bridges, a minimum of 1/4 inch of deck surface must be removed by planing
- The planing equipment must be approved by the Engineer
- Cycles of evaluation and planing must continue until the smoothness criteria is met but removal must not exceed 1/2 inch total in order to avoid reducing the concrete cover to below 2 inches

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400-15.2.5.5 Smoothness Evaluation and Concrete Surface Planing, Long Bridges (including approach slabs) (continued): Regardless of whether expansion joints are installed before or after deck planing is complete, plane off the concrete deck surface to a minimum depth of 1/4 inch and also meet or exceed the profilograph smoothness criteria. Longitudinally plane the entire bridge deck and exposed concrete surfaces of the approach slabs using a self-propelled planing machine with gang mounted diamond saw cutting blades specifically designed for such work. Use the profilograph generated smoothness data, to establish the optimum planing machine settings. Plane the deck surface to within 2 feet of the gutter line so that there is a smooth transition, without vertical faces or sudden surface discontinuities, from the fully planed surface to the unplanned surface. Use a machine with a minimum wheel base length of 15 feet, constructed and operated in such manner that it does not cause strain or damage to deck or approach slab surfaces, excessive ravels, aggregate fractures or spalling. The equipment shall be approved by the Engineer. Perform longitudinal planing parallel to the roadway centerline, and provide a consistent, textured surface. Clean the surface of all slurry/debris generated during this work concurrently with operation of the machine. After the deck has been planed the minimum 1/4 inch, reevaluate the surface smoothness using the profilograph testing described above. Perform cycles of planing and profilograph retesting as necessary until the deck and exposed concrete surfaces of approach slabs are in compliance with the smoothness criteria but do not exceed the maximum concrete removal depth of 1/2 inch.



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400-15.2.5.6 Class 4 Deck Finishes Grooving

- Grooves nominally 1/8" wide and 3/16" deep
- Groove spacing and tolerances must comply with the spec
- Grooves shall be cut continuously across deck or approach slab to within 18" of gutter lines at barrier rail, curb line and median divider



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400-15.2.5.6 Grooving: After the concrete surface profile, as required by 400-15.2.5, has been accepted by the Engineer, and prior to opening the bridge to traffic, groove the bridge deck and approach slabs perpendicular to the centerline of the structure. Do not groove the deck surface of pedestrian or trail bridges unless otherwise shown in the Contract Documents. Cut grooves into the hardened concrete using a mechanical saw device which will leave grooves nominally 1/8 inch wide and 3/16 inch deep. Space the grooves apart in random spacing center of grooves in the following sequence: 3/4 inch, 1 1/8 inch, 5/8 inch, 1 inch, 5/8 inch, 1 1/8 inch, 3/4 inch in 6 inch repetitions across the width to be grooved in one pass of the mechanical saw device. One 6 inch sequence may be adjusted by 1/4 sequence increments to accommodate various cutting head widths provided the general pattern is carried out. The tolerance for the width of the grooves is +1/16 to -0 inch and the tolerance for the depth of grooves is $\pm 1/16$ inch. The tolerance for the spacing of the grooves is $\pm 1/16$ inch.

Cut grooves continuously across the deck or approach slab to within 18 inches of gutter lines at barrier rail, curb line and median divider.



400-15-2.6 Class 5 Applied Finish Coating

- Applied Finish Coating must be from APL and comply with Section 975 – Structural Coating Materials
- The coating material must be from one manufacturer
- Submittal of materials certification and analysis is required

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Concrete Field Inspector Specifications

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Inspectors must make sure that the contractor applies the coating at the correct spread rate. This can only be determined by observing the containers the coating comes from and then observing the surface area upon which that coating is applied. Coatings applied with spread rates above the specified limit will not look good and will have a reduced service life. If the inspector is uncertain about the spread rate, he can check the coating thickness.

400-15.2.6 Class 5 Applied Finish Coating:

400-15.2.6.1 General: Place an applied finish coating upon all concrete surfaces where the Plans indicate Class 5 Applied Finish Coating. Apply the finish coating after completion of the general surface work specified for all exposed concrete surfaces. Select an Applied Finish Coating from the APL meeting the requirements of Section 975.

400-15.2.6.2 Material: For the coating material, use a commercial product designed specifically for this purpose. Use only coating material that is manufactured by one manufacturer and delivered to the job site in sealed containers bearing the manufacturer's original labels. Submit the manufacturer's written instructions to the Engineer.

(Notes continued next page.)



400-15.2.6.3 Surface Preparation

- The surface must be completely clean and be tested for remaining curing compound which must be removed prior to application or coating
- Finish coating to be applied at rate of 50 ± 10 ft²/gal and the maximum coating thickness must not exceed 1/8 inch

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400-15.2.6.3 Surface Preparation: Prepare the surface prior to the application of an applied finish coating by providing a surface finish in accordance with the requirements of 400-15.1. The Engineer will not require surface voids that are 1/4 inch or less in width and depth to be grouted prior to application of the finish coating. Fill surface void larger than 1/4 inch in width and depth an approved high strength, non metallic, non shrink grout meeting the requirements of Section 934, mixed and applied in accordance with the manufacturer's recommendations. Apply the grout by filling the surface voids using burlap pads, float sponges, or other acceptable methods. As soon as the grout has taken its initial set, brush the surface to remove all loose grout, leaving the surface smooth and free of any voids. Ensure that the surface to be coated is free from efflorescence, flaking coatings, curing compound, dirt, oil, and other substances deleterious to the applied finish coating. Prior to application of the finish coating onto precast or cast-in-place concrete surfaces, test the concrete surface at 30 foot intervals for the presence of curing compound using one or two drops of muriatic acid placed on the concrete surface. If curing compound is present, there will be no reaction between the acid and the concrete. If there is no reaction, remove the compound by pressure washing the concrete surfaces. Prepare the surfaces in accordance with the manufacturer's recommendations, and ensure that they are in a condition consistent with the manufacturer's requirements. Clean surfaces of existing structures in accordance with 400-19



400-16 Curing Concrete

- **All concrete placements** shall be cured as required herein for a minimum duration of 72 hours and if forms are removed before, curing compound must be applied
- The moisture evaporation rate must be determined and monitored **prior to** placement using an electronic device, ACI nomograph or an online calculator
- The moisture evaporation rate must be determined and monitored **during** concrete placement using an electronic device
- As good practice, document evaporation rate at time of placement

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400-16 Curing Concrete.

400-16.1 General: Cure cast-in-place and precast (non-prestressed) concrete as required herein for a minimum duration of 72 hours. If forms are loosened or removed before the 72 hour curing period is complete, expand the curing to cover these surfaces by either coating with curing compound or extending the continuous moist cure area.

Until curing has begun, retain concrete surface moisture at all times by maintaining a surface moisture evaporation rate less than 0.1 lb/ft²/hr. Periodically, at the site of concrete placement prior to and during the operation, measure the ambient air temperature, relative humidity and wind velocity with industrial grade weather monitoring instruments to determine the on-site evaporation rate. If the evaporation is, or is likely to become 0.1 lb/ft²/hr or greater, employ measures to prevent moisture loss such as application of evaporation retarder, application of supplemental moisture by fogging or reduction of the concrete temperature during batching. Compute the evaporation rate by using the nomograph in the ACI manual of Concrete Practice Part 2, Section 308R Guide to Curing Concrete, or by using an evaporation rate calculator approved by the Engineer.



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400-16 Curing Concrete

- The surface moisture evaporation rate must be less than 0.1 lb/ft²/hr until curing compound or blankets are applied
- If evaporation is 0.1 lb. /ft²/ hr. or greater, measures must be employed to counteract moisture loss using evaporation retarder, water fogging, wind screen, etc.



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Velocity Graphs

GUIDE TO CURING CONCRETE

3088.23

Point Forecast: Tallahassee FL
30.43N 84.28W (Elev. 125 ft)

Last Update: 3:15 pm EDT Jun 1, 2017

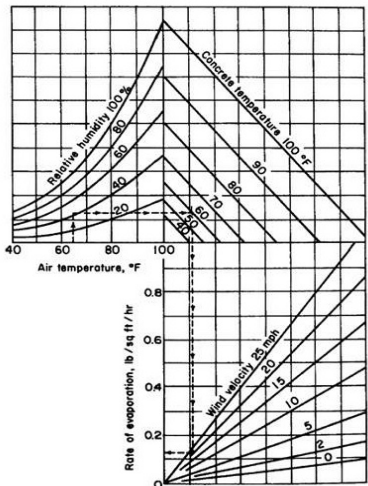
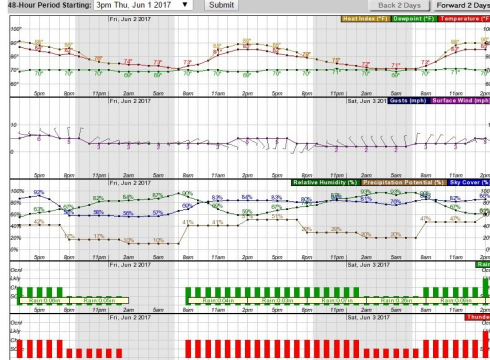


Fig. 4.1—Nomograph for estimating the maximum potential rate of evaporation of the environment, assuming a water-covered surface in which the water temperature is equal to the concrete temperature (Reinforced Concrete Institute, 1934; ASTM C 959).

Hourly Weather Forecast Graph

Weather Elements	Weather-Precipitation	Fire Weather
☒ Temperature (°F) ☒ Dewpoint (°F) ☒ Heat Index (°F) ☒ Surface Wind (mph) ☒ Sky Cover (%) ☒ Precipitation Potential (%) ☒ Relative Humidity (%)	☒ Rain ☒ Thunder ☒ Fog	☐ Mixing Height (x100ft) ☐ Lightning Activity Level ☐ Trans. Wind (mph) ☐ 20ft Wind (mph) ☐ Dispersion Index ☐ Low Visibility Occurrence Risk Index

48-Hour Period Starting: 3pm Thu, Jun 1 2017



Saturday, June 3 at 12pm
 Temperature: 85 °F Dewpoint: 71 °F Heat Index: 90 °F Surface Wind: 10MPH Clouds: 0

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Concrete Field Inspector Specifications
Release 11, Module 4-73

Evaluating Concrete Curing Conditions

Developed By : Luke Snell And Aamir Munir

This program computes the Rate Of Evaporation for concrete according to Nomographs in the American Concrete Institute Standard Practice for Curing Concrete (ACI 308-92). The Air Temperature, Humidity, Concrete Temperature, and Wind Velocity are variables which may be known by the user to determine if Adequate Curing is being achieved.

Please Enter the Correct Values :

1. Air Temperature in °F

(Temp Range 40 to 99 °F)

2. Humidity in %age

(Humidity Range 0 to 99 %)

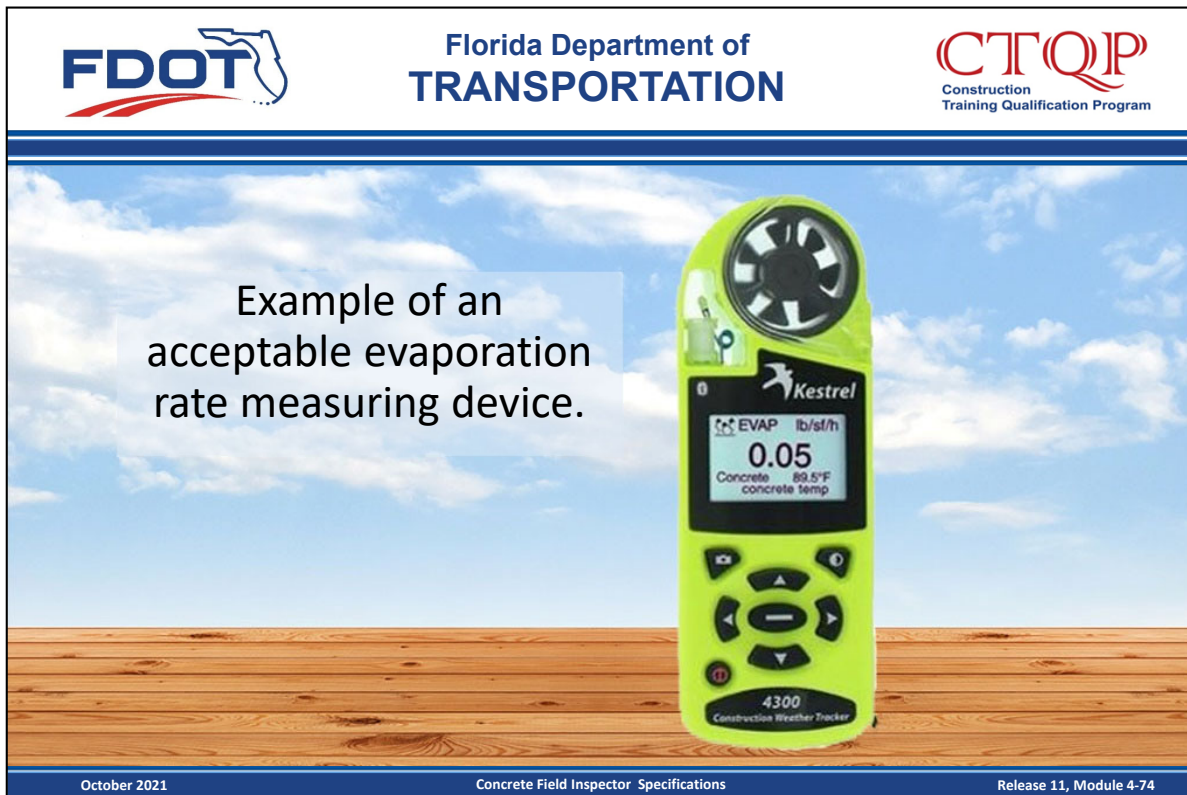
3. Concrete Temperature in °F

(Temp Range 40 to 99 °F)

4. Wind Velocity in MPH

(Wind Velocity 1 to 25 MPH)

Air Temperature
Computer Change



This specification covers the importance of controlling moisture evaporation from concrete surfaces prior to application of curing compound and what measures should be implemented to prevent excessive evaporation. Devices that measure ambient air temperature, humidity and wind velocity are available as separate devices or in one device. There is also a device that will display evaporation rate directly: see accompanying photo. Evaporation rate input parameters (concrete temperature, ambient air temperature, humidity, and wind velocity) can be measured separately with less sophisticated devices and then used as input with the ACI nomograph to determine the evaporation rate. In lieu of the nomograph, an easy to use and accurate internet based evaporation rate calculator can be used.



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Sample Weather Data for Various Florida Seasons with Corresponding Evaporation Rates					
Typical Florida Season	Ambient Air Temperature (°F)	Relative Humidity (%)	Concrete Temperature (°F)	Wind Velocity (mph)	Evaporation Rate (lbs/ft²/hr)
Windy Winter Day	65	25	80	15	0.34
Summer Day	90	65	95	10	0.19
Summer Night	72	90	85	5	0.08

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Evaporation rates increase dramatically as wind velocity increases and humidity decreases so careful monitoring is particularly important during times of the year when humidity is low and wind velocity is high such as spring and fall. Of course, very hot weather will always produce increased evaporation because the hotter the concrete gets the higher is the rate of moisture loss regardless of wind velocity or humidity so careful monitoring during very hot weather is always critical. The following table contains examples of typical weather conditions at different times of the year in Florida with their corresponding evaporation rates.

Inspectors should verify that the Contractor is measuring evaporation rates accurately by performing independent weather data gathering and evaporation rate determinations using weather monitoring instruments of their own. The specification does not directly penalize the Contractor for failing to control the evaporation rate; however, deliberate violation of this specification must be reflected in the Contractor's Past Performance Report (CPPR) and the cracks that may result from a violation, with consequent repair costs, will be a very negative consequence.

As can be seen from the table, a cool windy winter day produces the highest evaporation rate which far exceeds the 0.1 limit. This means that the Contractor will have to employ measures to control the evaporation rate such as the application of evaporation retarder: an inexpensive fluid that is sprayed onto the surface which holds in moisture. The summer night condition is below the 0.1 limit so no measures are required. Inspectors should make Contractors aware of the fact that evaporation rates are low at night. Other advantages of night placements include reduced traffic congestion that can delay concrete delivery, concrete plants that produce concrete for the project only and so are less stressed, and easier conditions for workers.



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400-16.2 (Curing) Methods

- Curing can be provided by continuous moisture from burlap covers, application of curing compound or curing blankets
- Burlap covers must be kept saturated by use of automated sprinklers
- Curing compound must be applied with a compressor driven sprayer at a coverage rate of 0.06 gal/square yard (1 gallon/150 square feet)



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Concrete Field Inspector Specifications

Release 11, Module 4-76

400-16.2 Methods: Except where other curing methods are specified, select from the following options the chosen method(s) for curing all concrete components.

(1) Continuous Moisture: Place burlap on the surface and keep it continuously saturated for the curing period by means of soaker hoses or automatic sprinklers. Water flow may be metered to cycle repetitively for five minutes on and five minutes off during the 72 hour curing period. Do not apply moisture manually. If side forms are loosened or removed during the curing period, extend the burlap so as to completely shield the sides of the members.

(2) Membrane Curing Compound: Apply a white Type 2 curing compound to all surfaces at a uniform coverage as recommended by the manufacturer but not less than 0.06 gal/yd².

If curing compound is to be applied by spraying, use a compressor driven sprayer of sufficient size to provide uniform mist. Standby equipment is required in case of mechanical failure and hand held pump-up sprayers may be used only as standby equipment.

(3) Curing Blankets: Curing blankets may be used for curing the top surfaces of members while the member side forms remain in place. Do not use curing blankets which have been torn or punctured. Securely fasten all edges to provide as tight a seal as practical. Should the system fail to maintain a moist condition on the concrete surface, discontinue use of the blankets and continue curing using another method. Keep curing blankets in place for the duration of the curing period.

(4) Accelerated Cure:

The Specification continues addressing accelerated curing methods.



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400-16.2 (Curing) Methods

- Curing blankets must provide a water proof seal that prevents concrete surface moisture from evaporating
- Accelerated curing, which is produced by the introduction of artificial heat such as steam, is permitted and is predominantly used for the production of precast concrete members that are produced in off site plants



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Concrete Field Inspector Specifications

Release 11, Module 4-77

400-16.2 Methods: Except where other curing methods are specified, select from the following options the chosen method(s) for curing all concrete components.

(1) Continuous Moisture: Place burlap on the surface and keep it continuously saturated for the curing period by means of soaker hoses or automatic sprinklers. Water flow may be metered to cycle repetitively for five minutes on and five minutes off during the 72 hour curing period. Do not apply moisture manually. If side forms are loosened or removed during the curing period, extend the burlap so as to completely shield the sides of the members.

(2) Membrane Curing Compound: Apply a white Type 2 curing compound to all surfaces at a uniform coverage as recommended by the manufacturer but not less than 0.06 gal/yd².

If curing compound is to be applied by spraying, use a compressor driven sprayer of sufficient size to provide uniform mist. Standby equipment is required in case of mechanical failure and hand held pump-up sprayers may be used only as standby equipment.

(3) Curing Blankets: Curing blankets may be used for curing the top surfaces of members while the member side forms remain in place. Do not use curing blankets which have been torn or punctured. Securely fasten all edges to provide as tight a seal as practical. Should the system fail to maintain a moist condition on the concrete surface, discontinue use of the blankets and continue curing using another method. Keep curing blankets in place for the duration of the curing period.

(4) Accelerated Cure:

The Specification continues addressing accelerated curing methods.

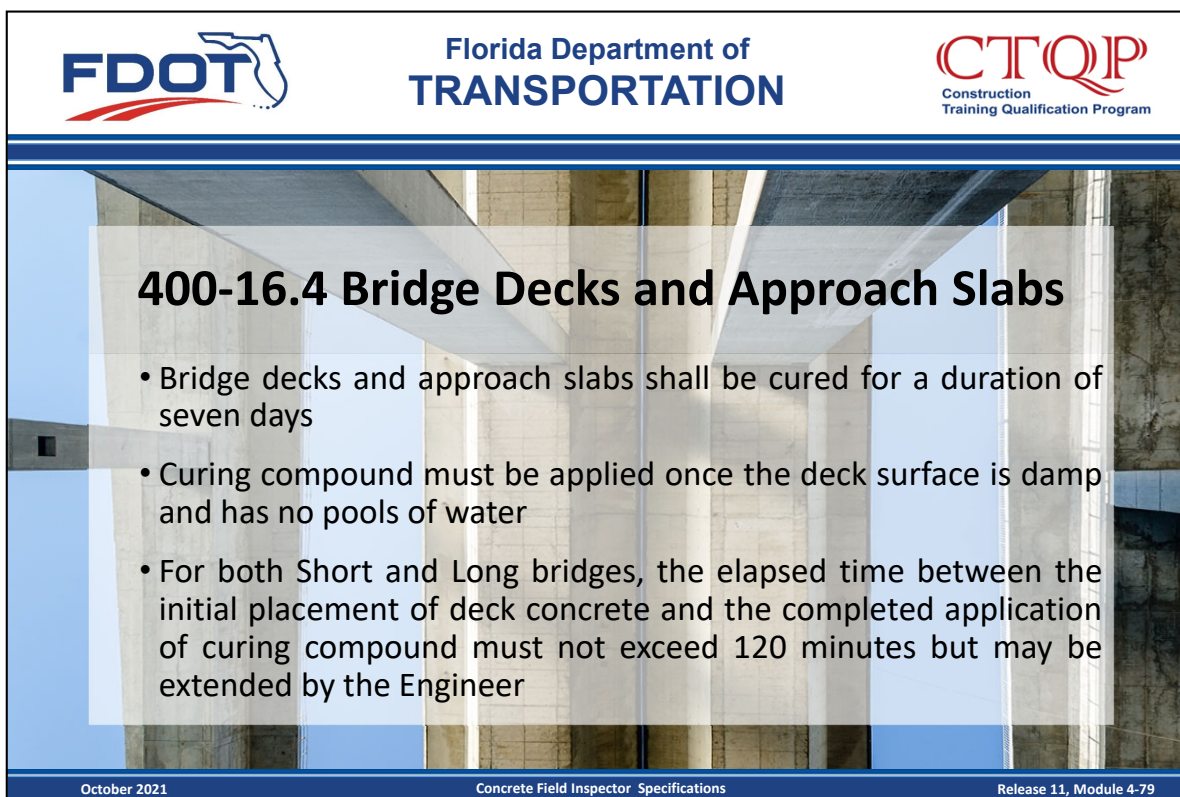


400-16.3 Silica Fume Concrete

- Silica fume concrete shall be cured a minimum of 72 hours using continuous moisture cure.
- Substitution of alternative methods or reduction in the time period is not allowed.
- After completion of the 72-hour curing period, a membrane curing compound shall be applied to all concrete surfaces

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400-16.3 Silica Fume Concrete: Cure silica fume concrete a minimum of 72 hours using continuous moisture cure. No substitution of alternative methods nor reduction in the time period is allowed. After completion of the 72-hour curing period, apply a membrane curing compound to all concrete surfaces. Apply curing compound according to 400-16.2.



The slide features a background image of a bridge deck and approach slabs. At the top, there are three logos: the FDOT logo on the left, the Florida Department of Transportation text in the center, and the CTQP (Construction Training Qualification Program) logo on the right. The main title '400-16.4 Bridge Decks and Approach Slabs' is prominently displayed in the center. Below the title, a list of three bullet points provides specific curing requirements. At the bottom of the slide, a blue bar contains the date 'October 2021', the text 'Concrete Field Inspector Specifications', and 'Release 11, Module 4-79'.

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400-16.4 Bridge Decks and Approach Slabs

- Bridge decks and approach slabs shall be cured for a duration of seven days
- Curing compound must be applied once the deck surface is damp and has no pools of water
- For both Short and Long bridges, the elapsed time between the initial placement of deck concrete and the completed application of curing compound must not exceed 120 minutes but may be extended by the Engineer

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Compound should be applied to a deck while the surface is still damp; however, compound will be effective even if diluted somewhat because the deck is still a little wet. Waiting until there is no doubt that the surface is damp may result in a surface that has dried beyond the damp condition. It is better for the compound to be diluted a little but still be effective than to apply the compound to a deck that is too dry. However, compound should not be applied to a deck with areas of standing water.

400-16.4 Bridge Decks and Approach Slabs: Cure bridge decks and approach slabs for a duration of seven days. Apply a membrane curing compound to the top surface in accordance with 400-16.2 using a compressor driven sprayer. In general, apply curing compound when the surface is damp and after all pooled water has evaporated. For Short bridges, begin applying curing compound immediately after the initially placed concrete has been floated, straightedged, textured and a damp surface condition exists and continue applying compound as concrete placement progresses with as little interruption as possible until the entire top surface has been coated with compound. For Long bridges, begin applying curing compound to the initially placed concrete as soon as a damp surface condition exists and continue applying compound as concrete placement progresses with as little interruption as possible until the entire top surface has been coated with compound. For all bridges, the elapsed time between the initial placement of deck or approach slab concrete and the completed application of curing compound must not exceed 120 minutes. The 120 minute limit may be extended by the Engineer if project specific factors (cool temperatures, high humidity, retarding admixtures, etc.) prolong wet surface conditions.



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400-16.4 Bridge Decks and Approach Slabs

- Before deck placement, the Contractor must submit for approval the method for determining the quantity of curing compound that will be used during application
- The Contractor must submit the final quantity of compound used to the Engineer so that the application rate (1 gal./150 square feet) can be verified
- All curing blankets shall be wet immediately after satisfactorily placing them and they shall be maintained in a saturated condition throughout the seven day curing period
- If the blankets are rolled back temporarily, the exposed surfaces must be kept wet until recovered

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The proper application of curing compound may be the most important curing requirement performed so it is critical that it be done correctly. Curing compound must be applied at a spread rate of not less than 1 gallon per 150 square feet and within 120 minutes of initial concrete placement. At this coverage rate, the deck surface should look completely white after application of the compound and should not have any areas that appear to be uncoated or where coating thickness is obviously deficient. Curing compound must also be applied to deck areas that will be beneath barrier walls. Prior to concrete placement, the contractor is required to tell the Engineer how the number of gallons of curing compound will be measured. For example, a graduated rod that reads gallons will be lowered into a 55 gallon drum of curing compound and will directly measure remaining gallons. The contractor is also required to report to the Engineer how many gallons, at the required spread rate, it will take to meet the Specification requirements prior to application, and finally, the contractor is required to report to the Engineer the actual gallons used after completing application.

(Notes continued on next page.)



400-16.4 Bridge Decks

- If bottom or side forms are removed after 72 hours then curing compound must be applied within one hour to the exposed surfaces
- Curing compound delivered to the jobsite shall be in the manufacturer's original container and clearly labeled with the manufacturer's name, product name (trade name), type, batch or LOT number, date of manufacture
- Curing compounds not used within one year of the date of manufacture shall not be incorporated into the work

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400-16.4 Bridge Decks (continued): Prior to the first deck or approach slab placement, submit to the Engineer the method that will be used to periodically measure the rate of application of curing compound in, gallons/sq ft as the deck placement progresses. Prior to the placement of each deck or approach slab, submit to the Engineer the anticipated quantity of curing compound in gallons along with the corresponding square feet of deck to be covered to meet the coverage rate in 400-16.2. Compute the actual quantity of curing compound applied at the conclusion of each deck placement and submit the quantity to the Engineer. Apply the curing compound from a work platform.

Place curing blankets on all exposed surfaces which are not formed as soon as possible with minimal effect on the surface texture. Place the curing blankets with sufficient overlapping seams to form an effective moisture seal. Before using curing blankets, mend tears, splits, or other damage that would make them unsuitable. Discard curing blankets that are not repairable. Wet all curing blankets immediately after satisfactorily placing them and maintain them in a saturated condition throughout the seven day curing period. Supply sufficient quantity of water meeting the requirements of Section 923 at the job site for wetting the blankets.

Where a bridge deck or approach slab is to be subjected to walking, wheeling or other approved construction traffic within the seven day curing period, protect the curing blankets and the concrete surface from damage by placing wooden sheeting, plywood or other approved protective material in the travel areas.

When the ends of the curing blankets are rolled back to permit screeding of adjacent concrete, keep the exposed surfaces wet throughout the period of exposure.

Bridge deck bottom and side forms may be removed after 72 hours upon compliance with 400-14. Approach slab side forms may be removed after 72 hours. Apply membrane curing compound to all surfaces stripped of forms within one hour of loosening. Apply curing compound according to 400-16.2.



400-16.4 Bridge Decks

- Construction joint areas must be cured with continuous moisture or curing blankets
- Curing compound must be applied to slip form barriers within 30 minutes of extrusion and must remain intact for at least 7 days
- The compound determination, application rate, and quantity reporting is the same as for decks
- An applied finish coating (paint) on the APL may be used in lieu of curing compound; however, a conventional curing compound application system must be available for backup if the paint application system fails
- When curing compound must be removed, sand or water (2,900 psi) blasting shall be used



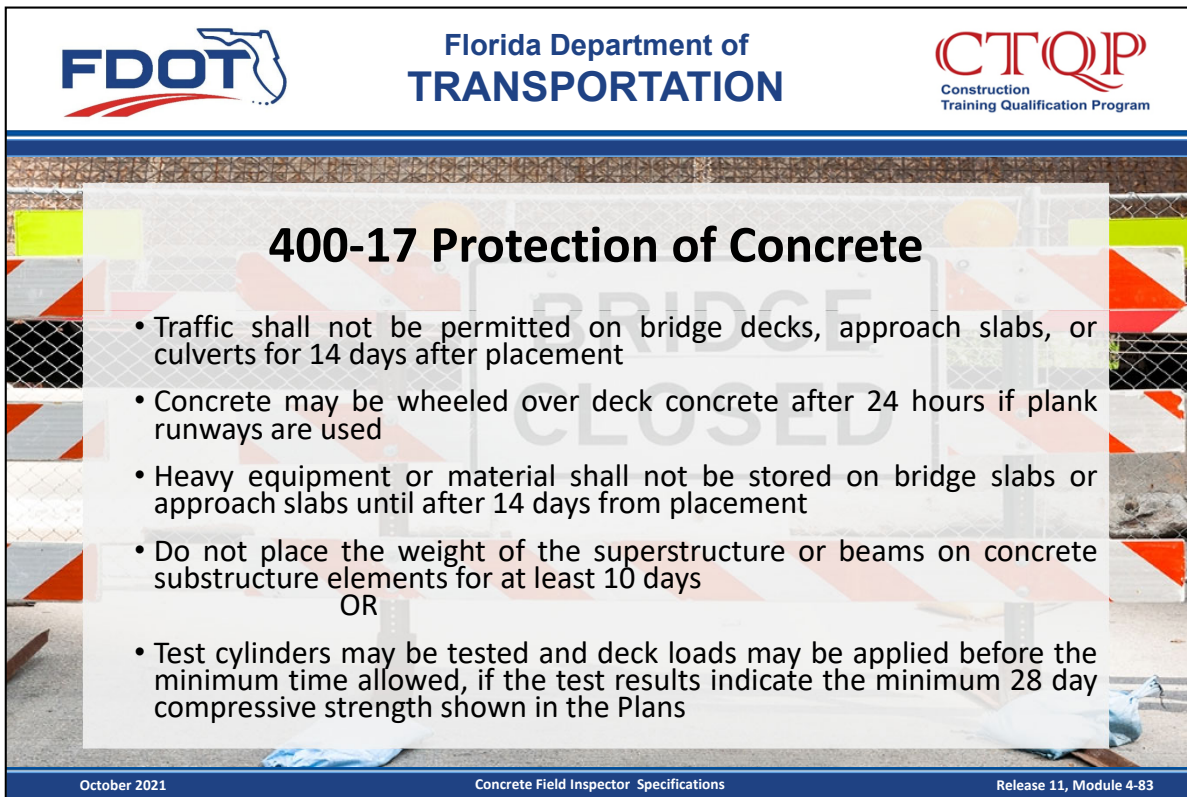
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Slip formed barrier walls require the use of self supporting concrete which has minimal moisture content. Because of the low moisture content, exposed barrier wall surfaces dry rapidly which can cause cracking. In order to prevent excessive drying, the specification requires the application of curing compound within 30 minutes of concrete extrusion or loss of water sheen whichever comes first. The application rate must be 1 gal/150 square feet and the contractor must report his method for measuring the gallons of compound used as well as how much was used after application. To maximize the effectiveness of the curing compound, it must not be removed prior to seven days after application. Inspectors should verify that the contractor complies with the curing compound spread rates and duration of coverage.

If barrier wall placement is a critical path item, the contractor may want to use a class 5 applied finish coating (textured paint) in lieu of curing compound and this also has to be applied within 30 minutes. Applied finish coatings, that are on the APL and that are flagged as permitted for use as a curing compound, may be used in lieu of a curing compound. However, if this product is used, a standby conventional curing compound application system shall be available at all times in case the painting operation is interrupted.



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400-17 Protection of Concrete

- Traffic shall not be permitted on bridge decks, approach slabs, or culverts for 14 days after placement
- Concrete may be wheeled over deck concrete after 24 hours if plank runways are used
- Heavy equipment or material shall not be stored on bridge slabs or approach slabs until after 14 days from placement
- Do not place the weight of the superstructure or beams on concrete substructure elements for at least 10 days
OR
- Test cylinders may be tested and deck loads may be applied before the minimum time allowed, if the test results indicate the minimum 28 day compressive strength shown in the Plans

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400-17 Protection of Concrete.

400-17.1 Opening to Traffic: Do not open concrete bridge decks, approach slabs, or culverts to traffic for at least 14 days after concrete placement. During placement operations, concrete may be wheeled across previously placed slabs after they have set for 24 hours and plank runways are used to keep the loads over the beams.

400-17.2 Storing Materials on Bridge Slabs: Do not store heavy equipment or material, other than light forms or tools, on concrete bridge slabs or approach slabs until 14 days after they have been placed. Obtain approval from the Engineer prior to storing materials, tools or equipment on bridge decks at any time. Disperse any such loads to avoid overloading the structure.

400-17.3 Time of Placing Superstructure: Do not place the weight of the superstructure or beams on concrete substructure elements for at least 10 days after placement.

400-17.4 Alternate Procedure: As an alternative to the time delay periods set forth in 400-17.1 and 400-17.3, test cylinders may be prepared and tested by the Contractor in accordance with 346-5 and a determination made using one of the following methods:

1. When the cylinder test results indicate the minimum 28 day compressive strength shown in the Plans, concrete bridge decks, approach slabs, and culverts may be opened to traffic or the superstructure and beams may be placed on caps.
2. Submit signed and sealed calculations, prepared by a Specialty Engineer, demonstrating that the concrete caps can safely support the weight of the girders for the current concrete strength to the Engineer for approval.

In any event, comply with the curing provisions of 400-16.



400-20 Approach Slabs

- Approach slabs must be constructed in compliance with Specification 350, Cement Concrete Pavement, but with Class II Bridge Deck concrete



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400-20 Approach Slabs.

Construct approach slabs at the bridge ends in accordance with the applicable requirements of Section 350 using Class II (Bridge Deck) concrete. Place the reinforcement as specified in 350-7 and Section 415.



400-21 Disposition of Cracked Concrete

- All cast-in-place concrete members and to prestressed/precast members once installed



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The elevation of cracks in concrete are important because the closer the crack gets to salt water the more likely the steel rebars are to corrode prematurely, and conversely, the rebars in a crack far above salt water will not be effected significantly. The number of crack width ranges was increased from 3 to 8 because 3 ranges did not account for the effect of width on susceptibility to deterioration accurately enough. A measure of crack severity, referred to in the Specification as “cracking significance,” was added because the previous version treated the significance of one crack in a component the same as hundreds of cracks which was obviously not adequate since the impact of many cracks on long term durability will be much more significant than will one crack.

400-21 Disposition of Cracked Concrete.

400-21.1 General: The disposition of cracked concrete is described in this Article and applies to all cast-in-place concrete members, and once installed, to the precast and prestressed concrete members that are produced in accordance with 410, 450, 521, 534, 548 and 641.

The Department’s “Crack Inspection and Disposition Procedures” may be found in the Self Study materials in Appendix 7.



400-21.2 Investigation, Documentation and Monitoring

- The Engineer must inspect all concrete surfaces as soon as they are visible after casting, again after application of full dead loads, and finally after full unrestricted traffic is using the bridge
- The Engineer will measure the width, length and depth of each crack and establish the precise location of the crack termination points relative to permanent reference points on the member
- The Engineer will determine if coring of the concrete is necessary when an accurate measurement of crack depth cannot be determined by use of a mechanical probe

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The article had always applied to cast-in-place concrete components but it now applies to precast components as well with the exception of those covered by specification 449, precast concrete drainage products. It applies to precast components, only after the component has been installed since precast components are produced in a plant and the specifications that govern plant operations contain provisions for dealing with cracks if they happen while still in the plant.

400-21.2 Investigation, Documentation and Monitoring:

Provide the access, equipment and personnel needed for the Engineer to safely perform this work at no expense to the Department. Core cracks for use by the Engineer in locations and to depths specified by the Engineer at no expense to the Department.

400-21.3 Classification of Cracks: The Engineer will classify cracks as either nonstructural or structural and determine the cause.



400-21.2 Investigation, Documentation and Monitoring

- The Engineer will monitor and document the growth of individual cracks at an inspection interval determined by the Engineer to determine if cracks are active or dormant after initial inspection
- The Engineer will perform all final bridge deck crack measurements once the deck is free of all debris and before transverse grooves are cut and after planing is complete for decks that require planing

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Concrete Field Inspector Specifications

Release 11, Module 4-87

The article had always applied to cast-in-place concrete components but it now applies to precast components as well with the exception of those covered by specification 449, precast concrete drainage products. It applies to precast components, only after the component has been installed since precast components are produced in a plant and the specifications that govern plant operations contain provisions for dealing with cracks if they happen while still in the plant.

400-21.2 Investigation, Documentation and Monitoring:

Provide the access, equipment and personnel needed for the Engineer to safely perform this work at no expense to the Department. Core cracks for use by the Engineer in locations and to depths specified by the Engineer at no expense to the Department.

400-21.3 Classification of Cracks: The Engineer will classify cracks as either nonstructural or structural and determine the cause.



400-21.2 Investigation, Documentation and Monitoring

- The Engineer will classify cracks as either nonstructural or structural.
 - Structural cracks are those which result from incorrect design, faulty construction or overloading and these may endanger the safety of public.
 - Non-Structural cracks are caused by natural things like temperature changes, moisture content, weather conditions and vegetation or trees. But they pose not danger to the safety of the public.

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Concrete Field Inspector Specifications

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**Any
Questions?**

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