

400 CONCRETE STRUCTURES.
(REV 12-6-07) (FA 2-4-08) (7-08)

ARTICLE 400-1 (Page 359) is deleted and the following substituted:

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 storage, shipping and erection.

Obtain incidental precast products from a plant that is currently on the list of Producers with Accepted Quality Control Programs. Producers seeking inclusion on the list shall meet the requirements of 105-3.

SUBARTICLE 400-7.1 (Pages 368 and 369) is deleted and the following substituted:

400-7.1 Weather Restrictions:

400-7.1.1 Concreting in Cold Weather: Do not place concrete when the temperature of the concrete at placement is below 45°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 concrete and air within the enclosure can be kept above 60°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: Meet the temperature requirements and special measures for mixing and placing concrete in hot weather as specified in Section 346.

When the temperature of the concrete as placed exceeds 75°F, incorporate in the concrete mix a water-reducing retarder or water reducer if allowed by Section 346.

Spray reinforcing steel 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 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.

SUBARTICLE 400-7.5 (Pages 369 and 370) is deleted and the following substituted:

400-7.5 General Requirements for Placing Concrete: Do not place any concrete prior to approval of the Contractors quality control plan in accordance with 105-3. 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 with a protective coating 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.

SUBARTICLE 400-7.7 (Pages 370 and 371) is deleted and the following substituted:

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.

SUBARTICLE 400-9.5 (Page 375) is deleted and the following substituted:

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.

SUBARTICLE 400-16.1 (Page 384) is deleted and the following substituted:

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.

SUBARTICLE 400-17.3 (Page 388) is deleted and the following substituted:

400-17.3 Time of Placing Superstructure: In the case of piers or bents with concrete caps, do not place the weight of the superstructure or of beams on the caps until they have reached the age of 10 days.

SUBARTICLE 400-17.4 (Page 388) is deleted and the following substituted:

400-17.4 Alternate Procedure: As an alternate procedure, in lieu of the time delay periods set forth in 400-17.1 and 400-17.3, test beams or cylinders may be cast from representative concrete and cured identically with the concrete in the corresponding structural component. Make the test beams in accordance with ASTM C 31 and test them in accordance with ASTM C 78. When the test results indicate a minimum flexural strength of 550 psi or indicate a minimum required compressive strength, concrete bridge decks and culverts may be opened to traffic or the superstructure and beams may be placed on caps.

ARTICLE 400-21 (Pages 390 and 391) is deleted and the following substituted:

400-21 Disposition of Cracked Cast-in-Place Concrete.

400-21.1 General: The investigation and disposition of cracked cast-in place concrete are described herein.

400-21.2 Investigation, Documentation and Monitoring: The Engineer will perform a thorough inspection of the concrete surfaces for cracks. If cracks are found, the Engineer will measure crack lengths and widths. The Engineer will inspect concrete surfaces as soon as surfaces are fully visible after casting, between 7 and 31 days after the component has been burdened with full dead load, and a minimum of 7 days after the bridge has been opened to full unrestricted traffic. The Engineer will measure the width, length, termination points and precise location of all cracks and display, to scale, the results on a drawing referred to as a crack map. After initial inspection, the Engineer will monitor and document the growth of individual cracks at an inspection interval determined by the Engineer. Provide the access, equipment and personnel needed for the Engineer to perform this work.

400-21.3 Classification of Cracks: The Engineer will classify cracks as either nonstructural or structural. In general, nonstructural cracks are shallow depth cracks (between the surface of the concrete and the first layer of reinforcement), which form during curing. Structural cracks are cracks that extend beyond the depth of the reinforcing steel, which can form as a result of excessive load or inadequate support conditions during casting or from uncontrolled temperature gradients. The Contractor will be given an opportunity to review and comment on the Engineer's classification of cracks. The Engineer will make the final determination as to whether cracks are nonstructural or structural.

400-21.3.1 Cracking Significance: The Engineer will determine the cracking significance on the basis of total crack area as a percentage of concrete surface area. Cracking shall be categorized as Isolated, Occasional, Moderate or Severe according to the criteria in Tables 1 and 2. Computations for purposes of determining cracking significance shall be done on a LOT by LOT basis where a LOT is made up of not more than 100 square feet of concrete surface area on bridge substructures, or not more than 400 square feet of bridge deck. Where cracking is localized, the LOT will be reduced to encompass only the immediate area of cracks. Individual evaluation and repairs will be performed on a LOT by LOT basis as directed by the Engineer.

The area to be used in Tables 1 or 2 is the summation of the product of the crack length times the average crack width of all the cracks in a LOT computed in square feet.

The Engineer will identify cracks that are not representative of the overall typical cracking of the LOT(s) and evaluate these separately.

The Contractor will be given an opportunity to review and comment on the Engineer's determination of cracking significance. The Engineer will make the final determination of cracking significance with regard to Tables 1 and 2.

400-21.4 Resolution: Repair nonstructural cracks in accordance with Tables 1 or 2 where applicable. For disposition of structural cracks provide a structural evaluation and written recommendation by a Specialty Engineer.

Where Table 1 or 2 requires investigation to determine adequate repair or rejection, either replace the defective concrete or engage a Specialty Engineer to determine the structural and durability significance of the cracking and develop recommended repair methods for approval of the Engineer.

Cracks shown in Table 1 or 2 with no repair methods listed are considered unacceptable and the affected portions of the structure are required to be removed and replaced.

The Engineer will make the final determination of whether the cracked concrete shall be repaired or replaced, and must approve repair methods prior to start of the work.

No additional compensation or contract time shall be allowed for repairing or replacing cracked concrete that was caused by inadequate curing effort or inadequate construction practice as determined by the Engineer.

Table 1
CAST-IN-PLACE SUBSTRUCTURES AND SUPERSTRUCTURES OTHER THAN DECKS

	Crack Width ⁽²⁾ (inch)	Crack Total Area (In Percent of Concrete Surface) ⁽¹⁾												
		<0.005%			0.005%-0.017%			0.017%-0.029%			>0.029%			
		Isolated			Occasional			Moderate			Severe			
		Environment			Environment			Environment			Environment			
	SA	MA	EA	SA	MA	EA	SA	MA	EA	SA	MA	EA		
Elevation 0 to 6 ft AMHW	$x \leq 0.004$	NT	NT	PS	NT	PS	PS	PS	PS					
	$0.004 < x \leq 0.008$	NT	PS	EI ⁽³⁾	PS	EI ⁽³⁾	EI ⁽³⁾	PS						
	$0.008 < x \leq 0.012$	PS	PS	EI										
	$0.012 < x \leq 0.016$	PS	Investigate to Determine Appropriate Repair ^(4,5) or Rejection											
	$0.016 < x \leq 0.020$													
	$0.020 < x \leq 0.024$										Reject and Replace			
	$0.024 < x \leq 0.028$													
	$0.028 < x$													
Elevation 6 to 12 ft AMHW	Crack Width	SA	MA	EA	SA	MA	EA	SA	MA	EA	SA	MA	EA	
	$x \leq 0.004$	NT	NT	PS	NT	PS	PS	PS	PS	PS	PS			
	$0.004 < x \leq 0.008$	NT	PS	EI ⁽³⁾	PS	PS	EI ⁽³⁾	PS	EI ⁽³⁾					
	$0.008 < x \leq 0.012$	NT	PS	EI	EI	EI								
	$0.012 < x \leq 0.016$	PS	EI	EI	EI									
	$0.016 < x \leq 0.020$	EI												
	$0.020 < x \leq 0.024$		Investigate to Determine Appropriate Repair ^(4,5) or Rejection									Reject and Replace		
	$0.024 < x \leq 0.028$													
$0.028 < x$														
Elevation 12 ft plus AMHW	Crack Width	SA	MA	EA	SA	MA	EA	SA	MA	EA	SA	MA	EA	
	$x \leq 0.004$	NT	NT	NT	NT	PS	PS	PS	PS	PS	PS			
	$0.004 < x \leq 0.008$	NT	PS	PS	PS	PS	EI ⁽³⁾	PS	EI ⁽³⁾	EI ⁽³⁾	PS			
	$0.008 < x \leq 0.012$	NT	PS	EI	EI	EI	EI	EI	EI					
$0.012 < x \leq 0.016$	PS	EI	EI	EI	EI	EI								

Table 2
CAST-IN-PLACE BRIDGE DECK

Crack Total Area (In Percent of Concrete Surface) ⁽¹⁾													
Crack Width ⁽²⁾ (inch)	<0.005%			0.005%-0.017%			0.017%-0.029%			>0.029%			
	Isolated			Occasional			Moderate			Severe			
	Environment			Environment			Environment			Environment			
	SA	MA	EA	SA	MA	EA	SA	MA	EA	SA	MA	EA	
Up to 12 feet AMHW	$x \leq 0.004$	NT	NT	PS	NT	PS	PS	PS	PS	PS			
	$0.004 < x \leq 0.008$	NT	NT	EI/M ⁽³⁾	NT	PS	EI/M ⁽³⁾	EI/M ⁽³⁾	EI/M ⁽³⁾	EI/M ⁽³⁾			
	$0.008 < x \leq 0.012$	NT	PS	EI/M	PS	EI/M	EI/M	EI/M	EI/M				
	$0.012 < x \leq 0.016$	PS	PS	EI/M	PS	EI/M							
	$0.016 < x \leq 0.020$	PS	PS	EI	EI								
	$0.020 < x \leq 0.024$	PS	EI	EI			Investigate to Determine Appropriate Repair ^(4,5) or Rejection					Reject and Replace	
	$0.024 < x \leq 0.028$	PS	EI										
	$0.028 < x$												
12 feet plus AMHW or over Land	Crack Width	SA	MA	EA	SA	MA	EA	SA	MA	EA	SA	MA	EA
	$x \leq 0.004$	NT	NT	PS	NT	NT	PS	PS	PS	PS			
	$0.004 < x \leq 0.008$	NT	NT	PS	NT	PS	EI/M ⁽³⁾	PS	EI/M ⁽³⁾	EI/M ⁽³⁾			
	$0.008 < x \leq 0.012$	NT	NT	EI/M	PS	PS	EI/M	EI/M	EI/M				
	$0.012 < x \leq 0.016$	NT	PS	EI/M	PS	EI/M							
	$0.016 < x$	NT	PS	EI	PS		Investigate to Determine Appropriate Repair ^(4,5) or Rejection						

≤ 0.020														
$0.020 < x \leq 0.024$	NT	PS	EI										Reject and Replace	
$0.024 < x \leq 0.028$	NT	PS												
$0.028 < x$														
PS = Penetrant Sealer EI = Epoxy Injection NT = No Treatment Aggressive													M = Methacrylate AMHW = Above Mean High Water	SA = Slightly Aggressive MA = Moderately Aggressive EA = Extremely Aggressive
Table Notes (Both Tables)														
(1) Calculate total crack area by multiplying the average of 3 width measurements on each crack by the length of the crack and adding the results of all the cracks within the designated representative LOT. (2) Use the average width of all the cracks representative of the LOT to determine the table crack size. (3) For cracks 0.004 inch to 0.008 inch, determine if injectable. If not injectable, use penetrant sealer or methacrylate as directed by the Engineer. (4) (a) Perform epoxy injection of cracks in accordance with Section 411. Seal cracks with penetrant sealer or methacrylate as per Section 413. (b) Use methacrylate or penetrant sealer to repair cracks that are compatible with previously applied materials or remove such materials. (c) Use sealers to repair riding surfaces that are designed for that purpose. (5) Seal the cracks after it has been determined that no additional growth will occur. (6) Investigate cracks which occur underwater or at elevations below zero to determine appropriate repair.														