

ORIGINATION FORM

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Specification: 400-21

Subject: 400-21, Classification of Cracks in Concrete Structures to be Sealed

Origination date: 7/24/08- Steve Plotkin revised the article based on our comments and review. 3/4/08

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Problem statement: **400-21**, The current specification was the result of a major rewrite in 2006 and as such was a first generation specification. As a result, many problems with the spec. have been identified by Department staff in the offices of Maintenance, Design, Materials and Construction which have been deemed valid by a Task Team of Department Engineers.

Proposed solution: The CPAM Chapter 10.3 has been modified to provide guidance to the CEI on implementing the specification change. In addition, portions of this article have been removed and placed in CPAM.

The responsibilities of the CEI and contractor are more clearly defined by providing more explanation.

In the current version, all cracks for a determined Cracking Significance range are repaired the same based on the average crack width. This has been changed so that cracks are repaired based on the width of individual cracks in a Cracking Significance range.

Information source: The following Department Engineers provided information on this issue: Rafiq Darji, Jonathan Van Hook, Jeffrey Pouliotte, Rod Powers, Ivan Lasa, Ghulam Mujtaba and David Sadler.

Recommended

Usage Note: These revisions shall apply to the standard specifications and shall be included in all projects



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M E M O R A N D U M

DATE: October 27, 2008
TO: Specification Review Distribution List
FROM: Rudy Powell, Jr., P.E., State Specifications Engineer
SUBJECT: Proposed Specification:4002100, Disposition of Cracked Concrete

In accordance with Specification Development Procedures, we are sending you a copy of a proposed specification change.

This change was proposed by Steve Plotkin to specify that cracks in concrete are repaired based on the width of individual cracks in a Cracking Significance range.

Please share this proposal with others within your responsibility. Review comments are due within four weeks and should be sent to Mail Station 75 or to my attention via e-mail at ST986RP or rudy.powell@dot.state.fl.us. Comments received after November 27, 2008 may not be considered. Your input is encouraged.

RP/dr
Attachment

**DISPOSITION OF CRACKED CONCRETE.
(REV 10-17-08)**

ARTICLE 400-21 (of the Supplemental Specifications) 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 east-in-place concrete ~~is~~ *are described herein in this Section, and applies to all cast-in-place concrete members and to all precast and prestressed concrete members after installation. See other Sections for the disposition of cracks in precast and prestressed concrete members prior to installation.*

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, and depth of each crack and establish termination points and the precise location of the crack termination points relative to permanent reference points on the member. all cracks and display, to scale, the results on a drawing referred to as a crack map. 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. 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.~~

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.

~~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 *and determine the cause. In general, nonstructural cracks are cracks 1/2 inch or less deep from the surface of the concrete; however, the Engineer may determine that a crack greater than 1/2 inch deep is nonstructural.* ~~In general, nonstructural cracks are shallow depth cracks (between the surface of the concrete and the first layer of reinforcement), which form during curing. In general, structural cracks are cracks that extend deeper than 1/2 inch. A crack that is fully or partially underwater at any time during its service life will be classified as a structural crack. 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 Rreview and comment on the Engineer's crack classification and determination of cause of cracks.; however, tThe Engineer will make the final determination as to whether cracks are nonstructural or structural.~~

400-21.43.1 Cracking Significance of Nonstructural Cracks: The Engineer will determine the Cracking Significance on the basis of total crack area as a percentage of concrete surface area. *The Cracking Significance will be determined on the basis of total crack surface area as a percentage of total concrete surface area.* Cracking significance will be categorized as Isolated, Occasional, Moderate or Severe according to the criteria in Tables 1 and 2. Computations for purposes of determining Cracking Significance will be determined on a LOT by LOT basis. *where A LOT will be typically be made up of not more than 100 square feet and not less than 25 square feet of concrete surface area for structures other than bridge decks or typically not more than 400 square feet or not less than 100 square feet for bridge decks.* of concrete surface area on bridge substructures, or not more than *A LOT will not extend beyond a single Elevation Range as shown in Table 1 or 2.* 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; *however,* The Engineer will make the final determination of cracking significance with regard to Tables 1 and 2.

400-21.54 Repair solution Method: *Repair or remove and replace cracked concrete as directed by the Engineer. Additional compensation or a time extension will not be approved for repair or removal and replacement of cracked concrete when the Engineer determines the cause to be the responsibility of the Contractor.* 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.

400-21.5.1 Nonstructural Cracks: *Repair each crack using the method as determined by the Engineer for each LOT in accordance with Table 1 or 2. When further investigation is required to determine repair or rejection, either remove and replace the cracked concrete or provide a structural evaluation signed and sealed by the Contractor's Engineer of Record that includes recommended repair methods and a determination of structural capacity and durability to the Engineer. Upon approval by the Engineer, repair the cracked concrete. Upon approval by the Engineer use epoxy injection in accordance with Section 411 to repair cracks in a member inside a dry cofferdam prior to flooding of the cofferdam. –"Reject and Replace" in Table 1 or 2 means there is no acceptable repair method.*

400-21.5.2 Structural Cracks: *Provide a structural evaluation signed and sealed by the Contractor's Engineer of Record that includes recommended repair methods and a determination of structural capacity and durability to the Engineer. Upon approval by the Engineer, repair the cracked concrete. Complete all repairs to cracks in a member inside a cofferdam prior to flooding the cofferdam.*

	$0.020 < x \leq 0.024$	EI	Investigate to Determine Appropriate Repair ^(4,5) or Rejection									
	$0.024 < x \leq 0.028$									Reject and Replace		
	$0.028 < x$											

Table 2 CAST-IN-PLACE BRIDGE DECK													
Crack Width ⁽²⁾ (inch)	Crack Total Area (In Percent of Concrete Surface) ⁽⁴⁾												
	<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	* ≤0.004	NT	NT	PS	NT	PS	PS	PS	PS	PS			
	0.004< * ≤0.008	NT	NT	EI/M ⁽³⁾	NT	PS	EI/M ⁽³⁾	EI/M ⁽³⁾	EI/M ⁽³⁾	EI/M ⁽³⁾			
	0.008< * ≤0.012	NT	PS	EI/M	PS	EI/M	EI/M	EI/M	EI/M				
	0.012< * ≤0.016	PS	PS	EI/M	PS	EI/M							
	0.016< * ≤0.020	PS	PS	EI	EI								
	0.020< * ≤0.024	PS	EI	EI			Investigate to Determine Appropriate Repair ^(4,5) or Rejection					Reject and Replace	
	0.024< * ≤0.028	PS	EI										
	0.028< *												
12 feet plus AMHW or over Land	Crack Width	SA	MA	EA	SA	MA	EA	SA	MA	EA	SA	MA	EA
	* ≤0.004	NT	NT	PS	NT	NT	PS	PS	PS	PS			
	0.004< * ≤0.008	NT	NT	PS	NT	PS	EI/M ⁽³⁾	PS	EI/M ⁽³⁾	EI/M ⁽³⁾			
	0.008< * ≤0.012	NT	NT	EI/M	PS	PS	EI/M	EI/M	EI/M				
	0.012< * ≤0.016	NT	PS	EI/M	PS	EI/M							
	0.016< * ≤0.020	NT	PS	EI	PS		Investigate to Determine Appropriate Repair ^(4,5) or Rejection						
	0.020<	NT	PS	EI								Reject and Replace	

	*												
	≤0.024												
	0.024<	NT	PS										
	*												
	≤0.028												
	0.028<												
	*												
PS = Penetrant Sealer		M = Methacrylate				SA = Slightly Aggressive							
EI = Epoxy Injection		AMHW = Above Mean High Water				MA = Moderately Aggressive							
NT = No Treatment		EA = Extremely Aggressive											
<u>Table Notes (Both Tables)</u>													
<p>(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.</p> <p>(2) Use the average width of all the cracks representative of the LOT to determine the table crack size.</p> <p>(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.</p> <p>(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.</p> <p>(5) Seal the cracks after it has been determined that no additional growth will occur.</p> <p>(6) Investigate cracks which occur underwater or at elevations below zero to determine appropriate repair.</p>													

*Table 1
DISPOSITION OF CRACKED CONCRETE OTHER THAN BRIDGE DECKS
[see separate Key of Abbreviations and Footnotes for Tables 1 and 2]*

Elev. Range	Crack Width Range (inch) ⁽²⁾ <i>x</i> = crack width	Cracking Significance Range per LOT ⁽¹⁾												
		Isolated Less than 0.005%			Occasional 0.005% to <0.017%			Moderate 0.017% to <0.029%			Severe 0.029% or gr.			
		Environment Category												
		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 ⁽⁶⁾	NT	PS ⁽⁶⁾	PS ⁽⁶⁾	PS ⁽⁶⁾	PS ⁽⁶⁾					
	$0.004 < x \leq 0.008$	NT	PS ⁽⁶⁾	EI ⁽³⁾	PS ⁽⁶⁾	EI ⁽³⁾	EI ⁽³⁾	PS ⁽⁶⁾						
	$0.008 < x \leq 0.012$	NT	PS ⁽⁶⁾	EI										
	$0.012 < x \leq 0.016$	PS ⁽⁶⁾	Investigate to Determine Appropriate Repair ^(4,5) or Rejection											
	$0.016 < x \leq 0.020$													
	$0.020 < x \leq 0.024$										Reject and Replace			
	$0.024 < x \leq 0.028$													
	$x > 0.028$													
Elev.: More Than 6 ft 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 ⁽⁶⁾	NT	PS ⁽⁶⁾	PS ⁽⁶⁾	PS ⁽⁶⁾	PS ⁽⁶⁾	PS ⁽⁶⁾	PS ⁽⁶⁾			
	$0.004 < x \leq 0.008$	NT	PS ⁽⁶⁾	EI ⁽³⁾	PS ⁽⁶⁾	PS ⁽⁶⁾	EI ⁽³⁾	PS ⁽⁶⁾	EI ⁽³⁾					
	$0.008 < x \leq 0.012$	NT	PS ⁽⁶⁾	EI	EI	EI								
	$0.012 < x \leq 0.016$	PS ⁽⁶⁾	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		
	$0.024 < x \leq 0.028$													
	$x > 0.028$													
Elev.: Over Land or More Than 12 ft	Crack Width	SA	MA	EA	SA	MA	EA	SA	MA	EA	SA	MA	EA	
	$x \leq 0.004$	NT	NT	NT	NT	PS ⁽⁶⁾	PS ⁽⁶⁾	PS ⁽⁶⁾	PS ⁽⁶⁾	PS ⁽⁶⁾	PS ⁽⁶⁾			
	$0.004 < x \leq 0.008$	NT	PS ⁽⁶⁾	PS ⁽⁶⁾	PS ⁽⁶⁾	PS ⁽⁶⁾	EI ⁽³⁾	PS ⁽⁶⁾	EI ⁽³⁾	EI ⁽³⁾	PS ⁽⁶⁾			
	$0.008 < x \leq$	NT	PS	EI	EI	EI	EI	EI	EI					

<i>Key of Abbreviations and Footnotes for Tables 1 and 2</i>		
<i>Type Abbreviation</i>	<i>Abbreviation</i>	<i>Definition</i>
<i>Repair Method</i>	<i>EI</i>	<i>Epoxy Injection</i>
	<i>M</i>	<i>Methacrylate</i>
	<i>NT</i>	<i>No Treatment Required</i>
	<i>PS</i>	<i>Penetrant Sealer</i>
<i>Environment Category</i>	<i>EA</i>	<i>Extremely Aggressive</i>
	<i>MA</i>	<i>Moderately Aggressive</i>
	<i>SA</i>	<i>Slightly Aggressive</i>
<i>Reference Elevation</i>	<i>AMHW</i>	<i>Above Mean High Water</i>
<u><i>Footnotes</i></u>		
<p>(1) <i>Cracking Significance Range is determined by computing the ratio of Total Cracked Surface Area (TCSA) to Total Surface Area (TSA) per LOT in percent [(TCSA/TSA) x 100] then by identifying the Cracking Significance Range in which that value falls. TCSA is the sum of the surface areas of the individual cracks in the LOT. The surface area of an individual crack is determined by taking width measurements of the crack at 3 representative locations and then computing their average which is then multiplied by the crack length.</i></p> <p>(2) <i>Crack Width Range is determined by computing the width of an individual crack as computed in (1) above and then identifying the range in which that individual crack width falls.</i></p> <p>(3) <i>When the Engineer determines that a crack in the 0.004 inch to 0.008 inch width range cannot be injected then for Table 1 use penetrant sealer unless the surface is horizontal, in which case, use methacrylate if the manufacturer's recommendations allow it to be used and if it can be applied effectively as determined by the Engineer.</i></p> <p>(4) (a) <i>Perform epoxy injection of cracks in accordance with Section 411. Seal cracks with penetrant sealer or methacrylate as per Section 413. (b) Use only methacrylate or penetrant sealer that is compatible, according to manufacturer's recommendations, with previously applied materials such as curing compound or paint or remove such materials prior to application.</i></p> <p>(5) <i>When possible, prior to final acceptance of the project, seal cracks only after it has been determined that no additional growth will occur.</i></p> <p>(6) <i>Methacrylate shall be used on horizontal surfaces in lieu of penetrant sealer if the manufacturer's recommendations allow it to be used and if it can be applied effectively as determined by the Engineer.</i></p>		

**Estimated fiscal
impact, if
implemented:**

These revisions have no fiscal impact since they are all related to providing improved guidance and reduced confusion for Contractors with regard to the Department's expectations related to repairing concrete defects. The intent of the revised specifications has not been changed.

Implementation of these changes, if and when approved, will begin with the July 2009 letting.