Dowel Bar Standardization

NC^2 Spring Meeting
Savannah, GA

Dowel Bar Task Force

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Dowel Bar Diameters: Summary of Current Practices

	6.0"	6.5"	7.0"	7.5"	8.0"	8.5"	9.0"	9.5"	10.0"	10.5"	11.0"	11.5"	12.0"	12.5"
Recommended	1.000	1.000	1.000	1.000	1.250	1.250	1.250	1.250	1.250	1.500	1.500	1.500	1.500	1.500
California	1.250	1.250	1.250	1.250	1.250	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500
Iowa	0.750	0.750	0.750	0.750	1.250	1.250	1.250	1.250	1.500	1.500	1.500	1.500	1.500	1.500
Illinois	1.000	1.000	1.250	1.250	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500
Indiana	1.000	1.000	1.000	1.000	1.000	1.000	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.500
Michigan	1.000	1.000	1.000	1.000	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.500	1.500	1.500
Minnesota	1.000	1.000	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.500	1.500	1.500	1.500	1.500
Missouri	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.500	1.500	1.500	1.500	1.500
North Dakota	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.500	1.500	1.500	1.500	1.500
Ohio	1.000	1.000	1.000	1.000	1.000	1.250	1.250	1.250	1.250	1.500	1.500	1.500	1.500	1.500
Texas					1.000		1.125		1.250		1.375		1.500	
Wisconsin			1.000	1.000	1.250	1.250	1.250	1.250	1.500	1.500	1.500	1.500	1.500	1.500

Based on NC^2 March 2009 dowel bar questionnaire, question number 9 responses.

Proposed dowel bar size and dowel basket height to center of dowel

Pavement Thickness	6” – 7.5”	>7.5” – 10”	> 10” – 12”	>12”
Dowel Bar Diameter	1”	1¼”	1½”	1 ½”
Height to center of dowel**	3”	4”	5”	6”

**Elect to have thinner cover in bottom of slab vs. top of slab

Proposed Dowel Bar Diameters "Engineering behind it"

- Proposed dowel diameters are essentially the same diameters that have been used as standard (for the top end of each pavement thickness range) since the AASHO Road test: D = T/8.
- The load transfer capacity will be at least the same (or slightly better) for all proposed designs, meaning that performance will be equal or better than standard in all cases.
- There should be no need to perform an engineering analysis of the proposed systems unless the proposed dowel sizes are smaller than their current standards.

Proposed Dowel Bar Diameters "Engineering behind it"

- Any required engineering analysis would have to be done on case-by-case basis (using agency-specific assumptions for slab geometry and structural design parameters) and could be done one of two ways:
  - The hard/complex way
  - The easier/simpler way
- Again, these two approaches shouldn't be necessary unless the proposed dowel diameters represent a decrease from current practices, which should not be the case for most agencies.
- The real justification should be in terms of ease of construction and fabrication (which should translate into lower costs).

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**Elect to have thinner cover in bottom of slab vs. top of slab

Dowel Bar Length – How did we get to 18 inches?

- As a bit of background, the first pavement dowels used consistently in this country were ½-in diameter, 24-in long bare steel bars, 4 per lane back in the 1920s, I believe.
- Dowel diameter increased and spacing decreased until we got the use of 1-in dowels on 1-ft centers as standard in the 40s and 50s. The 18-in length came about mainly because it was determined that this was the length (9 inches of embedment) that would result in dowel behavior (for a 1-in dowel) that was close enough to the assumptions of Timoshenko's analysis, which assumed a semi-infinitely long dowel embedded in concrete and loaded on the exposed end.

Dowel Bar Length – How did we get to 18 inches?

- In order to maintain the validity of his analysis with larger dowels, dowel length should actually *increase* with dowel diameter, so a 1.5-in dowel might require 24 inches or more of length to behave consistently with Timoshenko's model! Fortunately, we don't require that.
- Current rationale: We need that length in order to make sure that the joint is formed somewhere that provides adequate embedment on both sides of the joint.
- In reality, we probably need only a few inches of embedment to make the system work properly (Tom Burnham concluded in his paper).

- **Dowel bar length - Individual DOT decision**

Dowel Bar Material

- Dowel bar steel – AASHTO M 227 Grade 70-80 (ASTM A 615 Grade 40 or 60)
- 7–13 mil epoxy coating thickness on dowel bar
- Alternate Dowel Bar Materials – may need to be considered

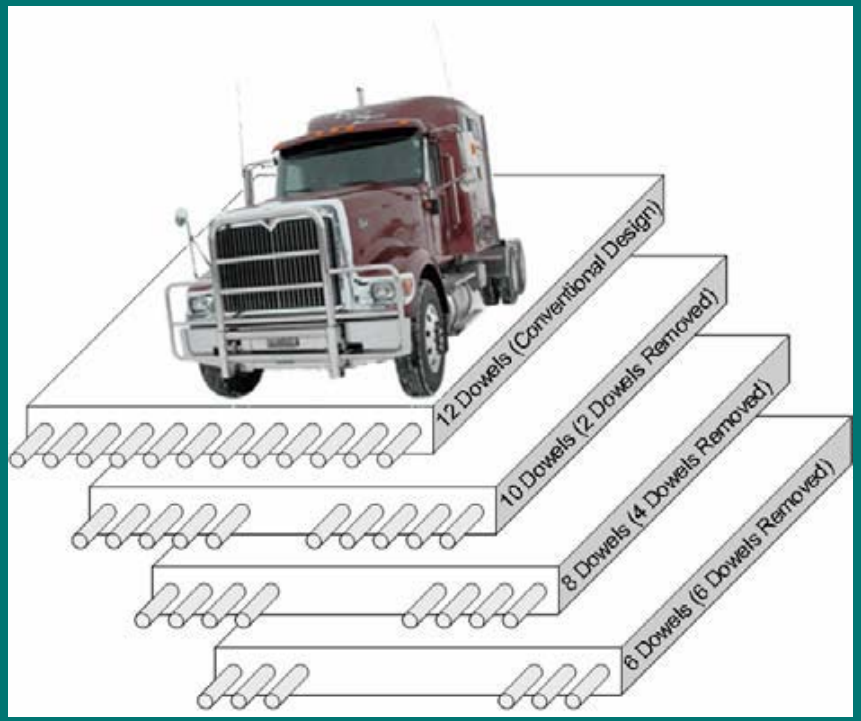
Dowel Bar Material Comparison (#9)

	AASHTO M227 GR 70-80	ASTM A615 Grade 40	ASTM A615 Grade 60	AASHTO M31	Not Specified
Recommended	**x**	**x**	**x**		
California					
Iowa		x	x		
Illinois	x				
Indiana		x	x		
Louisiana			x		
Michigan		x			
Minnesota		x	x		
Missouri				x	
North Carolina			x		
North Dakota					x
Ohio					x
Texas			x		
Wisconsin		x	x		

ASTM A615 Grade 40 is recertifiable as AASHTO M227, 99% of time, ASTM A615 Grade 60 is also becoming re-certifiable as AASHTO M227 Grade 70-80 (Eder NC^2 March 2009)

Dowel Bar Configuration (May affect basket length)

- Innovative Concrete Pavement Dowel Design Guidelines from ACPA: http://www.pavement.com/dowelcad/



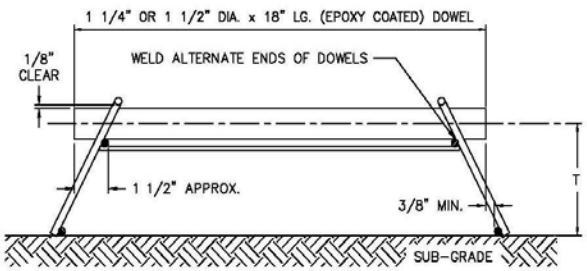
Wires and Basket Style

	Wire Gauge Comparison (#5)				Cut Shipping (Spacer) Wires (#11)				Basket Leg Style (#4)				
	Top	Bottom	Side	Shipping	Yes	No	Contractor's Option		U-leg	V-leg	J-leg	Choked V-leg	Not Specified
Recommended	**0.306**	**0.306**	**0.306**	**0.177**					**x**	**x**			
California	W10	W10	NG	NG	x				x	x			
Iowa	0.306	0.306	0.306	0.135			x	(must cut every 4th)	x	x	x	x	
Illinois	0.306	0.306	0.306	0.177	x								x
Indiana	W7.5	W7.5	W7.5	NG	x								x
Louisiana	0.306	0.306	0.306	NG	x					x			
Michigan	0.306	0.306	0.306	NS	x				x		x		
Minnesota	0.306	0.306	0.243	0.177			x		x	x	x		
Missouri	#0(.306)	#0(.306)	#0(.306)	NG		x			x		x		
New York	0.306	0.306	0.243	NG						x			
North Carolina	0.276	0.276	0.276	0.192	x					x			
North Dakota	NS	NS	NS	NS		x							x
Ohio	0.306	0.306	0.306	0.177	x				x		x		
Texas	NG	NG	NG	NG		x							x
Wisconsin	NG	NG	NG	NG		x				x			

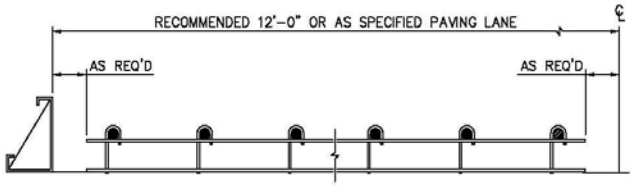
NG = Not Given NS = Not Specified

From NC^2 March 2009 Survey

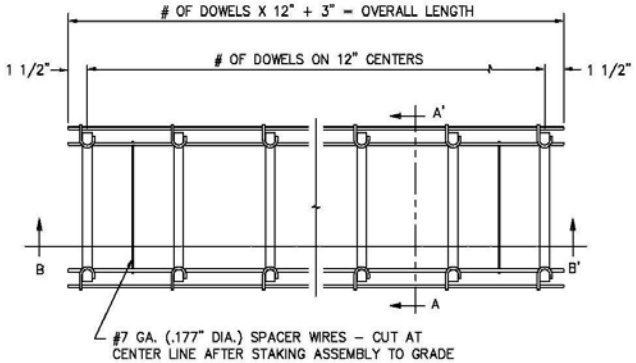
2001 Universal Basket



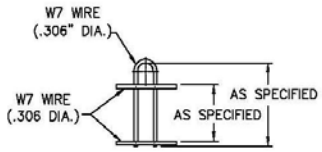
SECTION: A–A'



SECTION: B–B'

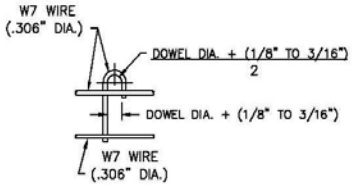


PLAN VIEW



DETAIL: U–LEG

– OR –



ALTERNATE
DETAIL: J–LEG

NOTES:

1) DOWELS TO BE BILLET STEEL BARS PER AASHTO SPECIFICATION M–31 GR. 40 LATEST REV. (ASTM A–615 GR. 40).
2) DOWELS ARE TO BE: ☐ EPOXY COATED ☐ TECTYL 506 COATED OR FACTORY COATED WITH A VISIBLE COATING OF AN APPROVED COATING COMPOUND, UNIFORMLY APPLIED BY DIPPING AND WITHOUT EXCESSIVE DRIPS OR THICKNESS, BUT IN SUCH A THICKNESS THAT ITS PRESSENCE CAN BE READILY IDENTIFIED
3) DOWELS ARE TO BE CUT WITH STRAIGHT SURFACE AND DEBURRED.
4) WIRE SIZES SHOWN ARE MINIMUM REQ'D.
5) ALL WIRE INTERSECTIONS ARE TO BE WELDED
6) STAKES TYPICALLY APPLIED AT WORKING ENDS OF DOWELS WITH SUFFICIENT INSTALLATIONS TO PREVENT UNIT FROM OVERTURNING UNDER LOAD.
7) TOLERANCES:
   A) ±1/4"/lf UNLESS OTHERWISE SPECIFIED.
   B) BASKETS SHALL BE MANUFACTURED SO THAT THE DOWELS ARE HORIZONTAL AND PARALLEL FROM EACH OTHER AND PERPENDICULAR TO THE BASKET, +/–1/8"/lf
   C) ON CENTER SHOULD BE ±1/2"
   D) DOWELS SHOULD BE PLACED AT MID DEPTH OF SLAB ±1/2" OR AS OTHERWISE SPECIFIED
8) U–LEG OR J–LEG TO BE INSTALLED ON INSIDE OR OUTSIDE OF SUBFRAME
9) DOWELS SHALL BE COATED WITH EPOXY COATING IN ACCORDANCE WITH AASHTO M284 AND THE CUT ENDS ARE NOT REQUIRED TO BE COATED
10) DOWEL DIAMETERS TO BE IN 1/4" INCREMENTS

PROJECT	MIDWEST CONCRETE CONSORTIUM	
LOCATION	STATE	
ACCOUNT		
SCALE	NOT TO SCALE	DRAWING NO.
DRAWN		
DATE		SHEET 1 OF 1

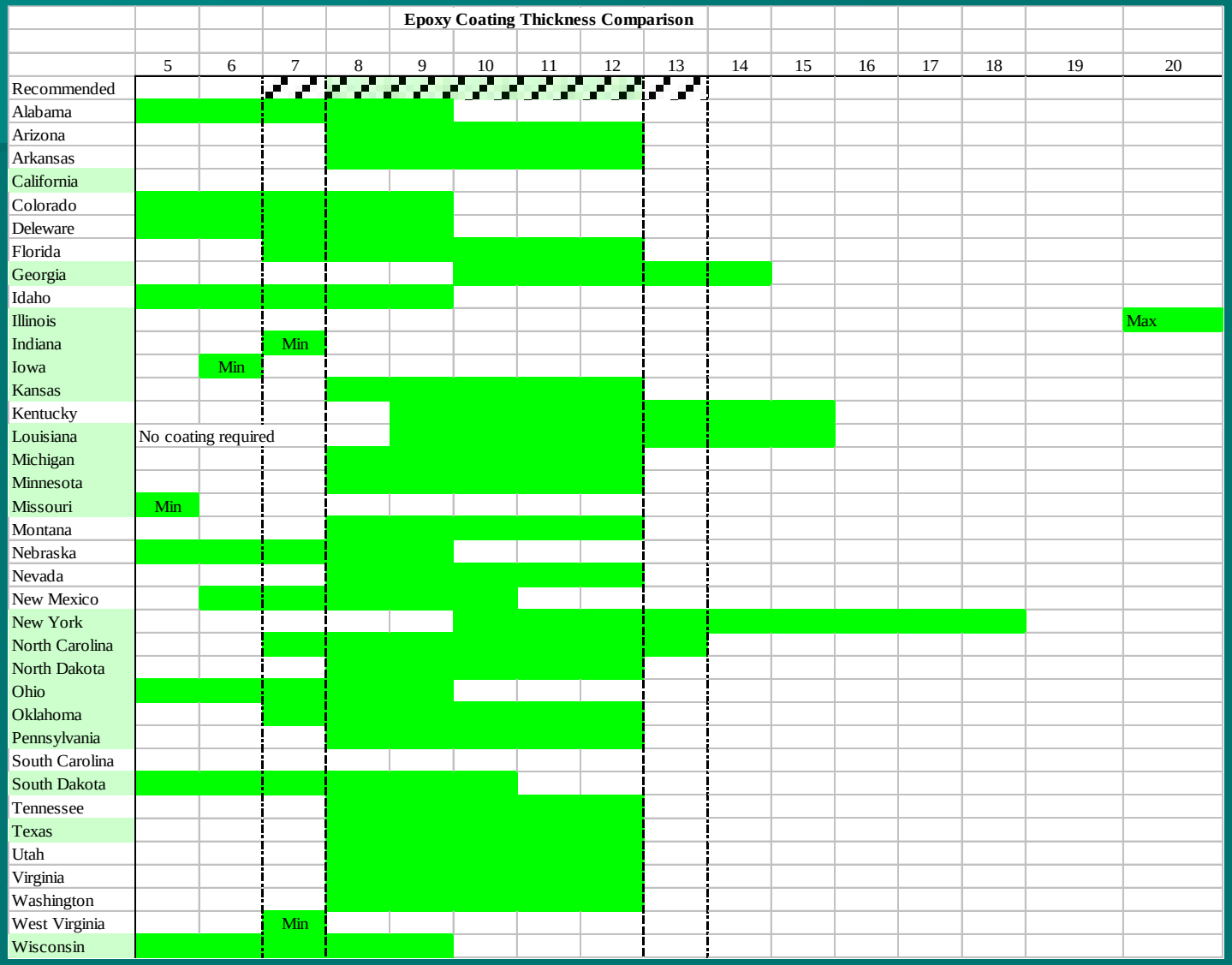
Dowel Bar Standardization Recommendations

Recommendations

The following recommendations are based on the information received from 22 states as well as contractors and manufacturers.

- *Basket frame*
  - Basket/frame wire diameter of 0.306 in.
  - Side rail wire diameter of 0.243 in.
- *Spacer wires*
  - Spacer wire diameter of 0.177 in.
  - Number of spacer wires required – 3 minimum
- *Leg configuration*
  - U-leg and V-leg

Epoxy Coating Thickness



Implementation Benefits

- Fabrication will be simplified knowing the frames could be supplied to many different DOTs.
- Standardization will reduce the lead time needed to supply baskets to projects.
- When projects are delayed, baskets that are being stored outside in manufacturing yards could be shipped to other projects, reducing the time they sit in the yard and decreasing the potential for degradation of the epoxy coating.
- Epoxy coating thickness standardization will eliminate the risk of sending the wrong dowels to a project and will streamline the epoxy coating process since plants will not have to modify options to adjust for varying coating thicknesses.

Future discussion points

- **Dowel basket anchoring methods and materials**
  - We should recommend the industry work with the manufacturer's to develop and propose the best systems for DOT's to ensure baskets are sufficiently anchored into the underlying material
- **Lubrication material used as bond breaker on dowels**
  - Several states are allowing the baskets to be pre-coated prior to shipment with Tectyl 506 which eliminates a construction operation
  - Consideration of the value of the Tectyl material protecting the epoxy coating from nicks caused by handling and placement and ultraviolet exposure to the elements (UV rays) during outdoor storage
  - We should recommend the industry show us the benefits of pre-coating the dowel bars with a Tectyl type material