High performance fusion-bonded epoxy-coated dowels

David McDonald, Ph.D., P.E.

Managing Director

Epoxy Interest Group of CRSI

EIG CRSI
EPOXY INTEREST GROUP

BACKGROUND

EIG CRSI
EPOXY INTEREST GROUP

Epoxy Coated Bars

- Developed in 1970s by NIST
- First used 1973
- Over 74,000 bridges
  - 850,000,000 sq ft of deck
- #1 corrosion-resistant reinforcing
- ~600,000 ton/year

Current Situation

- ~20 million dowel bars used per year
- Principally epoxy-coated
  - ASTM A775 material (green)
  - Some agencies looking at ASTM A934 (purple)
- Individual dowels or dowel baskets

WisDOT report 2003

- *A 1996 WisDOT study*
  - *no epoxy-coated dowel corrosion after five years at installed sites*
- *Corrosion resistance can be offset*
  - *when the concrete surrounding the dowel scrapes this shell during installation or pavement load transfer moments*

Approximate Dowel and Pavement Costs

Type	Approximate Cost	Paving cost increase**
Stainless	$21 - $23	51%
Stainless Clad	$15 - $19	25%
Stainless tube with epoxy insert	$14 - $16	33%
Zinc	$9 - $11	10%
Epoxy-coated	$4 - $6	0%

pavementinteractive.org/images/3/35/PCC_construction_CEE597.ppt

For each $1 increase in price, approximately $0.60/sy paving cost increase

EPOXY-COATED DOWELS

EIG CRSI
EPOXY INTEREST GROUP

Manufacturing Process

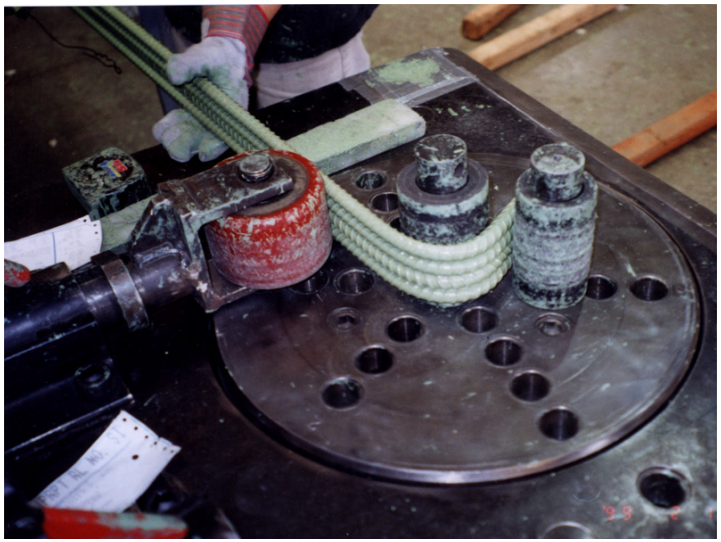
- Cleaned
- Heated
- Coated
  - Electrostatic attraction moves powder to bar surface
- Cure
  - Residual heat forms a thermosetting polymer on the bar surface

- Cut and patched
- Welded into baskets

AASHTO requirements

- Coating
  - AASHTO M254
  - Tested using AASHTO T253
- Coating thickness: 7 +/- 2 mil

- Coating
  - Formulated for 180 degree bend
  - Preserve Bond



Epoxy Bars
< #5 7 – 12 mil
>#5 7 – 16 mil

coating thickness

AL 5-9	IN 7 min	NY 10-18	SD 5-10
AZ 8-12	IA 6 min	NV 8-12	TN 8-12
AR 8-12	KS 8-12	NC 7-13	TX 8-12
CO 5-9	KY 9-15	NM 6-10	UT 8-12
DE 5-9	MI 8-12	ND 8-12	VA 8-12
FL 7-12	MN 8-12	OH 5-9	WA 8-12
GA 10-14	MO 5 min	OK 7-12	WV 7 min
ID 5-9	MT 8-12	PA 8-12	WI 5-9
IL 20 max	NE 5-9	SC None	WY 5-9

http://www.cptechcenter.org/t2/documents/Eder--VariablesforDowelBasketManufacturingandStandardization.pdf

AASHTO M254 Tests

- Load-deflection
- Pull out
- Abrasion followed by corrosion/Freeze thaw
- Cathodic debonding
- Chemical resistance
- Hardness
- Coating impact damage

Many coatings can exceed these requirements

ASTM A775 vs A934

Test	ASTM A775	ASTM A934
Chemical resistance 45 days at 75F	No softening, debonding	No softening, debonding
Cathodic debonding 168 hours at 75F	< 4 mm	< 2 mm
Salt spray Disbondment at 800 hours	< 3 mm	< 3 mm
Chloride permeability 45 days at 75F	1 x 10^{-4} M	1 x 10^{-4} M
Flexibility	180 degrees	6 degrees
Bond in concrete	Not less than 85% of black	Not less than 85% of black
Abrasion	0.0035 oz/1000 cycles	0.0035 oz/1000 cycles
Impact	80 in.-lb	40 in.-lb

The status quo

- Thickness based upon preserving bond
  - reinforcing steel, not dowels
- Coating toughness based upon need for rebar flexibility

- Neither case applies to dowels

Standard Specification for Epoxy-Coated Steel Dowels for Concrete Pavement

ASTM A1078/A1078 M - 12

EIG CRSI
EPOXY INTEREST GROUP

Coating Types

- Type 1 coating
  - A775/A775M (Green)
  - A1055/A1055M (+ zinc layer)
  - May be cut after coating
- Type 2 coating
  - A934/A934M
  - Shall not be cut after the final coating application unless permitted by the purchaser

Defaults in A1078

Default

- Length
  - 18 in.
- Diameter
  - 1-1⁄4 in. or 1-1⁄2 in.
- Grade 60
- Minimum coating thickness
  - 8 mil
- Cut ends coated
  - 5 mil patching material

Options

- Pretreatment
- Cutting of dowels with Type 2 coating

All defaults can be over-ridden by the purchaser

HIGH PERFORMANCE COATINGS

EIG CRSI
EPOXY INTEREST GROUP

Many improvements

- **Dowels are not bent**

- Harder coatings are available
- May require additional handling in plants

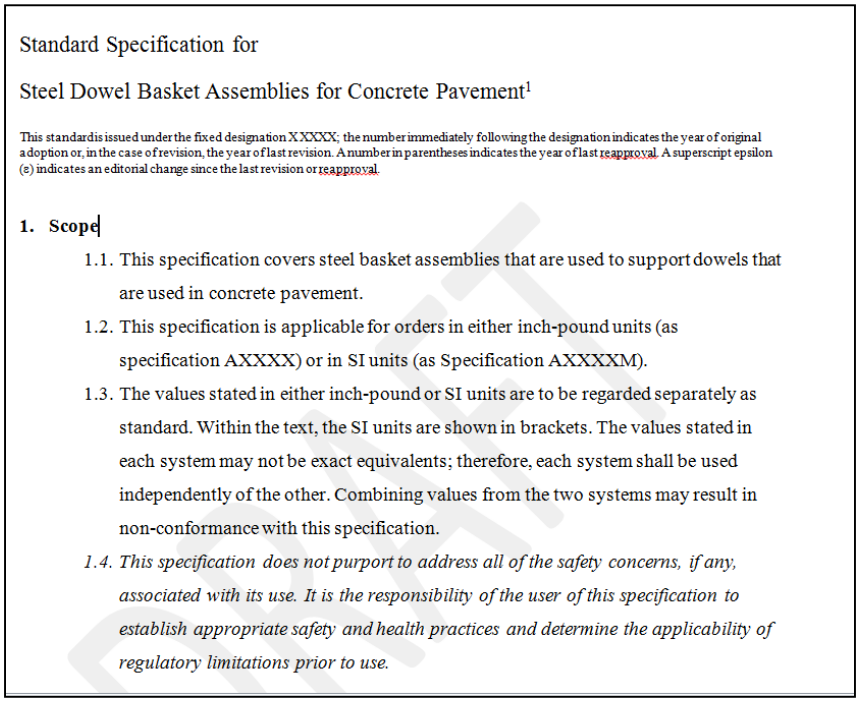
Other Coatings from Pipe Industries

- Non-proprietary

New materials are being explored
Thicker coatings are available

National Standard for Baskets

- Based upon TTCC/NCC figure
- Need input to review and complete
- Make manufacturing more uniform, promote competition, provide more rapid delivery



Standard Specification for

Steel Dowel Basket Assemblies for Concrete Pavement[1]

This standard is issued under the fixed designation XXXX; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1. This specification covers steel basket assemblies that are used to support dowels that are used in concrete pavement.

1.2. This specification is applicable for orders in either inch-pound units (as specification AXXXX) or in SI units (as Specification AXXXXM).

1.3. The values stated in either inch-pound or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with this specification.

1.4. This specification does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this specification to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

DRAFT

Help needed to complete this specification

MOVING FORWARD

EIG CRSI
EPOXY INTEREST GROUP

Next Steps

- Consider use of ASTM rather than modified AASHTO specifications
  - What do you need to obtain your performance requirements?
- Help develop national basket standard
- Assist with evaluation of high performance coatings

Questions?

EIG CRSI
EPOXY INTEREST GROUP