

New Specifications for Paving Dowels (NCC-sponsored research)



Presented by:

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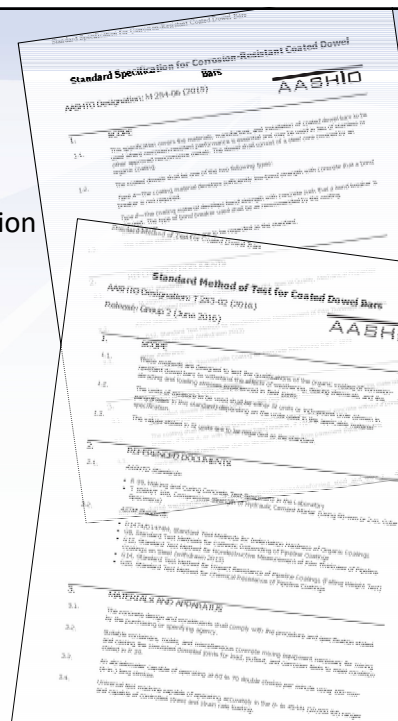
Pavement Engineering and Research Consultants, LLC
Special Consultant to ACPA National

National Concrete Consortium Fall 2023 Meeting

Portland, Oregon
September 12, 2023

Current AASHTO Dowel Specs

- M 254 – Standard Specification for Corrosion-Resistant Coated Dowel Bars (last revised 2006, reapproved 2019)
 - "... specification covers the materials, manufacture and installation of coated dowel bars to be used where corrosion-resistant performance is essential ...
 - "[t]he *dowel shall consist of a steel core covered by an organic coating.*" (Emphasis added)
 - *Dowels qualified as individual products, not as part of a system.*
- T 253 – Standard Method of Test for Coated Dowel Bars (last revised 2002, reapproved 2020)
 - "... methods to test the qualifications of the organic coating of corrosion-resistant dowel bars ... and the abrading and loading stresses experienced in field joints."



Limitations of Current AASHTO Dowel Specs

- Not directly applicable to many dowel products being used and developed today
 - Can't evaluate different dowel materials
 - Different tests needed for different materials, different coatings
 - Can't evaluate behavior of groups of dowels (including effects of nonuniform spacing)

Difficult for manufacturers to innovate.
Difficult for agencies to adopt new products.



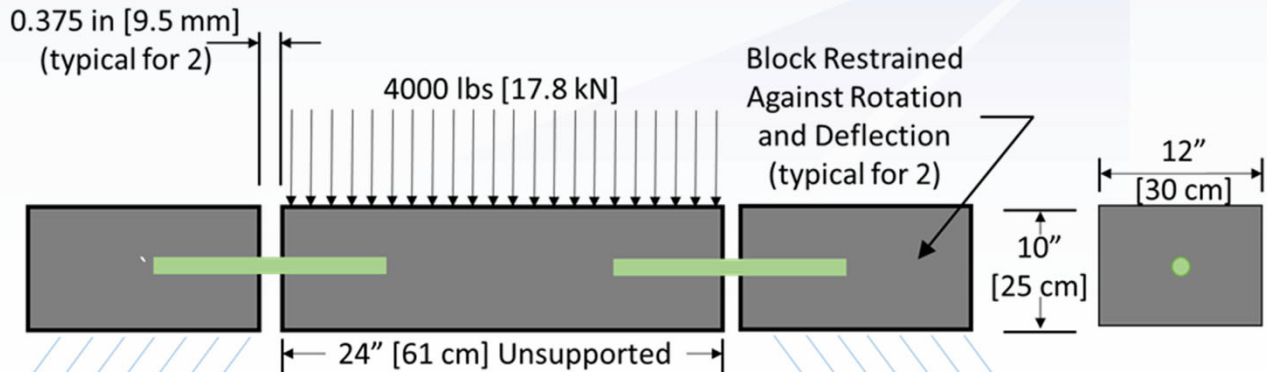
Specification Development

- Origins in NCC Dowel Bar Task Force 2.0 (formed Spring 2014 NCC Meeting, Jacksonville, FL)
 - Earlier NCC Dowel Bar Task Force Work goes back to at least 2010!
- NCC funded research into load-deflection testing in 2019 and 2021. ACPA provided tech support funding.
- Original Goals:
 - Develop load-deflection test protocol for dowel groups, and
 - Incorporate protocol in new spec based on AASHTO T253 and M254
- Revised scope:
 - Review and update entire T253 and M254 specs to produce single set of specifications applicable to all current pavement dowel systems.

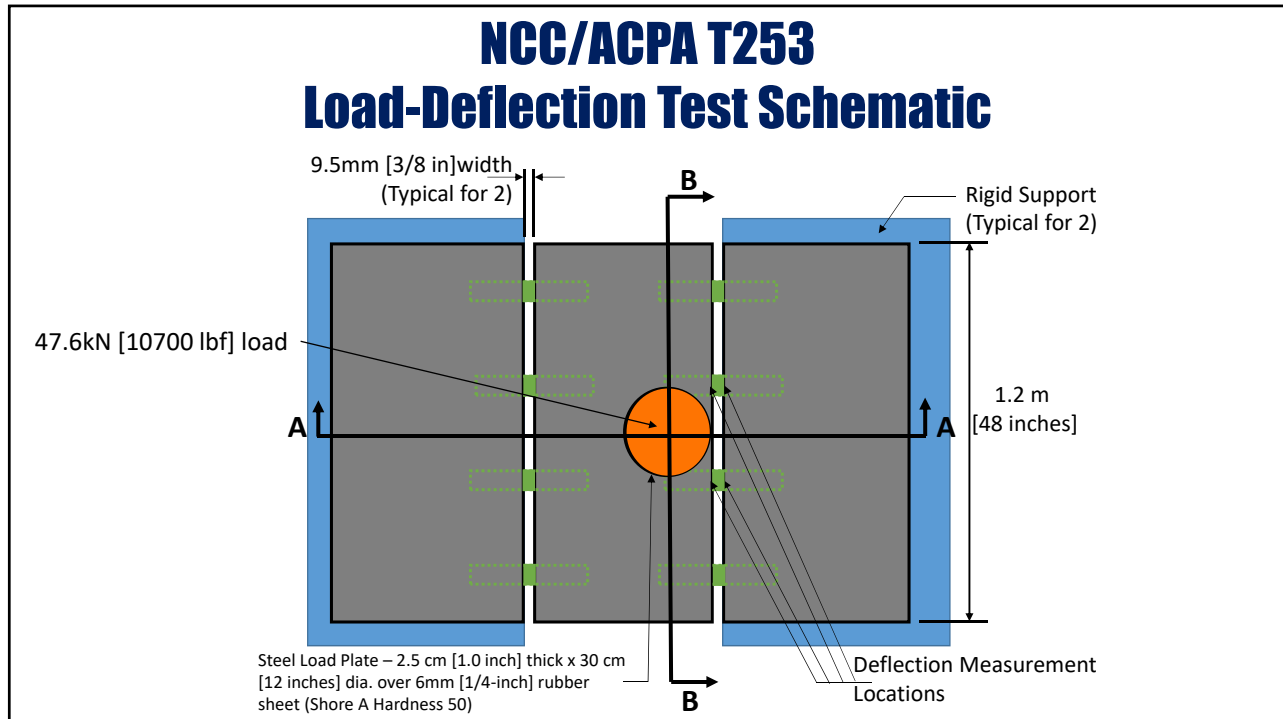
Specification Development Committee

- Barragan, Bryan
 - Eder, Glenn
 - Fannin, Neal
 - Eric Ferrebee
 - Golish, Rob
 - Gremel, Douglas
 - Masten, Maria
 - Mather, Mike
 - McMullen, Kevin
 - Meskis, Ron
 - Mu, Feng
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 - Schenk, Chris
 - Snyder, Mark (lead author)
 - Trautman, Brett
 - Voigt, Gerald
 - Zaun, Brad
- OWENS CORNING
 - AMERICAN HIGHWAY
 - PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
 - AMERICAN CONCRETE PAVEMENT ASSOCIATION
 - MINNESOTA DEPARTMENT OF TRANSPORTATION
 - OWENS CORNING
 - MINNESOTA DEPARTMENT OF TRANSPORTATION
 - ARTAZN
 - WISCONSIN CONCRETE PAVEMENT ASSOCIATION
 - AMERICAN HIGHWAY
 - PNA CONSTRUCTION
 - COMMERCIAL METALS CORP.
 - O-DOWEL
 - PERC, LLC
 - MISSOURI DEPARTMENT OF TRANSPORTATION
 - AMERICAN CONCRETE PAVEMENT ASSOCIATION
 - MASTER DOWEL

Current AASHTO T253 Load-Deflection Test Schematic



Performance criterion: Limit relative deflection across joints to 10 mils (0.01 inches).



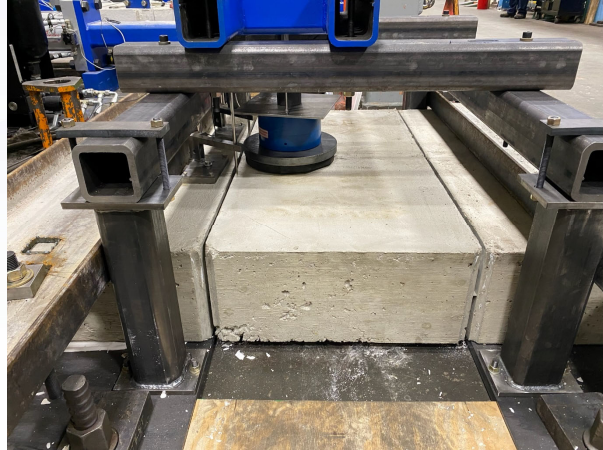
2022 Test Program (sequel to 2020 testing)

- Conducted at CTLGroup Labs (Skokie, IL)
- NCC/CPTech-funded Tests
 - 3 Standard AASHTO T253 (two 1.25-inch dowel, one 1.5-inch dowel)
 - 3 Modified T253 (two 1.25-inch dowel, one 1.5-inch dowel)
- Manufacturer Participation
 - Four manufacturers concurrently tested 9 additional modified tests of various dowel types and sizes at their own expense
 - Shared data for spec development purposes
- **Testing Completed May 27, 2022**
- **Re-testing of AASHTO Specimens completed early 2023**

Testing Specimens (May 23-24, 2022)



AASHTO T253



ACPA (Modified) T253

Test Results – AASHTO T253

2022 Testing

SPECIMEN	Load, Hold Time		
	4000 lbs, t = 0		
	Rel. Deflections, mils (0.001 in)		
	Joint 1	Joint 2	Avg.
1.25in-E	1.5	4.8	3.1
1.25in-F	3.0	N/A	3.0
1.5in	N/A	2.3	2.3

- $RD_{(avg, 1.25\text{ in})} = 2.7\text{ mils (n=10)}$
- $\Delta RD\text{ (hold)} = 0.2\text{ mils (n=7)}$
- $RD_{(1.5\text{ in})} = 2.3\text{ mils (n=1)}$
- Data make sense!
 - Larger diameter = smaller RD
 - Slight increase with hold

2020 Testing

SPECIMEN	Load, Hold Time					
	4000 lbs, t = 0			4000 lbs, t = 10 mins		
	Relative Deflections, mils (0.001 in)					
	Joint 1	Joint 2	Avg.	Joint 1	Joint 2	Avg.
1.25in-A	1.4	3.8	2.6	1.7	4.0	2.9
1.25in-B	2.9	2.7	2.8	3.0	2.8	2.9
1.25in-C	2.1	2.0	2.1	2.2	2.1	2.2
1.25in-D	2.8	N/A	N/A	3.0	N/A	N/A
Average	2.3	2.8	2.5	2.5	3.0	2.7

Note:
RD limit = 10 mils (per AASHTO T523)

Test Results – NCC/ACPA Test (Multiple Dowels)

SPECIMEN	Load, Hold Time											
	9000 lbs (no hold)			10700 lbs, t = 0 mins			10700 lbs, t = 10 mins			13500 lbs (cycle 10, no hold)		
	Relative Deflections, mils (0.001 in)											
	LVDT 1	LVDT 2	Avg.	LVDT 1	LVDT 2	Avg.	LVDT 1	LVDT 2	Avg.	LVDT 1	LVDT 2	Avg.
1.25in-A, Jt 1	1.7	2.1	1.9	2.1	2.5	2.3	2.4	2.8	2.6			
1.25in-A, Jt 2	1.9	3.0	2.5	2.6	3.7	3.1	2.8	3.8	3.3	4.0	5.9	4.9
1.25in-B, Jt 1	1.3	2.3	1.8	1.9	2.6	2.3	2.3	2.8	2.6			
1.25in-B, Jt 2	N/A	N/A		N/A	N/A		N/A	N/A		N/A	N/A	
1.25in Average	1.6	2.5	2.1	2.2	2.9	2.6	2.5	3.1	2.8	4.0	5.9	4.9
1.50in, Jt 1	1.0	1.3	1.2	1.2	1.7	1.5	1.3	1.7	1.5			
1.50in, Jt 2	N/A	1.7	1.7	N/A	2.4	2.4	N/A	2.0	2.0	N/A	1.8	1.8
1.50in Average	1.0	1.5	1.4	1.2	2.0	1.8	1.3	1.9	1.7	N/A	1.8	1.8

- Data generally makes sense (and are consistent with AASHTO test results)!
 - Size effects ($RD_{avg, 1.25\text{ in}} = 2.6\text{ mils @ }10700\text{ lbs}$; $RD_{avg, 1.5\text{ in}} = 1.8\text{ mils @ }10700\text{ lbs}$)
 - Hold effects ($\Delta RD = 0.2\text{ mils}$ for 1.25-in dowels – same as for AASHTO test)
 - Cycling effects (RD increase with cycling)
 - Overload effects (RD increase with higher load for 1.25-inch dowels)



Conclusion

- New NCC/ACPA Dowel Test can be used to evaluate alternate dowel systems (at 10700 lbs test load) using AASHTO T253 structural test criteria (10 mils relative deflection criterion).

BUT ... a caveat ...

- Structural test criteria should be varied with:
 - Equivalent cylindrical steel dowel size
 - Functional, traffic, environmental and structural conditions at project site.

Comparing AASHTO and NCC/ACPA M254 Specs – Dowel Types

1.2 The coated dowels shall be one of the two following types:

Type A – Coating material develops low bond strength with concrete – no bond breaker required.

Type B – Coating material develops bond strength with concrete – bond breaker is required.

1.2 Dowels are categorized according to primary material type (metallic or nonmetallic) and the type of corrosion protection coating used (e.g., none, metallic, or nonmetallic) – regardless of [dowel shape] – using the following type designations:

- *Type A* – The dowel comprises a single uncoated metallic material (e.g., carbon steel, low-carbon chromium steel, stainless steel, or other metallic alloys).
- *Type B* – The dowel comprises a single uncoated non-metallic material (e.g., FRP).
- *Type C* – The dowel has a metallic core and is coated, clad or sleeved with a different metallic material (e.g., stainless steel or zinc alloy cladding/sleeving of a carbon steel core).
- *Type D* – The dowel has a metallic core and is coated, clad or sleeved with a non-metallic material (e.g., epoxy-coated, plastic/polyethylene-coated and FRP-clad carbon steel dowels).

Comparing AASHTO and NCC/ACPA M254 Specs – Dimensions

5.1 Core metal shall be 1.25-in diameter or as specified.

5.2 Nonabraded thickness of coatings:

Type A: 25 ± 5 mils.

Type B: 7 ± 2 mils

5.3 Coating thickness determined using ASTM G12 or by stripping coating from bar.

5.4 Supply dowels in lengths and assemblies or baskets as specified.

5.1 Dowel bar dimensions as specified. Dimensions measured before application of coating or cladding materials except for D1 (CRT dowel – measured before cladding and overall diameter after cladding).

5.1.1 Solid cylindrical dowels – specify min length and min diameter. For D1, specify min core diameter and min overall diameter.

5.1.2 Solid elliptical dowels – specify min length and min required lengths of ellipse section axes.

5.1.3 Tube and pipe dowels – specify min length, wall thickness, and overall diameter.

5.1.4 Plate dowel systems – min required and max allowable plate thickness and all other dimensions to accurately define plate shape

5.1.5 Other dowel shapes – agency calls out structural or behavioral equivalency (e.g., EI or deflection results) of solid steel cylindrical dowel (e.g., 1.25-inch diameter round steel equivalent).

5.2 For Type C and D systems - non-abraded minimum thickness of coated systems shall be sufficient to resist corrosion and impact damage when tested in accordance with NCC/ACPA T253-21. Determine coating thickness according to ASTM D7091 or by measuring with high-precision calipers after cutting the bar across its section or stripping the coating from the bar.

Comparing AASHTO and NCC/ACPA T253 Specs – Concrete Mix for Tests

3.1 The concrete design and constituents shall be specified by the agency.

3.1 The concrete mix design and constituents shall comply with the following:

- 3.1.1 Type I, Type II or Type I/II cement conforming to ASTM C150/C150M.
- 3.1.2 Coarse and fine aggregate conforming with ASTM C33, with coarse aggregate meeting Gradings 57 and 67 and conforming to Class 4S (ASTM C33, Table 4).
- 3.1.3 Air-entrained concrete proportioned using ACI 211.1 procedures using 517 ± 5 lb/yd³ of concrete to produce concrete with $3\frac{1}{2} \pm \frac{1}{2}$ in. slump and 6.0 ± 1.0 percent air content.

Comparing AASHTO and NCC/ACPA T253 Specs – Pullout Test

- AASHTO requires initial $\frac{1}{2}$ -inch pullout after 48 hours, 12 days added curing, 50 cycles of freeze-thaw while half-submerged in deicing chemicals (1 cycle per day), then additional $\frac{1}{2}$ -inch pullout.
 - Approximately 54 days

Photo courtesy of
American
Engineering Testing

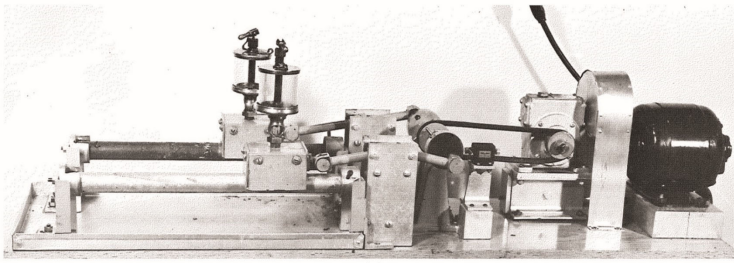


- NCC/ACPA requires only initial test (2-3 days); freeze-thaw and added pullout is agency option. Also specifies minimum concrete mould-dowel cover.

AASHTO and NCC/ACPA T253 Specs – Corrosion-Abrasion

AASHTO:

- Required for all dowels.
- Abrading block fits over about 1/3 dowel perimeter



NCC/ACPA:

- Type A (Uncoated metal) – Corrosion test only.
- Type B (Solid FRP) – Abrasion test only.
- Types C and D (coated and clad metal) – Both abrasion and corrosion tests.
- Abrading block covers standard area, regardless of dowel size/shape

Comparing AASHTO and ACPA T253 Specs – Corrosion-Abrasion

AASHTO:

- After abrasion, determine loss of coating thickness.
- Partially submerge abraded dowels in 10% NaCl for 50 cycles of freeze-thaw.
- Examine for corrosion under 5x magnification.

NCC/ACPA:

- After abrasion, determine loss of coating thickness (Types C and D) *or change in diameter (Type B only)*.
- Partially submerge Type A and abraded Types C and D dowels in 10% NaCl for 50 cycles of freeze-thaw.
- Examine for corrosion under 5x magnification.
- *Determine percentage of expansion due to corrosion.*

Comparing AASHTO and NCC/ACPA T253 Specs – Other Requirements

Chemical Resistance Test:

Test 3 replicate specimens, with and without holidays in each of 4 reagents, with and without holidays (as req'd by ASTM G20).

Cathodic Disbondment Test:

Consistent with ASTM A775 Annex

Coating Impact Resistance Test (Type D only):

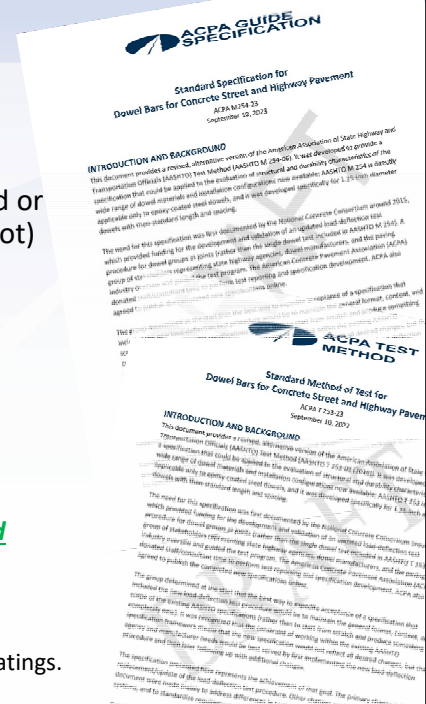
Consistent with ASTM A775 Annex

Coating Hardness Test:

Deleted. A method for determining “indentation hardness of organic materials such as dried paint, varnish and lacquer coatings applied to an acceptable plane, rigid surface, for example metal or glass.”

New ACPA Dowel Specifications

- M 254 – Standard Specification for Dowel Bars for Concrete Pavement
 - Specification developed to address the requirements for manufacture and installation of all types of dowel bars (coated or not, corrosion-resistant or not, cylindrical or not, metallic or not) intended for use in concrete pavements.
 - Dowels qualified as engineered load transfer systems, not as individual products.
- T 253 – Standard Method of Test for Dowel Bars for Concrete Pavement
 - Methods to test:
 - Structural behavior of dowel load transfer systems using modified protocol
 - Ability of dowels to withstand the effects of weathering, de-icing chemicals, abrasion and other measures of dowel durability.
 - Suite of applicable durability tests varies with dowel materials and coatings.



Specification Caveats and Context

- New specs always intended to update but mirror current AASHTO specs
 - Main goal was to incorporate load-deflection test protocol for dowel groups and to maintain scope and format of current AASHTO specs
 - Acceptance values provided only for load-deflection and pullout test (same values as before)
 - Notes provide some guidance to agencies for establishing different acceptance values for load-deflection test (e.g., for different dowel sizes, different types of roads, etc.)
 - If current AASHTO spec didn't provide an acceptance criterion for a specific test, neither does new spec.
- No attempt made to categorize dowels or test results as “good” “better” “best”
 - Agencies are capable of making these determinations (perhaps with some guidance) for their design conditions
 - Adding such labels would create resistance to implementation and defeat the purpose of the effort.

Next Steps

- Specs are available for review and comment at:
 - <https://www.acpa.org/expert-help/technical-service/>
 - Direct review comments to: mbsnyder2@gmail.com
- Implementation - Agency “champions” promote new specifications to AASHTO for adoption
- Engage NTPEP for use of new specifications and tests for single-source testing of dowel products

Thank You For Your Attention!

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