AGC/WSDOT Structures Team – Meeting Minutes
(March 2, 2023)

Attendees

[1] **Team co-chair**

Regular Attendees				
	Member	**Company**	**Phone**	**E-mail**
X	Allen, Buck	Hamilton Const.	360-742-3326	BALLEN@HAMIL.COM
X	Bowles, Eric	Conc. Tech.	253-383-3545	EBOWLES@CONCRETETECH.COM
X	Bressan, Michael	WSDOT-Const.	360-705-7828	BRESSAM@WSDOT.WA.GOV
X	Cucchiara, Kevin	Quigg Bros.	360-580-0015	KEVINC@QUIGGBROS.COM
X	Cuthbertson, Jim[1]	WSDOT-Const.	360-870-1108	CUTHBEJ@WSDOT.WA.GOV
X	Fraser, Corey	Concrete Pipe NW	210-445-0133	CFRASER@CONCRETEPIPE.ORG
X	Glassford, Patrick	WSDOT-Bridge	541-973-8525	GLASSFP@WSDOT.WA.GOV
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	Griffith, Steve	RMA Group	971-263-0611	SGRIFFITH@RMACOMPANIES.COM
	Helvey, Bryant	Graham	206-718-7266	BRYANT.HELEVY@GRAHAMUS.COM
X	Hunt, Neil[1]	The Walsh Group	206-348-1726	NWHUNT@WALSHGROUP.COM
	Johnson, Blake	Knife River PC	509-934-0286	BLAKE.JOHNSON@KNIFERIVER.ORG
X	Kane, Ed	WSDOT-NWR	425-225-8743	KANEED@WSDOT.WA.GOV
X	Moore, Stuart	Atkinson	360-340-6797	STUART.MOORE@ATKN.COM
X	Olson, Ryan	Granite Const.	206-793-8110	RYAN.OLSON@GCINC.COM
	Owen, Geoff	Kiewit IWCo.	360-609-6548	GEOFF.OWEN@KIEWIT.COM
	Quigg, John	Quigg Bros.	360-533-1530	JOHNQ@QUIGGBROS.COM
X	Lance Rasband	Michels	206-305-3386	LRASBAND@MICHELS.US
X	Rider, Kelli	Manson Const.	206-516-9576	KRIDER@MANSONCONSTRUCTION.COM
	Robinson, Eric	WSDOT-WSF	206-515-3897	ROBINSE@WSDOT.WA.GOV
	Schettler, Jim	Jacobs	425-239-7542	JIM.SCHETTLER@JACOBS.COM
	Smith, Will	WSDOT-SCR	509-577-1804	SMITHW@WSDOT.WA.GOV
	Stegeman, Dave	Kiewit IWCo.	253-255-2373	DAVID.STEGEMAN@KIEWIT.COM
X	Swett, Geoff	WSDOT-Bridge	360-705-7157	SWETTG@WSDOT.WA.GOV
	Thody, Ryan	DBM Contractors	206-870-3525	RYAN.THODY@DBMCONTRACTORS.COM
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X	Venn, Gary	Jensen Precast	253-929-1811	GVENN@JENSENPRECAST.COM
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X	Watts, Troy	WSDOT-OR	253-255-8215	WATTST@WSDOT.WA.GOV
	Welch, Pete	Granite Const.	425-551-3100	PETE.WELCH@GCINC.COM
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Guests			
Almaaroof, Yousif	WSDOT Bridge	360-705-7395	Almaary@wsdot.wa.gov

Agenda

9:00	**Welcome / Around the table intros, ice breaker.**	Cuthbertson/All
9:05	**Safety Briefing**	Cuthbertson/All
9:10	**Review of Agenda/Prior Minutes**	Cuthbertson
9:30	**Rock Excavation for Shafts**	Bressan
9:45	**Bridge Deck Flatness Test (6-02.3(10)D3)**	Troy Watts
10:00	**Timber Connections (6-02.3(17)I)**	Glassford
	ADDED TOPIC - Barriers	Swett
10:30	**Select Next Meeting Times / Adjourn**	All
	DEFERRED ITEMS **Geofoam Fill GSP – Michael Bressan** Work on taking a number of project specific special provisions and converting them into a Standard Specification with supporting GSPs. **Fiber Reinforced Bridge Deck Study (2023briefing at earliest) – Anthony Mizumori** The Bridge office has two pilot projects identified. Each project has a pair of bridges. The plan is to use fiber reinforced concrete on one and regular class 4000 concrete for bridge decks on the other. The two projects are: Purdy Creek which has not been advertised yet and 009786 I-90 Cabin Ck I/C to west Easton executed 07/18/22. **6-02.3(25) and (26) Const. Manual Updates – Scott Sargent→Michael Bressan** Michael needs to check the status and finish this up.	

1. Welcome / Review of Agenda

Jim started the meeting promptly at 9:00. Apologized for having virtual meetings, and proposed keeping the virtual format until more WSDOT staff return to buildings making conference rooms more readily available and reception staff can allow building entry. The team did introductions.

2. Approval of Previous Meeting Minutes

No comments on previous minutes.

3. Review Of Agenda

Jim made a request for new topics and informed the group that Geoff Swett wanted to add a topic about bridge Barriers to the meeting.

4. Rock Excavation

Michael Bressan stated that we had two projects that have rock excavation in them that he wanted to discuss. One is SC Region 009786 I-90, Cabin Creek I/C To W Easton I/C Phase 3. The project had six foot diameter shafts with about 150 LF of rock excavation, 110 LF of rock ex for seven foot shafts, and 60 LF for four foot shafts. All of the rock excavation was paid for under one standard item 4009 ROCK EXCAVATION FOR SHAFT INCLUDING HAUL. The second project is OLY Region 009891 US 101, Elwha River Bridge Replacement. The project had 250 LF of rock excavation for five foot diameter and 10 foot diameter bridge shafts with another 435 LF of rock excavation for two foot shafts associated with a soldier pile wall. Again, the one standard item was used in the project. Neither project made a differentiation in the payment item for the various sizes of shafts being constructed. The WSDOT Standard Specifications contains a payment for rock excavation that is in addition to the Constructing ___ Diam. Shaft item.

> Payment for "Constructing___Diam. Shaft" will be made upon Engineer acceptance of the shaft, including completion of satisfactory QA shaft tests as applicable.
>
> "Rock Excavation For Shaft Including Haul", per linear foot.
>
> When rock excavation is encountered, payment for rock excavation is in addition to the unit Contract price per linear foot for "Constructing___Diam. Shaft"

One of our drilled shaft contractors asked if WSDOT could differentiate the rock excavation by shaft size on future contracts stating that often different equipment and tooling is used depending upon the diameter and length of rock excavation required. The equipment drilling two-foot soldier piles is not the same equipment drilling eight foot bridge shafts. Michael asked the team if they supported making the payment specific to diameter. Lance Rasband supported the proposal. Stuart Moore, stated each driller sub had different pricing and it made it hard for them to distinguish which sub had the best pricing for them. Troy Watts spoke up for the Region's acknowledging the need to differentiate especially when needing to determine an equitable adjustment for quantity variations. Neil Hunt supported the change too.

5. Bridge Deck Flatness Test

This is actually a topic that Bryant Helvey of Graham wanted to discuss. Troy suggested that since Bryant was not here today that we defer to another time.

6. Timber Connections

Patrick Glassford and Yousif Almaaroof have been looking at our standards for formwork and false work. We currently require that the Timber Construction Manual, Third Edition by the American Institute of Timber Construction (AITC) be used when designing timber connections, see Standard Specs section 6-02.3(17)I Timber Connections. Patrick felt that this reference is outdated (1985) and wanted suggestions from the team on a more current manual or method. Several members mentioned they use the 2018 National Design Specification (NDS) for Wood Construction that was developed by the American Wood Council's (AWC) Wood Design Standards Committee and has been approved by ANSI as an American National Standard. Yousif mentioned that the Bridge office was considering requiring the American Concrete Institute's ACI SP-4 14 Formwork for Concrete 8th Edition, but review of recent submittals indicate that most contractors use the NDS. The team agreed that the NDS manual was the way to go.

7. Traffic Barriers (added topic)

Geoff Swett wanted to discuss the development and revision of some standard plans for 42-inch single slope barriers. Bridge is also updating the approach slab standard plans. Geoff had questions about the preferred geometry of the barrier below the curb line. Bridge could retain the 4:21 slope as a single plane all the way to the bottom of the barrier, or they can have an angle point at the curb line and have a vertical surface for the embedded portion. Geoff wanted to know what was preferred. The vertical option would make forming more difficult but may work better in some applications when constructing surfacing. Most of the Team preferred maintaining the slope and not having a vertical portion, but Kelly Griffith pointed out that when concrete roadway is constructed the roadway panel has a vertical edge. In that case, having a corresponding vertical surface on the barrier is best so the two elements can be snugged-up against each other, but the vertical does create issues with the reinforcing. The question was asked does it matter if the barrier is being slip formed, cast-in-place, or is precast. The team stated that the slip forming often has height limitation and what often happens is the bottom of the barrier below finish grade is CIP up to a certain elevation, then the slip form comes along and finishes the barrier, so the bottom geometry may not matter much when slip forming, but it could require a two-step operation. For CIP or Precast, bottom geometry wouldn't matter as much. With moment slabs, the continuous slope option to the top of the moment slab is preferred.

8. Next Meeting

Kelly Griffith suggested future topics for other meetings:

- Girder sweep. The changes to the girder sweep specifications for an eastern region job are very expensive as they require an engineer to check sweep for each girder as it is produced, rather than using plant personnel. They also require a licensed land surveyor. Kelly thought his surveyors who set grade on bridge decks and are unlicensed could perform a girder sweep survey just as accurately and they are unlicensed. Is the license really needed?

- A related sweep issue has to do with BNSF. BNSF will not allow the setting of girders that are out of tolerance, but WSDOT does have a process by which out of spec girders can be placed and corrected or left in place if calculations show the girder is structurally acceptable. This conflicts with BNSF and has caused issues on recent jobs.

- BNSF Submittals, BNSF has a number of different submittals that are required when performing work over or around their rail lines. Kelly pointed out that the WSDOT requirements and the railroad requirements are not necessarily in agreement. Wind loading is requested by BNSF in places where WSDOT does not require it, just an example.

Jim Cuthbertson suggested that we never finished the bracket loading issue we discussed earlier with Anthony Mizumori of Bridge.

Stuart Moore asked if we ever revised the technical requirements for CSL testing on Design Build projects. Jim Cuthbertson needs to check on this.

Next Meeting → April 13

Notes by Jim Cuthbertson

AGC/WSDOT Structures Team – Meeting Minutes
April 13, 2023

Attendees

[1] Team co-chair

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Present	**Member**	**Company**	**Phone**	**E-mail**
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	Fraser, Corey	Concrete Pipe NW	210-445-0133	CFRASER@CONCRETEPIPE.ORG
X	Griffith, Kelly	Max J. Kuney	509-535-0651	KELLY@MAXKUNEY.COM
	Griffith, Steve	RMA Group	971-263-0611	SGRIFFITH@RMACOMPANIES.COM
X	Helvey, Bryant	Graham	206-718-7266	BRYANT.HELEVY@GRAHAMUS.COM
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	Robinson, Eric	WSDOT-WSF	206-515-3897	ROBINSE@WSDOT.WA.GOV
X	Smith, Will	WSDOT-SCR	509-577-1804	SMITHW@WSDOT.WA.GOV
	Swett, Geoff	WSDOT-Bridge	360-705-7157	SWETTG@WSDOT.WA.GOV
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Guests			
Dyer, Bob	WSDOT-Const	N/A	dyerb@wsdot.wa.gov
Jewell, Sam	Knife River PC	N/A	Sam.Jewell@kniferiver.com

Agenda

9:00	Bob Dyer will review changes to Modified Concrete Overlays	Dyer

1 Welcome / Review of Agenda

Jim Cuthbertson welcomed everyone and stated that we would be having a short meeting today as we really only had one topic to cover and that was to review and provide comments on edits that Bob Dyer had been making to the WSDOT Standard Specifications for Modified Concrete Overlays.

2 Approval of Previous Meeting Minutes

No comments were provided on the previous meetings minutes.

3 Modified Concrete Overlays

Bob Dyer did a page turn presentation walking the team through proposed changes to division 6-09 of the Standard Specifications. The current (2023) version of that section covers multiple overlay materials within one specification. Bob has been working on separating the specification into material specific specifications. For the 2024 version of the Standard Specifications, WSDOT plans to eliminate section 6-09 making it Vacant and adding two new Sections: 6-21 Modified Concrete Overlay - Microsilica or Fly Ash and 6-22 Modified Concrete Overlay – Latex. Each new section will also have new GSPs that are associated with them.

Documents containing the proposed edits were sent to the team on April 5, 2023 for review prior to the meeting. Bob went through each page with the Team. Due to the volume of changes the Team did not provide a lot of editorial comments. There were questions about certain elements were structures or grouped the way they were in the specification. Bob explained his logic and asked the team to mark up the documents with their comments and suggestions and return them by April 21.

Notes by Jim Cuthbertson

AGC/WSDOT Structures Team – Meeting Minutes
May 25, 2023

Attendees

[1] Team co-chair

Regular Attendees				
Initials	**Member**	**Company**	**Phone**	**E-mail**
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X	Bressan, Michael	WSDOT-Const.	360-705-7828	BRESSAM@WSDOT.WA.GOV
	Cucchiara, Kevin	Quigg Bros.	360-580-0015	KEVINC@QUIGGBROS.COM
X	Cuthbertson, Jim[1]	WSDOT-Const.	360-870-1108	CUTHBEJ@WSDOT.WA.GOV
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X	Glassford, Patrick	WSDOT-Bridge	541-973-8525	GLASSFP@WSDOT.WA.GOV
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	Johnson, Blake	Knife River PC	509-934-0286	BLAKE.JOHNSON@KNIFERIVER.ORG
	Kane, Ed	WSDOT-NWR	425-225-8743	KANEED@WSDOT.WA.GOV
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	Lance Rasband	Michels	206-305-3386	LRASBAND@MICHELS.US
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	Venn, Gary	Jensen Precast	253-929-1811	GVENN@JENSENPRECAST.COM
	Watt, Doug	CJA	425-988-2150	DWATT@CONDON-JOHNSON.COM
X	Watts, Troy	WSDOT-OR	253-255-8215	WATTST@WSDOT.WA.GOV
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Guests			
Aldrich, Brian	WSDOT Bridge	360-705-7217	ALDRICB@wsdot.wa.gov
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Mediate, Vincent	HNTB	817-395-3208	MediatV@consultant.wsdot.wa.gov

Agenda

8:00 (15 min)	**Welcome / Around the table intros, ice breaker.**	Cuthbertson/All
8:15 (5 min)	**Safety Briefing**	Cuthbertson/All
8:20 (5 min)	**Review of Agenda/Prior Minutes**	Cuthbertson
8:25 (35 min)	**Project Review - US2/SR9 Bunk Foss Realignment Alternative (WDFW ID#932428)**	John Chi
9:00 (60 min)	**Bridge Office Standard Plan Reviews** **E-20.10 – Buried Structure – Split Box** **D-20.10 – Precast Reinforced Concrete Retaining Wall** **A-40.50 – Bridge Approach Slab** **C-81.10 – 42" Single Slope Concrete Barrier** **C-81.15 – 42" Single Slope Traffic Barrier Moment Slab (TL-4)**	Geoff Swett
10:00 (60 min)	**Specification Reviews** **2-03 GSP Geofoam (in progress)** **2-09 Structure Excavation** **6-02 Concrete Structures** **6-19 Shafts** **6-22 Modified Concrete Overlays - Latex** **6-21 Modified Concrete Overlay – Microsilica or Fly Ash** **6-23 Modified Concrete Overlay – Polyester (GSP due Sept)**	Michael Bressan
11:00	**Select Next Meeting Times / Adjourn**	All
	DEFERRED ITEMS **Geofoam Fill GSP – Michael Bressan** Work on taking a number of project specific special provisions and converting them into a Standard Specification with supporting GSPs. **Fiber Reinforced Bridge Deck Study (2023briefing at earliest) – Anthony Mizumori** The Bridge office has two pilot projects identified. Each project has a pair of bridges. The plan is to use fiber reinforced concrete on one and regular class 4000 concrete for bridge decks on the other. The two projects are: Purdy Creek which has not been advertised yet and 009786 I-90 Cabin Ck I/C to west Easton executed 07/18/22. **6-02.3(25) and (26) Const. Manual Updates – Scott Sargent→Michael Bressan** Michael needs to check the status and finish this up.	

1. Welcome / Around the table intros, ice breaker.

Jim Cuthbertson started the meeting at 8:00. We did an around the roster introduction for those in the meeting, but we did not do an ice breaker.

2. Safety Briefing

Jim Gave a brief safety meeting and since we were virtual, reminded everyone to follow their own safety procedures in the event of an emergency. Jim also noted that in Lacey, he has noticed a lot of hornet and wasp activity as they seem to be building nests furiously around the house. He encouraged everyone to take 5 minutes out of their day and watch a you tube video on how to administer EpiPen shots as many people who have severe allergies to hornets, wasps, and bees may not be able to administer a shot to themselves. Often people who are at severe risk will carry their own EpiPens. Here is a link to Nationwide Children's video on EpiPen use: https://youtu.be/EN83hen4D-Y or https://www.nationwidechildrens.org/family-resources-education/health-wellness-and-safety-resources/resources-for-parents-and-kids/how-to-use-an-epipen

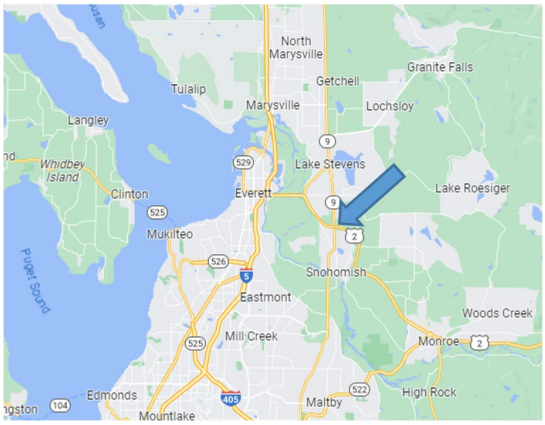
3. Review of Agenda/Prior Minutes

Jim reviewed the agenda and asked for comments on the March minutes which were included in the meeting request. No comments were provided.

4. Project Review - US2/SR9 Bunk Foss Realignment Alternative (WDFW ID#932428)

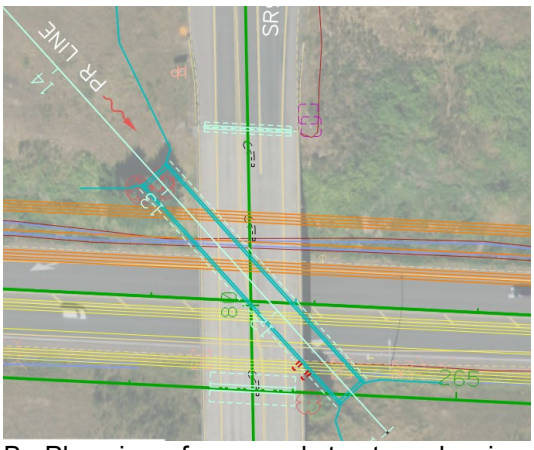
Vincent Mediate, HNTB - Presented

The project is located east of Everett WA, where US2 and SR9 intersect, see detail A. The project is a fish barrier removal project where the stream crosses through a diamond interchange. The team has selected a new fish passable structure type and sited the structure to minimize the number of stream crossings through the interchange, but the selected location places the new fish passable structure beneath the bridge which carries SR9 over US2.



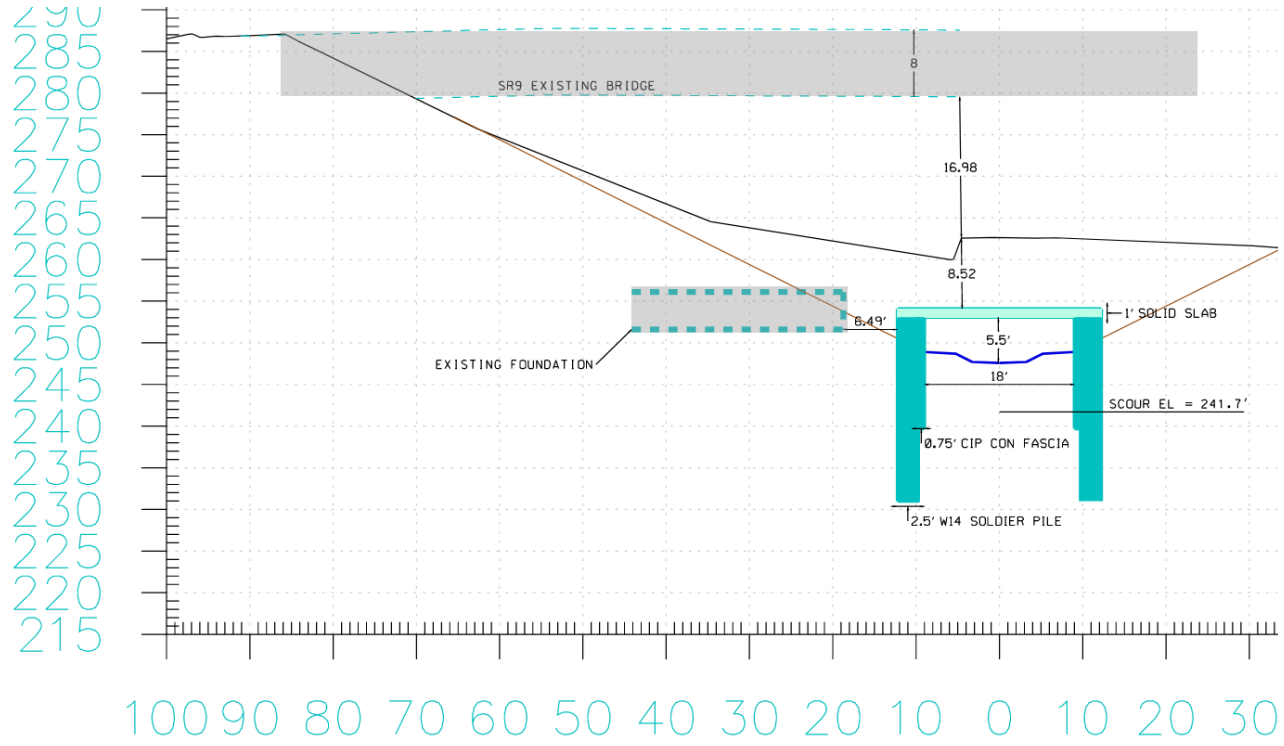
A - Location of project indicated by the arrow.

The new structure is planned to have a hydraulic opening width of 18-feet and a hydraulic length of 180-feet and will be at an approximate 45-degree angle relative to the existing SR9 bridge structure it passes beneath, see detail B. The construction concept is to shift US2 traffic to the north, as depicted by the orange lines. Then construct the southern half of the structure. Traffic would then be rerouted south to run over the newly constructed structure as depicted by the yellow lines while the northern half of the structure is constructed.



B - Plan view of proposed structure showing SR9 crossing US2.

The SR9 bridge is spread footing supported. The two abutment footings for that structure are located at different elevations. The northern abutment rests within the approach embankment. The southern abutment is located much lower in elevation and will be above the thalweg elevation of the new stream. The current concept consists of two, parallel, soldier pile walls forming the length of the structure upon which a flat slab will rest forming a lid, see detail C on the next page.



C – Cross section through structure showing proximity to foundation and superstructure.

Vertical clearance to construct the soldier piles under the SR9 bridge is a concern for the design team. Clearance is about 17 feet, with excavation to the lid that clearance can be increased to about 25 feet, but that is probably not enough clearance to avoid splicing soldier piles. The Structures team asked why this had to be a soldier pile system and what prevented this from being a precast buried structure? Vincent indicated it was the proximity of the abutment footing and soldier piles were selected so that they didn't need to install a shoring wall in addition to the structure. The selected structure type was self-shoring. It was pointed out that the footing conflict was only for a limited length and that shoring for the footing could probably be used enabling a precast structure to be used.

The Structures team also asked about changing the alignment and getting the new structure out from under the bridge. The design team acknowledged that they were considering that, but the goal was to minimize the number of crossings. Because of the diamond I/C additional crossings under the ramps would be needed. The structures team pointed out that they could use much smaller structures on an alternate alignment and could possibly construct the ramp crossings under a long weekend if precast buried structures were used. Crossing US2 could still occur using the staged concept presented with traffic shifted to the north, build the south half, shift traffic over the newly constructed southern half, and finish the constructing of the north half. Crossing SR9 may be more problematic though due to the fill height and proximity of the SB SR9 to WB US2 ramp terminal and intersection with Bunk Foss Rd.

The conversation with the contractors eventually went to them recommending a cast in place, buried, 4-sided structure, especially if there was enough room to shift traffic for the duration of time it would take to construct one half of a box structure. The recommendation was made because handling forms would be much easier with the limited headroom than handling precast units or installing soldier piles. With the option to shift traffic, time constraints associated with concrete curing may be less of a problem than is often the case for other fish passage projects.

One option that also was presented was using a corrugated metal plate structure which could be assembled in place using small equipment and hand tools rather than a CIP box or precast buried structure. Nobody really explored the option that was suggested.

In summary, the project as presented is constructible. The soldier pile walls will require specialized low clearance headroom equipment and the soldier piles may require splicing. The construction will be slow and the structure will be very expensive with the option presented. A precast buried structure may be feasible, but there would definitely be additional costs associated with temporary shoring near the bridge footing and along the centerline of US2 for the staged construction. An additional shoring wall will be required to retain some of the end slope fill from the North abutment of the SR9 bridge due to the need to shift traffic toward that abutment. That shoring wall is likely needed for all options that shift US2 traffic northward. If the project has the time, a CIP structure rather than a precast structure would drastically reduce the needed equipment and make construction under the bridge much easier. A longer wider structure could actually save money too, and the wingwalls could be much smaller.

5. Bridge Office Standard Plan Reviews

Geoff Swett and Brian Aldrich, WSDOT Bridge and Structures – Presented

The Bridge and structures office has been working to develop new standard plans for buried structures and they have been working to revise plans for bridge approach slabs and barriers. Geoff and Brian presented the following plans and briefly discussed some of the details associated with them. The plans are not reproduced and included as part of the notes since they are in draft form and the file sizes are quite large. They were distributed to team members for review and comment by e-mail within the meeting request.

E-20.10 – Buried Structure – Split Box
D-20.10 – Precast Reinforced Concrete Retaining Wall
A-40.50 – Bridge Approach Slab
C-81.10 – 42” Single Slope Concrete Barrier
C-81.15 – 42” Single Slope Traffic Barrier Moment Slab (TL-4)

Geoff noted that they are still working on developing a standard plan for three sided buried structures, but the buried structure plan presented at the meeting is for a four-sided split box. All of the plans are intended to work together to form a complete package for buried structures that can be used together or separately if needed. The plans are intended to provide a lot of options for contractors and precasters to choose from. Geoff included shipping and handling details on the plans for the precast units. None of the structures team had significant comments for Geoff on the buried structure or wall plans he presented or the barrier plans presented by Brian. The team did want to have a barrier option with a vertical bottom portion, and for the walls, a simplified “U” shaped gutter was requested. Brian plans to work on that for a future update. The team was encouraged to provide comments to Cuthbertson by June 2.

6. Specification Reviews

Michael Bressan, State Construction Office – Presented

Michael showed the team the specifications that he has been working on, listed below. Several of these had been shared with the team previously by Bob Dyer in the April team meeting, specifically changes to Modified concrete overlays and CDF and lean concrete in Division 2.

2-03 GSP Geofoam (in progress)
2-09 Structure Excavation
6-02 Concrete Structures
6-19 Shafts
6-22 Modified Concrete Overlays – Latex
6-21 Modified Concrete Overlay – Microsilica or Fly Ash
6-23 Modified Concrete Overlay – Polyester (GSP due Sept)

Michael explained that the modified concrete overlay specification will be divided into three separate specifications in the new 2024 issuance of the specifications book. Type 1L cement has been added to the specifications too and may be used where Type I or II Portland cement is used. Kelly Griffith pointed out that latex modified concrete is hard to work with, very expensive, and requires specialized equipment. He wanted assurance that contractors will still be able to select which type of overlay material is used. Michael indicated that in most cases yes, they will have options but there have been cases where an existing overlay was not to be completely removed and the new overlay type is required to be the same to be compatible with the existing. Instances of that should be rare though.

7. Select Next Meeting Times / Adjourn

Next Meeting June 29

Notes by Jim Cuthbertson

AGC/WSDOT Structures Team – Meeting Minutes
(September 14, 2023)

Attendees

[1] Team co-chair

Regular Attendees				
Present	**Member**	**Company**	**Phone**	**E-mail**
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	Cucchiara, Kevin	Quigg Bros.	360-580-0015	KEVINC@QUIGGBROS.COM
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Guests			
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Sadawi, Ben	MMFX Technologies/CMC	909-256-9555	BEN.SADAWI@CMC.COM
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Zeldenrust, Richard	WSDOT Bridge	360-705-7196	ZELDENR@WSDOT.WA.GOV

Agenda

9:00 (15 min)	**Welcome / Around the table intros, ice breaker.**	Cuthbertson/All
9:15 (5 min)	**Safety Briefing**	Cuthbertson/All
9:20 (5 min)	**Review of Agenda/Prior Minutes**	Cuthbertson
9:25 (35 min)	**ASTM A1094 GalvaBar Presentation**	Ben Sadawi Commercial Metals Co.
10:00 (15 min)	**GSP 6-02.3(25)J Prestressed Concrete Girders**	Rich Zeldenrust
10:15 (15 min)	**Precast Retaining Wall Standard Plans**	Geoff Swett
10:30 (15 min)	**GSPs 6-11 Reinforced Concrete Retaining walls**	Michael Bressan
10:45 (15 min)	**Shotcrete Changes and GSPs**	Michael Bressan
11:00	**Adjourn**	All
	DEFERRED ITEMS **Geofoam Fill GSP – Michael Bressan** Work on taking a number of project specific special provisions and converting them into a Standard Specification with supporting GSPs. **Fiber Reinforced Bridge Deck Study (2023briefing at earliest) – Anthony Mizumori** The Bridge office has two pilot projects identified. Each project has a pair of bridges. The plan is to use fiber reinforced concrete on one and regular class 4000 concrete for bridge decks on the other. The two projects are: Purdy Creek which has not been advertised yet and 009786 I-90 Cabin Ck I/C to west Easton executed 07/18/22. **6-02.3(25) and (26) Const. Manual Updates – Scott Sargent→Michael Bressan** Michael needs to check the status and finish this up.	

1. Welcome / Around the table intros, ice breaker.

Jim Cuthbertson started the meeting at 9:00. We did an around the "table" introduction for those in the meeting, but we did not do an ice breaker.

2. Safety Briefing

Jim Gave a brief safety meeting and since we were virtual, reminded everyone to follow their own safety procedures in the event of an emergency. Jim opened the National Safety Council's observance calendar and noted that tomorrow, the 15th was Concussion Awareness Day sponsored by the Brain Injury Association of America. Their web site for the event is: nationalconcussionawarenessday.com

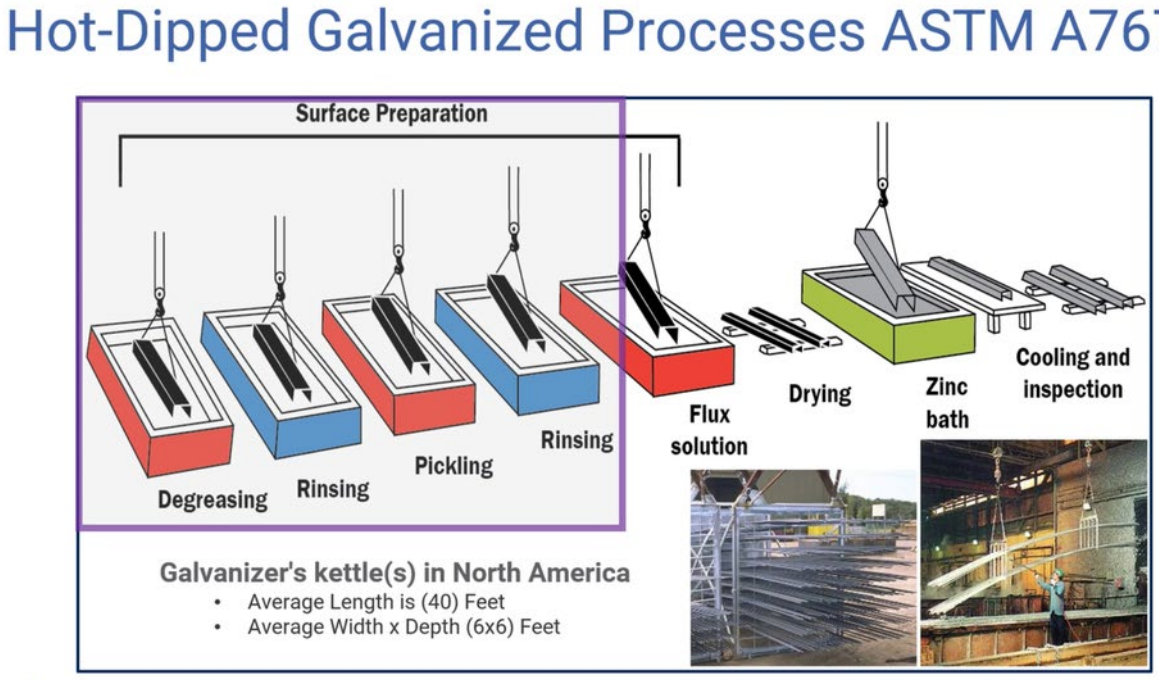
3. Review of Agenda/Prior Minutes

Jim reviewed the agenda and asked for comments on the May minutes which were distributed for review. No comments were provided.

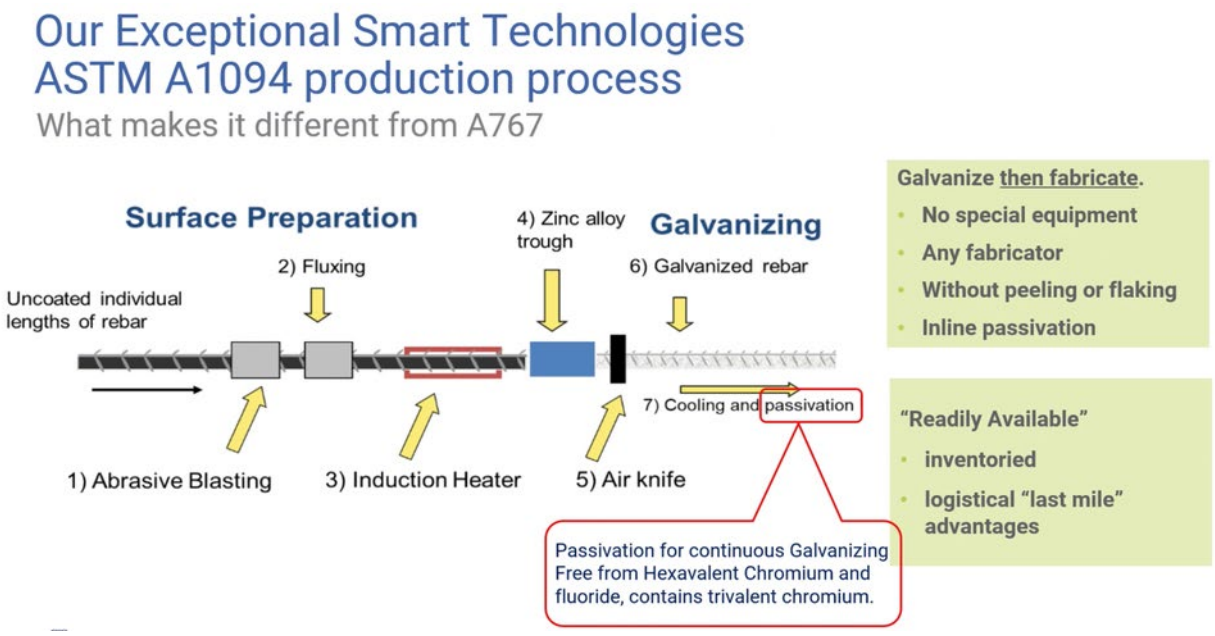
4. ASTM A1094 GalvaBar Presentation

Doug Johns West Division Sales Manager for Commercial Metals Company (CMC) and Ben Sadawi Technical Services Manager for CMC attended the meeting to talk about the GalvaBar and ChromX bar produced by CMC, predominantly GalvaBar. Ben was recently in Olympia and discussed their products with the Bridge Office. CMC as a company is expanding their products and fabrication capabilities nationwide. They are also pursuing and implementing green manufacturing processes. CMC first began producing their ChromX bar in 2001 and in 2013 they began producing bars with 4% chromium due to rising prices associated with chromium.

Seeing a need for corrosion resistive bars at a more competitive price point, they developed their GalvaBar product. GalvaBar is not produced using a conventional Hot-dipped galvanizing process. In conventional dipping the surface preparation involves immersion in various chemical tanks. The chemicals are caustic, hazardous, and not environmentally friendly.



The GalvaBar production method uses abrasive blasting to surface prepare the bars which eliminates the need for the processes highlighted in the above figure. The GalvaBar process is as follows:



The galvanization that occurs happens with a metallurgical bond to the steel and not a mechanical bond. The bond that is developed enables the bars to be bent and fabricated after coating with no debonding, damage, or flaking. The galvanic coating is also highly resistant to shipping damage and is more durable than typical epoxy coated bars which are often damaged in shipment and handling. CMC has a video that shows the GalvaBar production process in detail. https://www.youtube.com/watch?v=9kdMCWps5HE

GalvaBar is produced in Oklahoma and ChromX is produced in Oregon. Locally CMC's facility in Auburn has GalvaBar available. The difference between the two products is that GalvaBar derives its corrosion resistance through a zinc coating, but ChromX's chromium throughout the entire bars structure provides corrosion resistance throughout the entire bar. The two have different price points. Both products can be field bent with no degradation in corrosion resistance. GalvaBar is available in 20', 40' or 60' lengths No 3 to No 18 in size at grades between 60 and 100 ksi. WSDOT does have experience with ChromX bar. ChromX has been used

CMC Rebar
2306 B Street NW
Auburn, WA 98001
United States
P: 253.833.9060

in two bridge decks once on bridge deck replacement for a bridge over the Columbia River using precast panels and a new bridge constructed for the Medical Lake I/C on I-90.

Q: Stuart Moore asked if WSDOT Standard Specifications allow the use of GalvaBar ASTM A1094 bars.

A: In the meeting it was stated that WSDOT specs state that either A706 or A1094 bar could be used. It turns out that is not entirely correct. WSDOT's current specification states:

> **9-07.2 Deformed Steel Bars**
> Deformed steel bars for concrete reinforcement shall conform to either AASHTO M31 Grade 60 or ASTM A706 Grade 60, except as otherwise noted in this section or as shown in the Plans. Steel reinforcing bars for the cast-in-place components of bridge structures, and for precast substructure components of bridge structures, shall conform to ASTM A706 Grade 60 only.

The correct answer is… If the plans or special provisions required A1094 bar, the GalvaBar can be used. Doug pointed out that they GalvaBar is available in a A706 version which would definitely meet current WSDOT specifications.

Q: Geoff Swett asked if Ben was familiar with the AASHTO Guide Specification for Service Life Design where AASHTO has four classes of corrosion resistance for reinforcing.

Geoff asked if CMC had information regarding which class of corrosion resistance GalvaBar would fall into Class B or C.

AASHTO Excerpt:

4.2.4.2.1d—Reinforcement

The concrete cover requirements for each Exposure Class, target service life category, concrete material characteristics, and reinforcement type provided by Table 4.2.4.2.2-1 shall be taken to apply to four classes of reinforcement:

- Class A—Representative of uncoated typical reinforcing steel
- Class B—Improved corrosion resistance over Class A
- Class C—Higher corrosion resistance than Class B, but not to the extent of Class D
- Class D—Highly corrosion resistant materials, such as Type 316LN stainless steel

C4.2.4.2.1d

Critical chloride concentration assumed for each reinforcement class is included in Article C4.2.4.2.2.

The requirements that permit the use of Class A reinforcement represent a lower bound on reinforcement protection, and indicate that the desired service life can be achieved through reliance on the concrete material and cover requirements. Class A is intended for carbon steel reinforcing bars (e.g., ASTM A615). The classification of reinforcement coating systems (e.g. epoxy-coating, galvanizing) as Class A would serve to increase the probability that the desired service life would be achieved and, perhaps, exceeded.

The requirements for the use of Class D reinforcement (e.g., stainless steel) represent an upper-bound on reinforcement protection. This case reflects an "avoidance of deterioration" approach to achieving the desired service life. As a result, the material and cover

Ben stated that AASHTO appears to not recognize A1094 bars as being different from epoxy coated but pointed out that Texas A&M University is doing research on the topic. He offered to send Geoff information regarding the research.

Q: Jim Cuthbertson asked if there were plans to develop 150 ksi bars or all-thread bars.

A: Doug Johns stated that there were no plans to do that although CMC had ventured into that area with their ChromX line years ago, but that high strength product line was discontinued. He did state that the GalvaBar process could be applied to any conventional black bar so it would be possible to coat those types of products and that they even tried GalvaBar coating their ChromX bars just to see how that would turn out. One thing that was not discussed in the meeting that Jim did see on the CMC website is they can double coat their products. So, both GalvaBar and ChromX bar can be epoxy coated in their facilities as a special order.

5. GSP 6-02.3(25)J Prestressed Concrete Girders

Rich Zeldenrust presented a brief discussion regarding the upcoming GSP that bridge is working on developing. The Bridge and Structures Office (BSO) has recently experienced geometric issues on at least two contracts with long span girders, those over 150 ft in length. The issues were related to sweep and camber, and because of the issues BSO, recognized that there are needed improvements to our current specifications. BSO wants to ensure accurate and reliable girder survey data which is needed at key times. They want to remove ambiguity and better define responsibilities to avoid disputes, and they want to prevent the situation of out of tolerance girders being incorporated into WSDOT projects without an agreed upon strategy for repair prior to placement. The GSP essentially requires that geometry be checked at three key points -- initial when released from the casting bed, prior to shipping, and upon erection. Rich indicated that one of the changes in the GSP is altering the timing of the shipment check. Current specifications require the check 14 days prior to shipment and the revised specification allows 30 days prior to shipping to give the contractors more time to arrange the surveying and develop a repair procedure which Rich expanded upon later in his presentation. Rich also stated that for girders 150 feet and greater, BSO wants the measurement of sweep and camber to be performed by a licensed surveyor. Stuart Moore spoke up and stated that when this GSP was discussed in other meetings the contractors pointed out that Professional Land Surveyors really don't perform civil construction surveying, they survey property boundaries and plat maps. Rich stated WSDOT has a precedent of using licensed surveyors for checking ADA compliance and he felt that the requirement of a PLS was not overly burdensome. Neil Hunt pointed out that the GSP may not solve anything with regards to Design Build delivery. Stuart felt that there would be a burden upon the contractors as they would need to train the PLSs on construction surveying. Troy Watts, pointed out that what BSO was really trying to achieve by using the PLS was obtaining third party independence and ownership of the survey work product. He asked if it would be possible to accomplish the same thing by using an engineering firm and a PE rather than a surveyor. Neil stated the thing to emphasize is the idea of obtaining a third party quality assurance QA-esque unbiased check.

Rich also talked about the development of a repair plan for girders not meeting sweep and camber requirements at the shipment check. The GSP requires that a plan be approved by WSDOT prior to the girders being released for shipment, shipped, hoisted, and placed. Neil indicated that he felt that those may not resolve the issue of conflict. He pointed out that if the girders do not meet specification for shipment, the contractor may not take possession until the Precaster "fixes" them and they can be released for shipment. Eric Bowles stated that there were options to correct camber and sweep in the yard, but once the girders are shipped, sweep and camber could change. Neil was concerned about the case where the girders are out of tolerance in the yard. A plan is developed to field adjust the girder upon erection. The girders are marked for shipment, shipped and placed, but for whatever reason the field adjustment plan cannot be implemented, or it doesn't work. He felt that was a significant risk for the contractors especially knowing that the girder was not within specifications when at the yard before they took possession. There was no further discussion on that particular issue, but it is something that Jim as the note taker, feels needs to be thought through.

6. Precast Retaining Wall Standard Plans

New standard plans for buried structures have been discussed a couple of times previously. Geoff Swett was on deck to provide an update on the status of their development. Geoff stated that the precast wingwall standard plans had been signed and will be published soon. The split box structure standards were recently published, and the three sided structures were currently in FHWA review. There was no industry discussion.

7. GSPs 6-11 Reinforced Concrete Retaining walls

Michael Bressan presented the companion GSPs for the new standards. The specification modifications were not very extensive or contentious, and no industry comment was provided.

8. Shotcrete Changes and GSPs

Michael Bressan discussed the upcoming changes to the shotcrete specifications. He pointed out that for the last six years WSDOT has been utilizing special provisions that revise Standard Specifications 6-18 Shotcrete Facing. The specification changes that he is incorporating into the Standard Specifications is merging the special provisions we have been using into the standards. The changes are nothing that industry hasn't seen or used for the last six years. Michael stated that he would have the specification revisions circulated to the Structures team for comment.

NOTE TAKER NOTE: After the meeting Jim Cuthbertson distributed the 6-18 specification to the team via e-mail for comment. Thu 9/14/2023 @ 11:52 AM

9. Select Next Meeting Times / Adjourn

Future meeting date: October 26, 2023.

Notes by: Cuthbertson

AGC/WSDOT Structures Team – Meeting Minutes
(November 17, 2023)

Attendees

[1] Team co-chair

Team Members				
X	Bowles, Eric	Conc. Tech.	253-383-3545	EBOWLES@CONCRETETECH.COM
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X	Watt, Doug	CJA	425-988-2150	DWATT@CONDON-JOHNSON.COM
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Agenda

Timothy J. Barrett, Ph.D. Research Civil Engineer with the Office of Infrastructure R&D of the Federal Highway Administration will be presenting on “Internally Curing Concrete”. The topic is part of the Everyday Counts program and the EPIC[2] Initiative.

Future Meeting Date

Next Meeting – Jan 11, 2024

1 Welcome / Review of Agenda

Jim Cuthbertson welcomed everyone and ran through the roll call so that Timothy knew who was at the meeting. Timothy's presentation is the only thing on the agenda for this meeting.

2 Approval of Previous Meeting Minutes

No comments were received on the previous meeting minutes.

3 Internally Curing Concrete

Timothy Barrett

Message from Note Taker – The presentation by Timothy is reproduced in its entirety within the notes, but there is no narrative provided by me. There was simply too much verbal content for me to try to summarize, but I did try to capture comments and questions from the attendees. Timothy has provided numerous links to resources that are available on the subject including available webinars. For more information see:

- Initiative Homepage with external resource links along the right side: https://www.fhwa.dot.gov/innovation/everydaycounts/edc_7/enhancing_epic.cfm

- Initiative overview presentation that Timothy delivered at the National Concrete Consortium which includes QR codes to recordings of the webinars covering the theory and performance, mixture designing, and lessons learned and what to expect when piloting internal curing: https://intrans.iastate.edu/app/uploads/2023/09/Barrett-NCC-9-2023.pdf

Enhancing Performance with Internally Cured Concrete (EPIC²) On-Demand Webinars

Theory & Performance **Mixture Proportioning** **Lessons Learned**

- EDC News Spotlight stories about Federal Lands Highway's experience with internal curing: https://www.fhwa.dot.gov/innovation/everydaycounts/edcnews/20230817.cfm

- And a pilot project in Ohio: https://www.fhwa.dot.gov/innovation/everydaycounts/edcnews/20230831.cfm

Q: Is there another reason for using lightweight aggregate?
A: Timothy – The whole reason is that the lightweight aggregate has a higher water adsorption rate (5% to 24%) than conventional aggregate. Note, that water does not count towards the water to cement ratio water as the water is within the aggregate and not free to be used until after the time to set.

Q: Doesn't the water "leak" out of the lightweight aggregate?
A: The pores of the aggregate have their own pore pressures and they absorb and hold onto that water until it is pulled out later.

Q: There are producers using recycled glass to make Foam Glass lightweight aggregates. Can that material be used as a source for the lightweight aggregate?
A: It could be used in theory, but nobody has used it yet. Probably, because the product is so new to the market, Turner-Fairbanks has used and tried it in a lab setting and it seems to work. Turner-Fairbanks is also looking at super-absorbent polymers as a source for internal curing water. Polymers have been used in Denmark and Japan with success.

Q: Does the lightweight aggregate “float” to the surface when the fluid concrete is being worked, screeded, and finished?
A: The lightweight aggregates do not behave differently than other aggregates.

Q: How do they get the lightweight aggregate saturated?
A: The adsorption is time dependent. The aggregates are manufactured and generally start out in an oven dry condition. Upon exposure to water, most aggregates adsorb about 60% of their capacity in the first 5 minutes or so. As you continue to wet and soak them, they will continue to adsorb water. What is recommended in ASTM C1761 is that you design using a 24 hour adsorption number and then in practice soak the aggregate for more than 24 hours to ensure you exceed that amount of adsorption. At batching you need to measure the total moisture of the aggregate and determine the surface moisture so that you can account for that surface water when batching. The aggregate never gets fully saturated which is why we use the term pre-wetted rather than saturated. Typically, the aggregate is wetted by making a pile and applying soaker hoses to the surface for three days. The pile gets turned periodically to distribute the aggregate and wet the pile evenly. Depending on the source, you may be able to purchase the aggregate pre-wetted.

Q: There is a company marketing a concrete additive which they say acts as internally curing (E5 Internal Cure). Does that work?
Note taker comment: I included this question and Timothy’s response even though it does put Timothy in an awkward position. However, his answer does provide some clarity on the product.
A: The producers of the product have not provided any documentation that their product meets the definition of Internally Curing Concrete as defined in the presentation.

> *“Process by which the hydration of cement continues because of the availability of internal water that is not part of the mixing water.” – ACI Concrete Terminology*

The product does have an effect, but it is not due to having additional water available.

Q: When using internal curing methods do you eliminate the other shrinkage reducing admixtures or are you using them in combination?
A: Usually, you would do one or the other.

Q: Are fibers often added to also reduce cracking?
A: I don’t know how many States are doing both. It is becoming a desired combination. Caltrans does both shrinkage reducing admixtures (SRA) and fibers. SRAs are used to help prevent cracking and fibers are used for after cracks happen. Caltrans does a four pound fiber blend per yard of concrete; ½ pound of microfibers for plastic shrinkage cracking reduction and 3 ½ pounds of polyolefin plastic macro fiber for holding the cracks tight if they do form.

Q: How easy is it for concrete suppliers to produce internally curing concrete?
A: That depends on the supplier, but if they are already producing concrete using lightweight aggregates then it is going to be a simple change for them. If they don’t have that experience, there will be more involved because of them learning how to work with a new aggregate source. I [Timothy] have a talk for implementing internally curing concrete at the batch plant and would be happy to share that. For placing and finishing there are no real issues. The concrete can be pumped and can be checked for air conventionally. New York State likes the finishes they get on internally cured concrete better than they do their other high-performance concrete, and they also reduce their curing window from 14 days down to 7 days.

Q: Is there any information regarding the difference between precast bridge decks and cast in place bridge decks?
A: I [Timothy] am not familiar with any states that are doing precast internally curing concrete. Primarily all of the decks are CIP.

Q: Does this have applications for concrete deck overlays?
A: It does. If you are doing silica fume overlays they have a lot of inherent autogenous shrinkage and that is exactly what internally curing concrete was designed to address.

Notes by Jim Cuthbertson

Enhancing Performance with Internally Cured Concrete (EPIC^2)

Tim Barrett, Ph.D.

Federal Highway Administration

WSDOT Webinar
November 17, 2023

U.S. Department of Transportation
Federal Highway Administration

Every Day Counts
Innovation for a Nation on the Move

Internal Curing (IC)

"Process by which the hydration of cement continues because of the availability of internal water that is not part of the mixing water." – ACI Concrete Terminology

Key Takeaways From Today

- The technology is not difficult to try
- There are no design modifications required
- Internal curing can be the belt to your suspenders when it comes to cracking and enhancing performance in bridge decks
- At the end of the day, we're just putting wet rocks in concrete

Let's make this EPIC^2!

Motivation from Washington State

This is the Albro Street bridge over I-5 in Seattle showing deterioration with cracks and pothole patches. Crews will remove large sections of the deck to replace with new concrete.

Source: WSDOT

Source: WSDOT 2015

The Causes Are Many

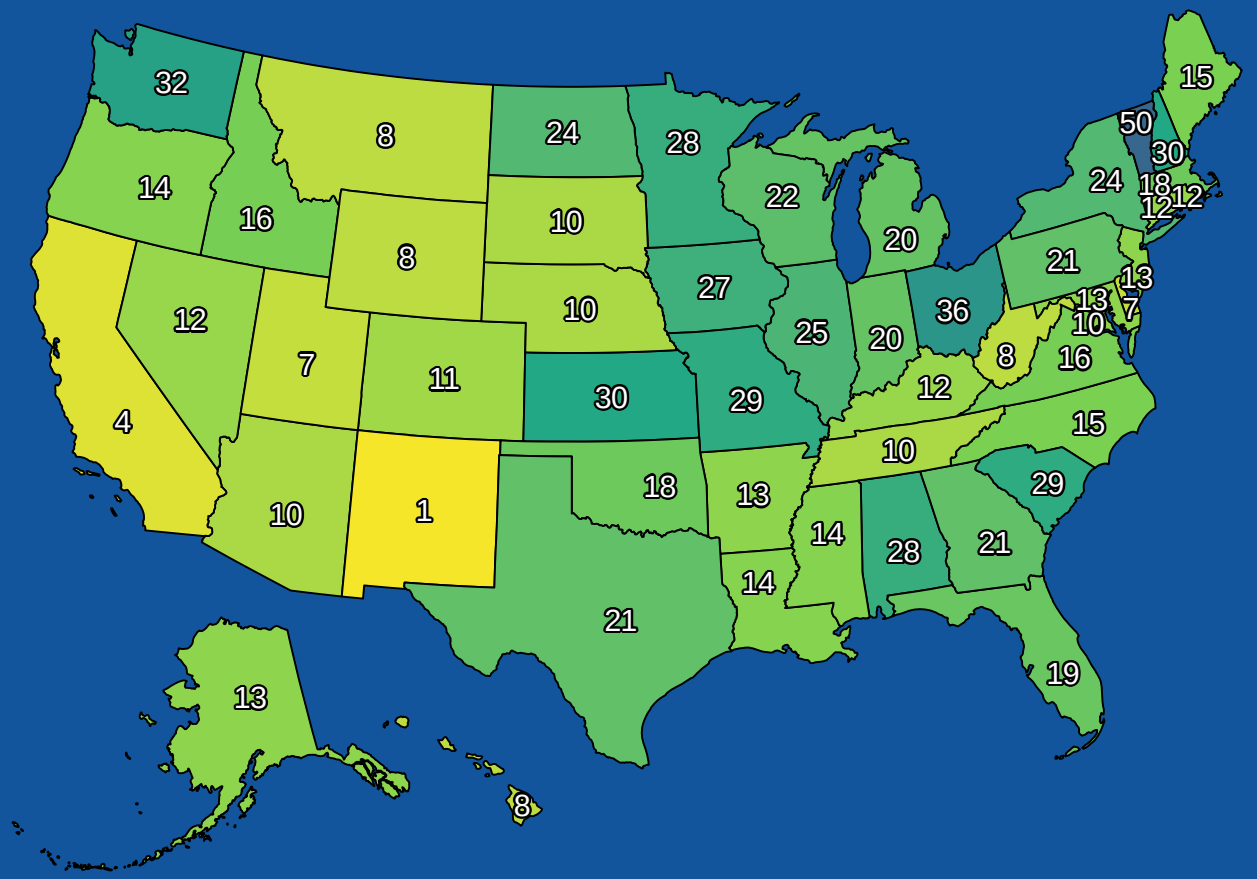
- Concrete Mixture Design
- Structural Design
- Environmental Exposure
  - Temperature
  - Relative Humidity
- Cements
- Chemical Admixtures
- Construction Practices
- Bad Luck… the list goes on…

Source: FHWA

"Everything but the kitchen sink."

The Effect is Clear.

Age (years) when more than half of bridges likely have inherent cracking in deck throughout:



Source: FHWA

Data Source: NBI, 2022.
Deck condition (Item 58) rating of 7 (Good) or lower.

AASHTO T-4 Construction & T-10 Concrete Design Committees Supported

NCHRP Domestic Scan 22-01: Recent Leading Innovations in the Design, Construction, and Materials Used for Concrete Bridge Decks.

“Deterioration of concrete bridge decks due to corrosion of steel reinforcement has limited the service life and increased the maintenance cost of bridge structures. Concrete bridge decks deteriorate faster than any other bridge component because of direct exposure to environment, deicing chemicals, and ever-increasing traffic loads. The magnitude of cracking and delamination of concrete bridge decks due to corrosion is a major problem when measured in terms of rehabilitation costs and traffic disruption. Steel reinforcement are often protected from elements causing corrosion or replaced with alternative non-corrodible materials in new structures.”

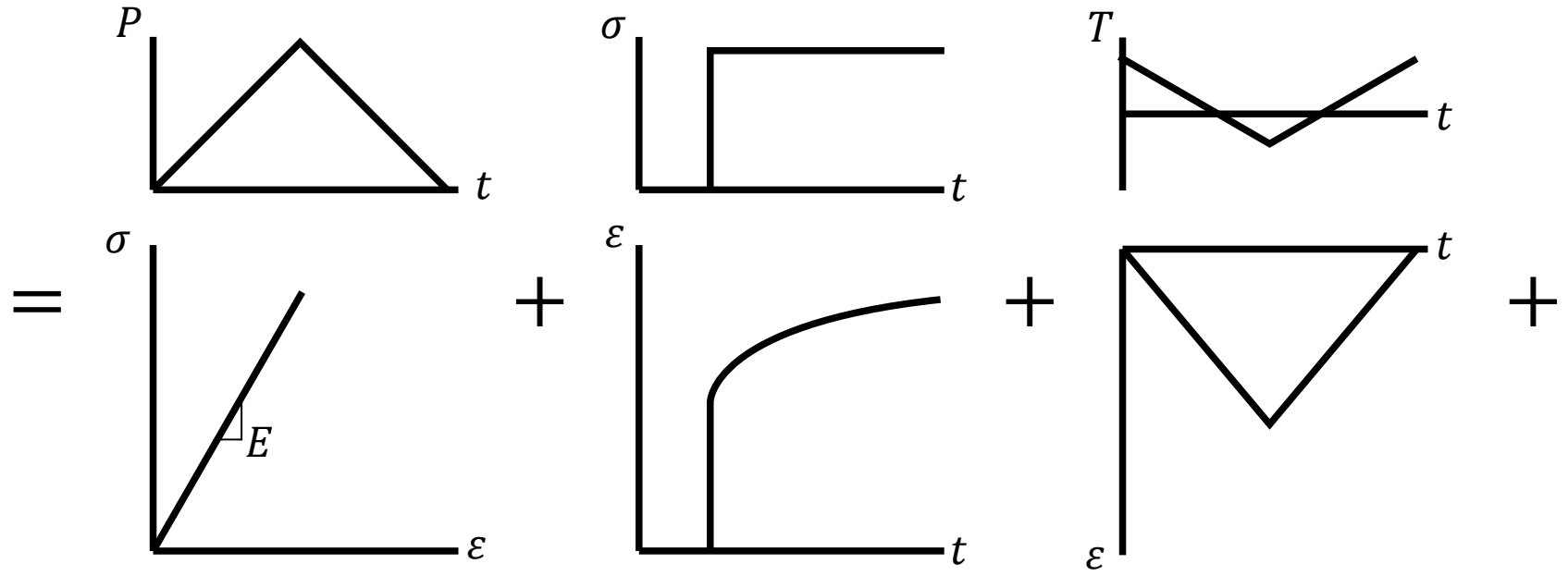
We all agree.

QR Code to 22-01 scan page.

What can we do?

Volume Changes

$$\varepsilon_{Tot} = \varepsilon_{Elastic} + \varepsilon_{Viscoelastic} + \varepsilon_{Thermal} + \varepsilon_{Shrinkage}$$



$$\varepsilon_{sh} = k_s k_{hs} k_f k_{td} 0.48 \times 10^{-3}$$

ASTM C157

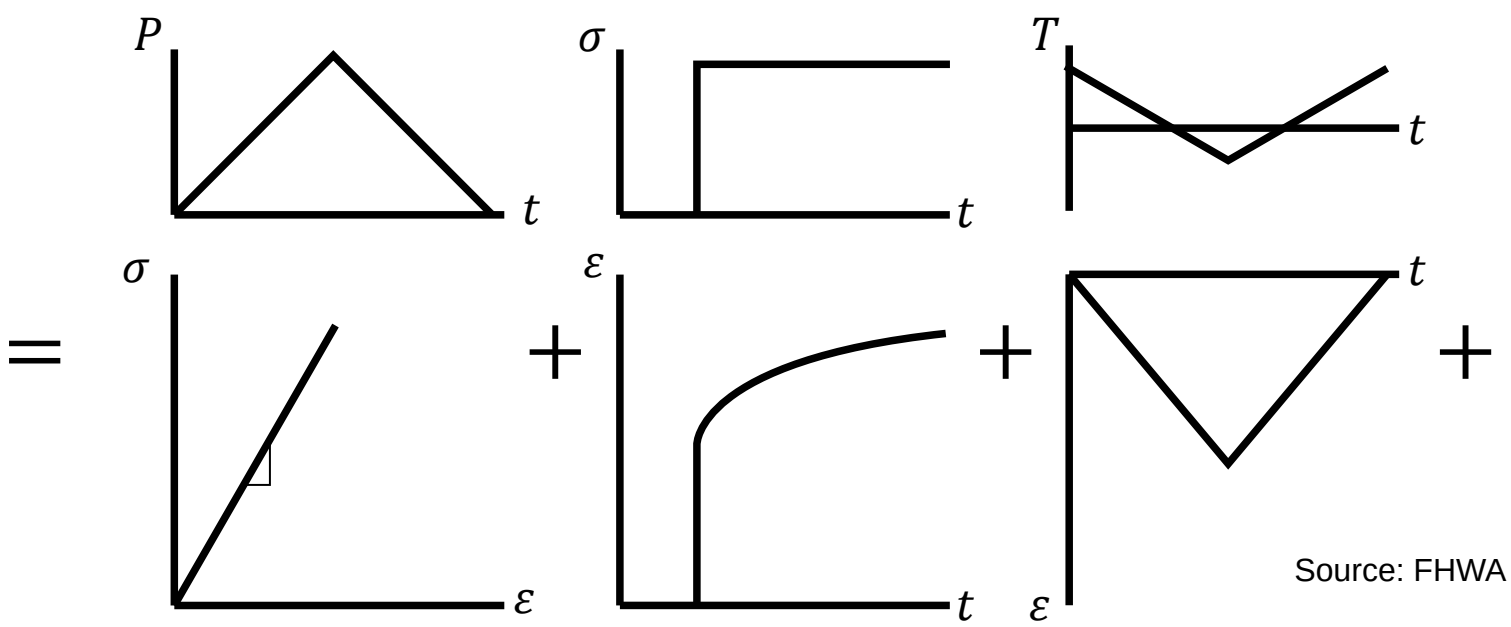
AASHTO T160

Source: FHWA

Shrinkage

$$\varepsilon_{Tot} = \varepsilon_{Elastic} + \varepsilon_{Viscoelastic} + \varepsilon_{Thermal} + \left(\varepsilon_{Drying} + \varepsilon_{Auto}\right)_{Shrinkage}$$

$$\varepsilon_{sh} = f(t, RH, V/S, V_{paste}, w/c)$$

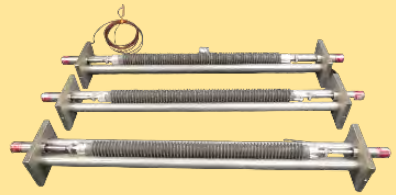


Source: FHWA

ASTM C157

ASTM C1581

Drying

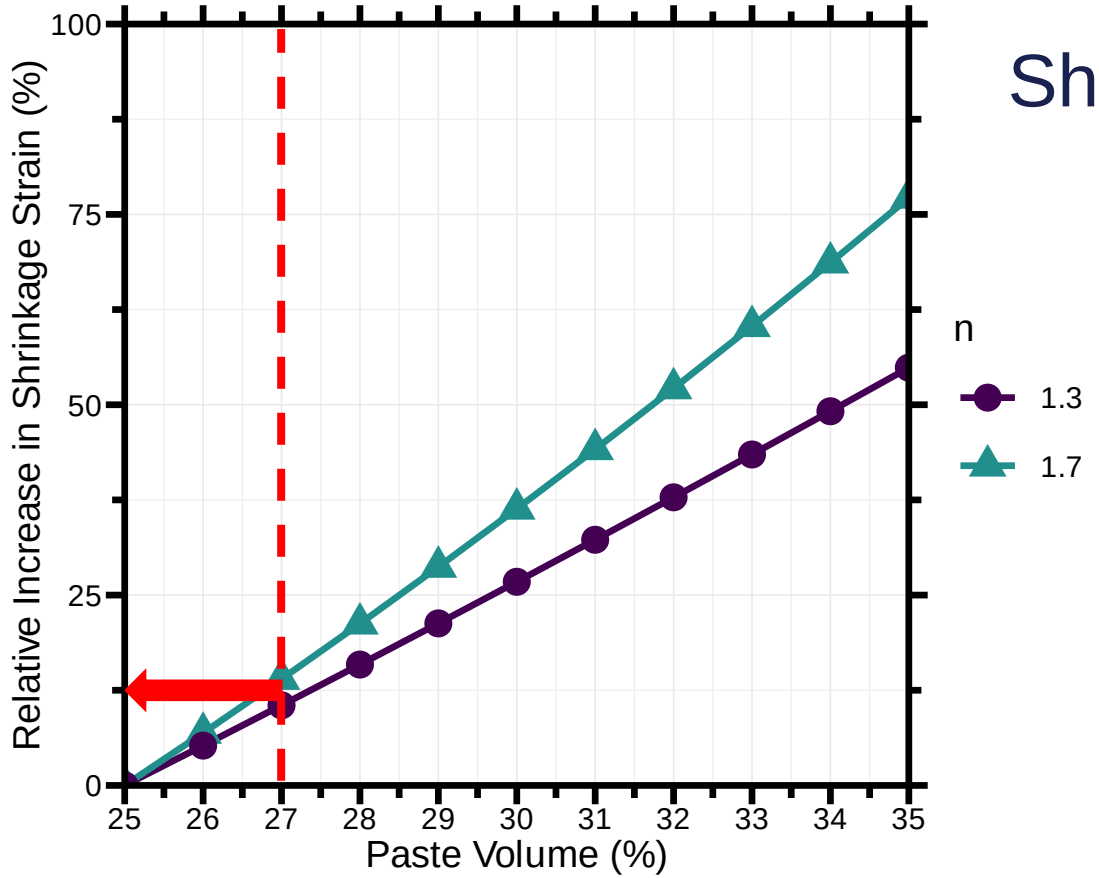


ASTM C1698

AASHTO T 363

Autogenous

Shrinkage Considerations



Source: FHWA

Shrinkage is a paste volume property

Pickett's Eq. for concrete shrinkage strain

$$\varepsilon_c = \varepsilon_p(1 - V_A)^n$$

ε_c: shrinkage of concrete

ε_p: shrinkage of paste

V_A: volume fraction of aggregate

n: aggregate stiffness parameter

w/c=0.40 ?

Paste volumes are for high intensity mixtures 31%,

< 27% for low cracking intensity.

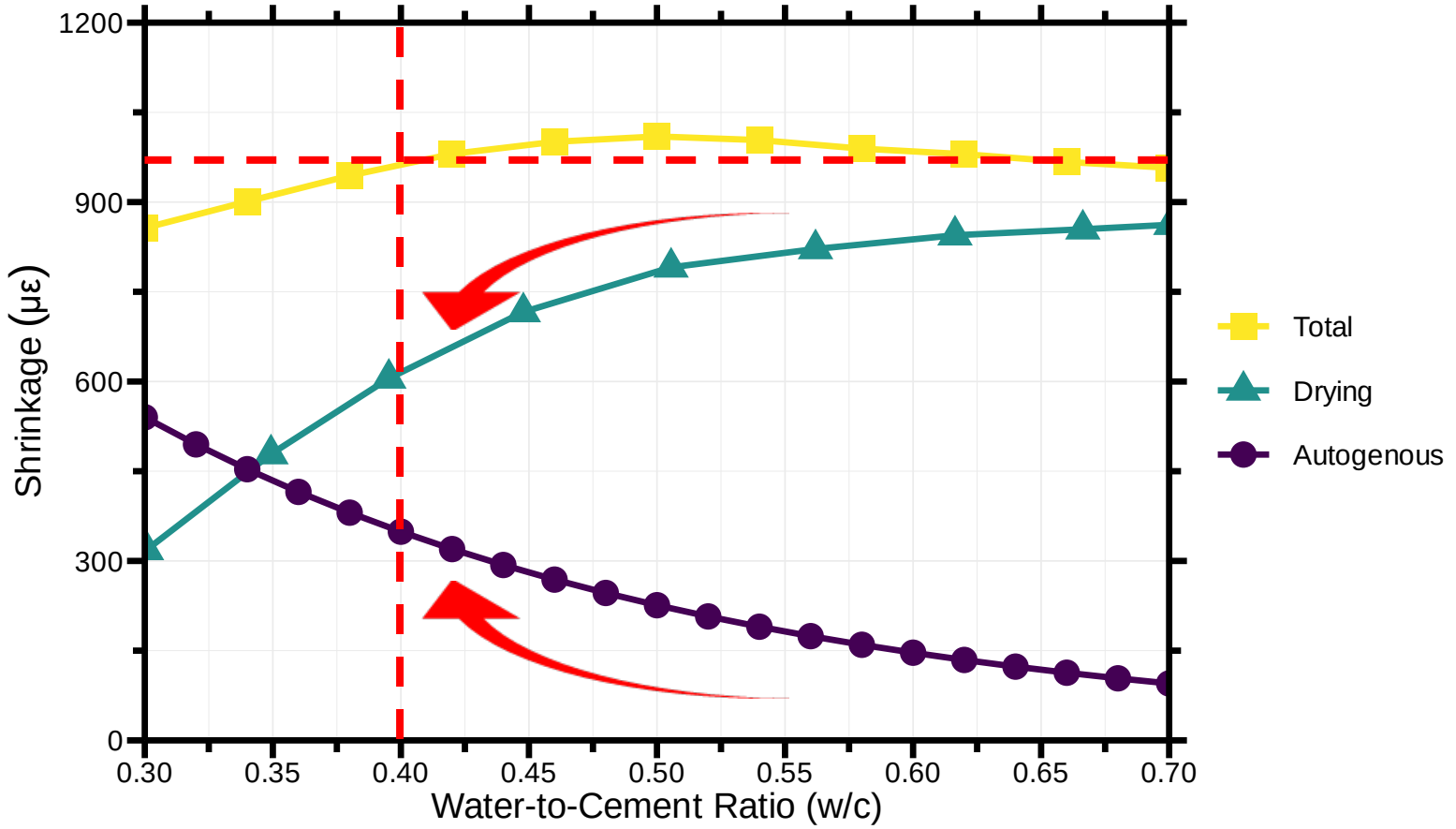
Br. No.	Bridge Name	Contract	Year	Perform.	Cement	Fly Ash	Microsilica	Total	Shrink.	Intensity
303/4A	MANETTE BRIDGE	7926	2011	No	660	75	--	735	--	73%
16/7S-E	S SPRAGUE RAMP	7594	2010	No	660	75	--	735	--	59%
90/106N	GOLD CREEK WB	7852	2012	No	660	75	--	735	--	44%
90/105.5S	GOLD CREEK ANIMAL CROSSING EB	7852	2010	No	660	75	--	735	--	40%
5/434SCD	SBCD OVER SR 16 HOV & RAMPS	8189	2013	Yes	480	85	--	565	0.028%	36%
529/25	EBEY SLOUGH	7948	2012	No	660	75	--	735	--	36%
6/115	S FORK CHEHALIS R	7587	2009	No	660	75	--	735	--	32%
90/105.5N	GOLD CREEK ANIMAL CROSSING WB	7852	2012	No	660	75	--	735	--	32%
5/302E	PRAIRIE CREEK NB	7465	2009	No	660	75	--	735	--	18%
2/651W-S	W-S RAMP OVER US 2/US 395	7610	2011	No	660	75	--	735	--	13%
195/117	CHENEY SPOKANE RD OVER US 195	8378	2014	Yes	---------- No Data Received ----------					10%
395/442W	US 395 OVER US 2	7610	2011	No	660	75	--	735	--	10%
5/234W	I-5 OVER BLAKESLEE JCT RR	8272	2013	Yes	464	116	--	580	0.030%	9%
16/3W	SR 16 OVER HOV	8189	2014	Yes	480	85	--	565	0.028%	9%
9/133	SR 9 OVER HARVEY CRK RD	7267	2008	No	660	75	--	735	--	8%
9/134	PILCHUCK CREEK	8383	2014	Yes	458	153	--	611	0.031%	7%
105/4	NORTH RIVER	8345	2014	Yes	460	150	--	610	0.018%	7%
2/8.5N-W	N-W RAMP (BICKFORD AVE) OVER US 2	8286	2013	Yes	480	90	10	580	0.032%	6%
105/3	SMITH CREEK	8345	2013	Yes	460	150	--	610	0.018%	6%
6/8	WILLAPA RIVER	8464	2014	Yes	460	150	--	610	0.018%	5%
5/302W	PRAIRIE CREEK SB	7465	2010	No	660	75	--	735	--	4%
5/232NCD	SKOOKUMCHUCK RIVER NCD	8272	2013	Yes	464	116	--	580	0.030%	2%
5/232SCD	SKOOKUMCHUCK RIVER SCD	8272	2013	Yes	464	116	--	580	0.030%	1%
5/229	MELLON STREET COUPLET	8473	2014	Yes	464	116	--	580	0.028%	< 1%
395/441N-E	N-E RAMP OVER N-N RAMP	7610	2011	Yes	435	130	--	565	0.034%	< 1%
101/44	BONE RIVER	8292	2013	Yes	460	150	--	610	0.018%	< 1%
101/31	MIDDLE NEMAH RIVER	8344	2014	Yes	460	150	--	610	0.018%	0%

Source: WSDOT 2015

Shrinkage Considerations

- For fixed volume of paste:
  - Drying shrinkage higher with higher w/c
  - Autogenous shrinkage higher with lower w/c
  - Total shrinkage approximately constant across w/c

70% Volume of Aggregate:

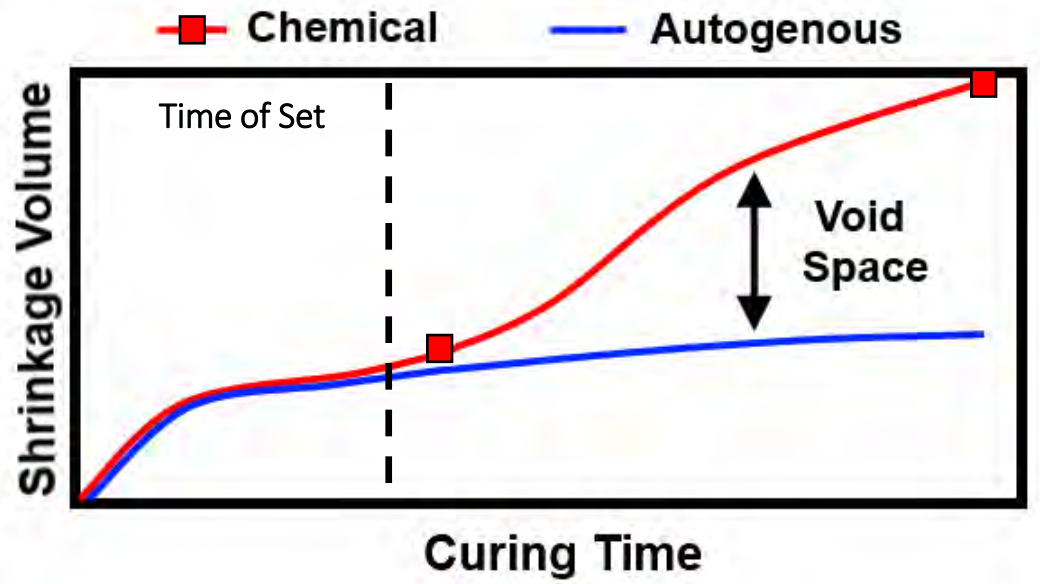


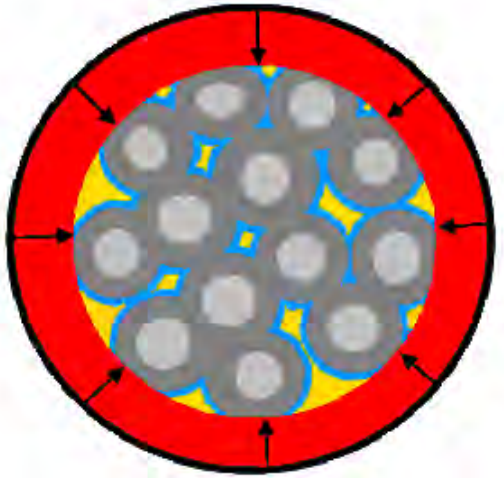
Source: FHWA after Weiss (2022)

Data: Neville (1995) & Rasoolinejad et al. (2019)

Volume Change at Early Ages

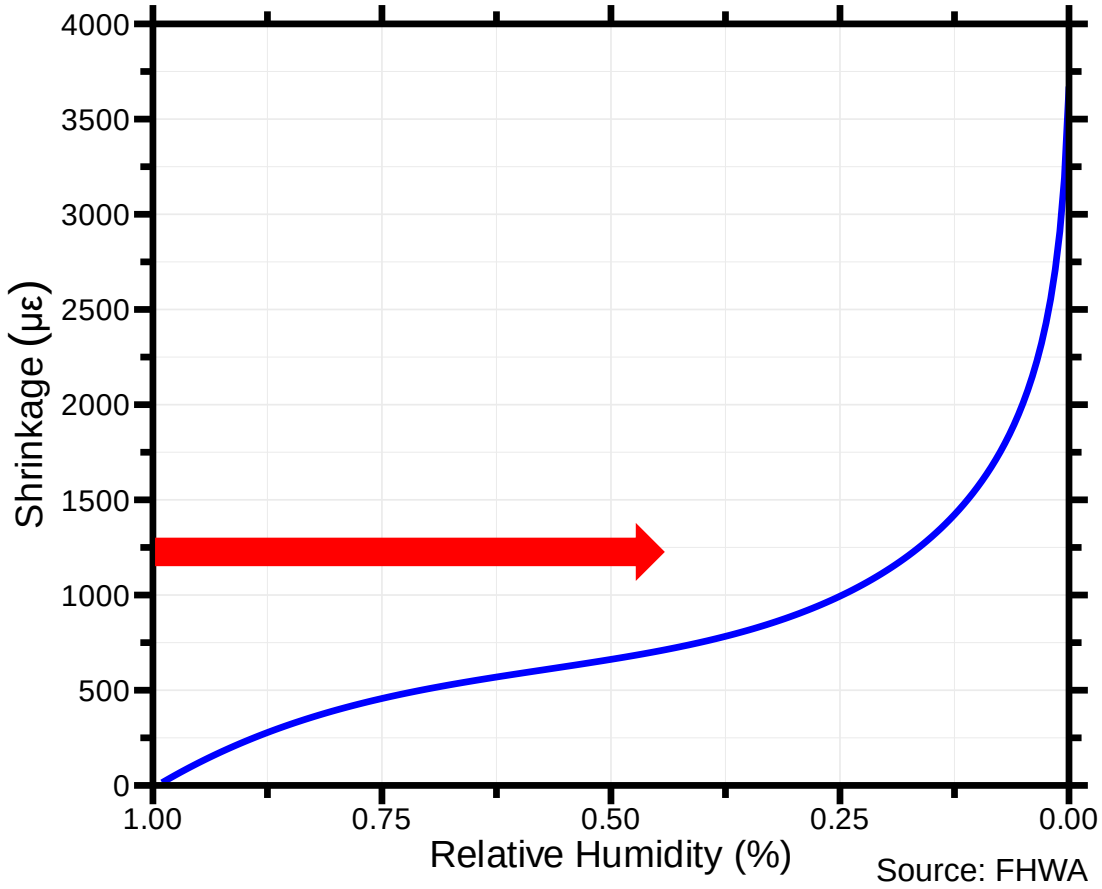
- Cement undergoes ~9% volume reduction when it reacts with water (chemical shrinkage)
- After set, this creates empty pores (void space) that cause shrinkage (autogenous)
- Result: Concrete can crack itself, even if no external drying occurs
- Solution: Refill the void space





Source: FHWA

Shrinkage Strain Generation



Source: FHWA

Modified Mackenzie Eq. for shrinkage strain

$$\varepsilon_{sh} = \frac{S}{3}\left(\frac{2\gamma}{r}\right)\left(\frac{1}{K_P} - \frac{1}{K_S}\right)$$

r: radius

γ: surface tension

S: saturation

K_P: bulk modulus of porous body

K_S : bulk modulus of solid body

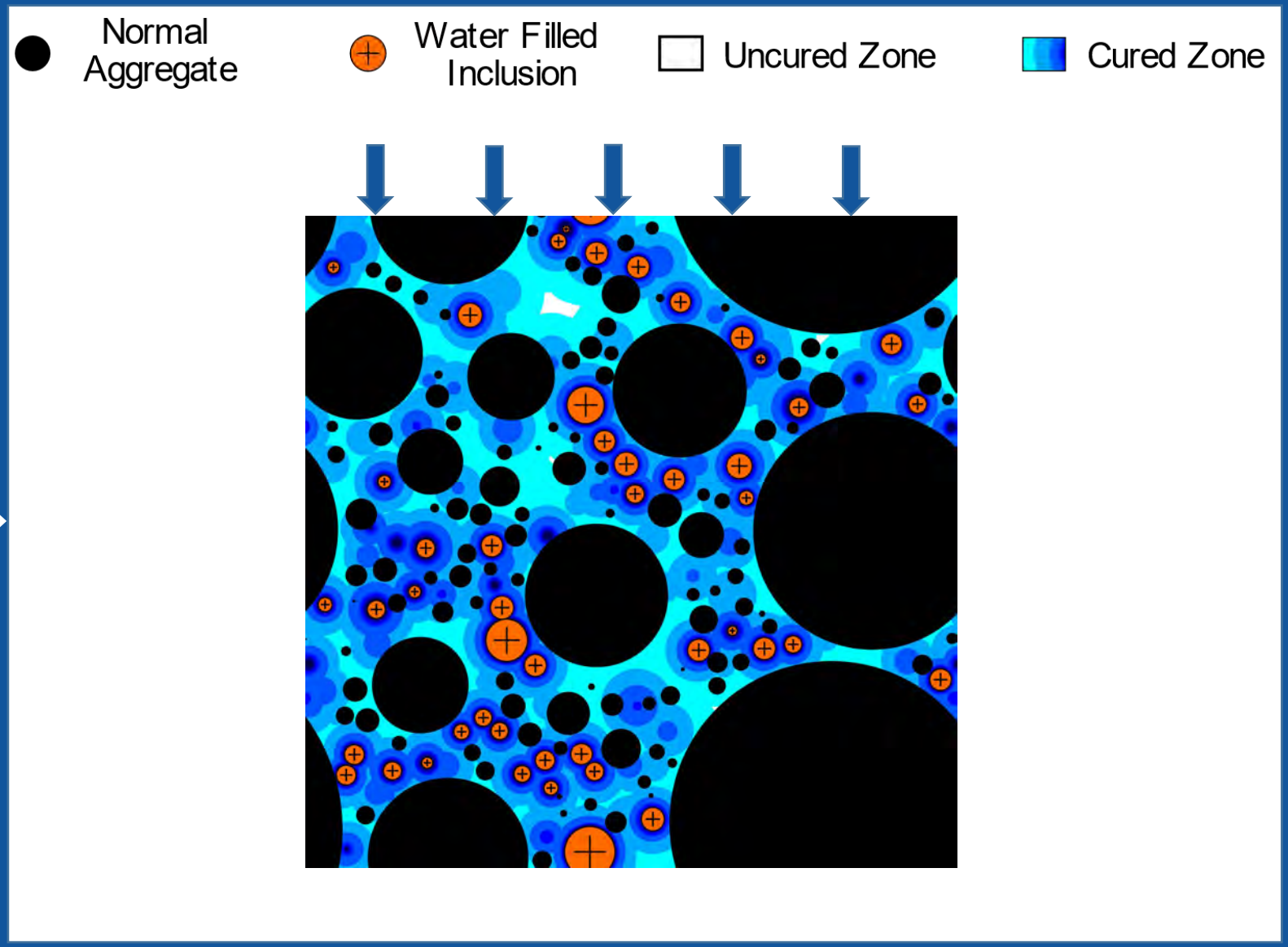
Internal Curing (IC)

~~"Process by which the hydration of cement continues because of the availability of internal water that is not part of the mixing water."~~

Hide the curing water inside the concrete when you make it.

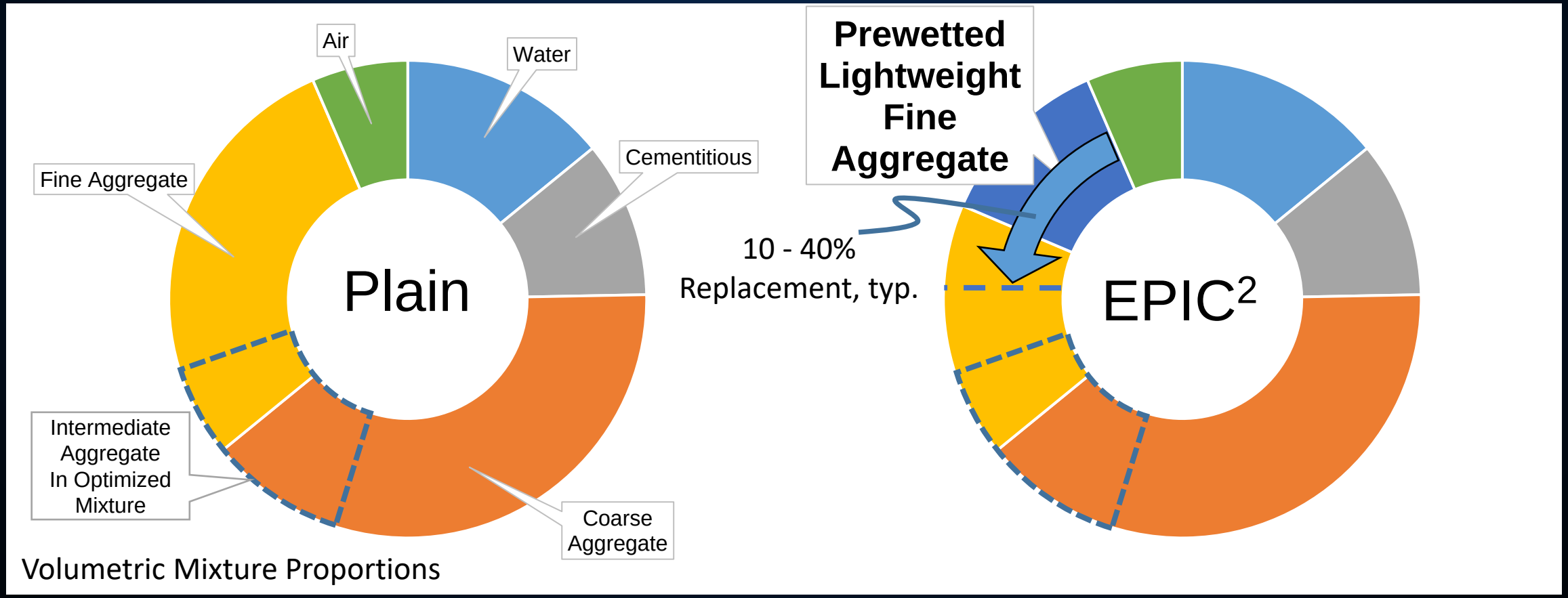
Solution:

Refill the emptying pores that cause shrinkage from an internal source.



20+ years of R&D, 400+ research products.
The science is clear, internal curing works.

Current Practice:
Just Replace Some Sand.



Mixture Proportions

Bentz & Snyder (1999)

$$M_{LWA,OD} = \frac{C_f \cdot CS \cdot \alpha_{max}}{S \cdot \phi_{LWA}}$$

Typically:

Supply 7 lb of water per 100 lb of cementitious (*CS* = 0.07)

C_f: Cement Content (lb/yd^3)

CS: Chemical Shrinkage (lb water / lb cementitious)

α_{max}: Degree of Hydration (%)

$M_{LWA,OD}$: Mass of LWA (oven dry basis)

ϕ_{LWA}: LWA Absorption (%)

S: Saturation Factor (%)

Spreadsheet Design

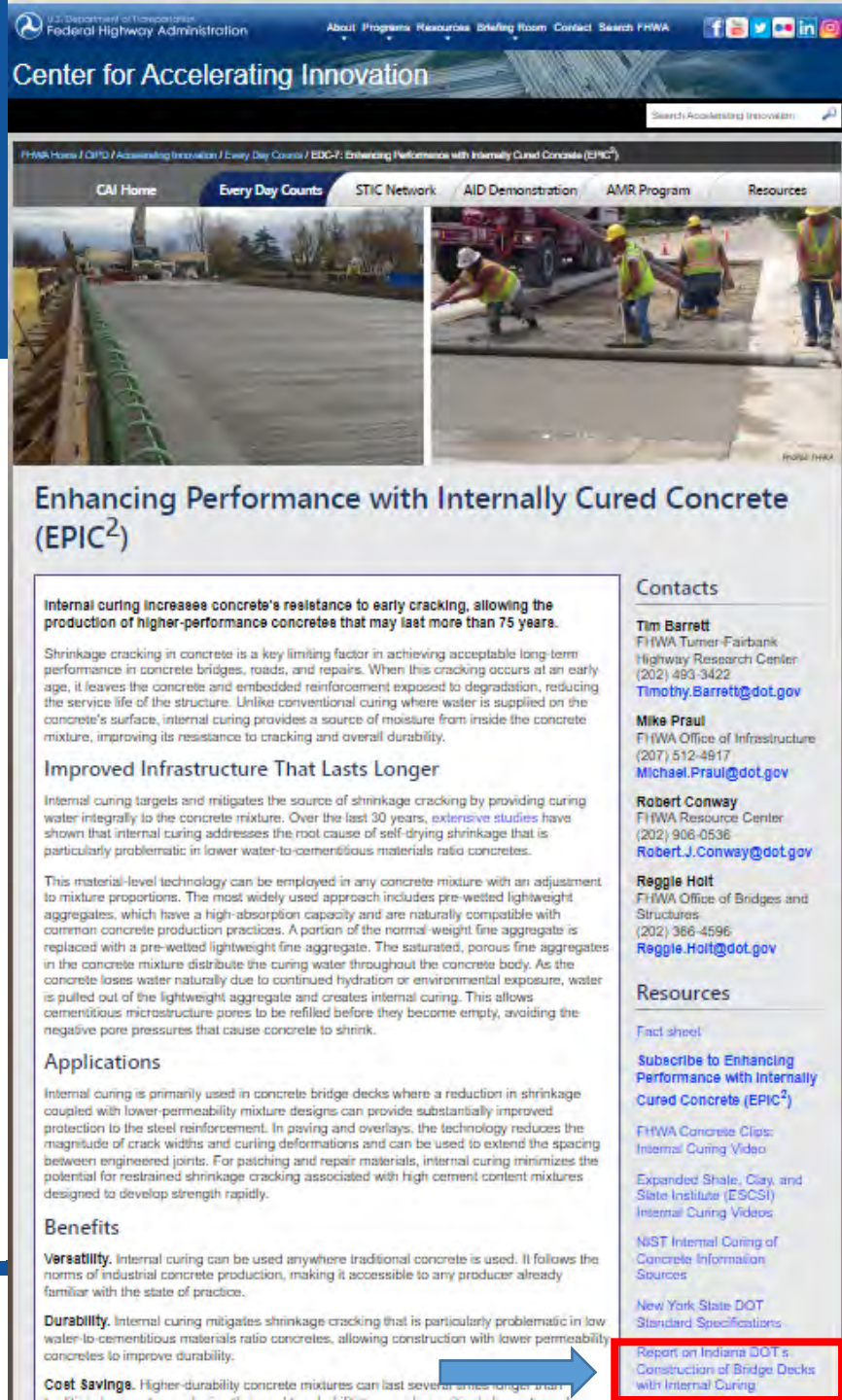
Developed as a part of the report for INDOT implementation.

Available for download:
https://docs.lib.purdue.edu/jtrp/1574/
APPENDIX H. Mixture Design Worksheet.xlsx

Webinar training module available now!

“Mixture Design” Tab:

- Plain mixture design (input)
- Internal curing properties (input)
- IC mixture design (output)



Lightweight Aggregate Specification

- ASTM C1761*
  - Covers aggregates for internal curing
  - Prewetting of aggregates
  - Testing
  - Mixture proportioning
  - Specifies use of 72 h absorption.

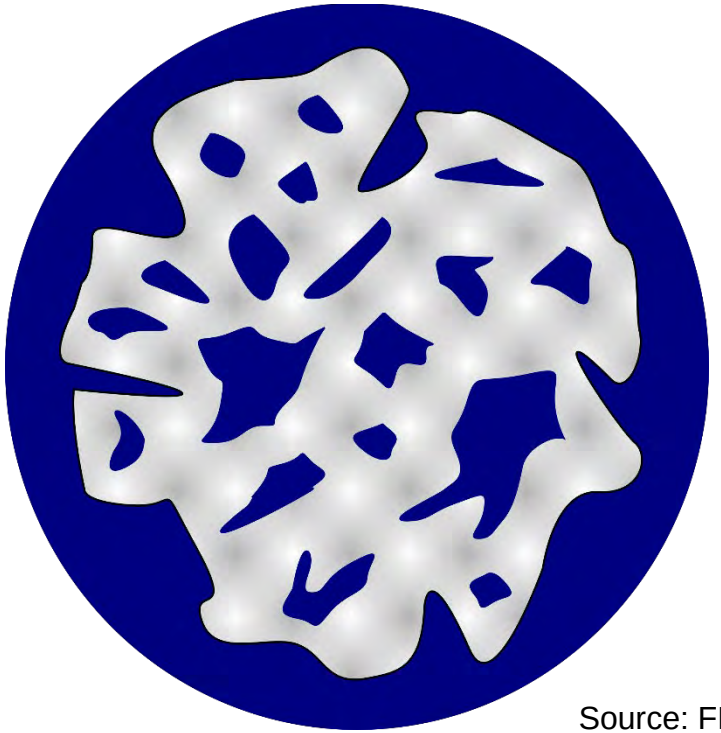
Some have used 24 h for design, which ensures specification in practice is met

  - Average change in absorption from 24 h to 48 h soak is ~7%

Source: FHWA

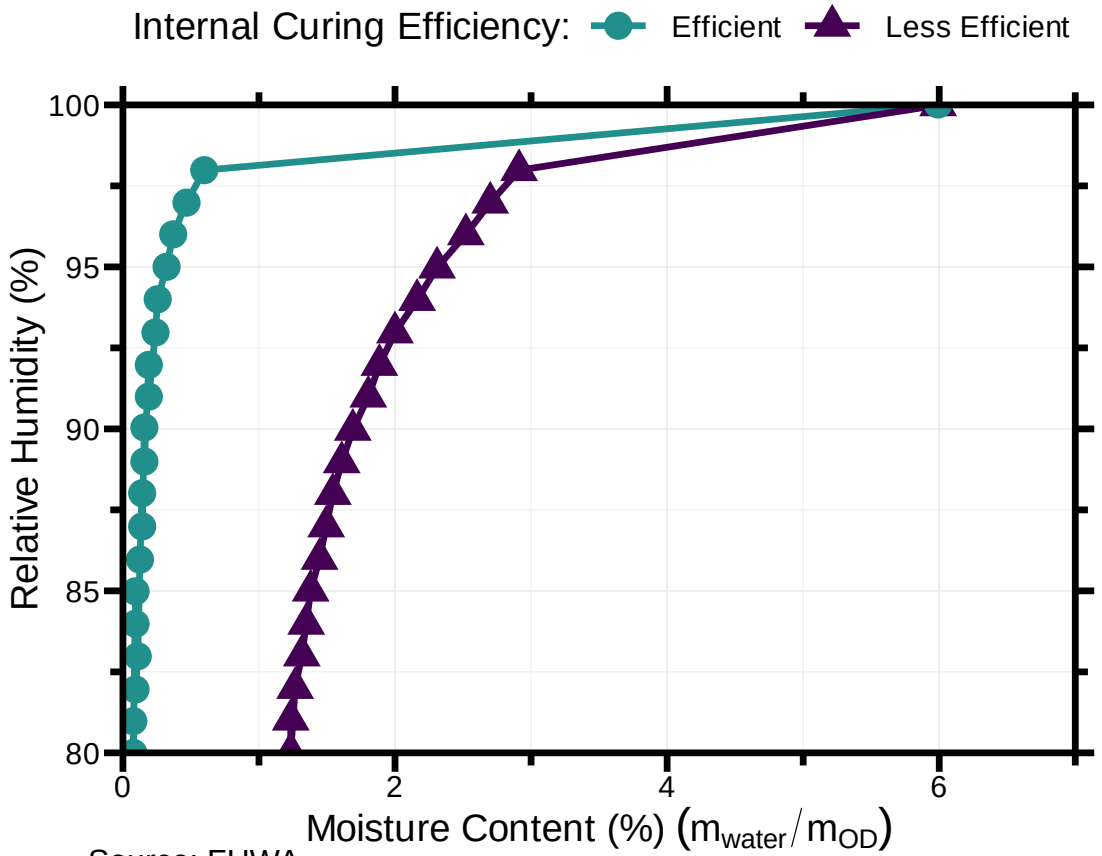
*Specification not required per statute or regulation.

Prewetted Lightweight Fine Aggregates



Source: FHWA

ASTM C1761: The lightweight aggregate shall release at least 85% of its absorbed water at 94% relative humidity.



Source: FHWA

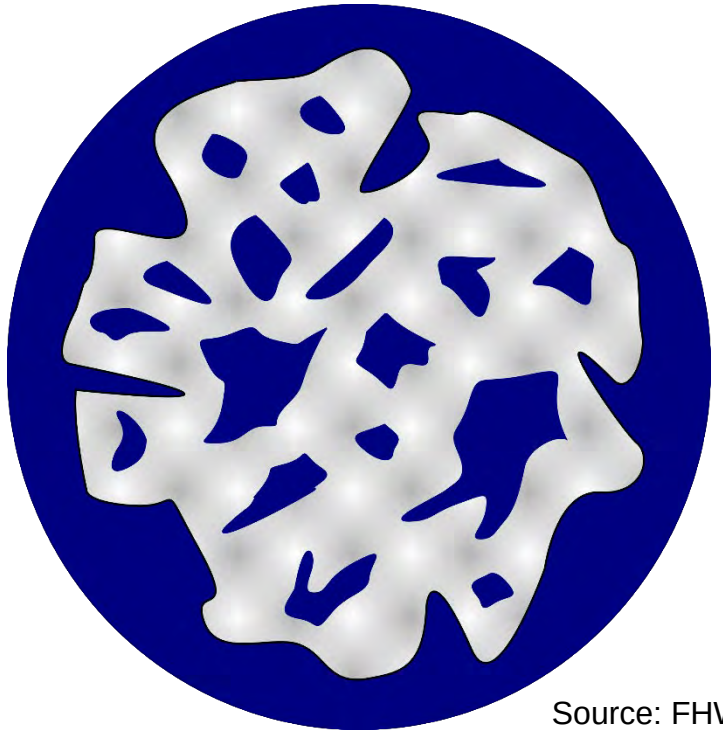
Data: Castro et al., 2011

Typical Lightweight Fine Aggregate (LWFA) Properties

LWA Source Location	Specific Gravity (Dry)	Absorption at 24 h (%)	Desorption at 93% Relative Humidity (%)
Erwinville, LA	1.29	16.0	0.906
Livingston, AL	1.10	30.5	0.922
Frazier Park, CA	1.39	17.7	0.887
Marquette, KS	1.45	17.5	0.919
New Market, MO	1.50	14.1	0.976
Brooklyn, IN	1.56	10.0	0.969
Cleveland, OH	1.40	15.6	0.958
Brooks, KY	1.51	15.0	0.951
Albany, NY	1.38	19.1	0.955
Boulder, CO	1.46	17.9	0.869
Streetman, TX	1.48	18.9	0.853
Coalville, UT	1.49	18.5	0.862
Buckingham, VA	1.62	12.2	0.960
Gold Hill, NC	1.51	6.0	0.962

Data: Castro et al., 2011

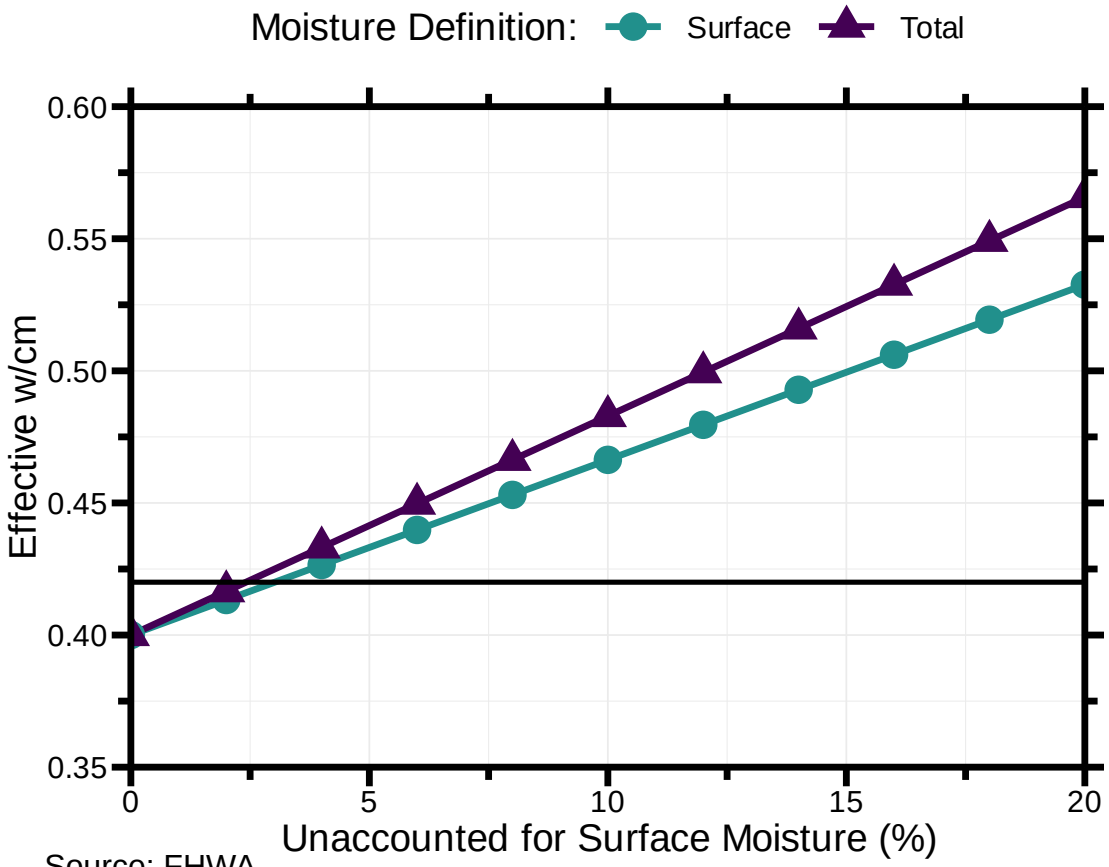
Moisture Properties



Source: FHWA

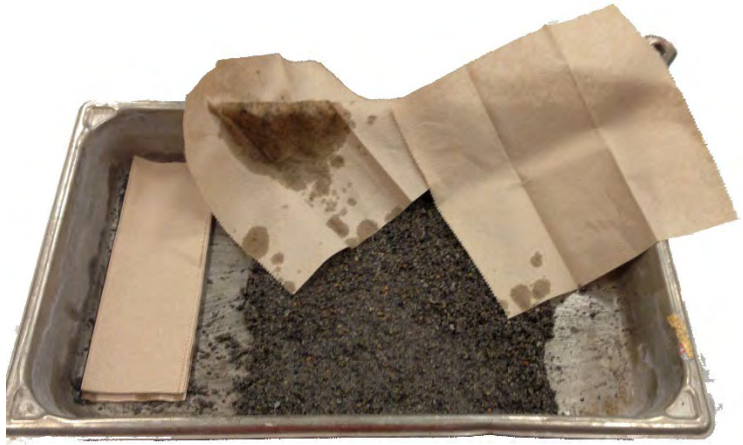
Absorbed water in LWA used for IC, required for batching

Surface moisture is free water and counts in w/c



Source: FHWA

Moisture Testing Methods



Source: FHWA

ASTM C1761 Paper Towel Method:

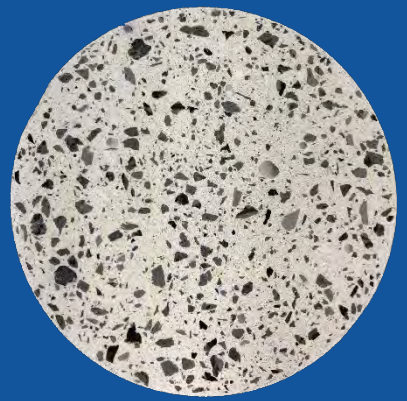
Pat the aggregates dry until sandcastle falls over.

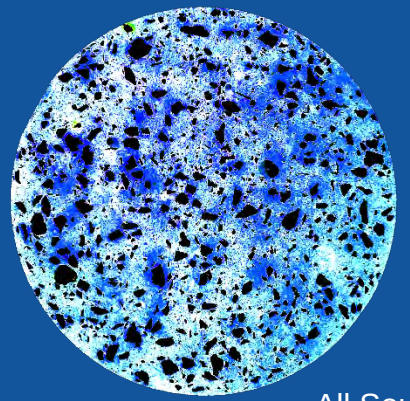
AASHTO TP139-20 Centrifuge Method:

Spin LWA at 2000 rpm for 3 min.

Source: FHWA

Where Should IC Be Used?





All Source: FHWA

1. Bridge Decks

Structures that need enhanced service life.

Source: FHWA

2. Repairs

-High Early Strength

-High-paste Content

Elements or mixtures that have high shrinkage or cracking potential.

Source: FHWA

3. Pavements

-Low Curl Performance
-Extended Control Joint Spacing

Any element where reduced shrinkage adds desired performance.

Source: FHWA

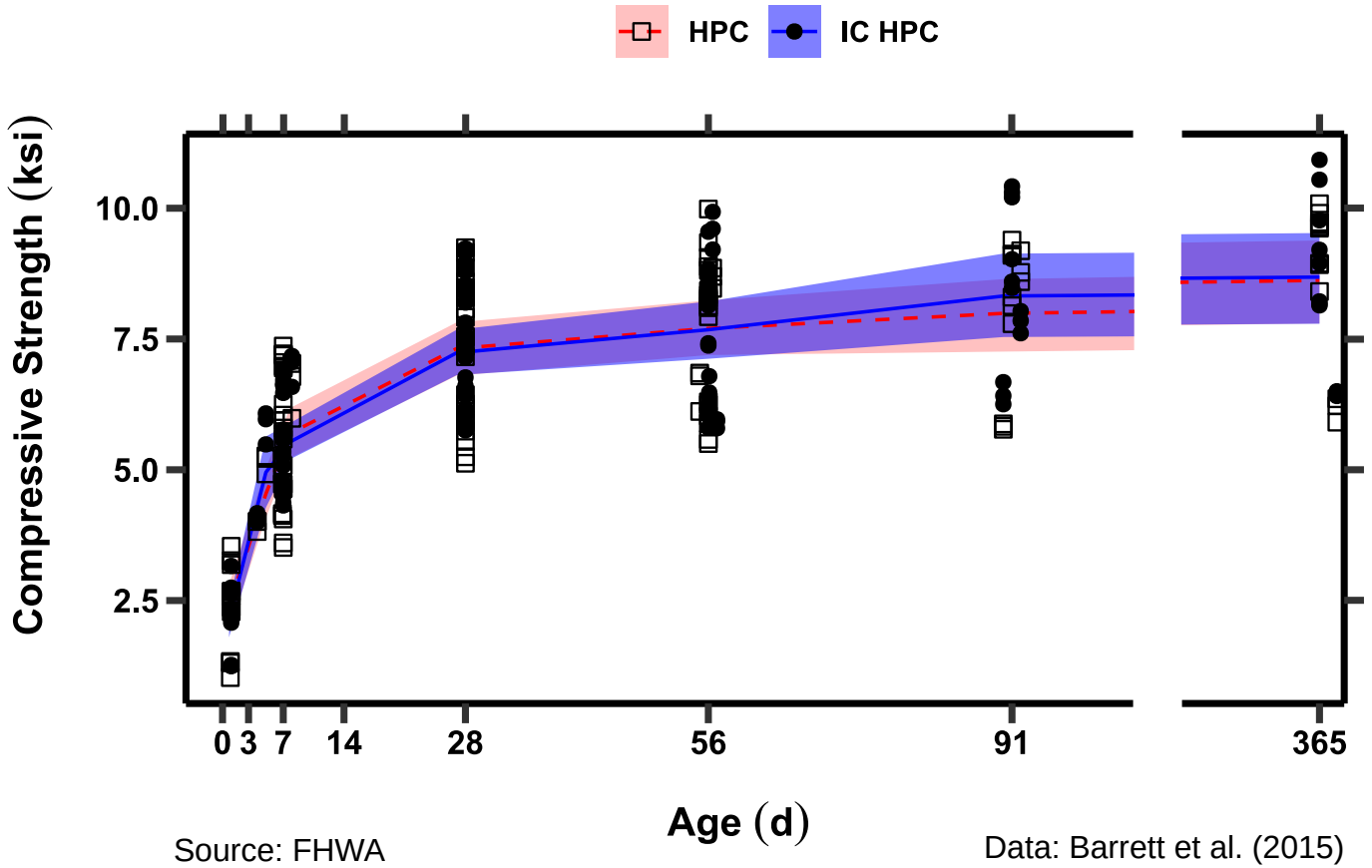
Advantages of Internal Curing

- Works automatically
- Compatible with current concrete practice
- Simple modification to concrete mixture design proportions
- No modifications to structural design process
- Economical
- Unlike some things in construction, it's hard to forget to do
- Works automatically

Performance Benefits

- Substantial reduction in total cracking potential
- Improved resistance to:
  - plastic shrinkage
  - drying shrinkage
  - thermal shrinkage or gradients
- Continued and extended hydration of cement
- Creates potential for very high durability concrete with mitigation of cracks typical in traditional “high performance concrete”
- Secondary benefits such as improved alkali silica reaction resistance

Compressive Strength



Source: FHWA

Data: Barrett et al. (2015)

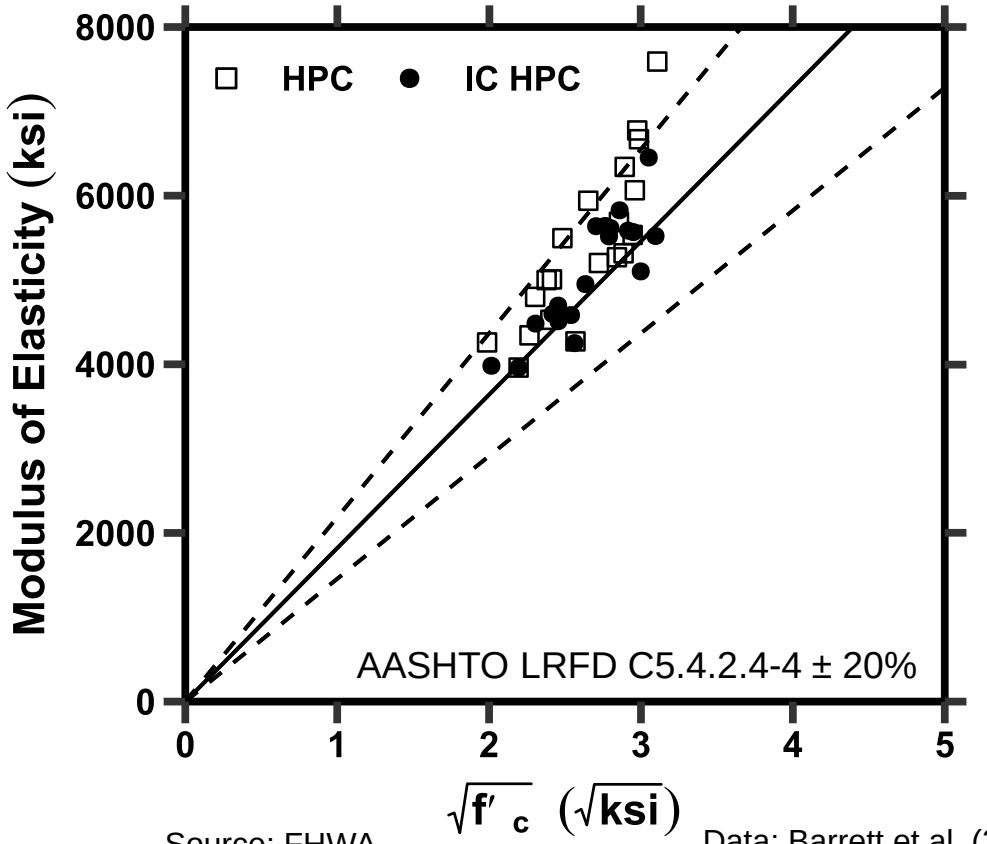
- Compressive strength may vary by small amounts in individual trials
- Variation as a class of concrete not significant
- If employing HPC, typically much stronger than designed

IC HPC: Internally cured, High performance concrete

HPC: High performance concrete

Young's Elastic Modulus

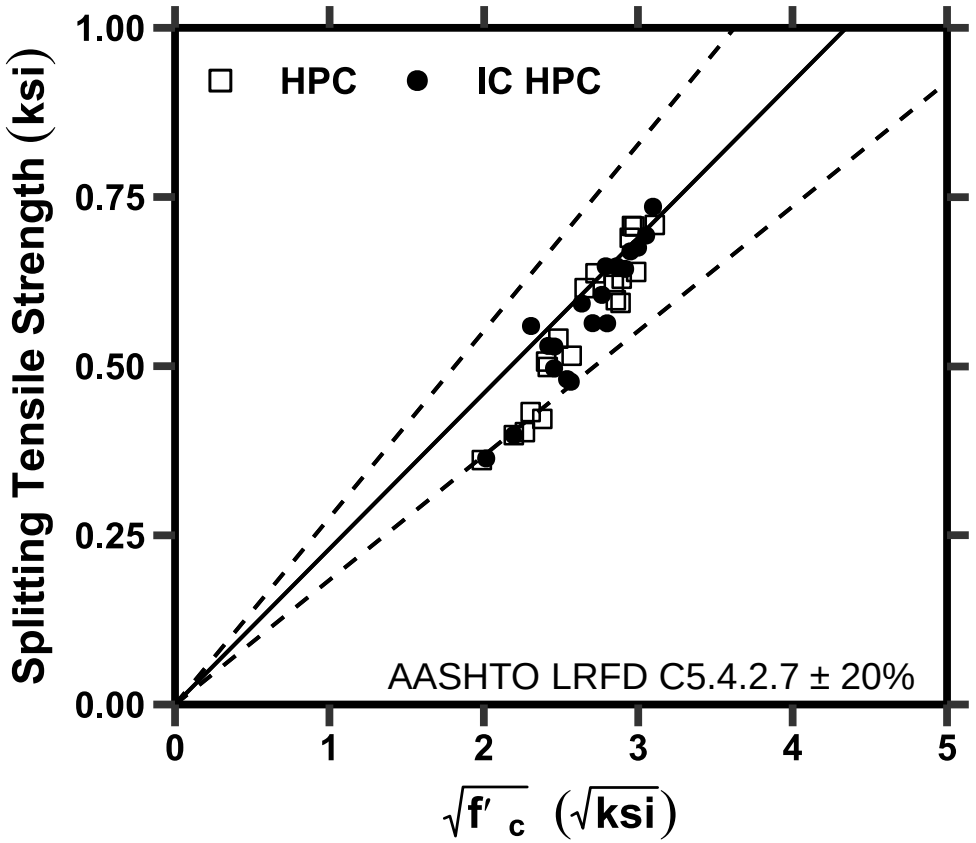
- Modulus of elasticity follows code expressions for conventional concrete
- This is not *lightweight* concrete (λ=1)
- Typical unit weight ~135+ lb/ft^3



Source: FHWA

Data: Barrett et al. (2015)

Tensile Strength

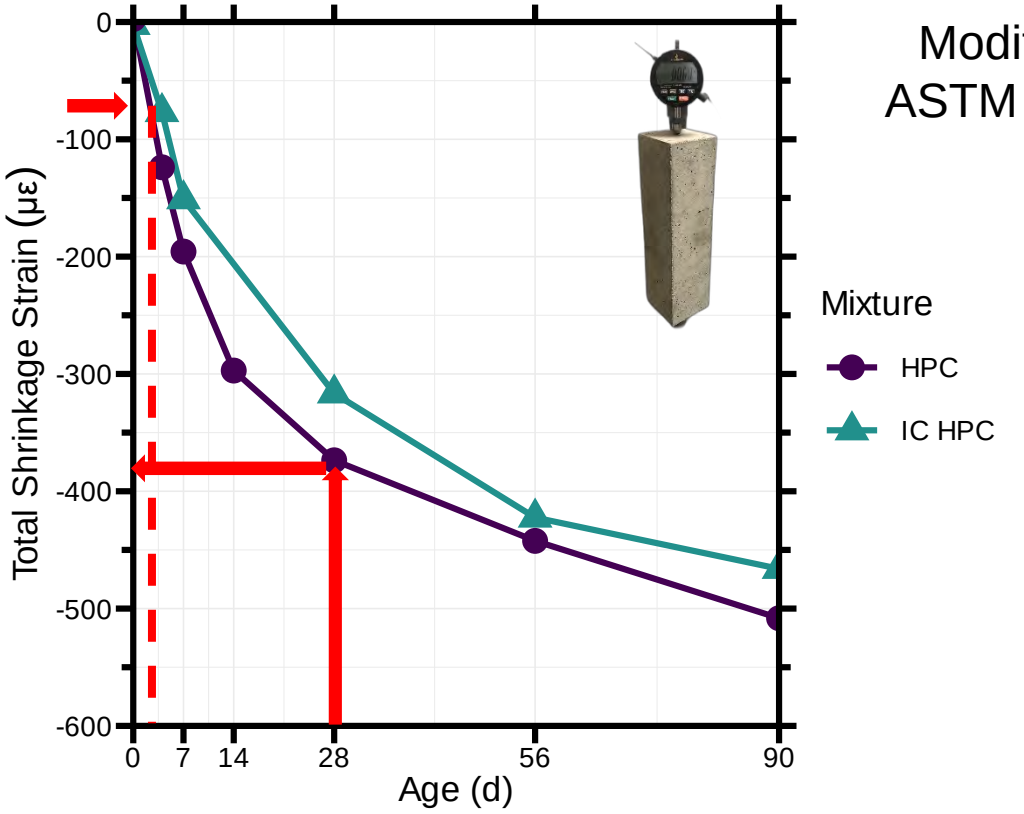


Source: FHWA

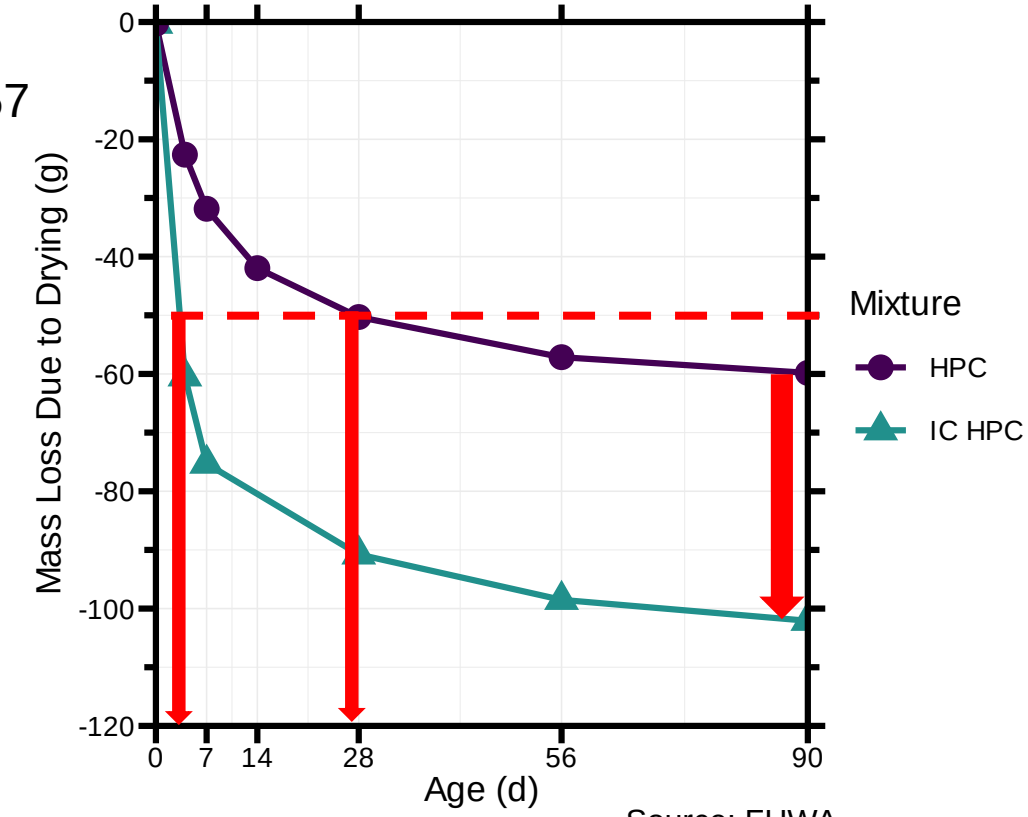
Data: Barrett et al. (2015)

- Tensile strength follows code expressions for conventional concrete
- This is not *lightweight* concrete (λ=1)

“Drying” (Total) Shrinkage



Modified ASTM C157



Source: FHWA

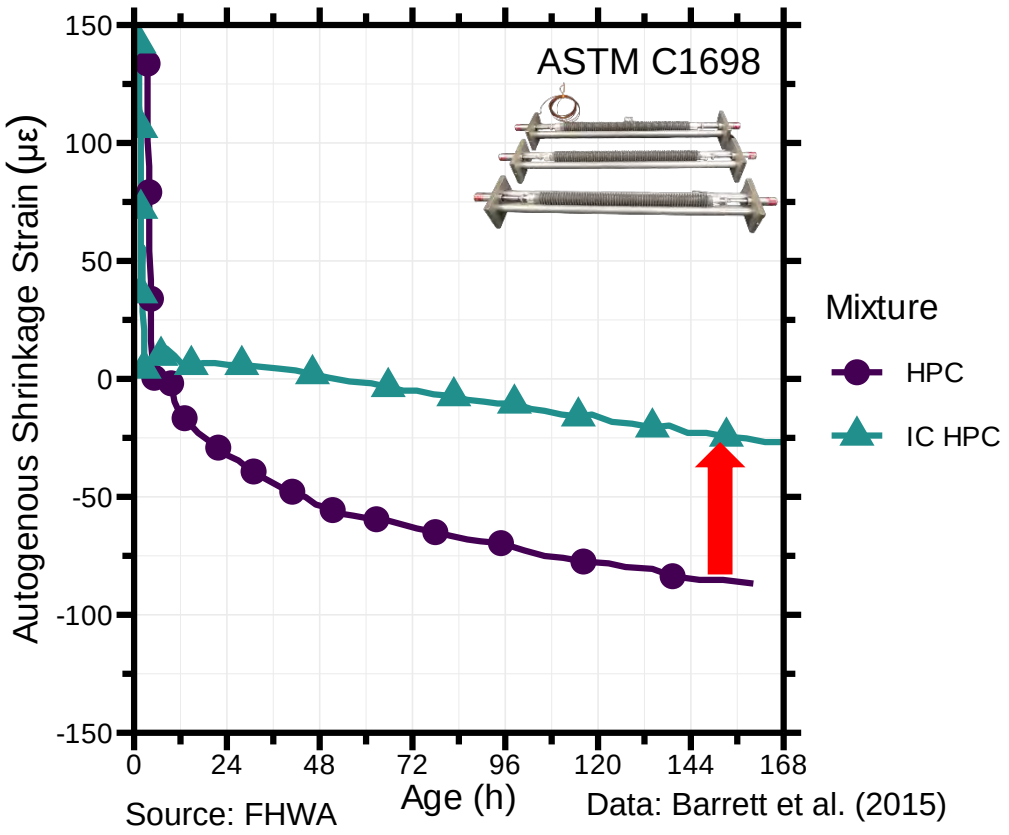
Data: Barrett et al. (2015)

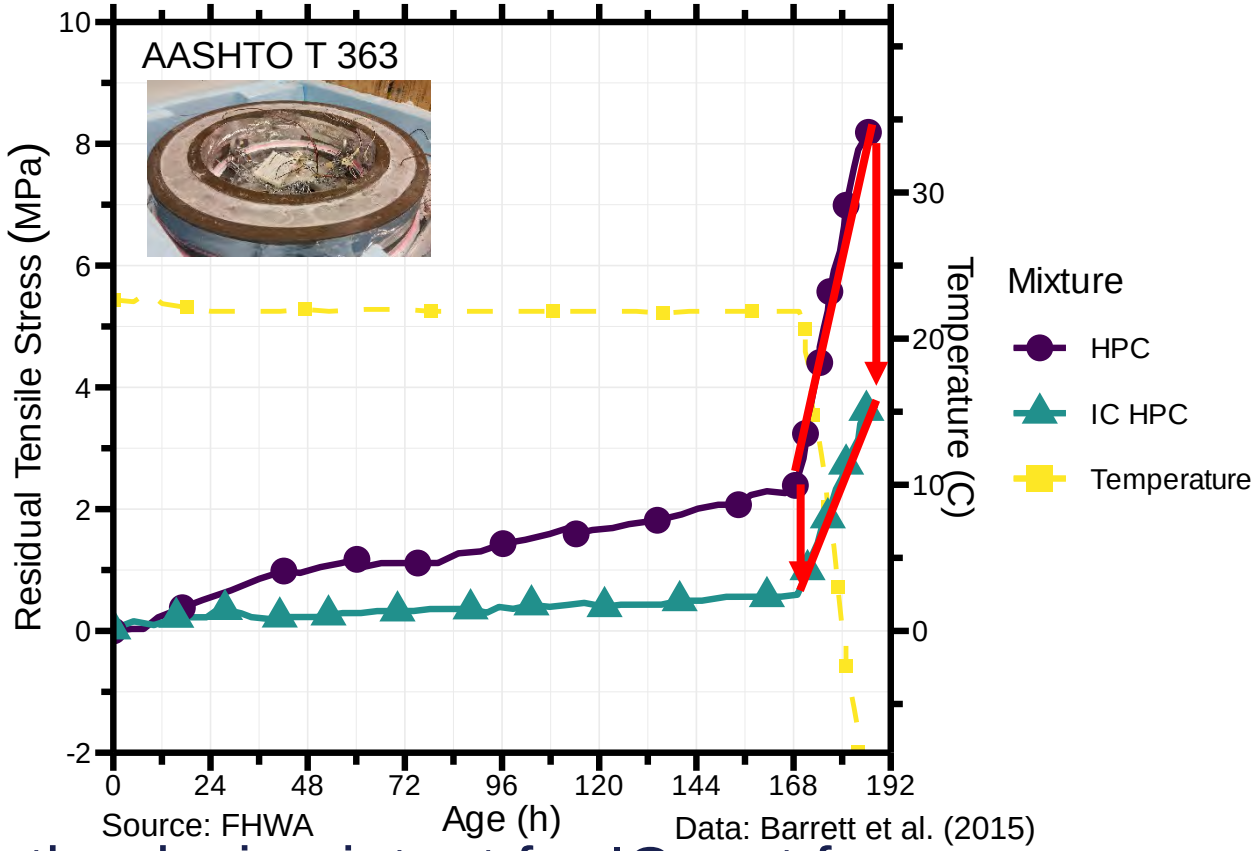
Not a test that should be necessarily specified

Source: FHWA

Data: Barrett et al. (2015)

Autogenous Shrinkage

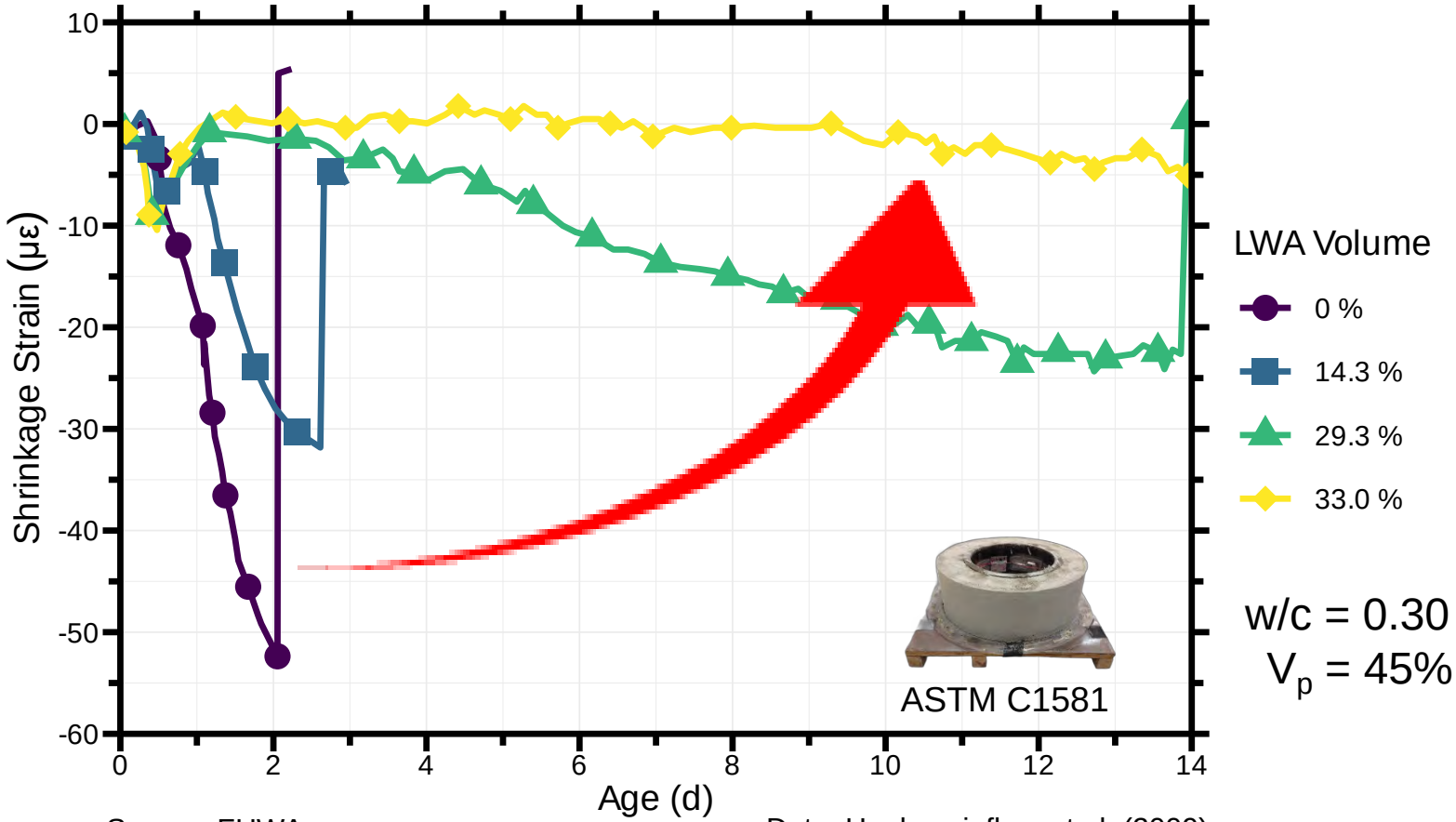




These are specialized tests that verify the design intent for IC, not for spec.

Combined Drying & Autogenous Shrinkage

- Benefits remain clear
- Providing sufficient curing water by amount of LWA is key
- Not a test that should be specified



Source: FHWA

Data: Henkensiefken et al. (2009)

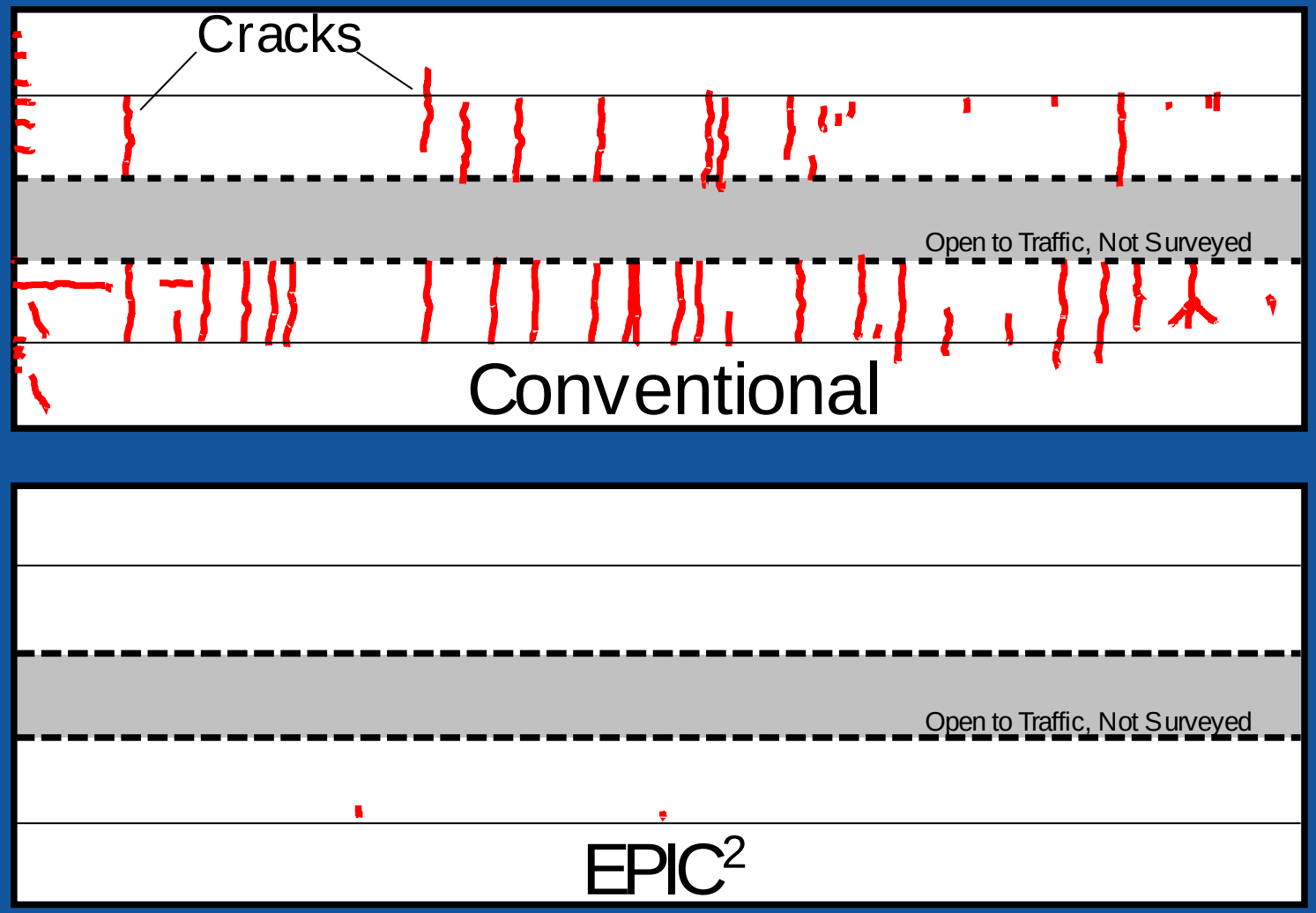
w/c: water-to-cement ratio (mass basis)
V_p: volume of paste

Performance Relative to Shrinkage Reducing Admixtures?

Similar reduction to cracking potential
as industry-standard optimum dosage of
1.5 gallon per cubic yard

“Head to Head” Comparison

Cracking after 1 Year of Service

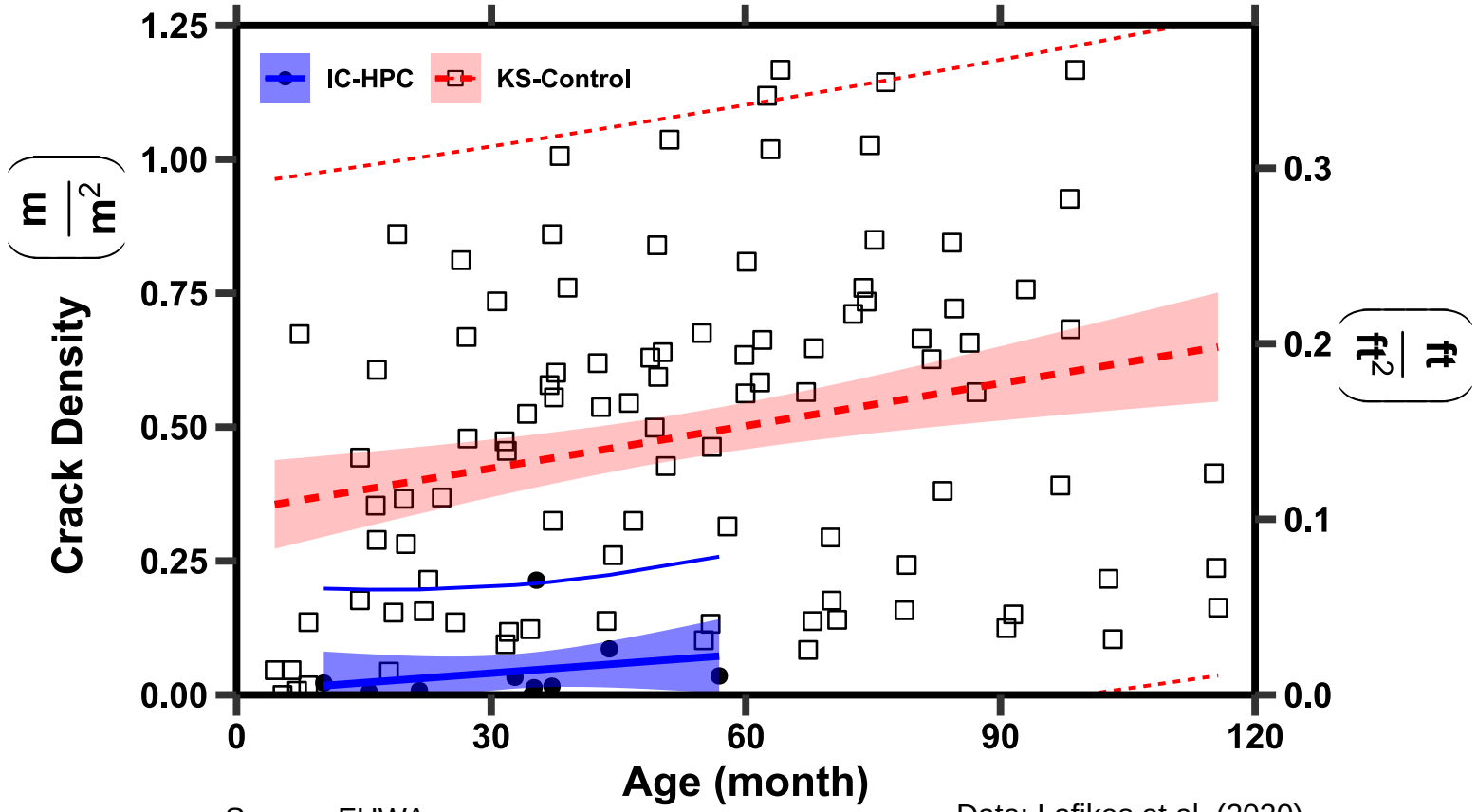


Source: FHWA

Data: Wang et al. (2019)

Shrinkage Cracking Performance

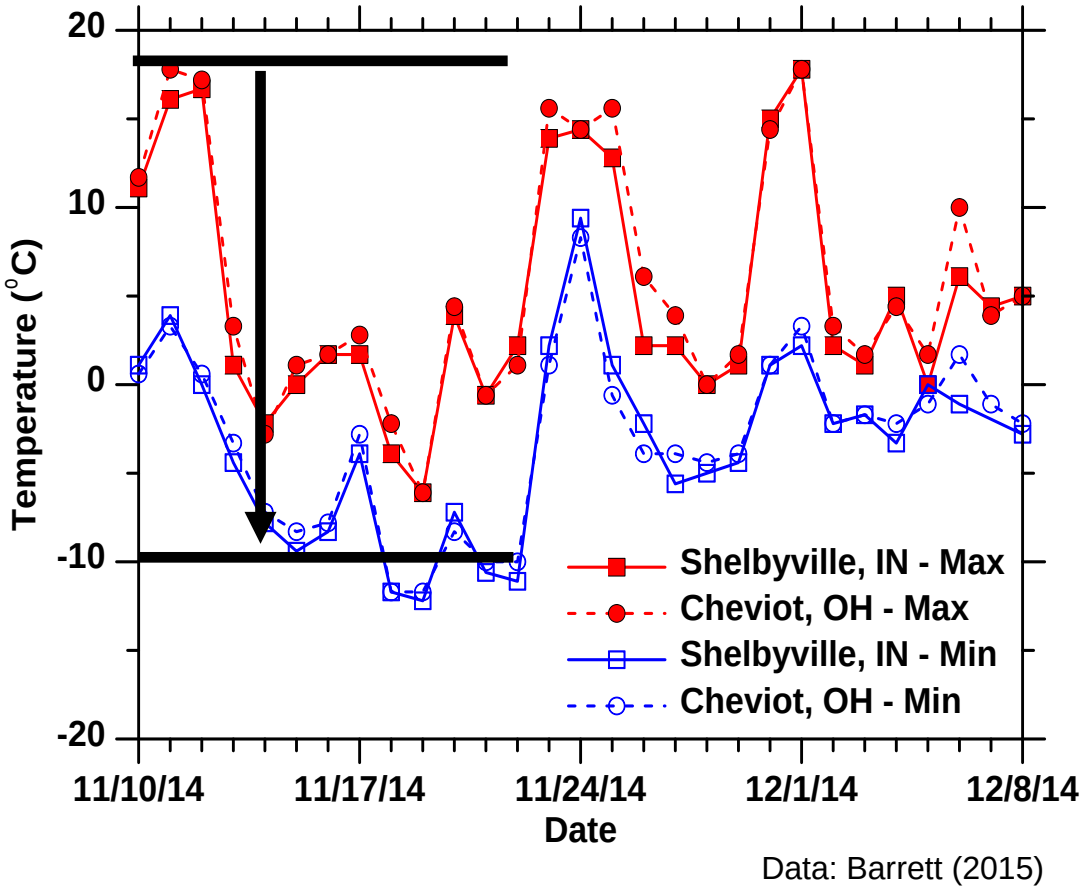
Cracking Substantially Reduced



Source: FHWA

Data: Lafikes et al. (2020)

Thermal Cracking Performance



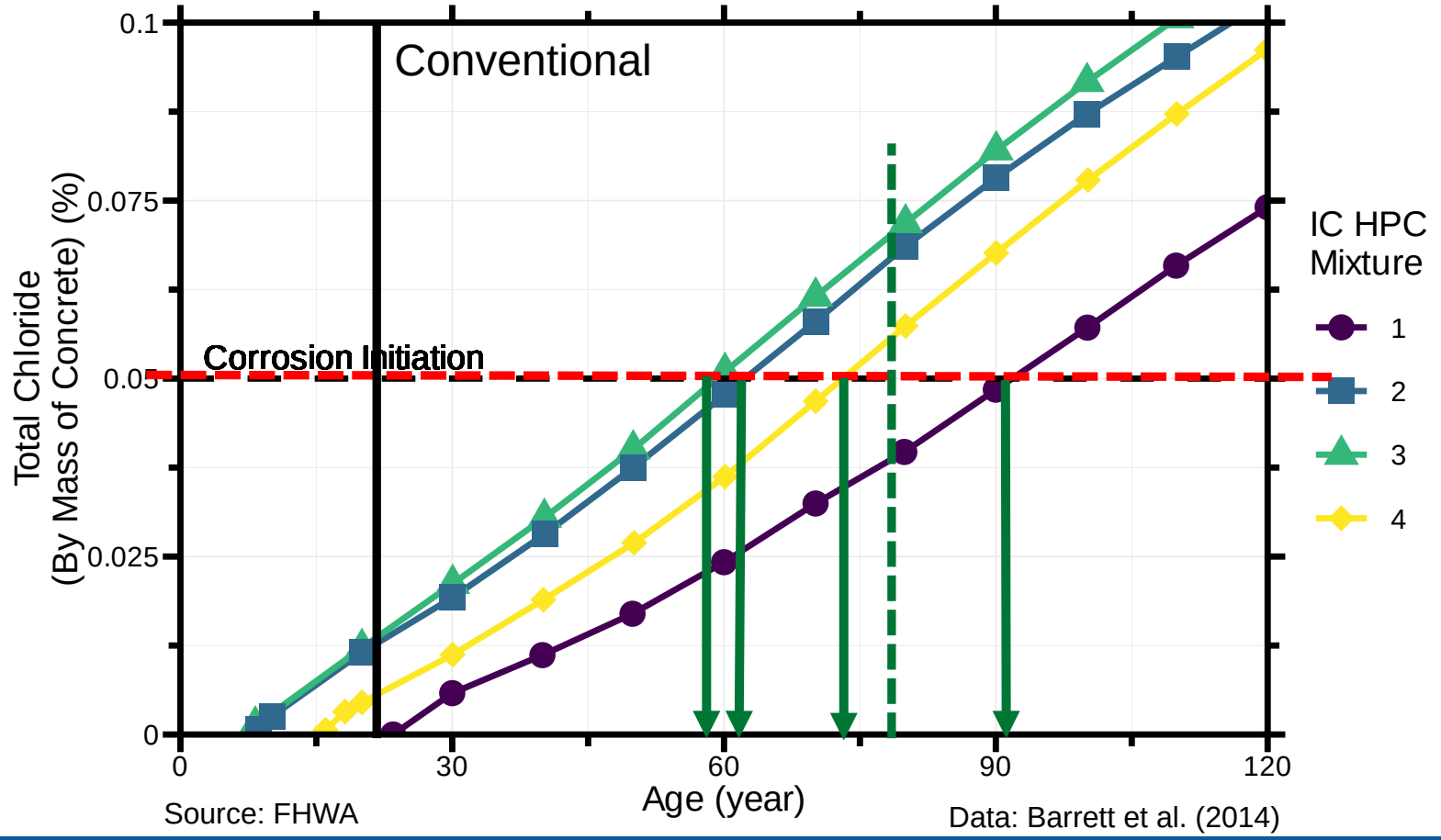
Data: Barrett (2015)

All Image Sources: FHWA

Internal curing lowers the coefficient of thermal expansion

Higher resistance to thermal cracking

Estimated Service Life



Estimated Corrosion Initiation Service Life:

60-90 years

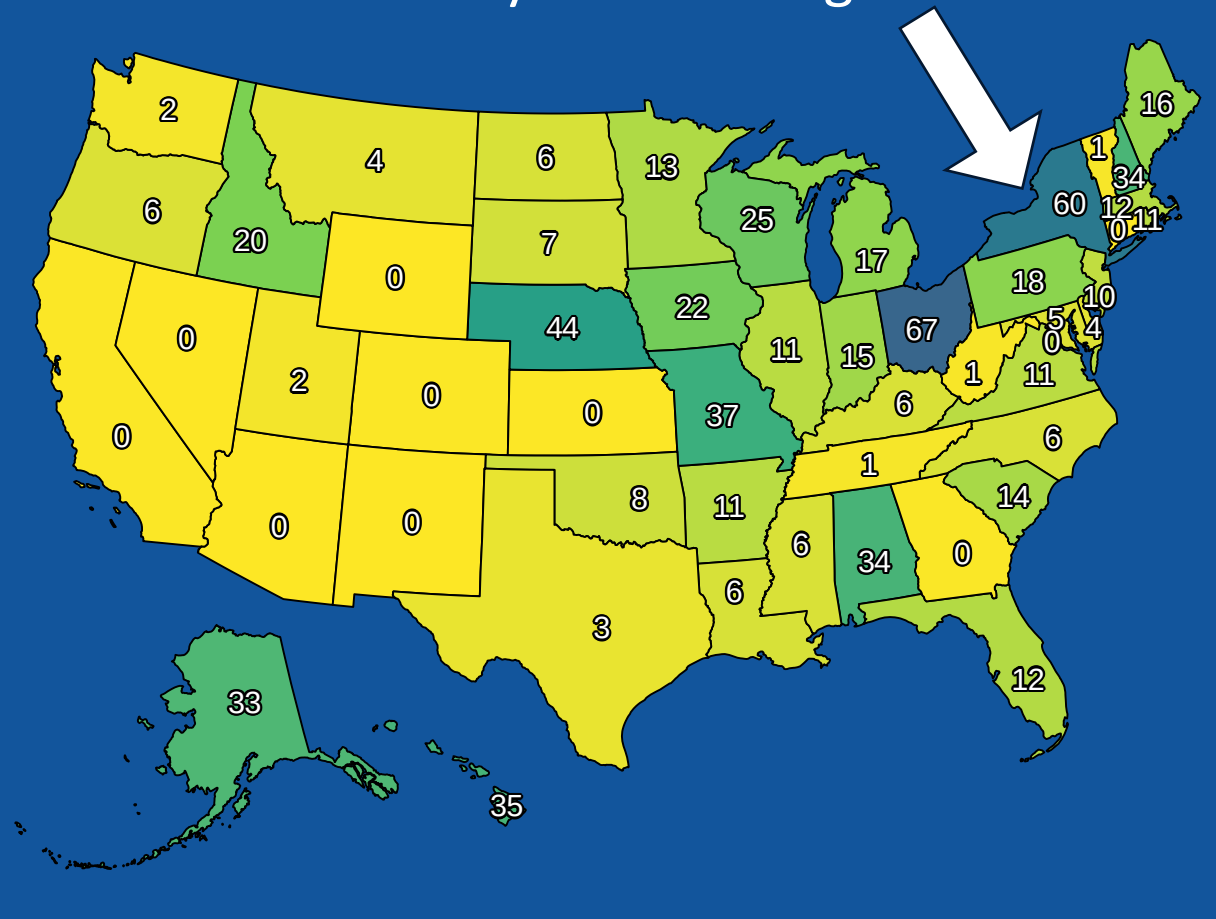
~3 to 4.5x increase

Percentage of Bridges,

Less Than 10 Years of Age,

Deck Condition Rating of 9

New York was the first to institutionalize, nearly a decade ago.



Source: FHWA

Data Source: NBI, 2022.
Deck condition (Item 58) rating of 9 (Excellent Condition).

Life Cycle Cost Analysis

Internally cured, high performance concretes have been estimated to reduce lifecycle cost by 29 - 70% compared to control

Sources: Cusson et al. (2010), Guo et al. (2014), Wang et al. (2019)

On-Demand Webinars

Theory & Performance of Internally Cured Concrete

Mixture Proportioning for Internally Cured Concrete

Lessons Learned in NY, IN, and LA

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Thank you

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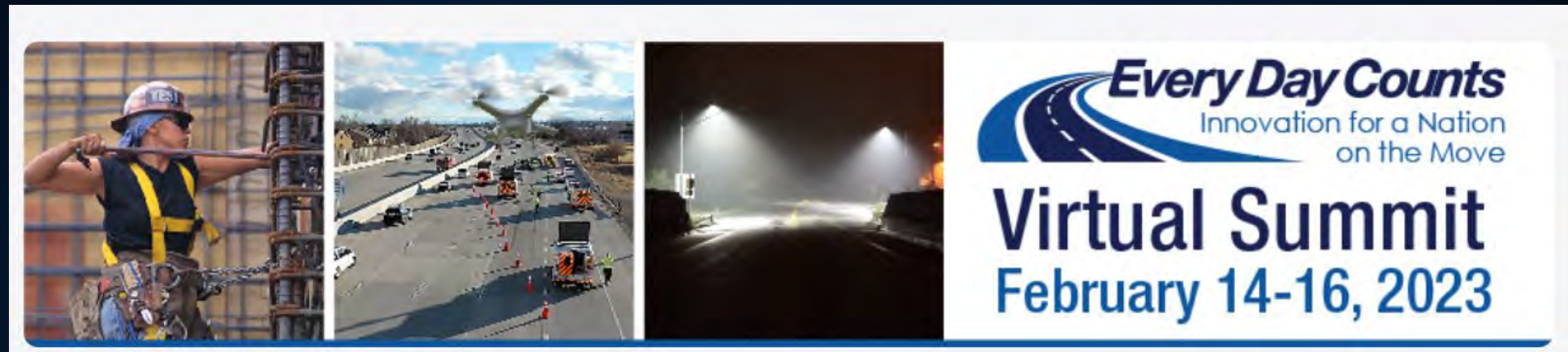

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