

# Lightweight Concrete – VDOT Experiences for Bridge Decks & Overlays

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# Outline

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- Lightweight Concrete (LWC)
- VDOT deck applications with sand LWC
  - Route 269 (old Route 60)
  - Route 60 near Bueno Vista
  - Route 33
- Low cracking concrete decks: LWC option
- All LWC
- VDOT overlay applications with sand LWC
  - I-64 Dunlap Creek
- Conclusions



# LWC Benefits

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- Low modulus of elasticity and high inelastic strain capacity
- Internal moist curing
- Low thermal coefficient of linear expansion
- Improved contact zone between the aggregate and the paste



# Pantheon



Almost 2,000 years old!

LWC dome



# LWC Use

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- Reduced loads on the substructure
- More efficient structural design  
(longer spans)
- Reduced cracking
- Improved durability
- Accelerated bridge construction



# VDOT Field Applications

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- Since 1961 mainly in deck widening projects.
- Mainly LW coarse aggregate and normal weight fine aggregate (sand LWC) in beams, decks, and overlays. Maximum fresh density 120 lb/ft<sup>3</sup>.
- All LWC; both fine and coarse aggregate LW in deck. Maximum density 105 lb/ft<sup>3</sup>.



# Route 269 – 1979 LWC Deck

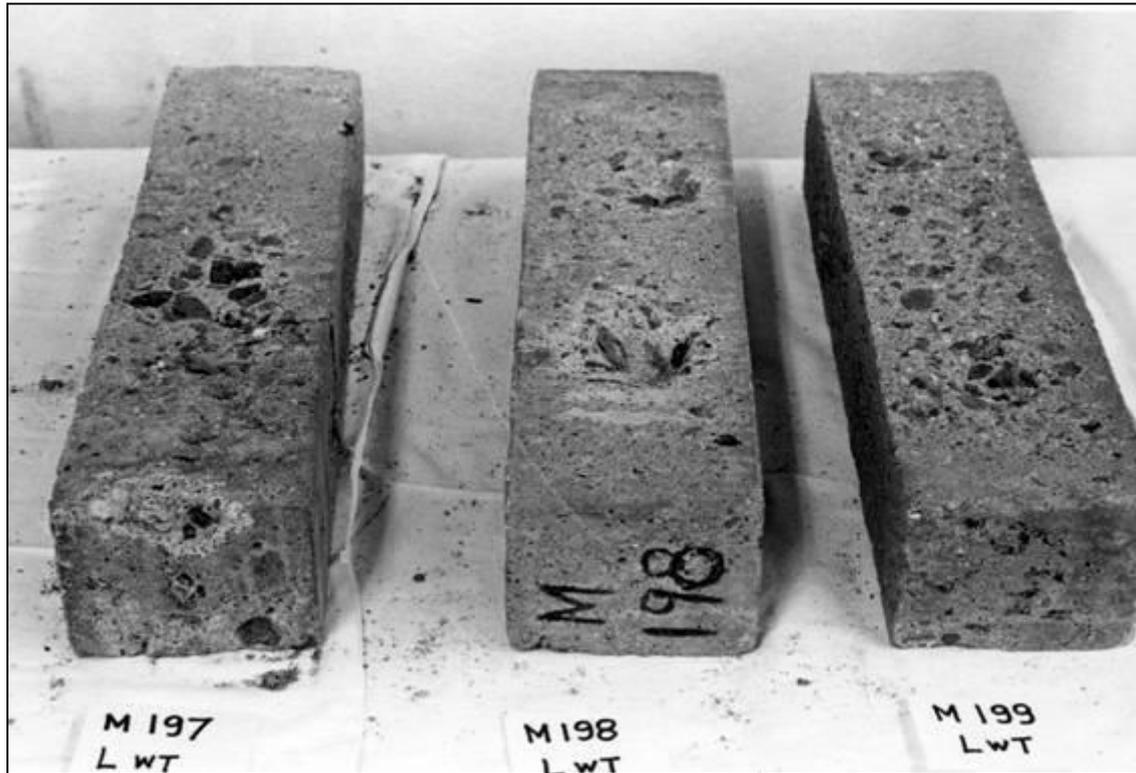


212-ft long two span, LW aggregate  
absorption=18%

No transverse cracks at the 33 year visit



# Route 269



Laboratory freeze-thaw testing  
Field performance satisfactory



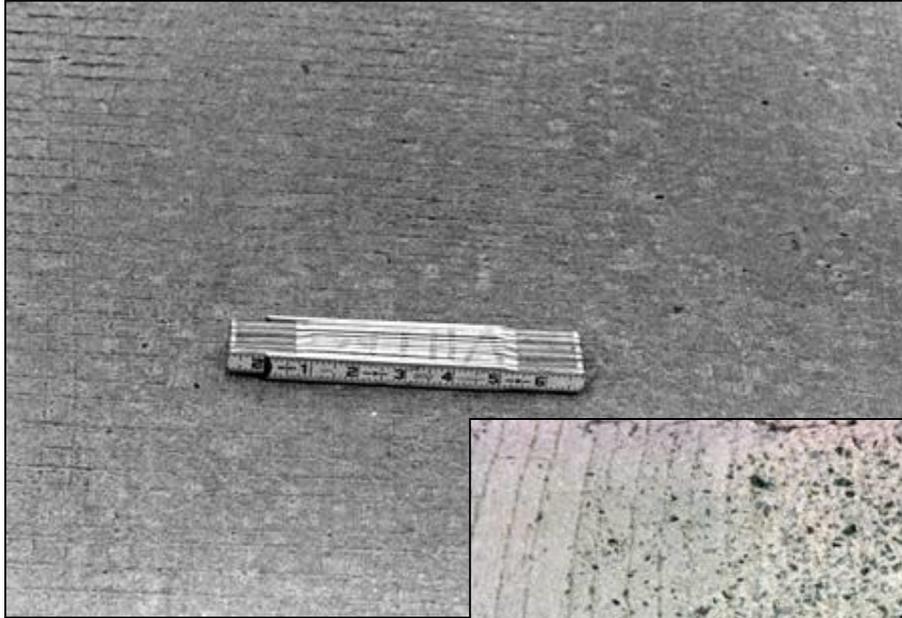
# Freezing and Thawing – ASTM C 666



Two weeks moist cure and at least 1 week drying and tested in 2% NaCl solution. ASTM C 330 indicates 2 weeks drying.



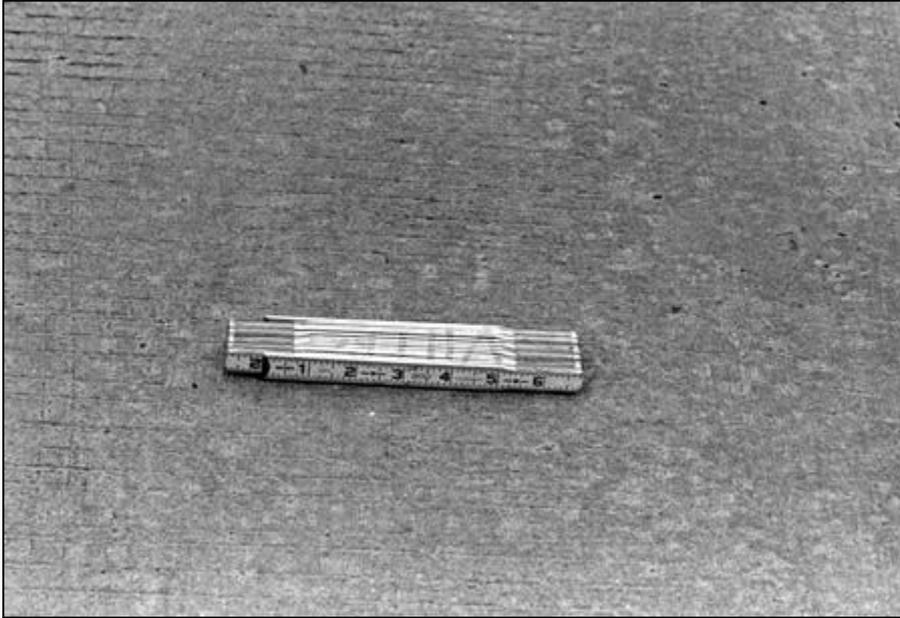
# Route 269 – 1983 Pictures



# Route 269 – 2008 Pictures



# Route 269



No visual change between the 1983 and 2008 pictures indicating satisfactory freeze-thaw and abrasion/wear resistance!



# Route 60 over Maury River - 1984



# Route 60 over Maury River - 1984



Skew, some exposed aggregates, no cracks at 30 year visit, good performance



# LWC - Rte. 33

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- Over the Mattaponi River, 3,454-ft long bridge - 2,195 ft with lightweight concrete beams and deck.
- Over the Pamunkey River, 5,354-ft long bridge - 2,169 ft with lightweight concrete beams and deck.
- 200 and 240 ft spans in four-span spliced girders; and > 120 ft spans in continuous for LL units.



# Route 33 over Mattaponi River



LWC deck = 5,000 psi  
LWC beam = 8,000 psi  
LW CA absorption = 5% to 6%



# Route 33 over Pamunkey River

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# Route 33 over Pamunkey River

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Ground section. Deck is performing satisfactorily!



# Low Cracking Deck Study - LWC

2012

- (i) Winchester, Staunton District
- (ii) Lynchburg District
- (iii) Opal, Culpeper District

2013

- (iv) Nokesville, NOVA District
- (v) Fredericksburg District
- (vi) Richmond District

2014

- (vii) Stafford, NOVA



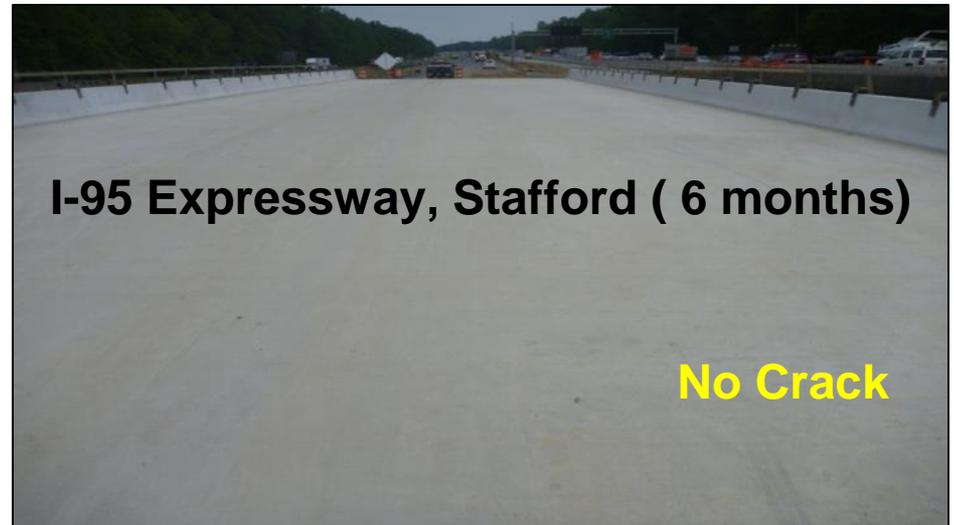
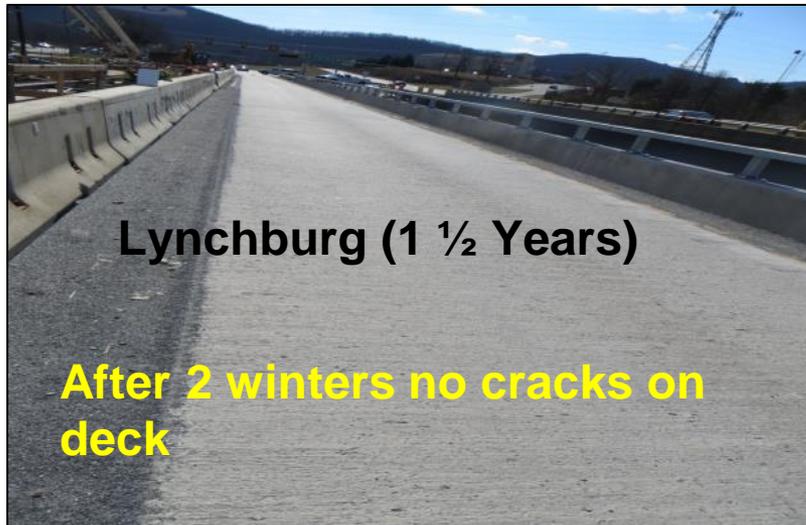
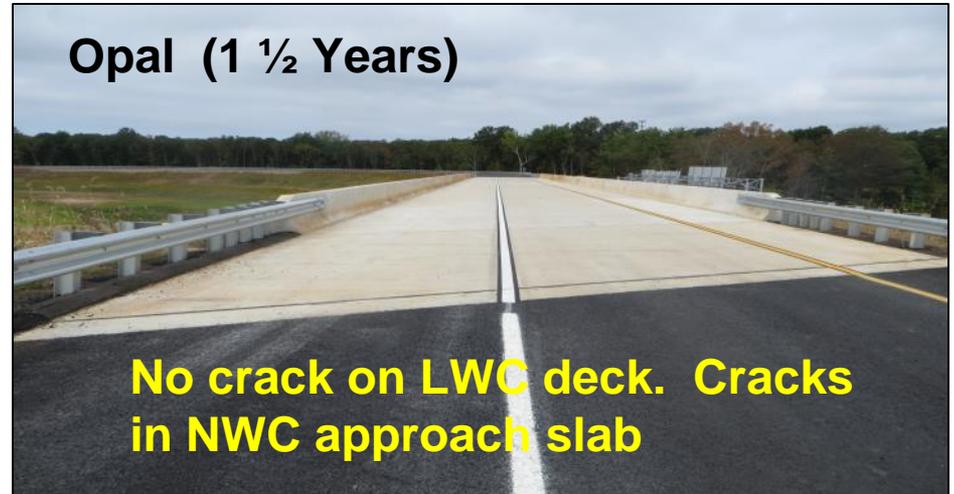
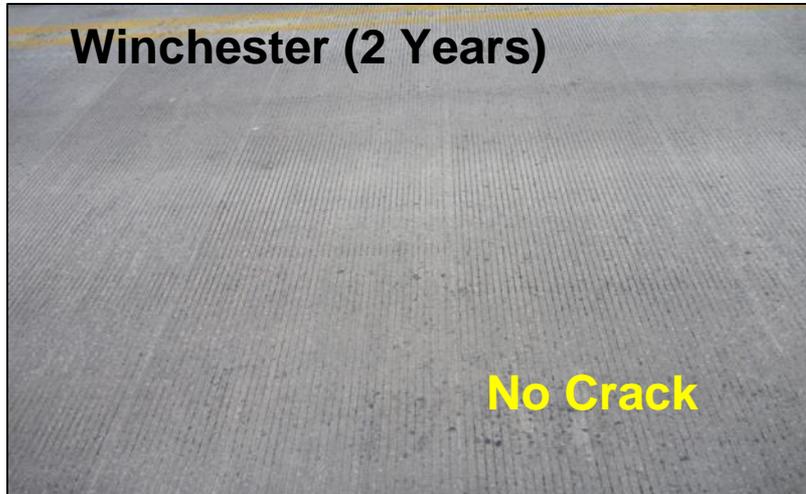
# Opal Bridge - 2012



Two 128' spans  
4 beams per span with LW SCC, LWC deck



# Low Cracking Deck Study - LWC



# Low Cracking Decks

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Drying shrinkage cracking can be minimized with the use of one or more of the following options:

- LWC with LW coarse aggregate
- Normal weight Concrete (NWC) with SRA (shrinkage reducing admixture)
- Shrinkage Compensating Concrete (Type K)

Proper concrete placement, consolidation and curing are important.



# VDOT 2016 R&B Specification for Low Cracking Bridge Deck Concrete

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Normal weight concrete: total cementitious materials content shall be  $\leq 600$  lb/yd<sup>3</sup>. If 28-day drying shrinkage is  $> 0.035\%$ , SRA shall be used to reduce the shrinkage to acceptable level.

Lightweight concrete: total cementitious materials content shall be  $\leq 650$  lb/yd<sup>3</sup> and the maximum fresh density shall be  $\leq 120$  lb/ft<sup>3</sup>.



# All LWC

- Route 198 (Dutton Road) over Harper Creek
- Cast-in place all LWC deck, backwalls, parapets, and substructure modifications with a maximum density of 105 lb/ft<sup>3</sup> (2016)

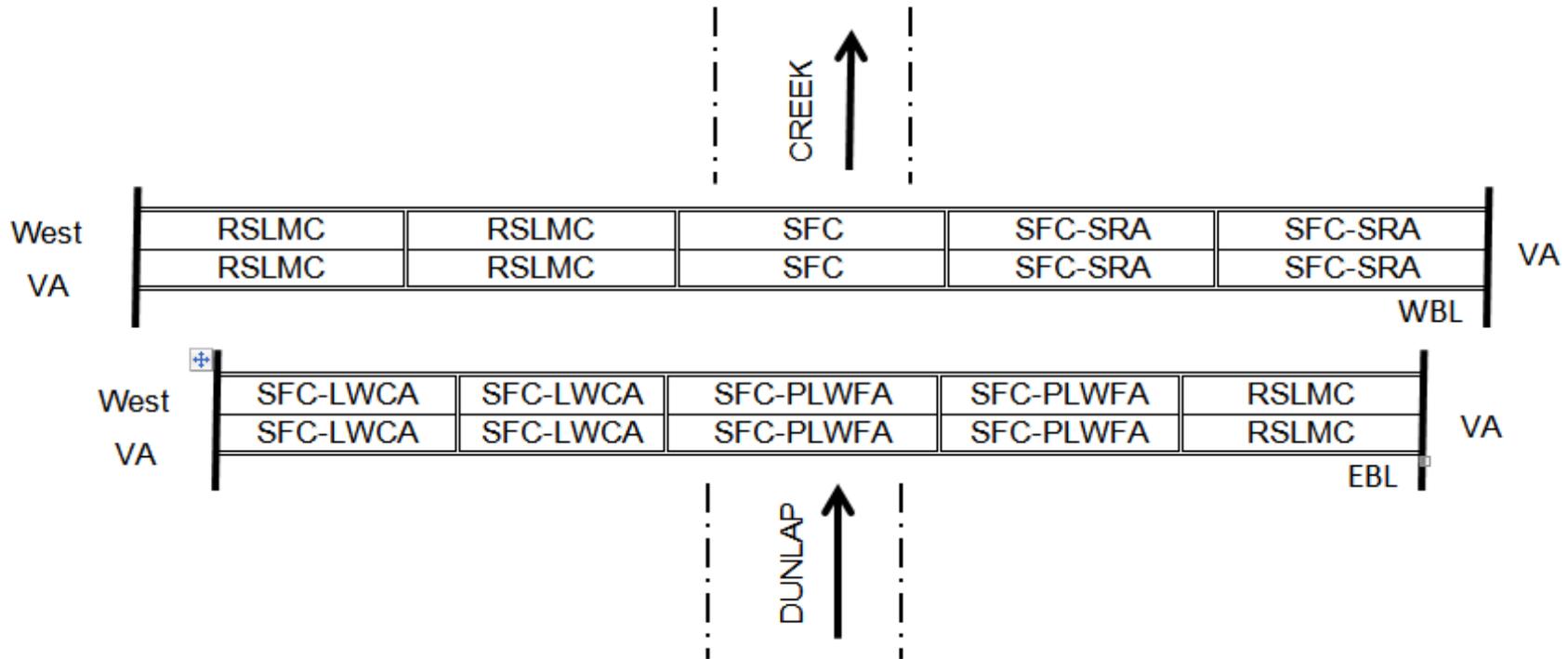


# LWC Overlays on I-64 over Dunlap Creek



# Overlays on I-64

WBL Rehabilitation: Fall-2014  
 EBL Rehabilitation: Summer-2015



RSLMC – Rapid set with Latex Modified Concrete

SFC – Silica Fume Concrete

LWCA – Lightweight coarse aggregate, PLWFA – Partial lightweight fine aggregate,

SRA – Shrinkage Reducing Admixture



# LWC Overlays on I-64



Prepared in RMC Truck



# Hydro-Demolition to Remove Deteriorated Concrete



# Overlay Curing

Prompt application of wet burlap



# Mixture Proportions (lb/yd<sup>3</sup>)

Material	SFC- LWCA	SFC-PLWFA
Type I/II portland cement	632	612
Silica fume	48	46
LWCA, ½ in	790	----
Normal weight CA, ½ in	----	1600
LWFA	----	495
NWFA	1486	645
w/cm	0.40	0.41



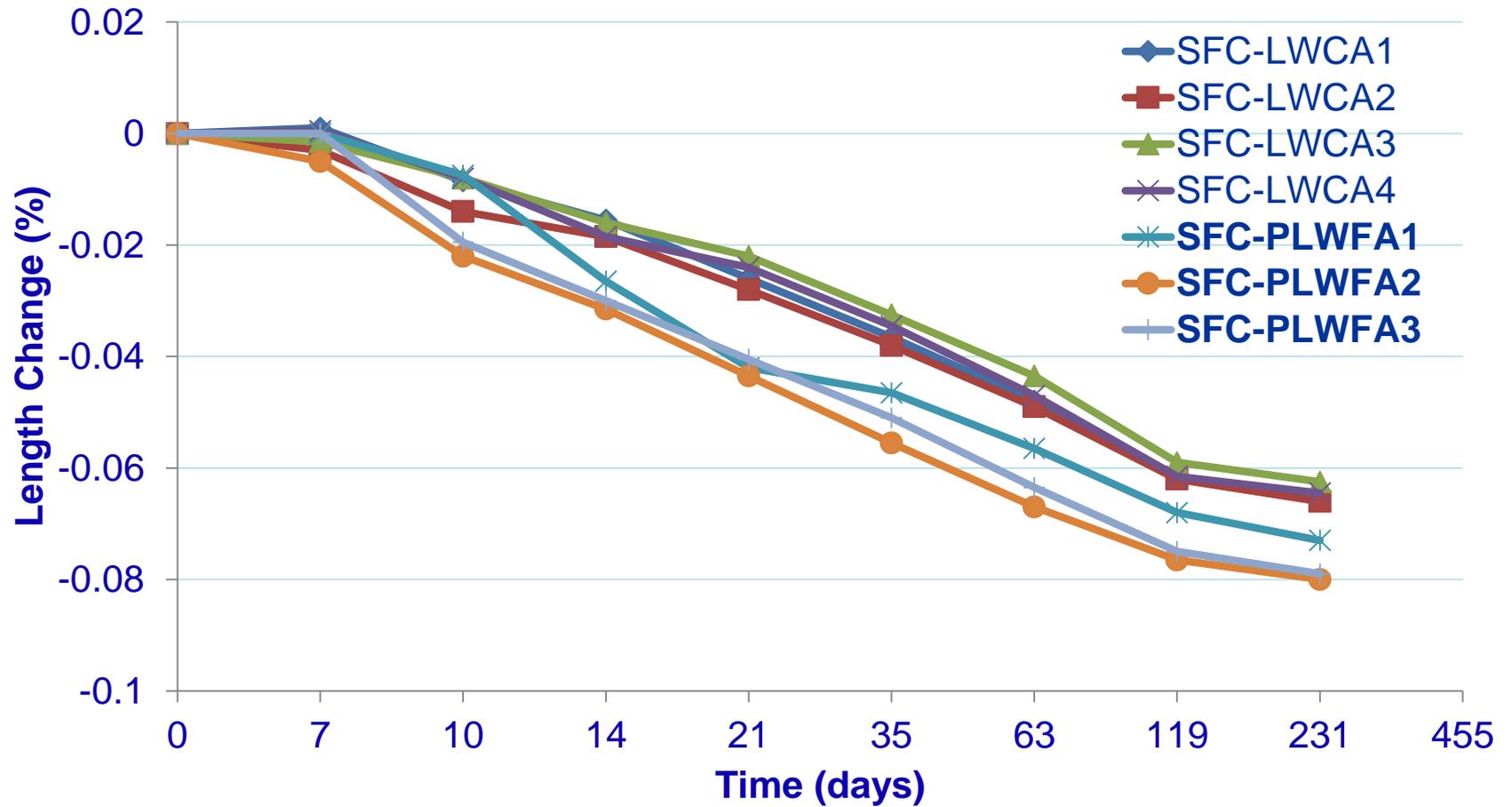
# Compressive Strength – EBL

Test	Age (d)	SFC-LWCA	SFC-PLWFA	RSLMC
Compressive strength (psi)	1	3180	2960	3690*
	3	4010	3760	----
	28	5930	6200	5280

\*3.5 hours 3020 psi



# EBL



# LWC Overlays on I-64

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- SFC with lightweight coarse aggregates or partial weight fine aggregate had shrinkage values as high as 0.06%
- Exhibited tight cracks (less than 0.1 mm).



# Conclusion

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- LWC properly consolidated and cured is performing satisfactorily.
- LWC has reduced cracking potential.
- LWC even with drying shrinkage values considered high for NWC has been performing well.



# Acknowledgements

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- FHWA
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