Effects of Concrete Cure Time on Healer Sealer Performance

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Bridge Maintenance Workshop

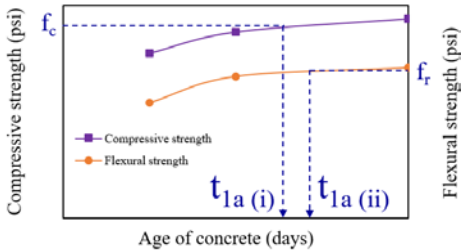
OBJECTIVE

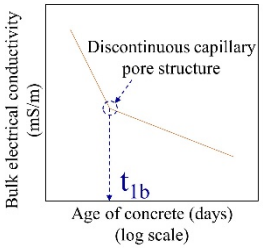
To determine if a procedure or a set time is better for deciding when to place an overlay or **a sealer** on MDOT standard materials and special/patching material.

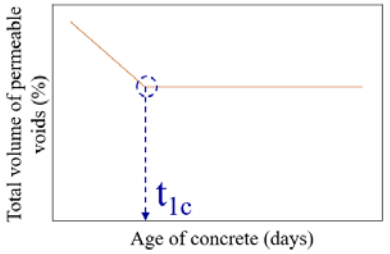
MIN. CONCRETE AGE TO RECEIVE A HEALER SEALER

t = Max

t_1

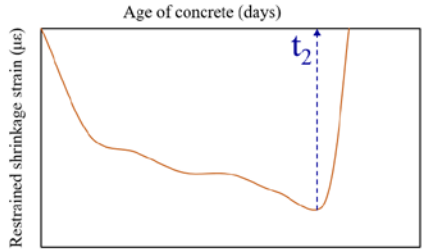






t_1 = max (t_{1a}, t_{1b}, and t_{1c})

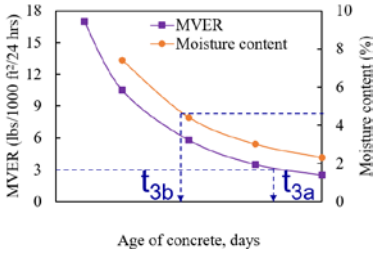
t_2



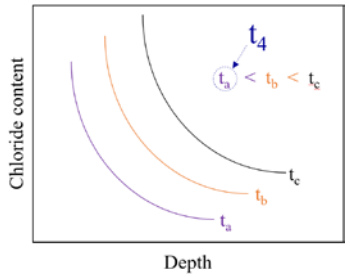
Concrete Mixes: Grade DM and BDJR

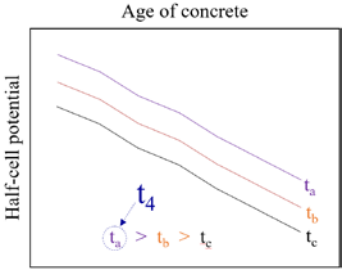
Healer Sealer	Viscosity (cps)	Label
Sikadur 55 SLV	105	S1
Pro-Poxy 40 LV LM	90	S2

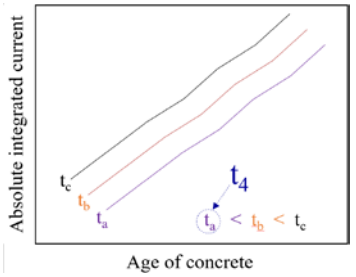
t_3



t_4







EXPERIMENTAL PROGRAM

Evaluation parameter (a)	Measurands (b)	ASTM standard (c)	Size of the specimen (in.) (d)	Healer sealer application age (e)	Curing condition (f)	Concrete age at testing (days) (g)
Concrete wet curing duration (t_1)	Compressive strength	C39	4 × 8		ASTM[2]	7, 14, 21, and 28
	Flexural strength	C78	4 × 4 × 14		ASTM	7, 14, 21, and 28
	Bulk electrical conductivity	C1760	4 × 8		ASTM	3, 7, 14, 21, and 28
	Porosity	C642	4 × 2		ASTM	3, 7, 14, 21, and 28
Concrete cracking (t_2)	Restrained shrinkage	C1581	As per the ASTM		RT[1]	
Substrate moisture (t_3)	MVER[4]	F1869	40 × 40 × 9		RT	14, 21, and 28
	Moisture content	F2659				7, 14, 21, and 28
Healer sealer application age (t_4) and performance comparison	Half-cell potential[6, 7] and voltage[7, 8]	C876 and G109 (modified)	6 × 6 × 20	14	RT	28, 42, 56, 70, 84, 98, 112, 126, 140
				21		35, 49, 63, 77, 91, 105, 119, 133, 147
				28		42, 56, 70, 84, 98, 112, 126, 140, 154
				Control		
	Chloride content	C1152		14		149
				21		156
				28		163
				Control[5]		163

1. Seven days moist curing then dry curing through testing ages under room temperature (RT)
2. Moist curing through testing ages according to ASTM C192
3. Specimens were fabricated using BDJR concrete mix only.
4. Moisture vapor emission rate
5. Control specimens were treated similar to 28-day healer sealer application specimens.
6. A copper sulfate electrode was used for half-cell potential measurement.
7. Half-cell potential and voltage across 10 Ω resistor were measured on BDJR concrete specimens only.
8. Voltage was measured across a 10 Ω resistor.

SLANT SHEAR BOND STRENGTH

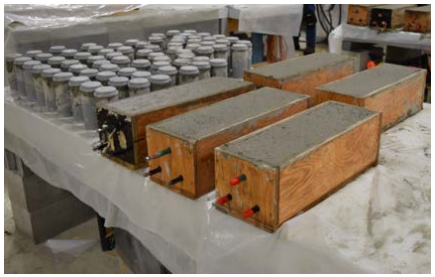
- Slant shear bond strength > 2000 psi, 2-day dry cured

Healer Sealer	Specimen no.	Slant shear bond strength (psi)	Average strength (psi)
S1	1	2413	2339
	2	2379	
	3	2224	
S2	1	1584	2141
	2	2870	
	3	1968	

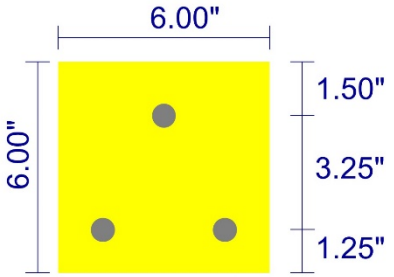
S2 is a low viscous sealant. The average of all 3 values was considered instead of considering 2870 psi as an outlier.

CONCRETE AGE TO RECEIVE A HEALER SEALER

Mold with rebar



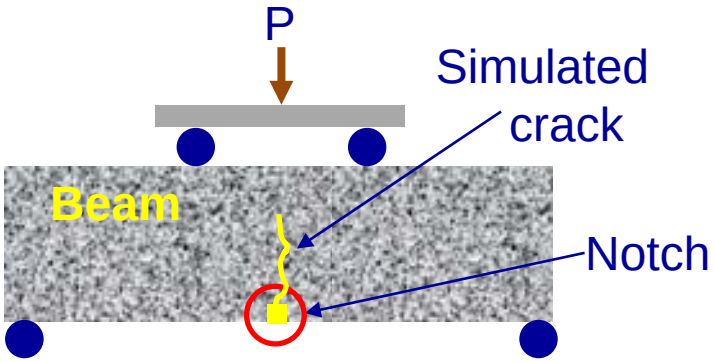
Casting



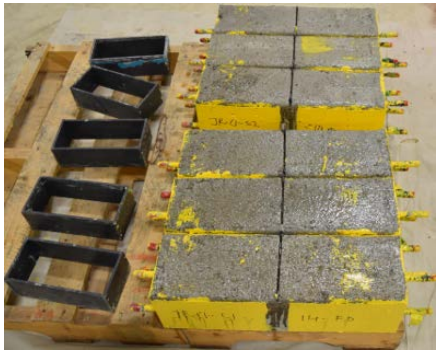
Cross-section

Curing

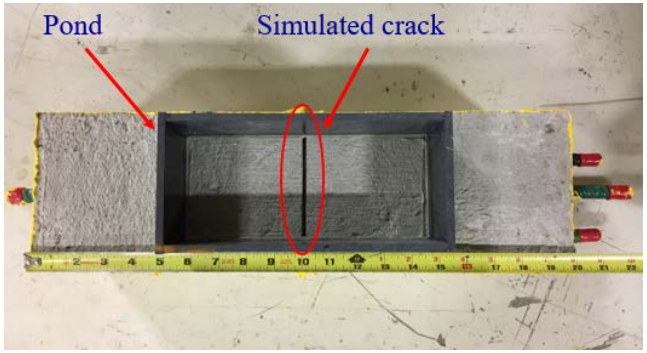
Epoxy painted surfaces



Four-point bending setup for cyclic loading



Beam with healer sealer

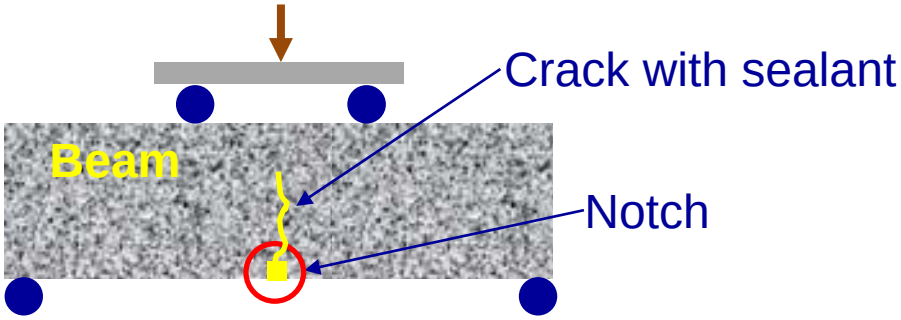


Simulated crack and pond

36 beams
6 in. x 6 in. x 20 in. beams

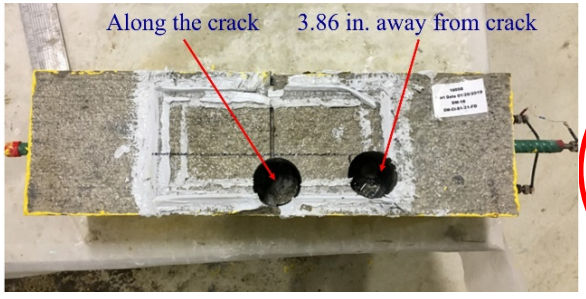
CONCRETE AGE TO RECEIVE A HEALER SEALER

P = 75% of the 28-day flexural capacity



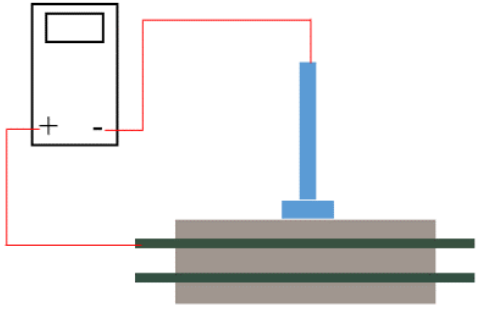
5 cycles of loading

Voltage measurement across a 10 Ω resistance



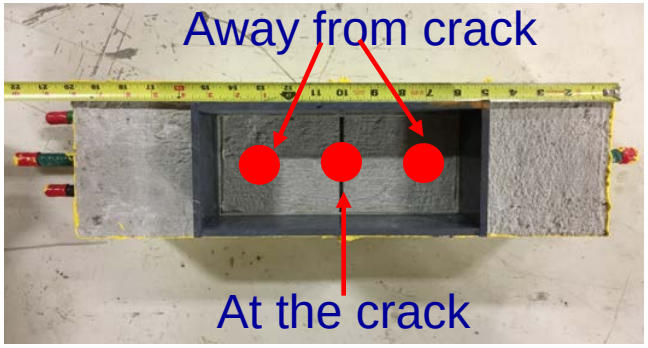
Coring location (top surface)

Samples passing #20 sieve



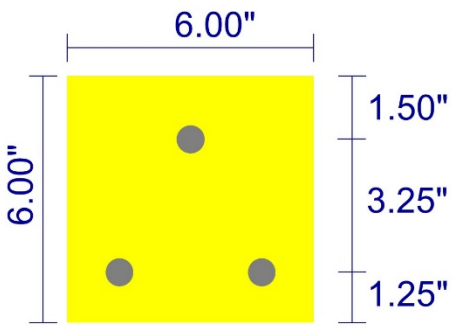
Half-cell potential reading following each wetting cycle (one-week)

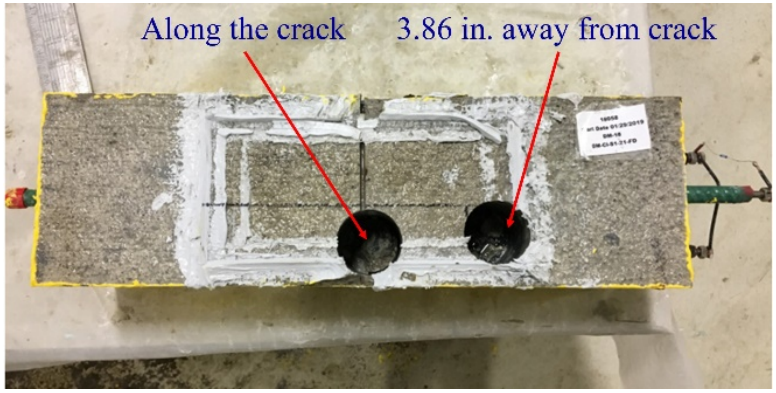
0.5 in. thick slices

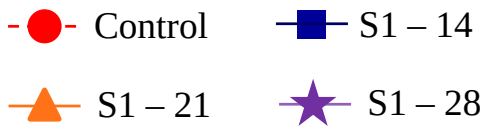


CONCRETE AGE TO RECEIVE A HEALER SEALER

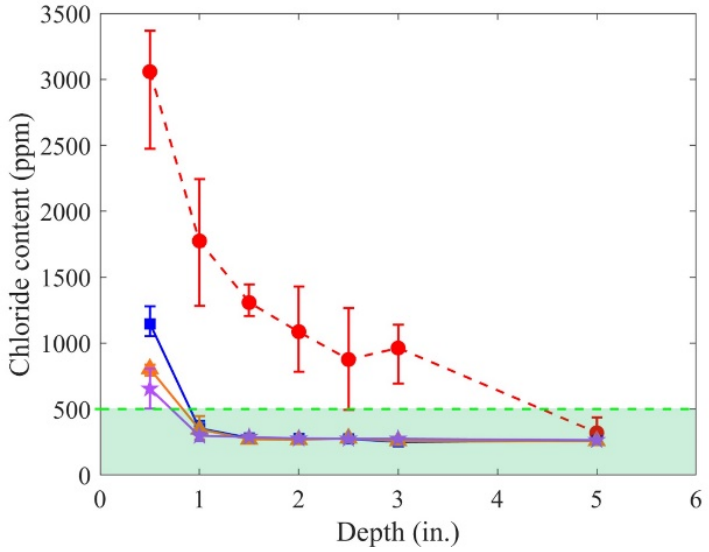
- **Grade DM** Chloride content limit < 500 ppm



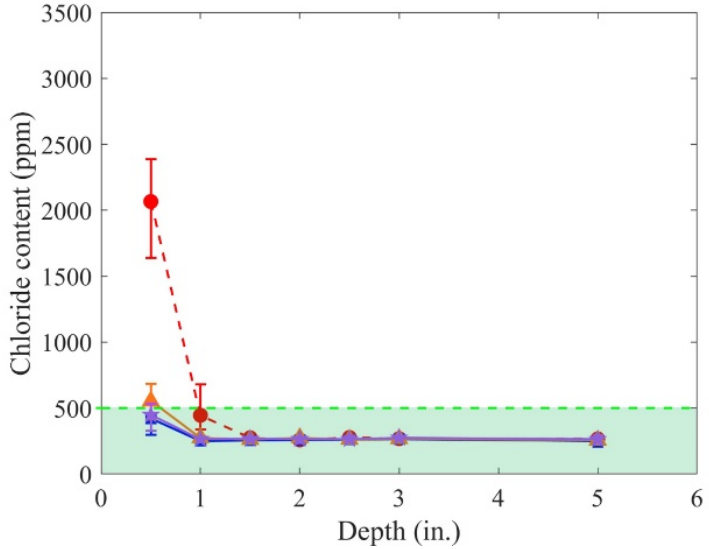




S1



At the crack



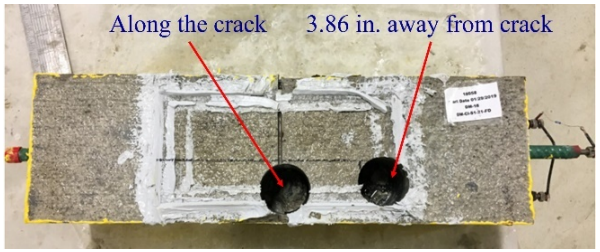
Away from the crack

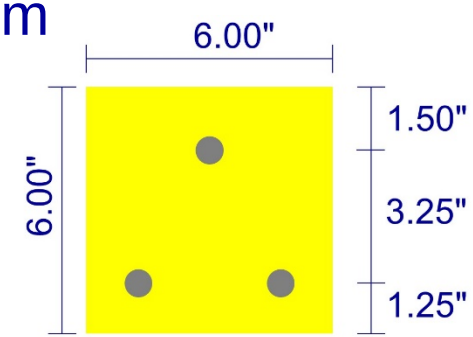
$t_4 \cong$ **14 days**

CONCRETE AGE TO RECEIVE A HEALER SEALER

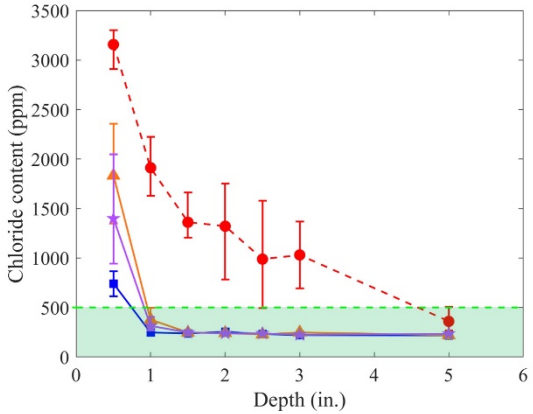
- **BDJR**

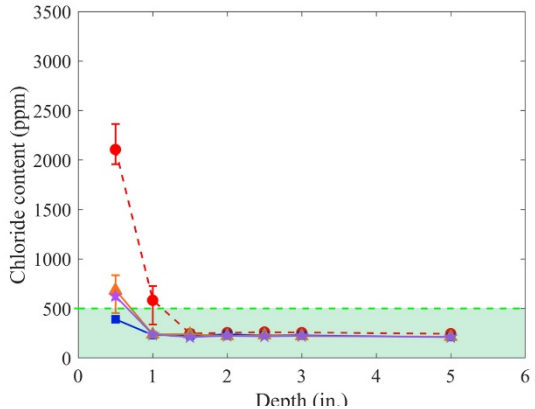
Chloride content limit < 500 ppm



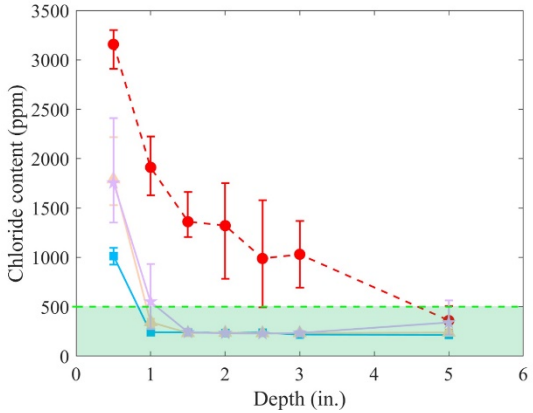


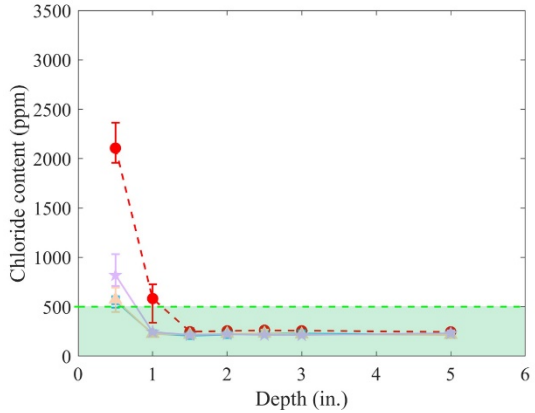
S1

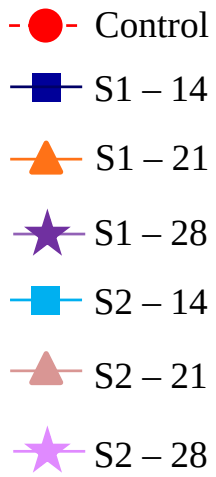




S2







At the crack

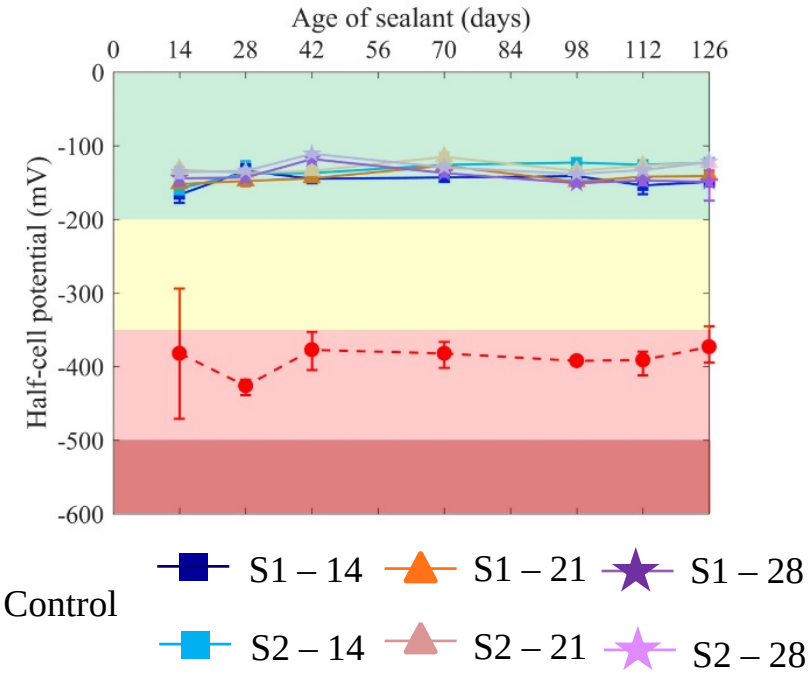
Away from the crack

$t_4 \cong$ **14 days**

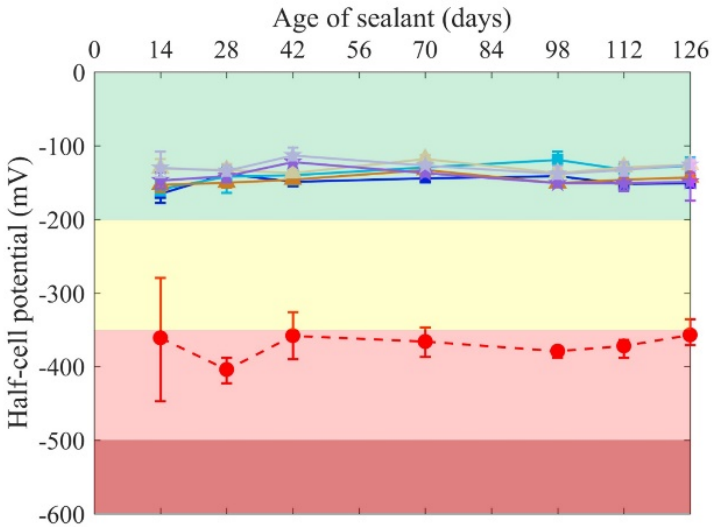
CONCRETE AGE TO RECEIVE A HEALER SEALER

- **BDJR** Half-cell potential (> - 200 ppm)

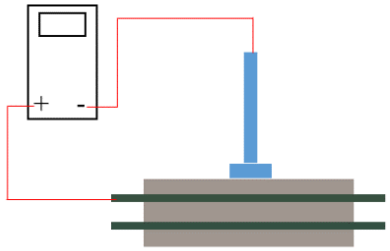
Along the crack



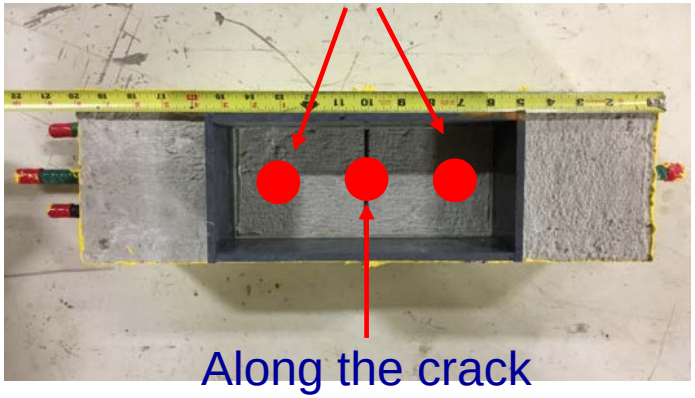
Away from crack center



Potential (mV)	Probability of corrosion risk
> – 200	Low (< 10%)
– 200 to – 350	Intermediate
– 350 to – 500	High (> 90%)
< – 500	Severe



Away from crack center

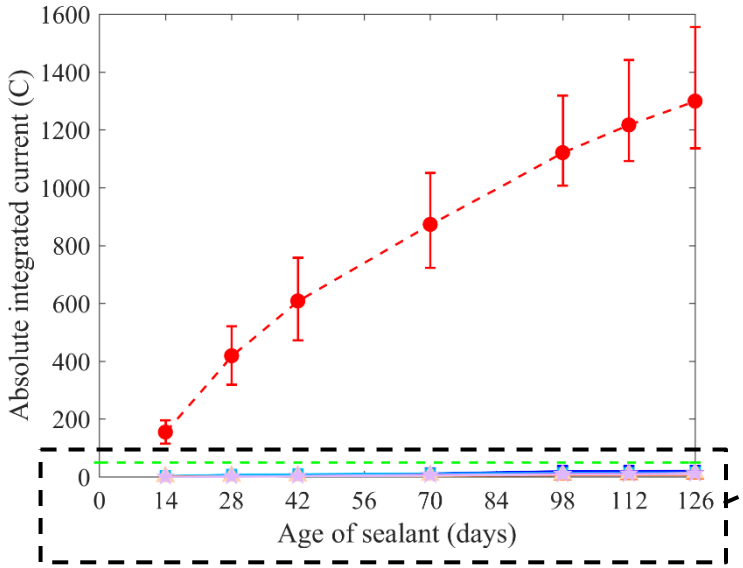


$t_4 \cong$ **14 days**

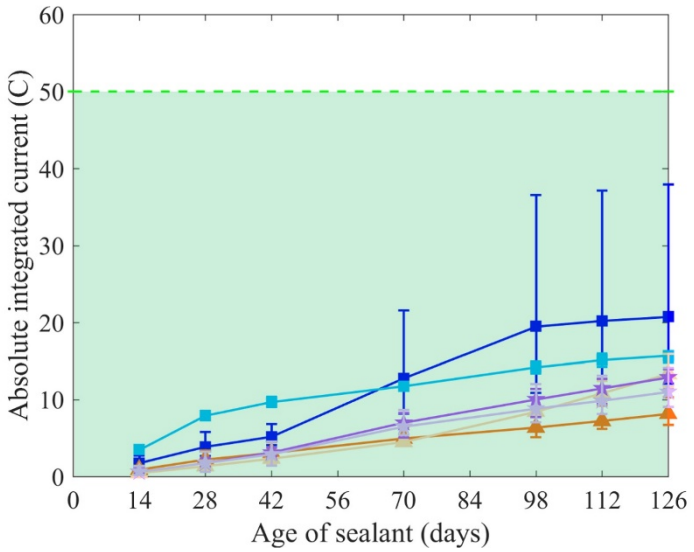
CONCRETE AGE TO RECEIVE A HEALER SEALER

- **BDJR** Absolute integrated current (< 50 C approximately)

Control and treated beams



Treated beams

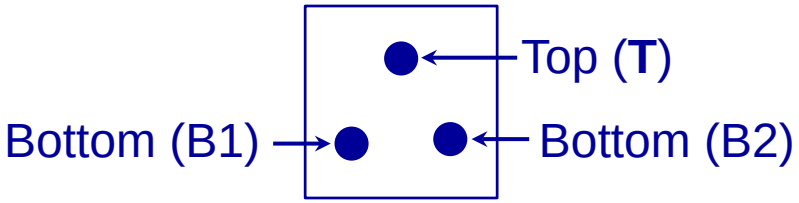


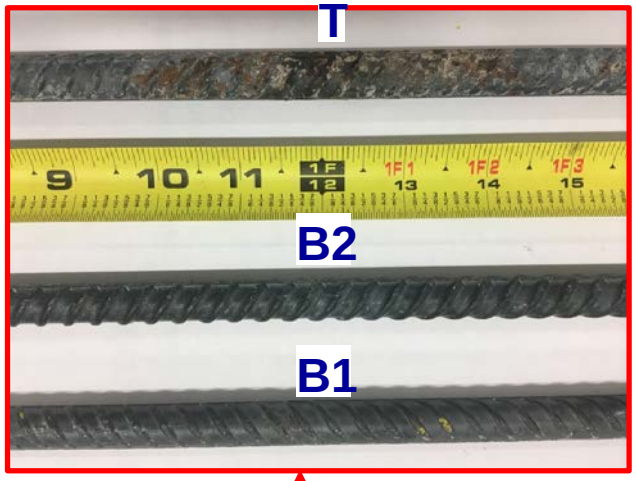
Control
S1 – 14
S1 – 21
S1 – 28
S2 – 14
S2 – 21
S2 – 28

$t_4 \cong$ **14 days**

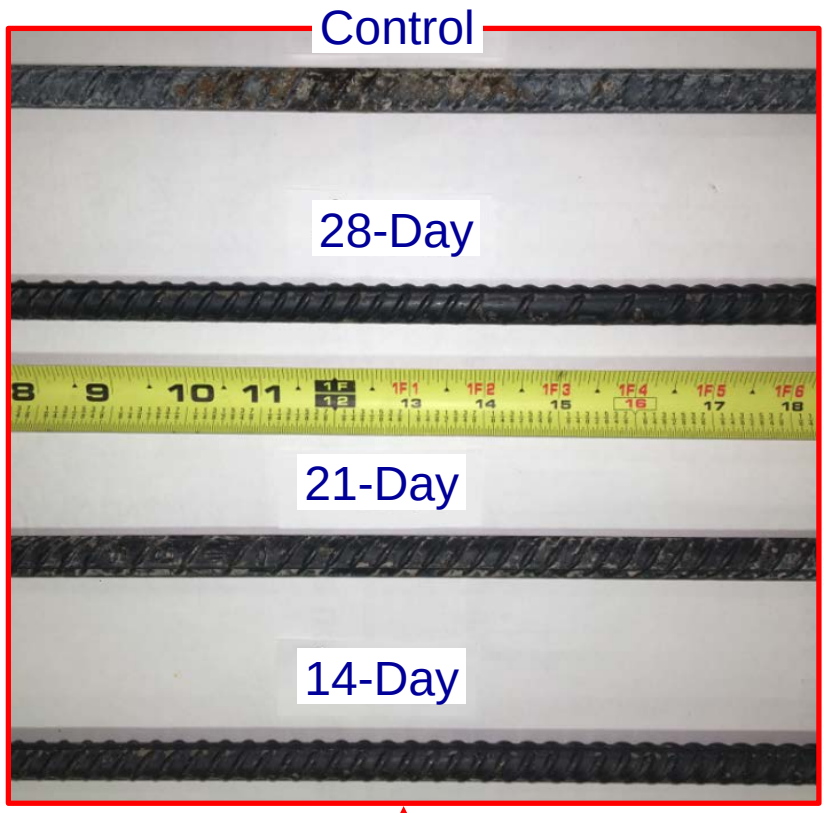
CONCRETE AGE TO RECEIVE A HEALER SEALER

- **BDJR** Rebar conditions





Control specimen

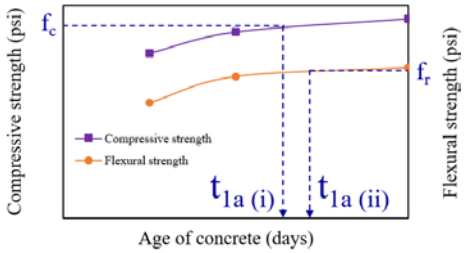


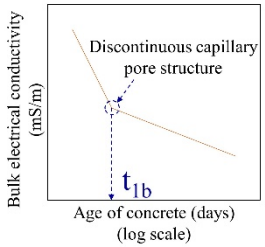
Top rebar of control and treated specimens

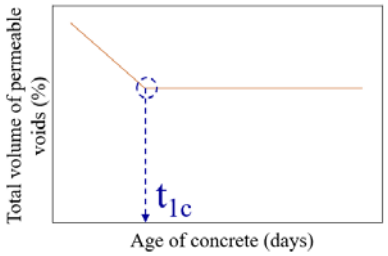
MIN. CONCRETE AGE TO RECEIVE A HEALER SEALER

t = Max

t_1

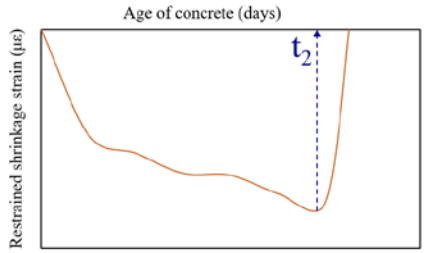




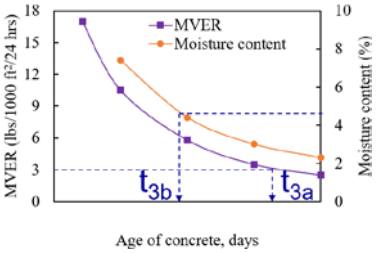


t_1 = max (t_{1a}, t_{1b}, and t_{1c})

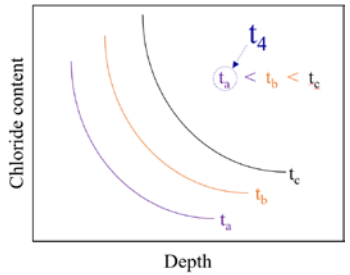
t_2

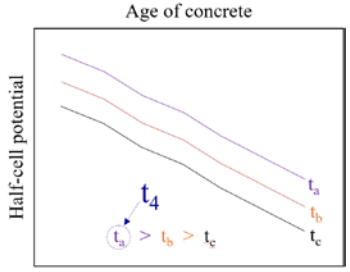


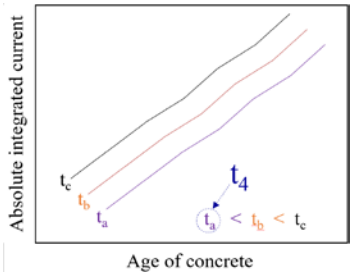
t_3



t_4







Grade DM	BDJR
$t_1 = 9$	$t_1 = 7$
$t_2 = 20$	**$t_2 = 18$**
$t_{3a} > 28$ $t_{3b} \cong 14$	$t_{3a} \cong 28$ $t_{3b} \cong 17$
$t_4 = 14$	$t_4 = 14$

PERFORMANCE EVALUATION ON AN IN-SERVICE BRIDGE DECK

HEALER SEALER PERFORMANCE EVALUATION

6TH STREET OVER I-94

HEALER SEALER PERFORMANCE EVALUATION

Injection of Epoxy Adhesive

Water coming out from an epoxy injection port

Water coming out from a crack

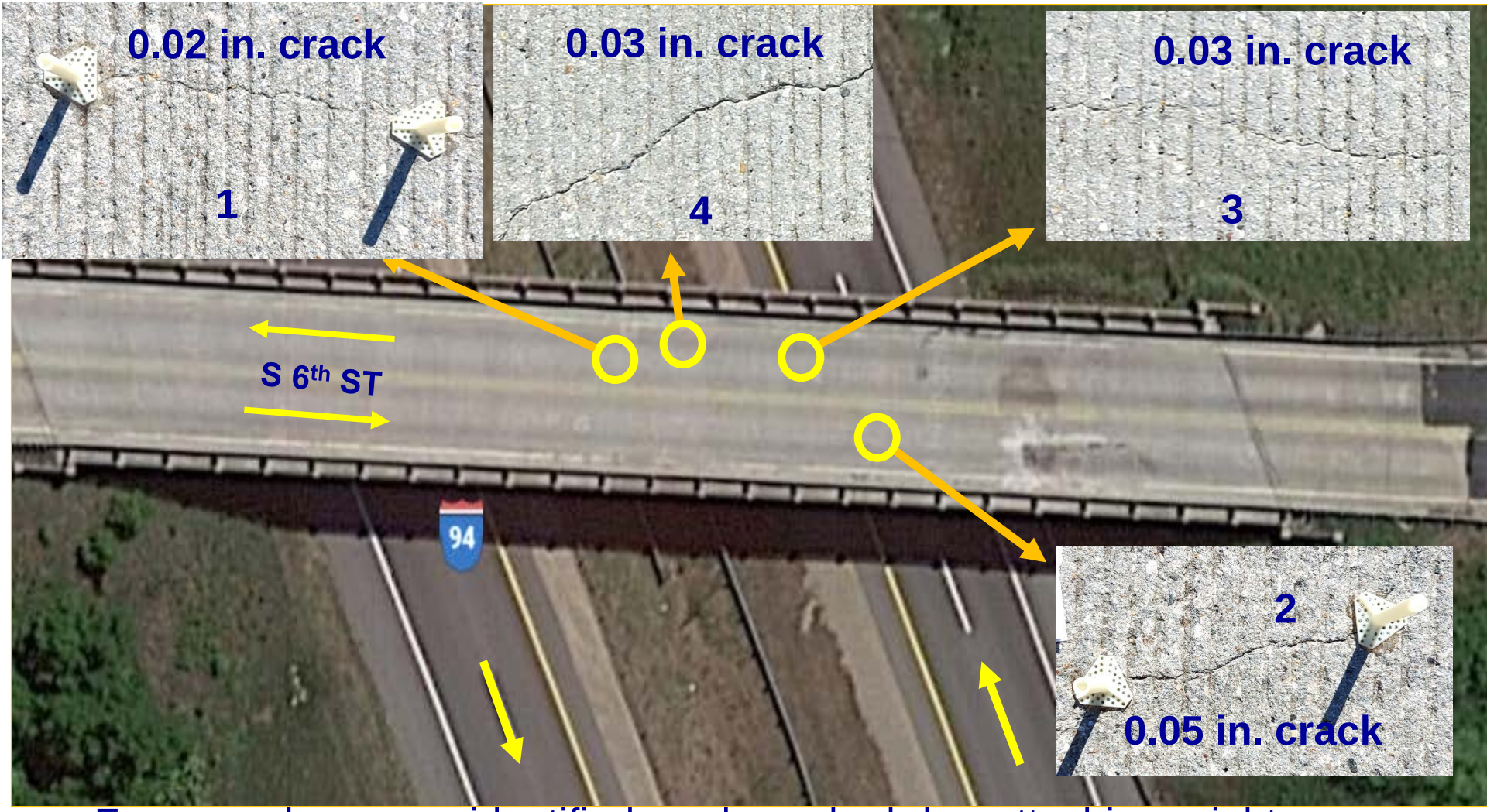
Epoxy Injection Process

2 x 4.5 in. core

A close-up near the rebar

2 x 4.5 in. Core Showing Injected Epoxy Adhesive

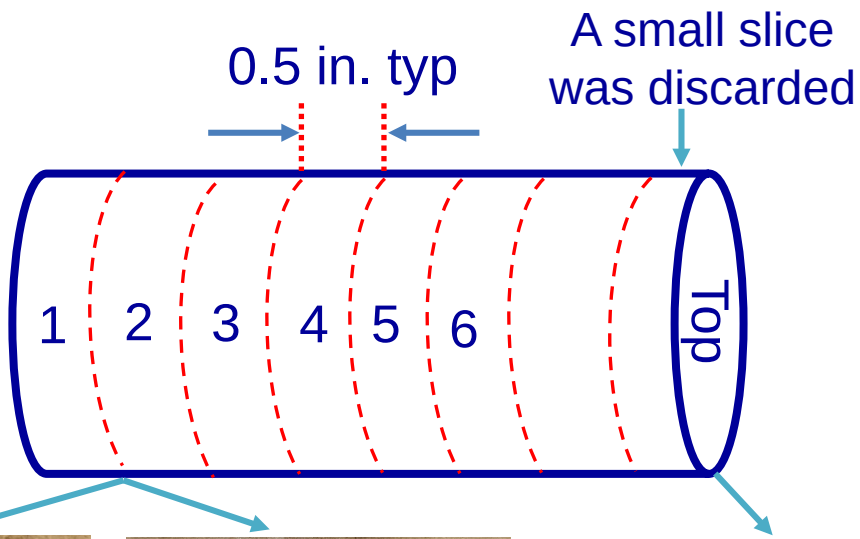
HEALER SEALER PERFORMANCE EVALUATION



- Four cracks were identified and marked by attaching eight epoxy injection ports prior to healer sealer application.
- Two cores were extracted from each crack following healer sealer application.

HEALER SEALER PERFORMANCE EVALUATION

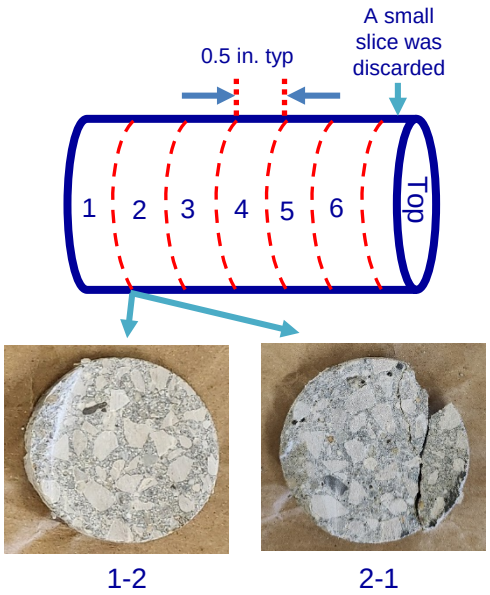
- Top 0.25 in. was removed before ponding with water mixed with a blue dye for 8 to 10 hrs to evaluate the integrity of the sealed crack.
- After removing the ponds and allowing the cores to get dried for 24 hours, the specimen was sliced starting from the bottom.



1-2

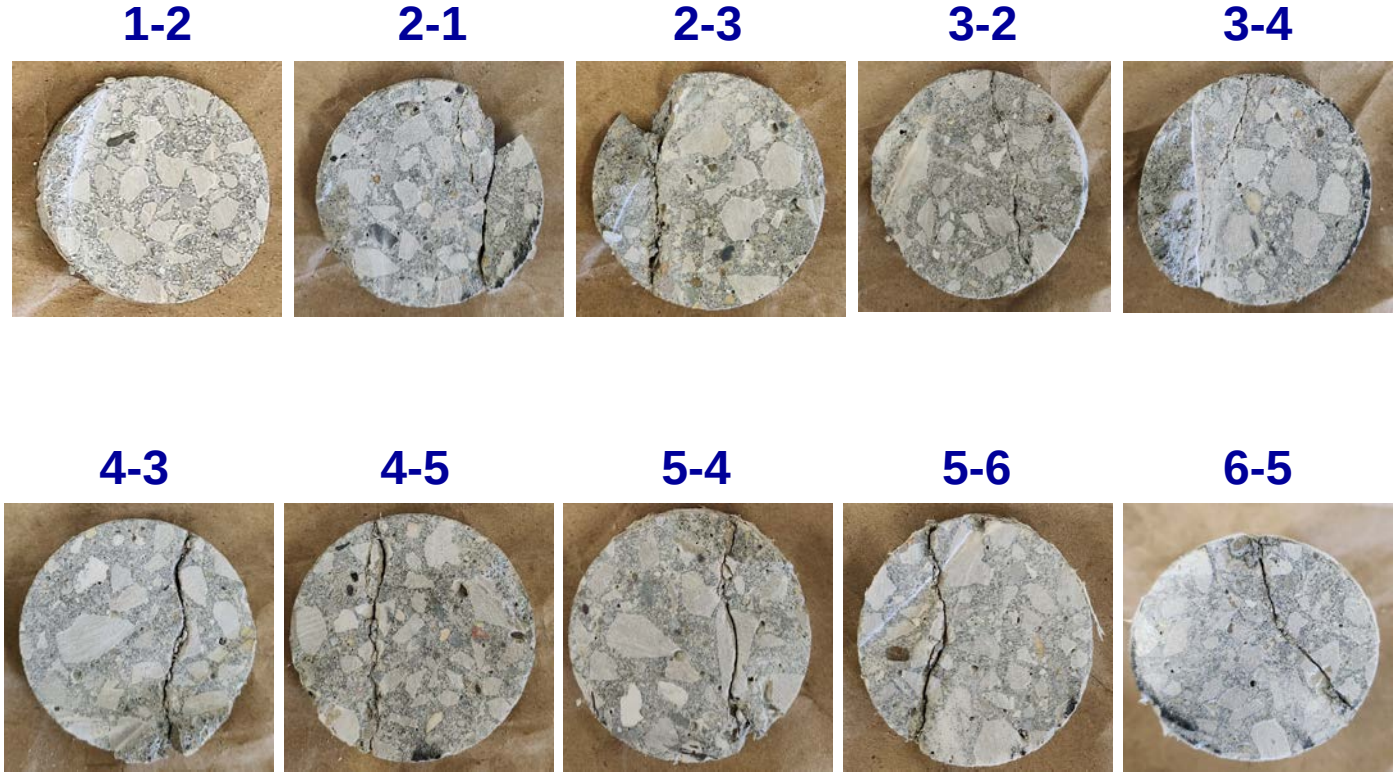
2-1

HEALER SEALER PERFORMANCE EVALUATION



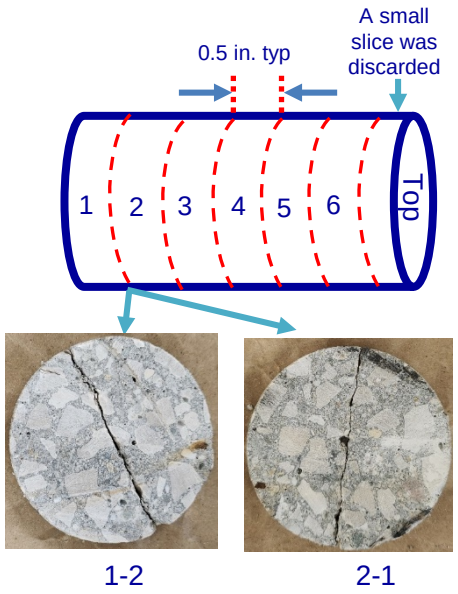
Specimen: T-1

2 x 2.5 in. core



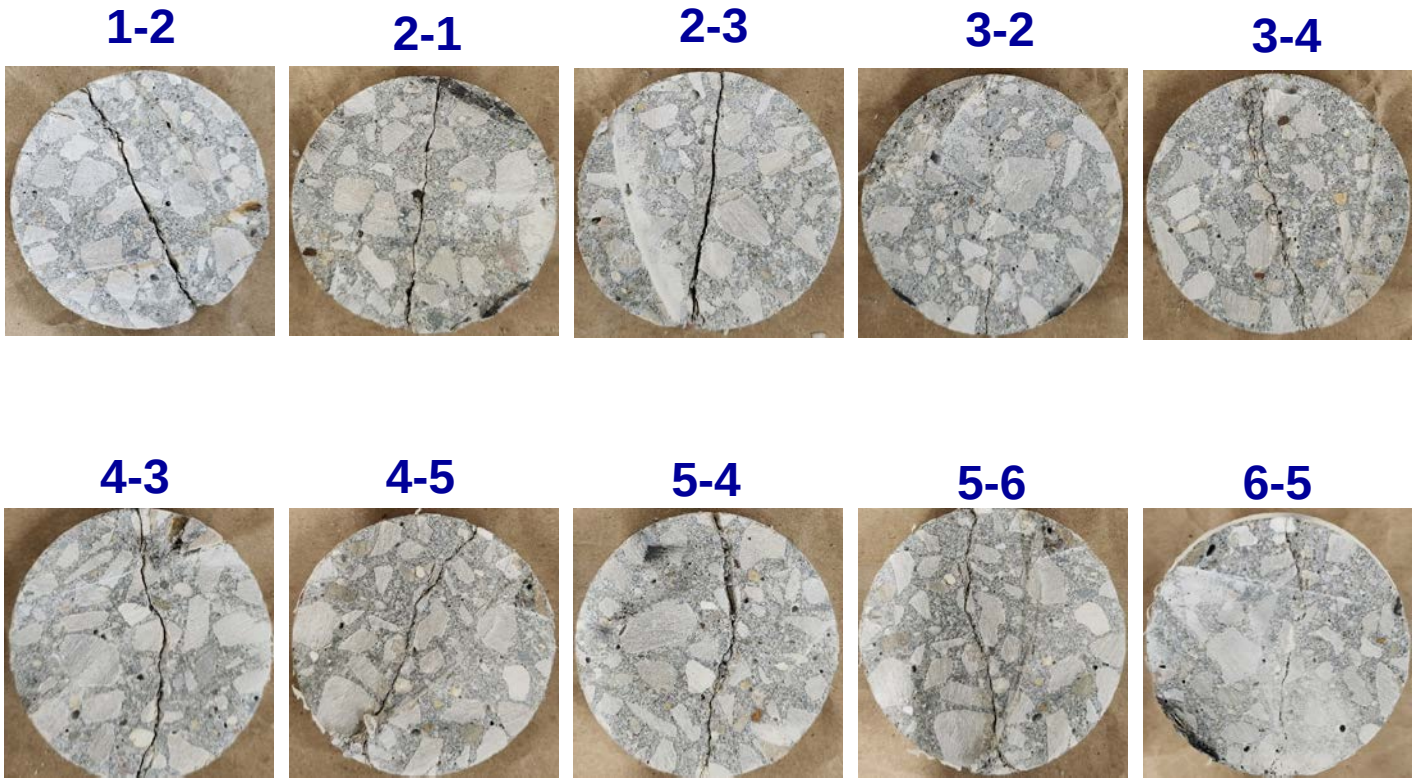
- Blue dye was not observe in the crack, an indication of a sealed crack.
- Slice # 5 broke into two pieces along the crack indicating a maximum healer sealer penetration depth of about 0. 5 in.

HEALER SEALER PERFORMANCE EVALUATION



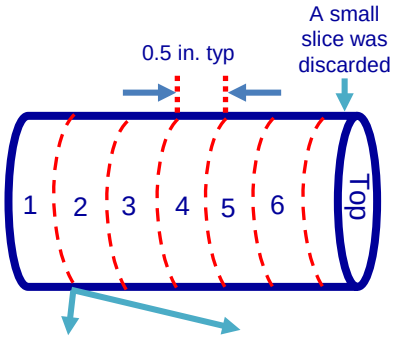
Specimen: T-2

2 x 2.5 in. core



- Blue dye was not observe in the crack, an indication of a sealed crack.
- Slice # 5 broke into two pieces along the crack indicating a maximum healer sealer penetration depth of about 0. 5 in.

HEALER SEALER PERFORMANCE EVALUATION



1-2

2-1

Specimen: T-3

2 x 2.5 in. core

1-2

2-1

2-3

3-2

3-4

4-3

4-5

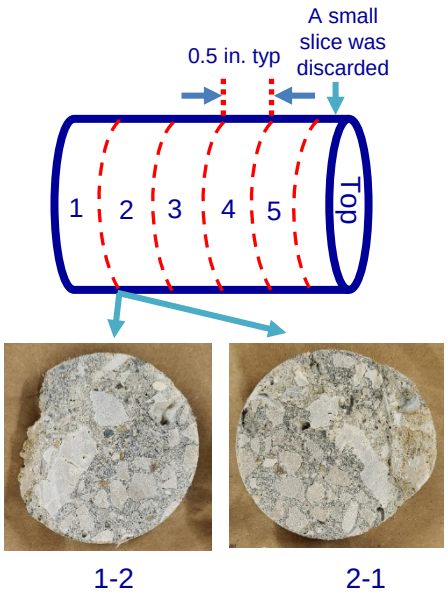
5-4

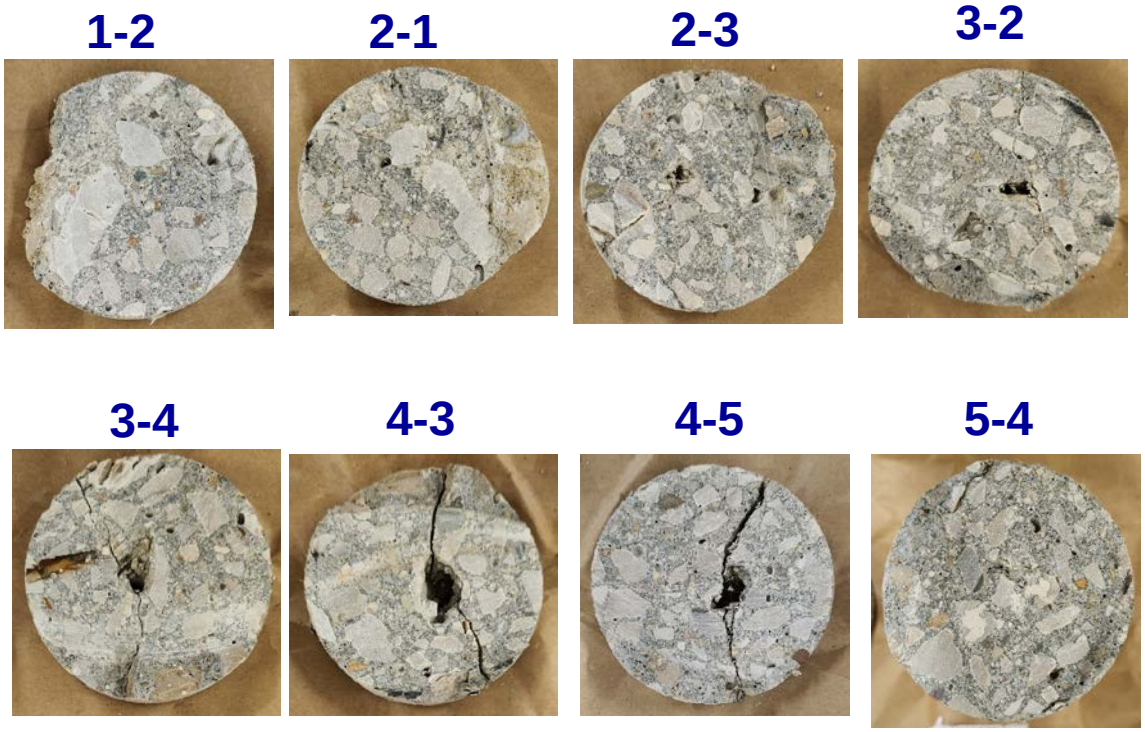
5-6

6-5

- Blue dye was not observe in the crack, an indication of a sealed crack.
- Slice # 5 broke into two pieces along the crack indicating a maximum healer sealer penetration depth of about 0. 5 in.

HEALER SEALER PERFORMANCE EVALUATION





Specimen: T-4

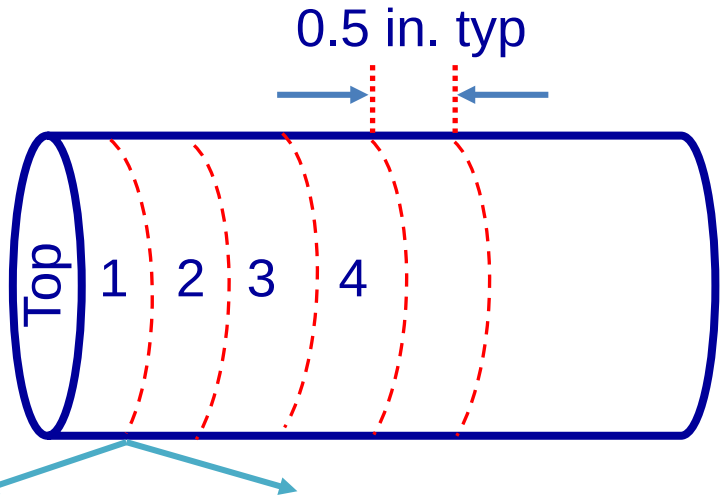
2 x 2.5 in. core

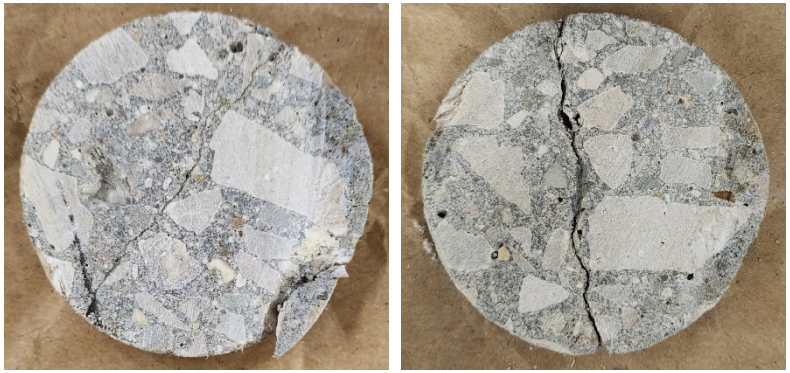
- Blue dye was not observe in the crack, an indication of a sealed crack.
- Slice # 4 broke into two pieces along the crack indicating a maximum healer sealer penetration depth of about 0. 5 in.

HEALER SEALER PERFORMANCE EVALUATION

- A pond was attached to the bottom surface of the core and filled it with a blue dye mixed water for 8 to 10 hrs to evaluate the integrity of the sealed crack.
- After removing the ponds and allowing the cores to get dried for 24 hours, the specimen was sliced starting from the top surface (the surface with the overlay).

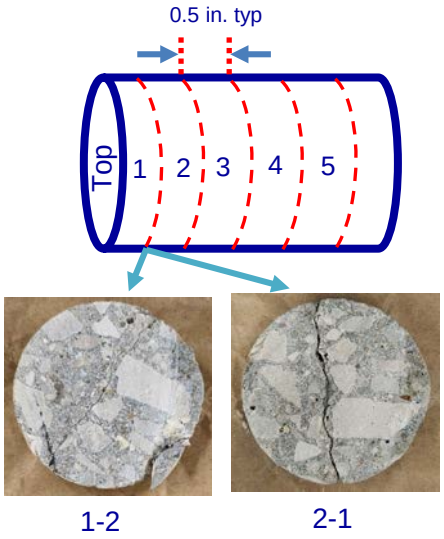
Top

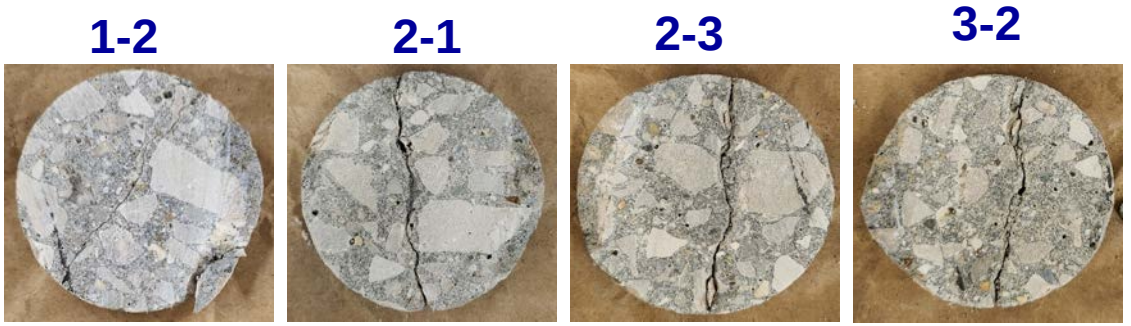


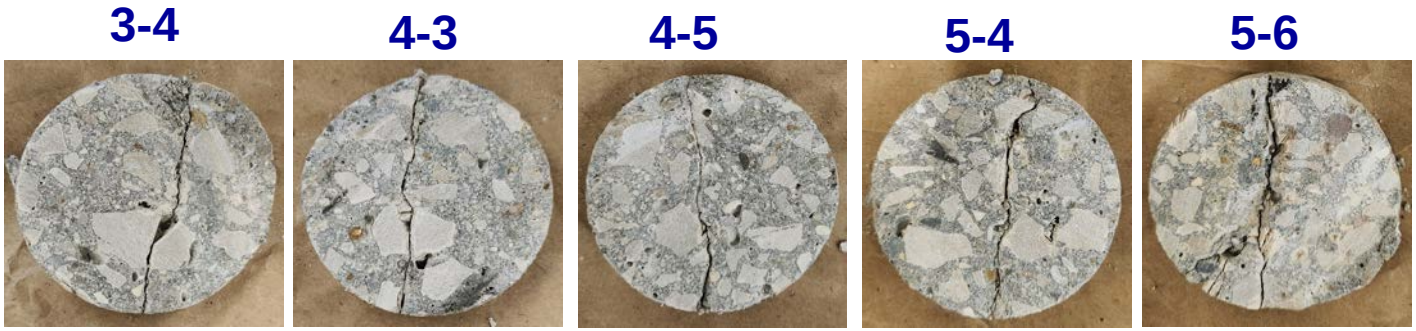


1-2 2-1

HEALER SEALER PERFORMANCE EVALUATION





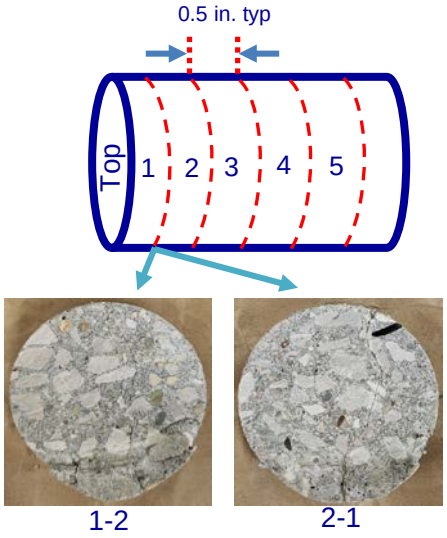


Specimen: B-1

2 x 2.5 in. core

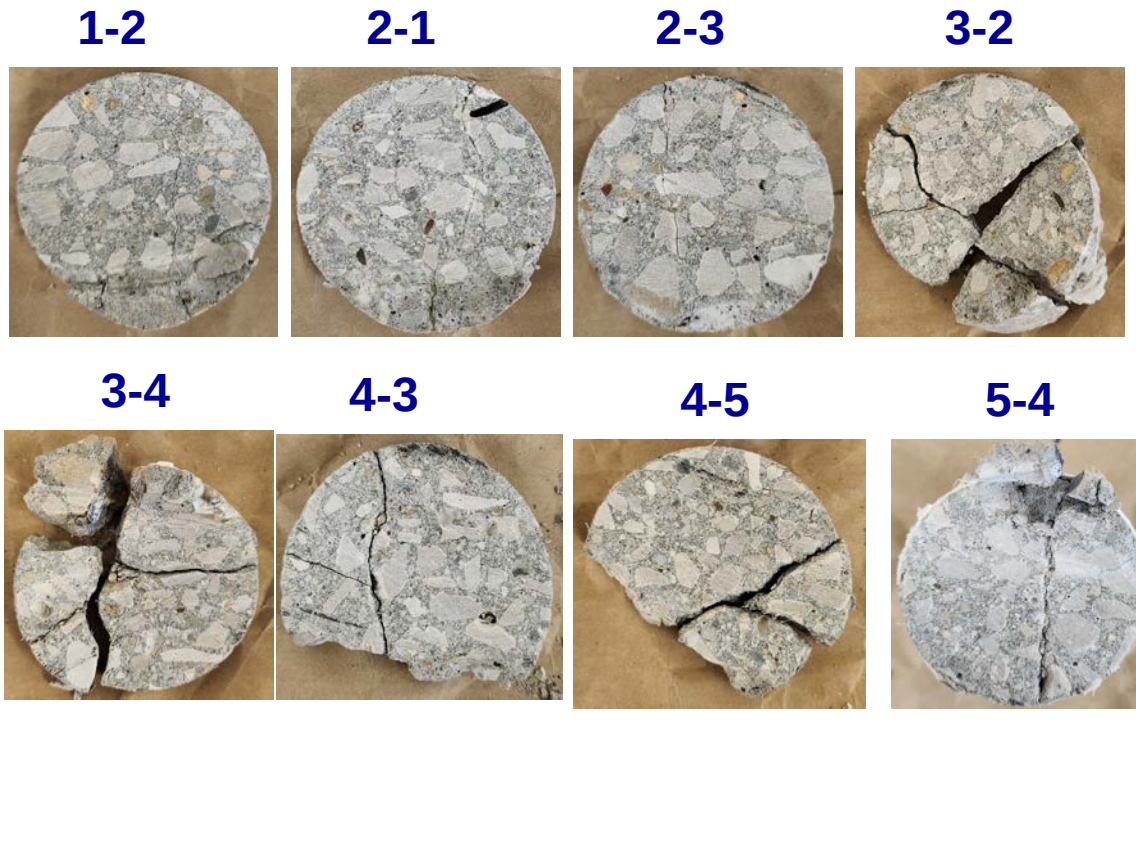
- Blue dye was observed in the crack at a slice #5.
- With a little effort, Slice #2 broken into two pieces along the crack indicating a maximum healer sealer penetration depth of about 0.5 in.

HEALER SEALER PERFORMANCE EVALUATION



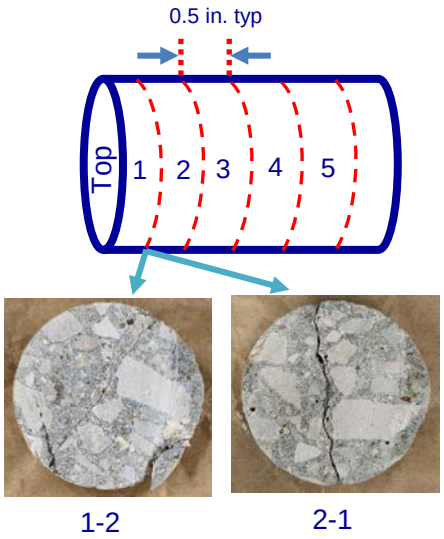
Specimen: B-2

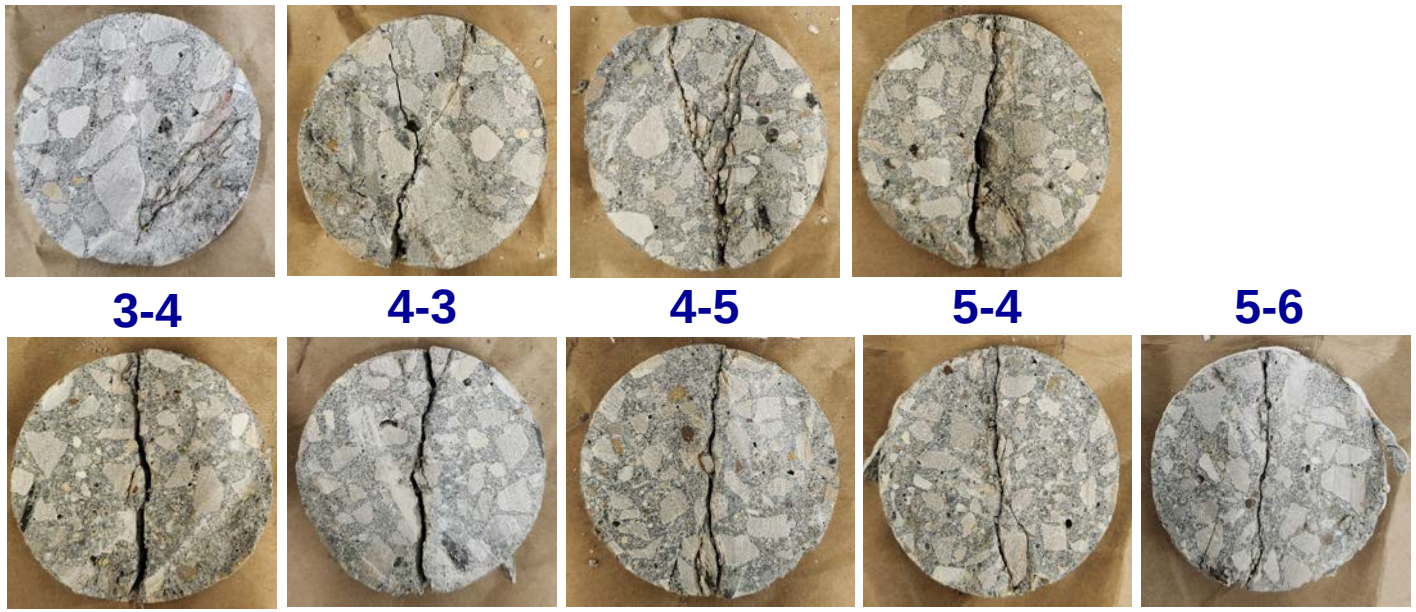
2 x 2.5 in. core



- Blue dye was observed in the crack at Slice #3.
- With a little effort, Slice #3 broken into two pieces along the crack indicating a maximum healer sealer penetration depth of about 1.0 in.

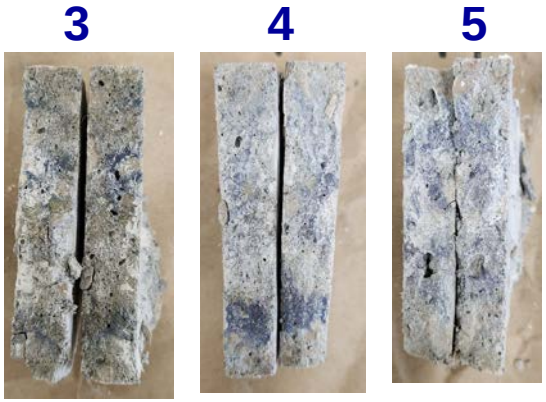
HEALER SEALER PERFORMANCE EVALUATION





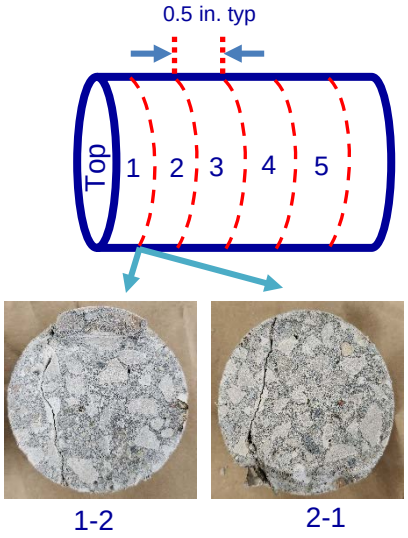
Specimen: B-3

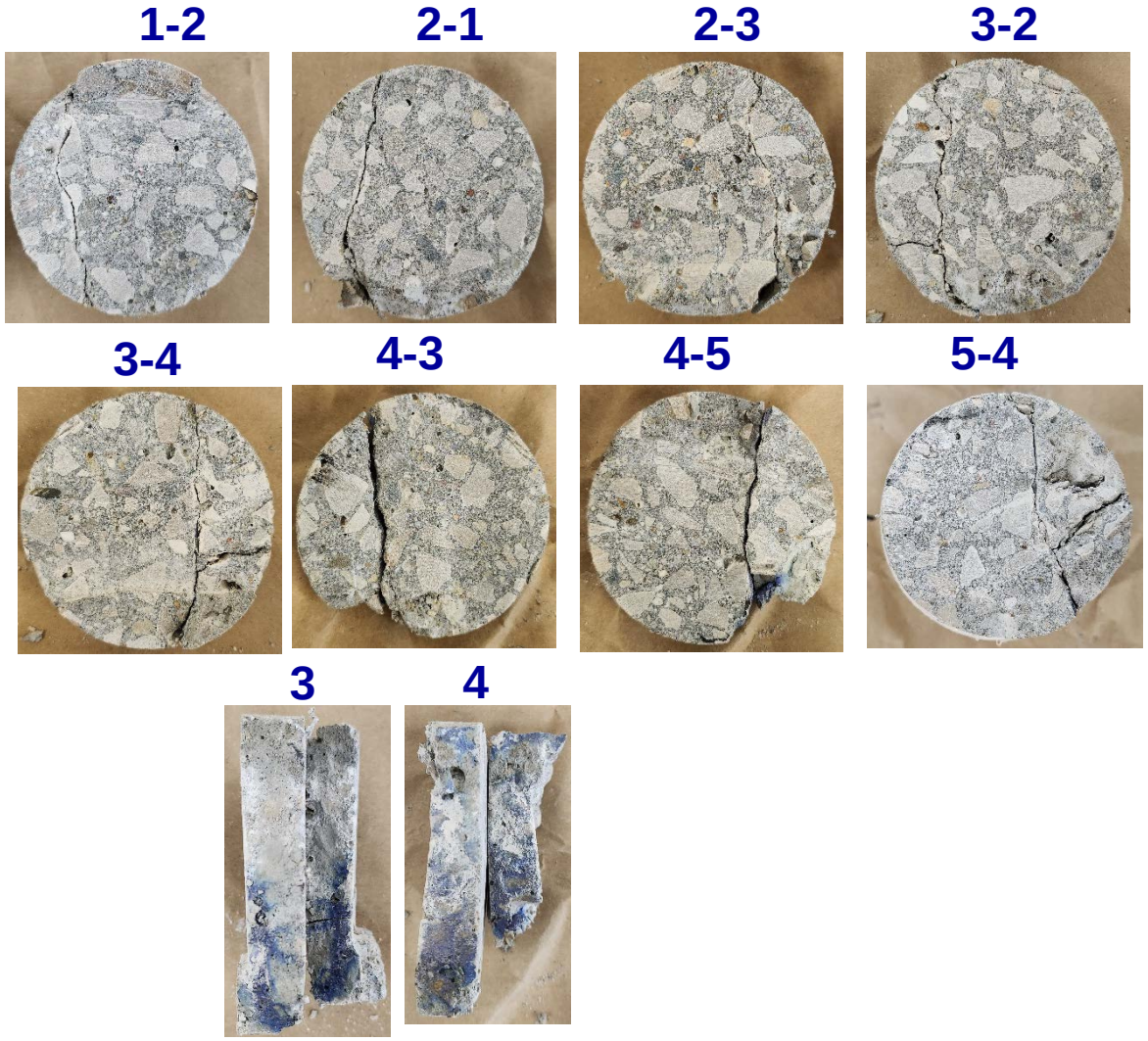
2 x 2.5 in. core



- Blue dye was observed in the crack all the way down to Slice #3.
- With a little effort, Slice #2 was broken into two pieces along the crack indicating a maximum healer sealer penetration depth of about 0.5 in.

HEALER SEALER PERFORMANCE EVALUATION





Specimen: B-4

2 x 2.5 in. core

- Blue dye was observed in the crack all the way down to Slice #3.
- With a little effort, Slice #2 broken into two pieces along the crack indicating a maximum healer sealer penetration depth of about 0.5 in.

CONCLUSIONS AND RECOMMENDATIONS

- A set time is identified to place healer sealers on Grade DM and DBJR mixes.
- Healer sealers can be applied on bridge decks when Grade DM concrete age is 20 days.
- Healer sealers can be applied on bridge decks when BDJR concrete age is 18 days.
- The special provision 12SP-710B-03 can be revised as follows:

Do not perform surface preparation or installation of healer sealer on patches with Grade DM or BDJR concrete less than 21 days of age.

- Additional research is needed to develop procedures for improving healer sealer penetration depth.

Questions?