Materials, Construction, and Emerging Best Practices for Exterior Slab Concrete

Spring 2026 National Concrete Consortium

San Diego, CA

April 8, 2026

massDOT Massachusetts Department of Transportation Highway Division

NATIONAL CONCRETE CONSORTIUM

Presenters

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Learning Outcomes

1. Scaling Deterioration Mechanisms and Causes
2. Materials and Construction Best Practices
3. Field Investigations and Petrographic Examination
4. Emerging Chemical Admixtures and Topical Treatments



Scaling Deterioration

Understanding the mechanisms and causes.

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Definition

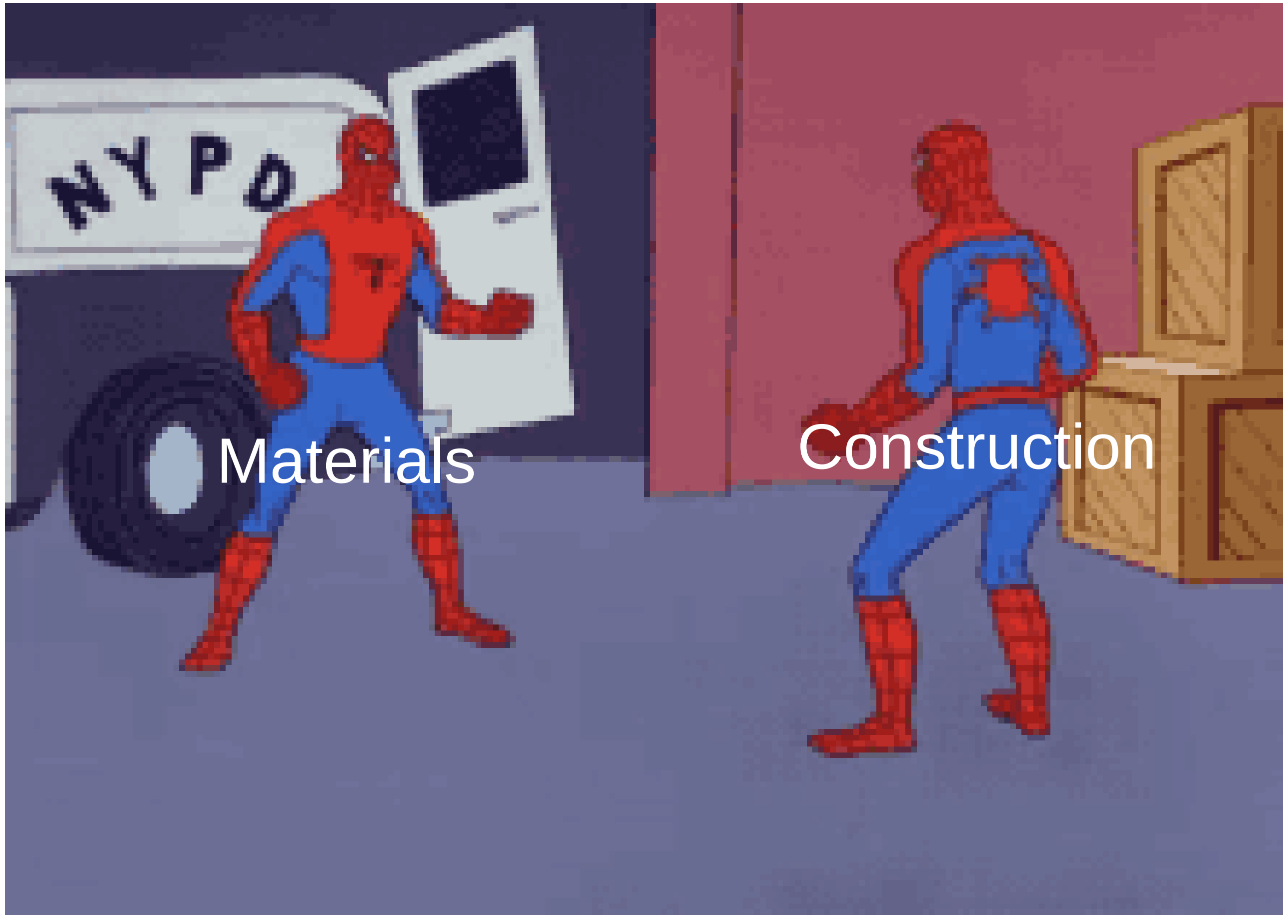
"A general loss of surface mortar or mortar surrounding the coarse aggregate particles on a concrete"

– American Cement Association

"Local flaking or peeling away of the near-surface portion of hardened concrete"

– American Concrete Institute

Causes



Causes

Scaling is Susceptible to concrete with insufficient…

- Materials
  - Durability
  - Workability
- Construction
  - Maturity
  - Workmanship

Causes – Materials

Insufficient Durability

- Poor air entrainment
- High water to cementitious ratio
- Unaccounted for free moisture on aggregate
- High permeability

Insufficient Workability

- Poor air, combined aggregate, and paste systems
- Improper dosage or insufficient usage of chemical admixtures
- Unaccounted for absorption of aggregate
- Too much water "held back" at the plant
- Improper "re-tempering" of hold-back water
- Deviation from the approved mix design

Causes – Construction

Insufficient Maturity

- Incomplete / interrupted hydration due to exposure to adverse conditions prior to the required protection period is complete

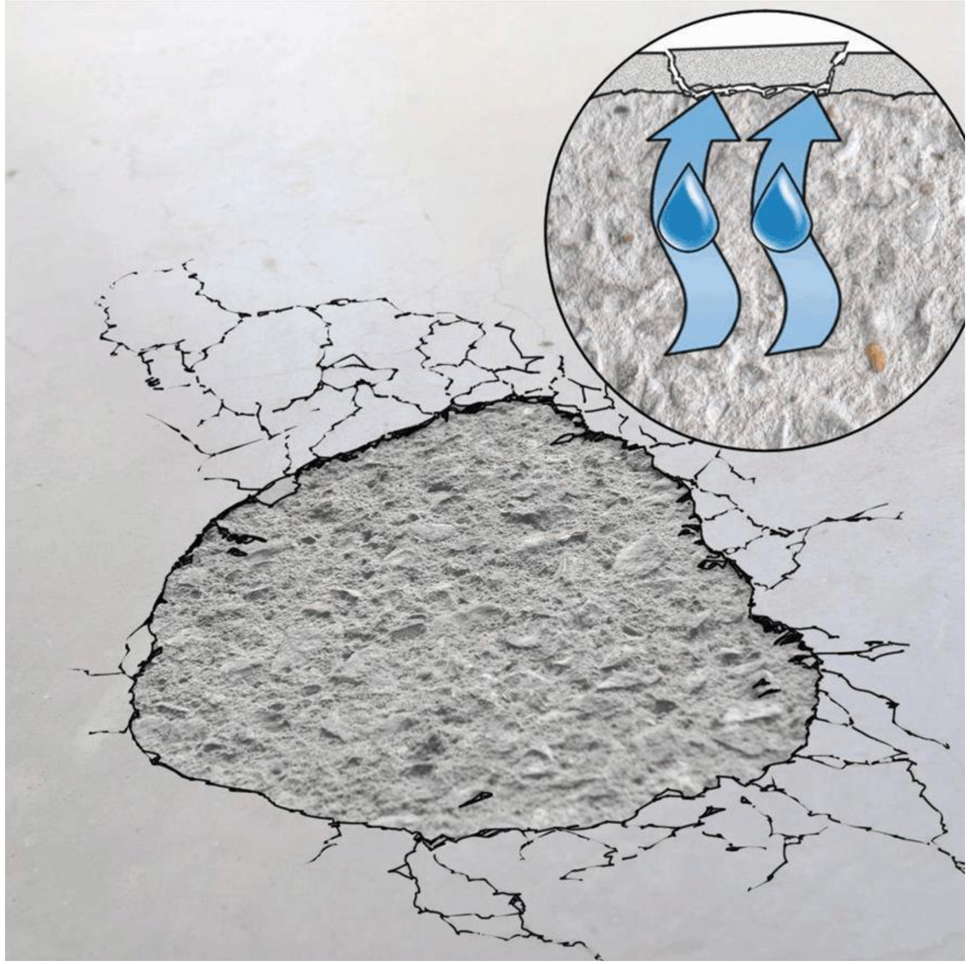
Improper Workmanship

- Lack of personnel certification for concrete flatwork and insufficiently sized work crew
- Unfamiliarity with the initial and final time of set for a given exterior slab concrete mix design
- Improper finishing methods
- Lack of protection from adverse conditions (precipitation, cold conditions, and hot conditions)
- Inadequate curing methods
- Use of prohibited tools and conducting prohibited practices

Mechanisms

Delamination

- Trapped bleed water (and air) under the hardened paste from use of prohibited finishing tools (steel trowels) or final finishing operations conducted too early (bleed water still rising)
- Bleed water (and air) collects under the hardened paste layer resulting in no bond with the substrate
- Insufficient application of evaporation reducing materials, causing moisture loss and surface "crusting" while the concrete is still plastic beneath
- Hardened paste layer chips off



Scaling Deterioration

Mechanisms

Weak Top Paste Layer

- "Blessing" the surface
- Finishing in bleed water
- Finishing in evaporation reducers
- Insufficient curing
- Insufficient protections from adverse conditions
- Results in substantially weak, porous, and carbonated top paste layer

PROPER APPLICATION

APPLY DURING EVAPORATIVE CONDITIONS TO PREVENT RAPID MOISTURE LOSS.

WARNING

NOT A FINISHING AID.
DO NOT FINISH INTO OR UNDER THE SURFACE.

Mechanisms

Weak Top Paste Layer – Internal Pressures

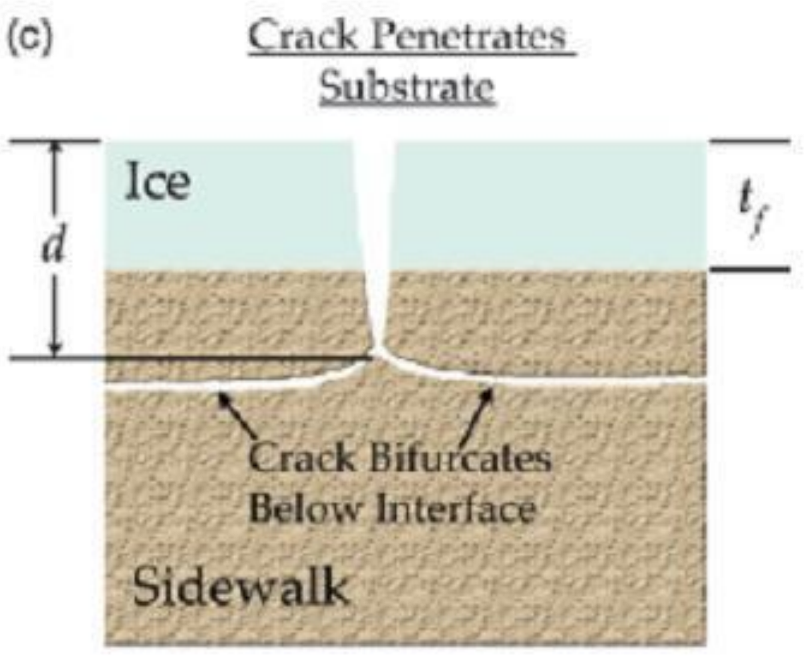
- Water in the concrete pore solution solidifies into ice
- As the temperature drops below freezing, the pore water freezes and increases 9% in total volume, causing internal pressures inside the concrete
- Dissolved chlorides in the pore solution are also expelled from the solution as it freezes, causing even more internal pressures
- Weak top layer scales

Scaling Deterioration

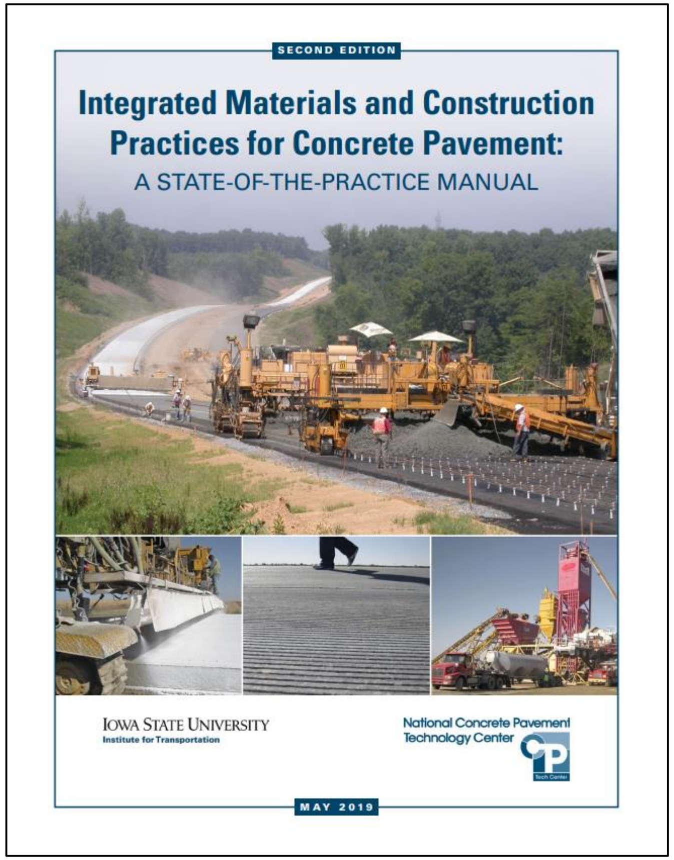
Mechanisms

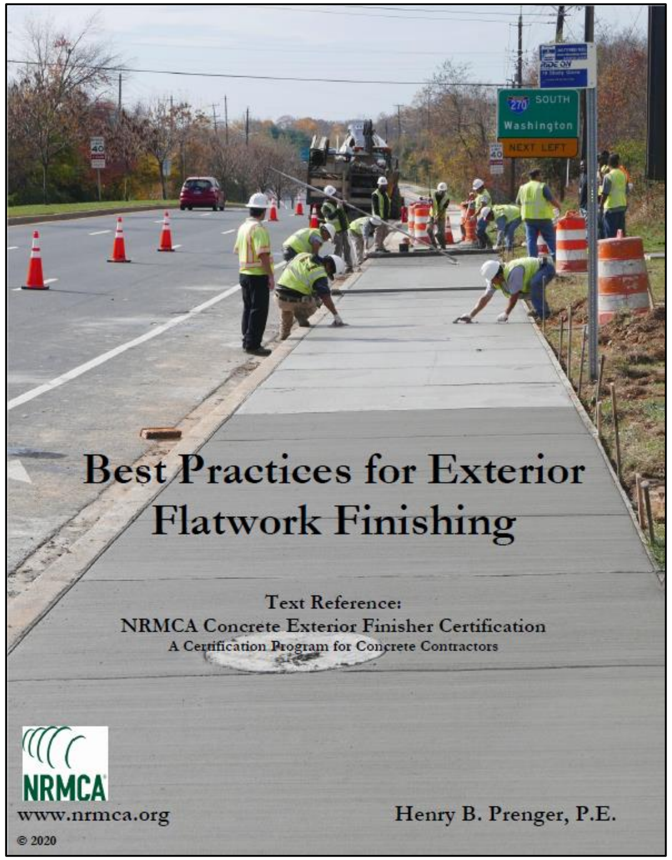
Weak Top Paste Layer – Glue Spall Mechanism

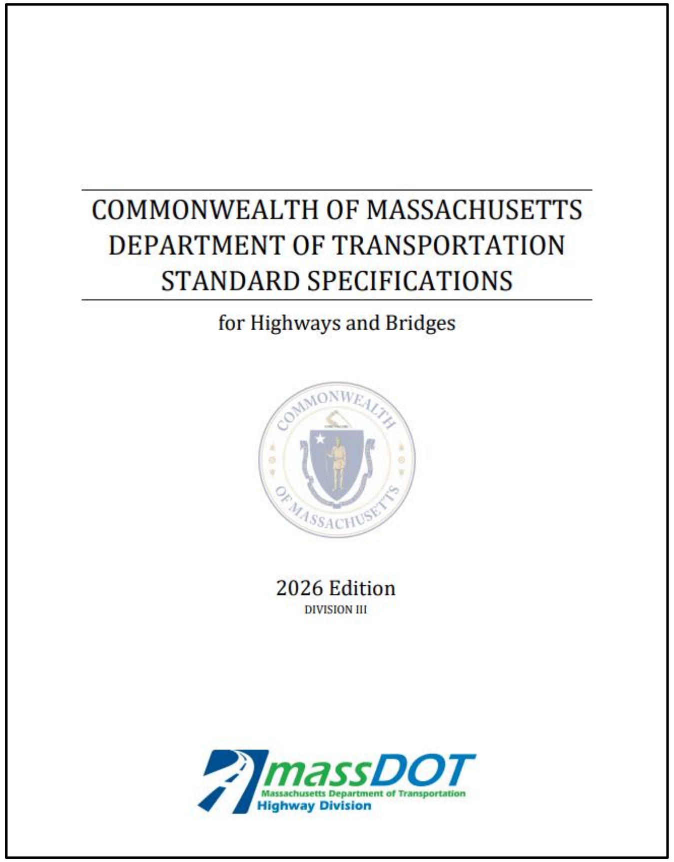
- Water (or brine solution) freezes onto concrete surface creating a composite
- Composite temperature decreases, stresses form from thermal expansion mismatch between ice and concrete
- Ice thermal expansion coefficient five times higher than concrete
- Ice is put in tension and fractures
- Cracks in ice penetrate the concrete substrate up to a depth (d) of 0.75 times thickness of the ice layer (t_f)
- Weak top layer scales



Valenza and Scherer (2006)







Materials and Construction Best Practices

Getting back to the basics…

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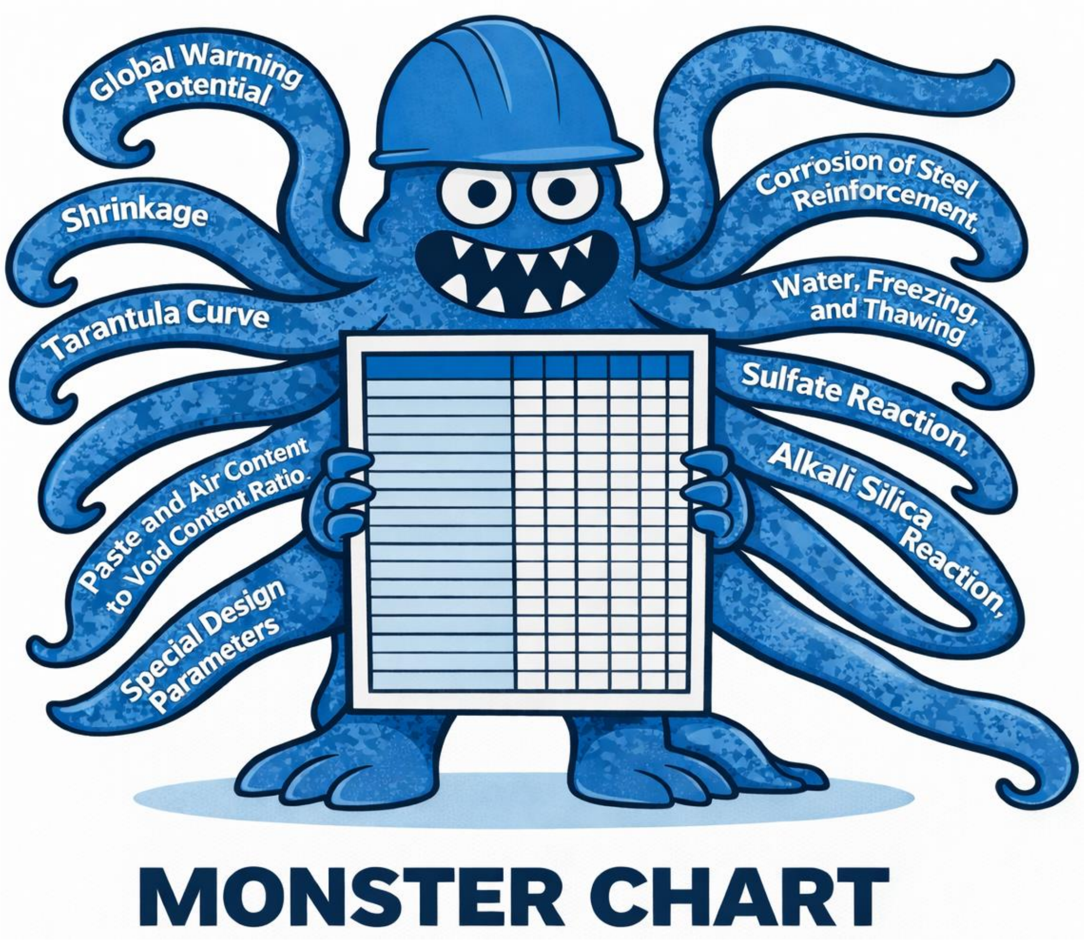
Materials and Construction Best Practices

Mix Design Formulation



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Materials and Construction Best Practices
Mix Design Formulation

Mix Design Parameters	CC	HPC	HESC	RHC	LWC	SCC	ESC	PC	MPC	FRC	UHPC	SHOT	UWC	DC	LMC	ICC
Alkali Silica Reaction	X	X	X	X	X	X	X	X	X	X	–	X	X	X	X	X
DEF and Thermal Cracking	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–
Corrosion of Steel Reinforcement	X	X	X	X	X	X	–	–	X	X	–	–	X	–	–	X
Water, Freezing, and Thawing	X	X	X	X	X	X	X	X	X	X	–	X	X	–	–	X
Sulfate Reaction	X	X	X	X	X	X	X	X	X	X	–	X	X	–	–	X
Shrinkage	–	X	X	–	X	X	X	X	X	–	–	–	–	–	–	–
Global Warming Potential	When Specified									–	–	–	–	–	–	–
Shilstone Workability-Coarseness	–	X	X	–	–	–	X	X	X	–	–	–	–	–	–	–
Tarantula Curve	–	–	–	–	–	–	X	X	–	–	–	–	–	–	–	–
Paste and Air Content to Void Content Ratio	–	X	X	–	–	–	X	X	X	–	–	–	–	–	–	–
Special Design Parameters	–	X	X	X	X	X	–	–	–	X	X	X	X	–	X	X

Materials and Constuction Best Practices

Mix Design Formulation

Effects on Concrete Properties from Incorporation of SCMs [1]

	Property	Coal Ash (F)	Coal Ash (C)	Calcined Shale	Calcined Clay	Meta-kaolin	Slag	Silica Fume
Fresh	Water Content	↓	↓	↔	↔	↑	↓	↑
	Workability	↑	↑	↑	↑	↓	↑	↓
	Bleeding and Segregation	↓	↓	↔	↔	↓	↕	↓
	Setting Time	↑	↕	↔	↔	↔	↑	↔
	Air Content	↓	↓	↔	↔	↓	↔	↓
	Heat of Hydration	↓	↕	↓	↓	↔	↓	↕

[1] ↑ = Increased; ↓ = Decreased; ↕ = Increased or Decreased; ↔ = No Impact

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Mix Design Formulation

Effects on Concrete Properties from Incorporation of SCMs [1]

	Property	Coal Ash (F)	Coal Ash (C)	Calcined Shale	Calcined Clay	Meta-kaolin	Slag	Silica Fume
Hardened	Curing Duration	↑	↑	↑	↑	↑	↑	↑
	Early Age Strength	↓	↔	↓	↓	↑	↕	↑
	Long Term Strength	↑	↑	↑	↑	↑	↑	↑
	Abrasion Resistance	↔	↔	↔	↔	↔	↔	↔
	Drying Shrinkage and Creep	↔	↔	↔	↔	↔	↔	↔
	Permeability	↓	↓	↓	↓	↓	↓	↓
	Corrosion	↓	↓	↓	↓	↓	↓	↓
	Alkali Silica Reaction	↓	↓	↓	↓	↓	↓	↓
	Sulfate Reaction	↓	↕	↓	↓	↓	↓	↓
	Freezing and Thawing	↔	↔	↔	↔	↔	↔	↔
	Scaling	↔	↔	↔	↔	↔	↔	↔

[1] ↑ = Increased; ↓ = Decreased; ↕ = Increased or Decreased; ↔ = No Impact

Materials and Construction Best Practices: Mix Design Formulation

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Rev. 03/06/2026

2026 CEMENT CONCRETE MIX DESIGN SHEET — RMS 043

PLANT INFORMATION: PLANT NAME	LOCATION	MAILING ADDRESS: STREET NO. & ADDRESS	CITY/TOWN	EMAIL ADDRESS	MIX DESIGN SHEET IDENTIFICATION: CONTRACT	SHEET IDENTIFICATION NO.
BORO SAND AND STONE	EASTON, MA	192 Plain Street	North Attleboro, MA 02760	dougs@borocorp.com		25-03-26-10-27-01

CONSTITUENT MATERIALS

ID	AGGREGATE SOURCE	LOCATION	NMAS	DESCRIPTION	SPEC.	SG	UW_{DR} (PCF)	VC (%)	2 IN.	1 1/2 IN.	1 IN.	3/4 IN.	1/2 IN.	3/8 IN.	#4	#8	#16	#30	#50	#100	#200	FM
FINE	BORO (80%) / RYCO (20%)	N. ATTLEBORO / CARVER, MA	FINE	NORMAL WEIGHT	M 6	2.63	108.3	33.9	100.0	100.0	100.0	100.0	100.0	100.0	97.0	85.0	68.0	49.0	25.0	8.0	2.0	2.68
CA1	CUMBERLAND QUARRY	CUMBERLAND, RI	3/8 IN.	NORMAL WEIGHT - 8	M 80	2.71	103.9	38.4	100.0	100.0	100.0	100.0	100.0	98.0	30.0	9.0	4.6	0.0	0.0	0.0	0.0	5.58
CA2	CUMBERLAND QUARRY	CUMBERLAND, RI	3/4 IN.	NORMAL WEIGHT - 57	M 80	2.70	99.1	41.1	100.0	100.0	100.0	99.0	58.0	13.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	6.86
CA3	CUMBERLAND QUARRY	CUMBERLAND, RI	1 1/2 IN.	NORMAL WEIGHT - 4	M 80	2.81	94.6	45.9	100.0	99.0	43.0	10.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.90

ID	CEMENT; SUPPLEMENTARY CEMENTITIOUS MATERIALS; PACKAGED; FIBERS SOURCE	LOCATION / PRODUCT	TYPE	DESCRIPTION	SPEC.	SG
CEM	ST MARYS CEMENT	GASCONS, QC (IL(10)MS)	L(10)MS	10% LIMESTONE BLEND (MS)	M 240	3.11
SCM1	AMRIZE (HOLCIM)	BALTIMORE, MD	S-120	HIGH ACTIVITY (120)	M 302	2.88
SCM2	SIKA	SIKACRETE 950DF	SF	SILICA FUME	M 307	2.20
SCM3						
PKG						
FIBER						

Type IL and Slag

ID	CHEMICAL ADMIXTURES SOURCE	PRODUCT	TYPE	DESCRIPTION	SPEC.	V_S (%)
AD1	CHRYSO INC	DAREX II AEA	AEA	AIR ENTRAINING	M 154	9.90
AD2	CHRYSO INC	RECOVER	D	ATER REDUCING AND RETARDI	M 194	15.53
AD3	CHRYSO INC	ADVA 140M	F	HIGH RANGE WATER REDUCING	M 194	12.66
AD4	CHRYSO INC	ADVA 190	F	HIGH RANGE WATER REDUCING	M 194	26.73
AD5	CHRYSO INC	DCI-S	CIA	CORROSION INHIBITING	C1582	22.00
AD6	SIKA	LIGHTCRETE POWDER	CLSM	CLSM ENHANCING	TDS	100.00

MIX DESIGN FORMULATION

MIX DESIGN ID NO. DOT	PRODUCER	MIX DESIGN TYPE	C (PSI)	NMAS (IN.)	S (IN.)	AC (%)	W/CM RATIO	PC (%)	AGGREGATE (LBS.) FINE	CA1	CA2	CA3	CEMENTITIOUS; PACKAGED; FIBER (LBS.) CEM	SCM1	SCM2	SCM3	PKG	FIBER	WATER (GAL.) W_T	W_{ADMIX}	ADMIXTURES (FL. OZ.) AD1	AD2	AD3	AD4	AD5	AD6	YIELD (CF)	UW (PCF)
01	DPWS4034	CC	4000	3/4	5.00	6.0	0.44	30.4	1109.0	525.0	1225.0		329.0	329.0					35.0	0.2	2.6		33.0				27.00	141.1
02	DPWS40112	CC	4000	1 1/2	5.00	6.0	0.42	29.4	1029.0	304.0	988.0	608.0	329.0	329.0					33.0	0.3	2.0		39.0				27.00	143.1
03	DPWHP5034	HPC ESC	5000	3/4	6.00	7.0	0.39	29.8	1089.0	465.0	1275.0		343.0	295.0	47.0				32.0	3.0	3.2		19.0	26.0	384.0		27.00	140.4
04	F/EGG	CLSM MANUAL EXC	100	FINE	10.00	25.0	[illegible]	[illegible]	[illegible]				[illegible]						[illegible]	[illegible]						[illegible]	27.00	[illegible]
05	DPWS4034SW	ESC	4000	3/4	5.00	7.0	0.44	28.5	1178.0	450.0	1270.0		310.0	310.0					32.7	0.3	3.0		36.6				27.00	140.4
07													300.0						30.0	0.0						0.5	27.00	112.8
08													150.0						35.0	0.0						0.8	27.00	101.2
09													292.0	258.0	35.0				28.1	3.0	3.0		17.5	23.4	384.0		27.00	142.1
10													2015.0						114.0	0.4		66.0					27.00	109.9

Exterior Slab Concrete (ESC)

COMBINED AGGREGATE AND PASTE SYSTEM

MIX DESIGN ID NO. DOT	PRODUCER	PERCENT BY MASS PASSING (%) 2 IN.	1 1/2 IN.	1 IN.	3/4 IN.	1/2 IN.	3/8 IN.	#4	#8	#16	#30	#50	#100	#200	ANDREASEN q	E (%)	TARANTULA CURVE	SHILSTONE ZONE	VOID CONTENT (%) VC_A	VC_{T19}	VC_M	PC_A / VC_M	SCM (%) SCM1	SCM2	SCM3	TCM (LBS.)	ECC (LBS.)	THICK (FT.)
01	DPWS4034	100.0	100.0	100.0	99.6	82.0	62.4	44.0	34.6	27.2	19.0	9.7	3.1	0.8	0.46	82.8	OUTSIDE	II: 3/4 - 2 IN.	27.2		17.3	2.10	50.0	0.0	0.0	658.0	625.1	2.0
02	DPWS40112	100.0	99.8	88.2	81.0	65.1	49.9	37.9	30.8	24.4	17.2	8.8	2.8	0.7	0.35	84.4	OUTSIDE	II: 3/4 - 2 IN.	27.3		17.6	2.01	50.0	0.0	0.0	658.0	625.1	2.0
03	DPWHP5034	100.0	100.0	100.0	99.5	81.1	60.5	43.2	34.2	26.9	18.9	9.6	3.1	0.8	0.48	81.0	OUTSIDE	II: 3/4 - 2 IN.	27.5		17.3	2.13	43.1	6.9	0.0	685.0	694.4	1.5
04	F/EGG	100.0	100.0	100.0	100.0	100.0	100.0	97.0	85.0	68.0	49.0	25.0	8.0	2.0	0.20	76.5	OUTSIDE	IV: TOO FINE	33.9		16.9	2.97	0.0	0.0	0.0	75.0	75.0	10.0
05	DPWS4034SW	100.0	100.0	100.0	99.6	81.6	61.6	45.0	35.9	28.4	19.9	10.2	3.3	0.8	0.45	81.0	OUTSIDE	II: 3/4 - 2 IN.	27.4		17.7	2.01	50.0	0.0	0.0	620.0	589.0	2.5
06	DPWS4038	100.0	100.0	100.0	100.0	100.0	98.9	59.8	42.8	32.8	21.8	11.1	3.6	0.9	0.51	85.9	OUTSIDE	III: < 3/4 IN.	26.6		16.0	2.49	50.0	0.0	0.0	705.0	669.8	1.5
07	F/EGGNEXC	100.0	100.0	100.0	100.0	100.0	100.0	97.0	85.0	68.0	49.0	25.0	8.0	2.0	0.20	76.5	OUTSIDE	IV: TOO FINE	33.9		19.1	2.28	0.0	0.0	0.0	300.0	300.0	6.0
08	F/EGGMEXC	100.0	100.0	100.0	100.0	100.0	100.0	97.0	85.0	68.0	49.0	25.0	8.0	2.0	0.20	76.5	OUTSIDE	IV: TOO FINE	33.9		17.6	2.74	0.0	0.0	0.0	150.0	150.0	10.0
09	DPWHP4034	100.0	100.0	100.0	99.6	82.2	62.8	46.3	37.2	29.3	20.6	10.5	3.4	0.8	0.42	81.5	OUTSIDE	II: 3/4 - 2 IN.	27.4		18.3	1.79	44.1	6.0	0.0	585.0	592.0	2.5
10	50NEAT														######	######	OUTSIDE		######		######		0.0	0.0	0.0	2015.0	2015.0	

We agree to produce cement concrete mix designs per the precise proportions, quantities, types, and sources of constituent materials identified on the approved RMS 043 Cement Concrete Mix Design Sheet for MassDOT construction contracts.

Mr. Doug Smith	Quality Control		4/7/2026
NAME	*TITLE*	*AUTHORIZED SIGNATURE*	*DATE*

Materials and Construction Best Practices
Mix Design Formulation

MIX DESIGN FORMULATION

MIX DESIGN ID NO.		MIX DESIGN TYPE	C (PSI)	NMAS (IN.)	S (IN.)	AC (%)	W/CM RATIO	PC (%)	AGGREGATE (LBS.)				CEMENTITIOUS; PACKAGED; FIBER (LBS.)						WATER (GAL.)		ADMIXTURES (FL. OZ.)						YIELD (CF)	UW (PCF)
DOT	PRODUCER								FINE	CA1	CA2	CA3	CEM	SCM1	SCM2	SCM3	PKG	FIBER	W_T	W_{ADMIX}	AD1	AD2	AD3	AD4	AD5	AD6		
05	DPWS4034SW	ESC	4000	3/4	5	7.0	0.44	28.5	1178.0	450.0	1270.0	0.0	310.0	310.0	0.0	0.0	0.0	0.0	32.7	0.3	3.0	0.0	36.6	0.0	0.0	0.0	27.00	140.4

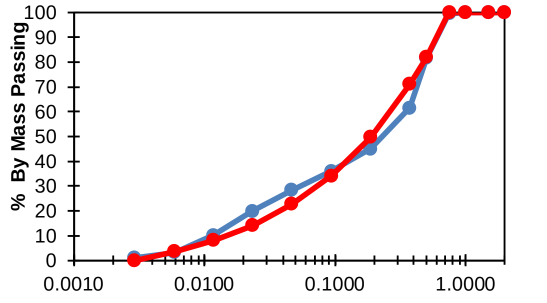
OPTIMIZED COMBINED AGGREGATE AND PASTE SYSTEM ANALYSIS

PERCENT BY MASS PASSING (%)												
2 IN.	1 1/2 IN.	1 IN.	3/4 IN.	1/2 IN.	3/8 IN.	#4	#8	#16	#30	#50	#100	#200
100.0	100.0	100.0	99.6	81.6	61.6	45.0	35.9	28.4	19.9	10.2	3.3	0.8

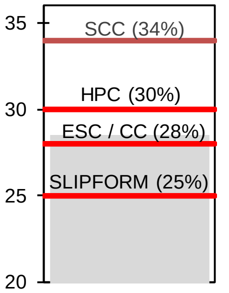
PERCENT RETAINED BY MASS (%) ON EACH SIEVE
TARANTULA CURVE RESULT
CLOSE CONFORMITY

SHILSTONE WORKABILITY-COARSENESS FACTOR		
CF	WF	ZONE
60.0	37.4	II: 3/4 - 2 IN.

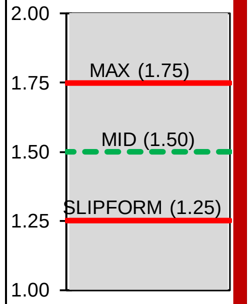
TCM (LBS.)	ECC (LBS.)	THICK (FT.)
620.0	589.0	2.5



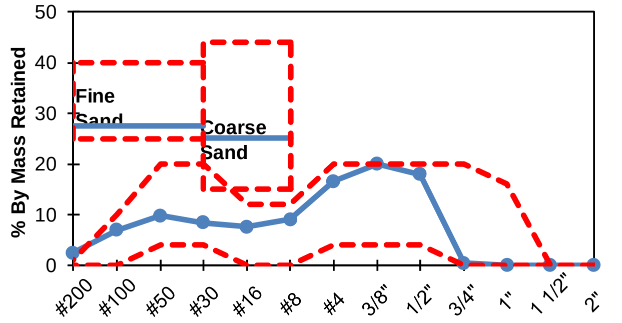
FM	CA (%)	q	E (%)	VC_A (%)
4.96	55.0	0.45	81.0	27.4



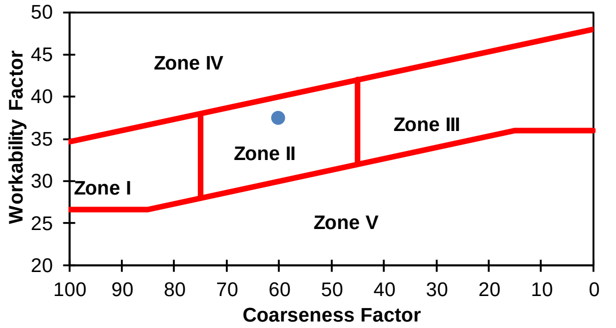
PC (%)
28.5



PC_A (%)	VC_M (%)	RATIO
35.5	17.7	2.01



OPTIMIZED GRADATION



ZONE II (OPTIMUM FOR NMAS 3/4 IN. - 2 IN.): OPTIMIZED WORKABILITY FACTOR AND COARSENESS FACTOR

DEF/Thermal Crack Resistance

T_{MAX} (°F)	T_C (°F)	T_A (°F)
158.00	70	60

SPECIFIC APPLICATION	THICK. (FT.)
DS (SOIL)	9.00
DS (CASING)	9.00
DS (WATER)	9.00
ABUTMENT	1.22
PIER (ABOVE)	1.52
PIER CAP	1.80
PILE CAP	2.68
BRIDGE DECK	9.00
SLAB (GRADE)	9.00

PC (%) > 28.0
PC_A / VC_M > 1.75

No segregation and good workability observed during the trial batch.

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Rev. 04/01/2025

SAM
V

Town/City:	STATEW
Contractor:	#N/A
Report to District:	RMS
Resident Engineer:	#N/A

Bid Item:	VER.M4
Bid Item Description:	VERIFIC
Sub-Item Description:	VER.M4
Bid Item Quantity:	#N/A
MassDOT Mix ID No.:	25-03-26
Produced by:	BORO S
Design Strength (psi):	4000
Tot. Cementitious (lbs.)	620
Proposed Use:	CONCRE

Date Sampled:	5/2/2025
Sampling Location:	BORO S
Truck No.:	181
Sample Time:	8:05 AM
Job Water Added:	NO
Random Sample:	Y
Quantity Represented:	Y

PREPA

Specimen Size:	☑ 4 x 8"
Specimens Covered:	☑ Yes

Test Method	Quality Chara
T 119 (C143)	Slump (
T 152 (C231)	Air Conten
T 309 (C1064)	Concrete Ter
T 121 (C231)	Unit Weigh

FIELD

Office:	RMS
Tested By:	MIKE NAUGHT
Witnessed By:	ROBERT BOU
Reviewed By:	Colin O'Brien

Results are within specification li

By typing my name below, I understand

Approved By: Colin O'Brien

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massDOT Highway
Rev. 04/01/2025

SAMPLE TYPE:	775A-T	DATE RECEIVED:	SAMPLE NUMBER:
VER	SAMPLE OF CEMENT CONCRETE	5/5/2025	2025-013060

PROJECT INFORMATION

Town/City:	STATEWIDE	Contract No.:	VER-CON
Contractor:	#N/A	Federal Aid No.:	#N/A
Report to District:	RMS	Cost Account No.:	#N/A
Resident Engineer:	#N/A	District Mat. Engr.	#N/A

CHLORIDE ION PENETRATION RESISTANCE TESTING (T 358)

Specimen Size:	4 x 8"	Curing Method:	Moist Cured

	Cylinder 1		Cylinder 2		Cylinder 3	
Specimen	00086139		00086140		00086141	
Temp. (°F)	73.5		73.6		73.5	

Angle	Cylinder 1 (kΩ-cm) 1st Test	Repeat	Cylinder 2 (kΩ-cm) 1st Test	Repeat	Cylinder 3 (kΩ-cm) 1st Test	Repeat
0°	16.1		17.5		17.5	
90°	16.5		17		17.1	
180°	17.1		16.9		16.5	
270°	16.9		17.5		16.7	
0°	16		17.6		17.5	
90°	16.5		17.1		17.2	
180°	17.1		16.8		16.5	
270°	16.9		17.5		16.8	
Average	16.6	Not Req'd	17.2	Not Req'd	17.0	Not Req'd
%CV	2.6%	Not Req'd	1.9%	Not Req'd	2.4%	Not Req'd
Average 16	Not Req'd		Not Req'd		Not Req'd	

Set Average Resistivity Determination (kΩ-cm)

Age (Days):	7
Curing Factor:	1.0
Cyl. 1 Average:	16.6
Cyl. 2 Average:	17.2
Cyl. 3 Average:	17.0
Set Average:	17
Penetrability:	Moderate
Spec. Min.:	-
Pass/Fail:	FIO

	Cylinder 1		Cylinder 2		Cylinder 3	
Specimen	00086142		00086143		00086144	
Temp. (°F)	75.6		75.5		75.3	

Angle	Cylinder 1 (kΩ-cm) 1st Test	Repeat	Cylinder 2 (kΩ-cm) 1st Test	Repeat	Cylinder 3 (kΩ-cm) 1st Test	Repeat
0°	33.6		37.4		36.5	
90°	31.4		36.2		37.1	
180°	35.1		35.2		39.7	
270°	36.5		36.8		36.7	
0°	33.5		37.5		36.5	
90°	31.5		36.4		37	
180°	34.9		35.3		39.8	
270°	36.6		36.8		36.8	
Average	34.1	Not Req'd	36.5	Not Req'd	37.5	Not Req'd
%CV	5.9%	Not Req'd	2.4%	Not Req'd	3.7%	Not Req'd
Average 16	Not Req'd		Not Req'd		Not Req'd	

Set Average Resistivity Determination (kΩ-cm)

Age (Days):	28
Curing Factor:	1.0
Cyl. 1 Average:	34.1
Cyl. 2 Average:	36.5
Cyl. 3 Average:	37.5
Set Average:	36
Penetrability:	Low
Spec. Min.:	-
Pass/Fail:	FIO

Calculate the average and the %CV for each sample in the set. If the %CV is > 7.5%, immerse sample in water bath (68 to 77 °F) for 2 h, and record results in the "Repeat" Column. If the %CV on the "Repeat" Set is < 7.5%, use the average of the "Repeat" Set. If the %CV is > 7.5%, average all 16 readings.

---

massDOT Highway
Rev. 04/01/2025

SAMPLE TYPE:	775A-T	DATE RECEIVED:	SAMPLE NUMBER:
VER	SAMPLE OF CEMENT CONCRETE	5/5/2025	2025-013060

PROJECT INFORMATION

Town/City:	STATEWIDE	Contract No.:	VER-CON
Contractor:	#N/A	Federal Aid No.:	#N/A
Report to District:	RMS	Cost Account No.:	#N/A
Resident Engineer:	#N/A	District Mat. Engr.	#N/A

LABORATORY PREPARATION, COMPRESSIVE STRENGTH TESTING (T 22 / C39)

Sample Condition: ☑ Acceptable ☐ Unacceptable (See Remarks) Lab Curing Method: Moist Cured

Lab Preparation: ☐ Sulfur (T 231) ☑ Neoprene (C1231) ☐ Cutting (T 22) ☐ Grinding (T 22)

Specimen ID	Age	Unit	Break Date	Weight (lbs)	Diameter (in)	Area (in^2)	Load (lbf)	Strength (psi)	Average (psi)	Break Type
00086136	3	DAY	5/5/2025	8.33	4.02	12.69	34246	2698	2720	5
00086137	3	DAY	5/5/2025	8.33	4.02	12.69	33881	2669		5
00086138	3	DAY	5/5/2025	8.33	4.02	12.69	35516	2798		5
00086139	7	DAY	5/9/2025	8.33	4.02	12.69	62082	4891	4790	2
00086140	7	DAY	5/9/2025	8.33	4.02	12.69	60303	4751		2
00086141	7	DAY	5/9/2025	8.33	4.02	12.69	59862	4716		2
00086142	28	DAY	5/30/2025	8.33	4.02	12.69	80017	6304	6200	2
00086143	28	DAY	5/30/2025	8.33	4.02	12.69	79600	6271		2
00086144	28	DAY	5/30/2025	8.33	4.02	12.69	76338	6014		2
00086145	56	DAY	6/27/2025	8.33	4.02	12.69	85053	6701	6440	5
00086146	56	DAY	6/27/2025	8.33	4.02	12.69	81945	6456		2
00086147	56	DAY	6/27/2025	8.33	4.02	12.69	78111	6154		5

Break Type T 22: 1 Cone; 2 Cone & Split; 3 Columnar; 4 Shear; 5 Side Fracture; 6 Pointed

REMARKS

TESTING LABORATORY, TECHNICIAN(S), AND REVIEW

Laboratory:	RMS	Location:	HOPKINTON, MA
T 358 (Set 1):	Jose Sanchez	Test Date:	5/9/2025
T 358 (Set 2):	Jose Sanchez	Test Date:	5/30/2025
T 22 (Set 1):	Frehiywot Tale	Test Date:	5/5/2025
T 22 (Set 2):	Jose Sanchez	Test Date:	5/9/2025
T 22 (Set 3):	Jose Sanchez	Test Date:	5/30/2025
T 22 (Set 4):	Timothy Berard	Test Date:	6/27/2025
Reviewed By:	Jose Sanchez	Review Date:	6/30/2025

SPECIFICATION LIMITS AND APPROVAL

Results are within specification limits: X Results are outside specification limits:

Approved By:

Signature:

Date:

***Results relate only to the items inspected or tested.**

****This report shall not be reproduced, except in full, without the prior written approval of the agency.**

Materials and Construction Best Practices

Critical Points During Construction

Mixing and Delivery

- **Hold-Back Water**
  - ≤10% of the approved total water design
- **Retempering**
  - Prior to the discharging of the first 1/3 of the load, no more than once

Handling and Placing Concrete

- **Transporting**
  - Chutes, pumps, buggies…
- **Depositing**
  - Operate come-alongs or flat headed shovels to move concrete in form; No toothed raking or dragging vibrators
- **Consolidation**
  - Vibration, Screeding, Bull Floating, etc.

Handling and Placing Concrete

Depositing

- Come-Alongs

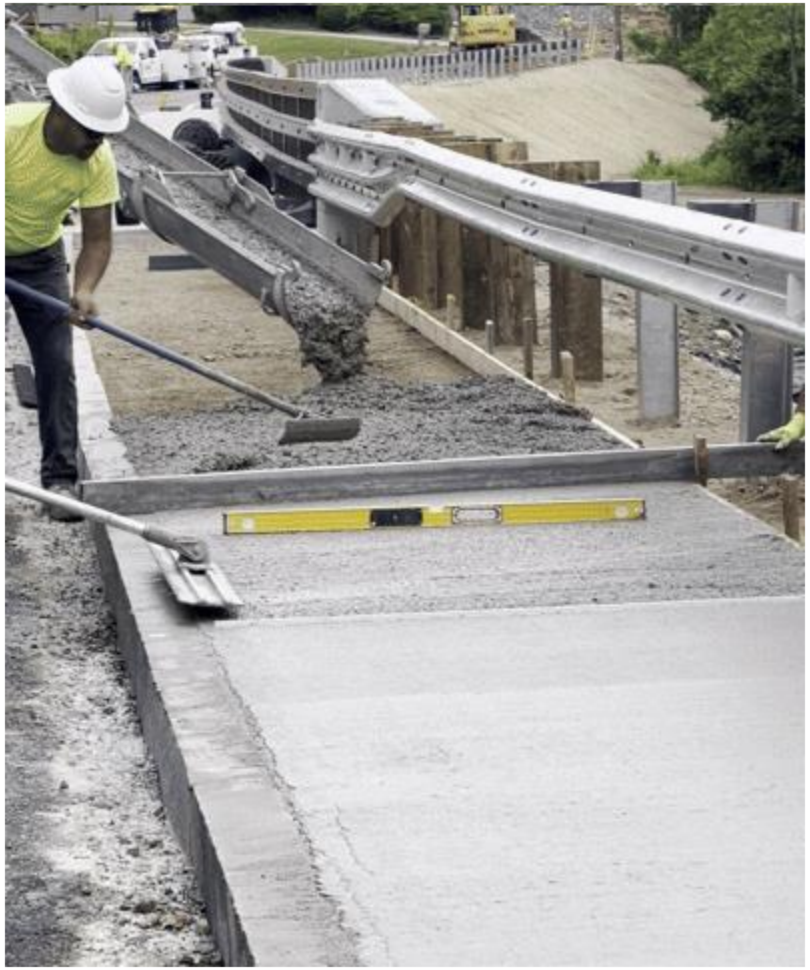
- Flat Headed Shovels

Materials and Construction Best Practices

Critical Points During Construction

Finishing

- **Dormancy (Placed)**
  - Screeding and Bull Floating
- **At Initial Set (Stiffened), After Bleed**
  - Final Floating and Texturing
- **Cold Conditions (< 40°F)**
  - Heated Mixing Water, Type C Accelerating Admixtures…
- **Hot Conditions (Evaporation > Bleed)**
  - Liquid-Applied Evaporation Reducers, Fogging Nozzles, Sunshades, Canopies, Windbreakers, Ice…
  - Colloidal Silica Finishing Aids



Materials and Construction Best Practices

Critical Points During Construction

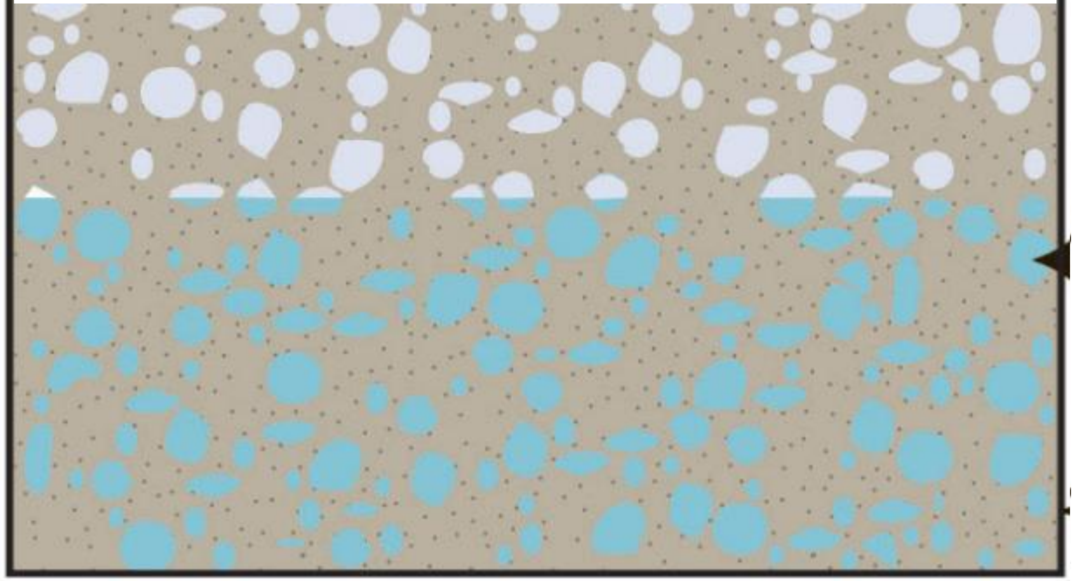
Evaporation Monitoring

- **Evaporation Rate of Surface Water**
  - $E = (T_c^{2.5} – r * T_a^{2.5})(1 + 0.4V) \times 10^{-6}$
- **Bleed Rate Determination Methods**
  - Assume: 0.45 w/cm = 0.15 lb/ft²/hr
  - Assume: 0.40 w/cm = 0.10 lb/ft²/hr
  - Mixes with < 0.40 w/cm, air > 7.5%, water reducers, or fine materials may have a lower bleeding rate
  - Test Panel: Placed concrete appears dry while the test panel accumulates water under transparent plastic = Evaporative Conditions
  - AASHTO T 158 Bleeding Test

Evaporative Conditions

Evaporation Rate > Bleed Rate

Plastic Shrinkage Cracking and Incomplete Hydration



Materials and Construction Best Practices

1. Right After Placing to Level Concrete

Screeding

- 2 x 4 in. Screed (Magnesium or Wood)

2. Right After Screeding to Push Aggregate Down

Bull Floating

- Magnesium Bull Float

2a. Hot Conditions (If Present)

Evaporation Reducing Materials

3. At Initial Set and Bleed Water Stops

Final Floating, Edging, Contraction Jointing

- Magnesium Hand Float

- Magnesium Darby Float

- Steel Edgers (Hand or Walking)

- Steel Groover (Hand or Walking, D = 1/4T)

4. Right After Final Floating, Edging, Joints

Texturing

- Soft-Bristled Broom that Produces 1/16 to 1/8 in. Deep Texture

4a. Hot Conditions (If Present)

Evaporation Reducing Materials

5. At Final Set

Curing Materials

Materials and Construction Best Practices

Critical Points During Construction

Curing

- **At Final Set (Hardened)**
  - Curing Water Nozzles, Saturated Covers, Sheet Materials, Liquid Membrane-Forming Compounds (Curing or Curing and Sealing)…
  - Penetrating Colloidal Silica Compounds for curing and sealing
- **Cold Conditions (< 40°F)**
  - Insulating Materials, Heating, and Enclosures
- **Hot Conditions (Direct Sunlight)**
  - Sunshades, canopies, white polyethylene film, and white pigmented curing compounds

Critical Points During Construction

Protective Sealing

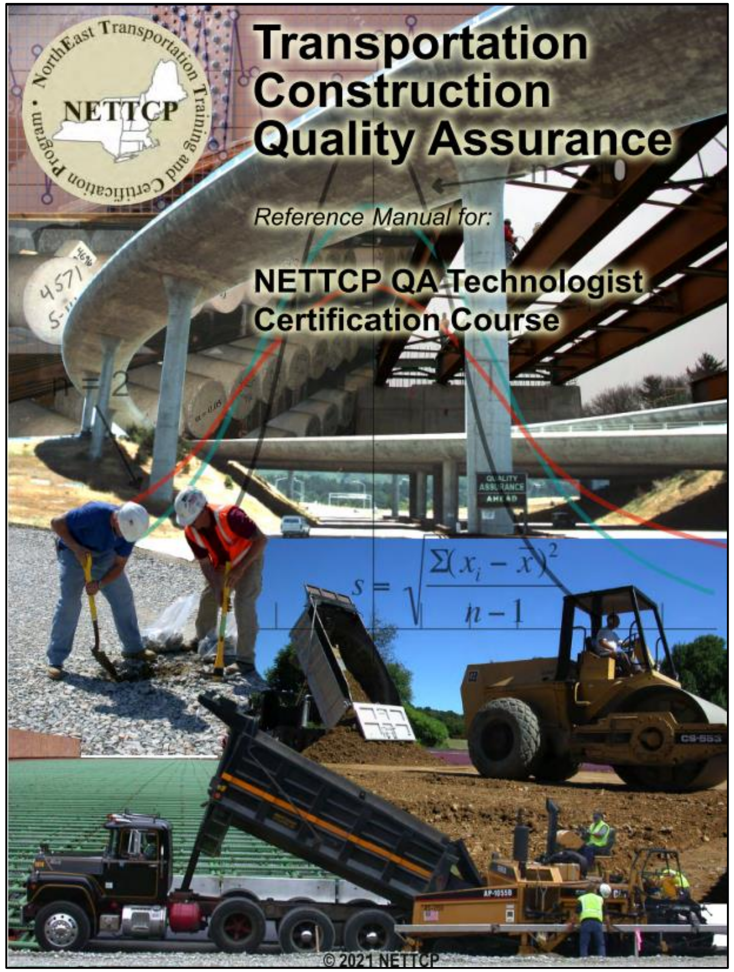
- **Usage and Adoption**
  - Non-existent due to application of Compounds for Curing and Sealing…but these aren't necessarily "true" sealers…
- **Surface Preparation**
  - Pressure Washing, Shotblasting, Abrasive Blasting, etc.
- **Surface Preparation Check**
  - Water absorption testing: ASTM F3191 or Penny Water Droplet Method
- **After Surface Preparation**
  - Penetrating Silanes, Siloxanes…
  - Colloidal Silica Compounds

Materials and Construction Best Practices

Critical Points During Construction

Contractor Quality Control (QC)

- **QC Operating Documents**
  - Quality System Manual and QC Plan
- **QC Laboratory**
  - Department Recognized Accreditation Program
- **QC Organization**
  - Frontline Personnel, QC Technicians, QC Manager
- **QC Sampling, Testing, and Inspection**
  - Random Sampling, Test Report Forms, Inspection Report Forms, and Non-Conformance Report Forms



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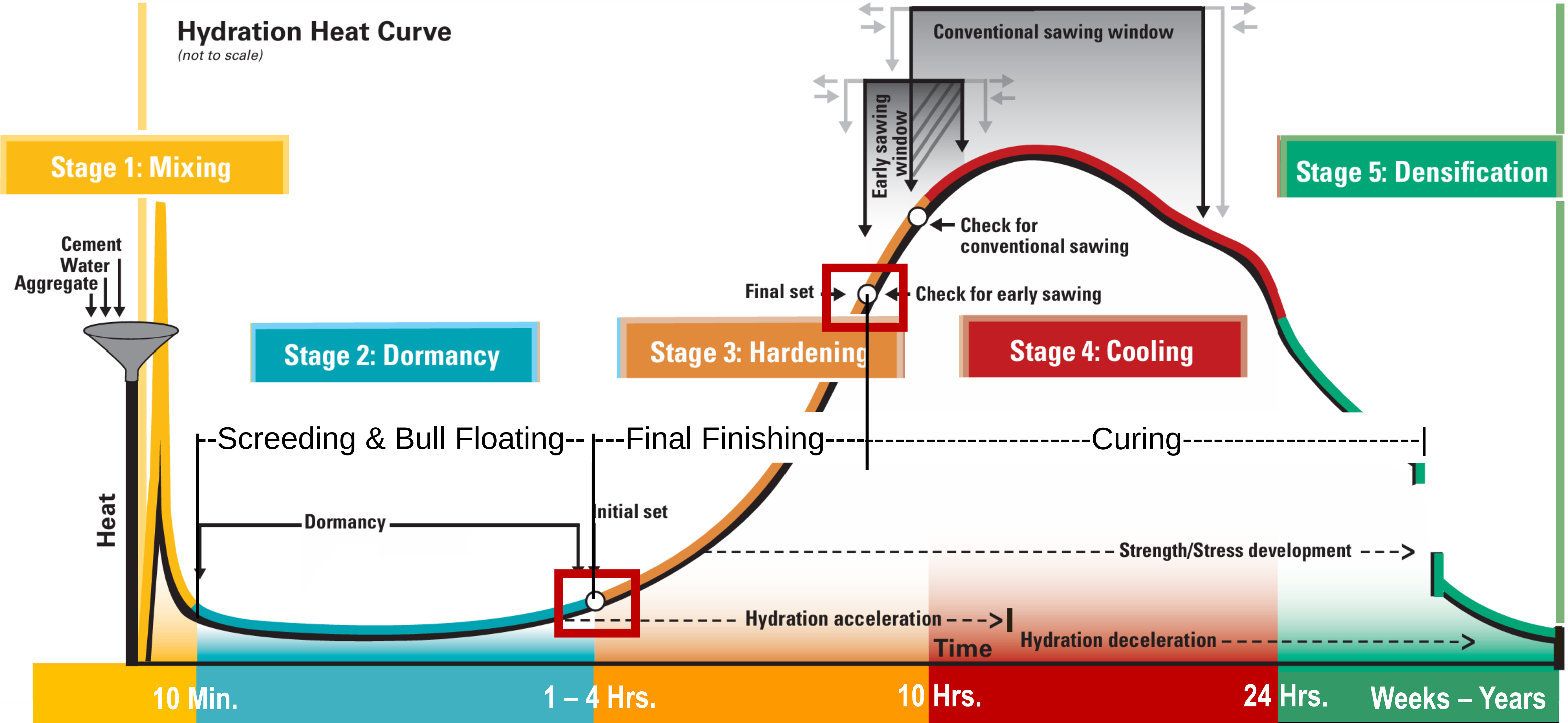
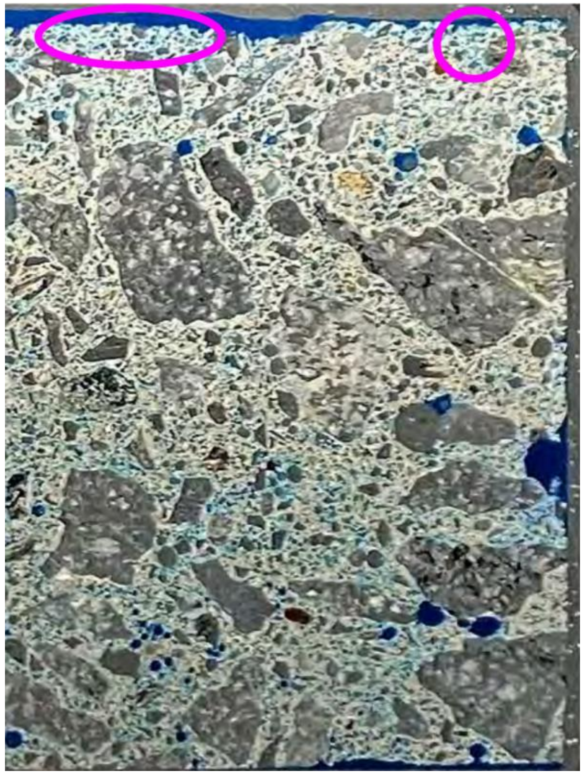
Critical Points During Construction





Field Investigations and Petrographic Examination

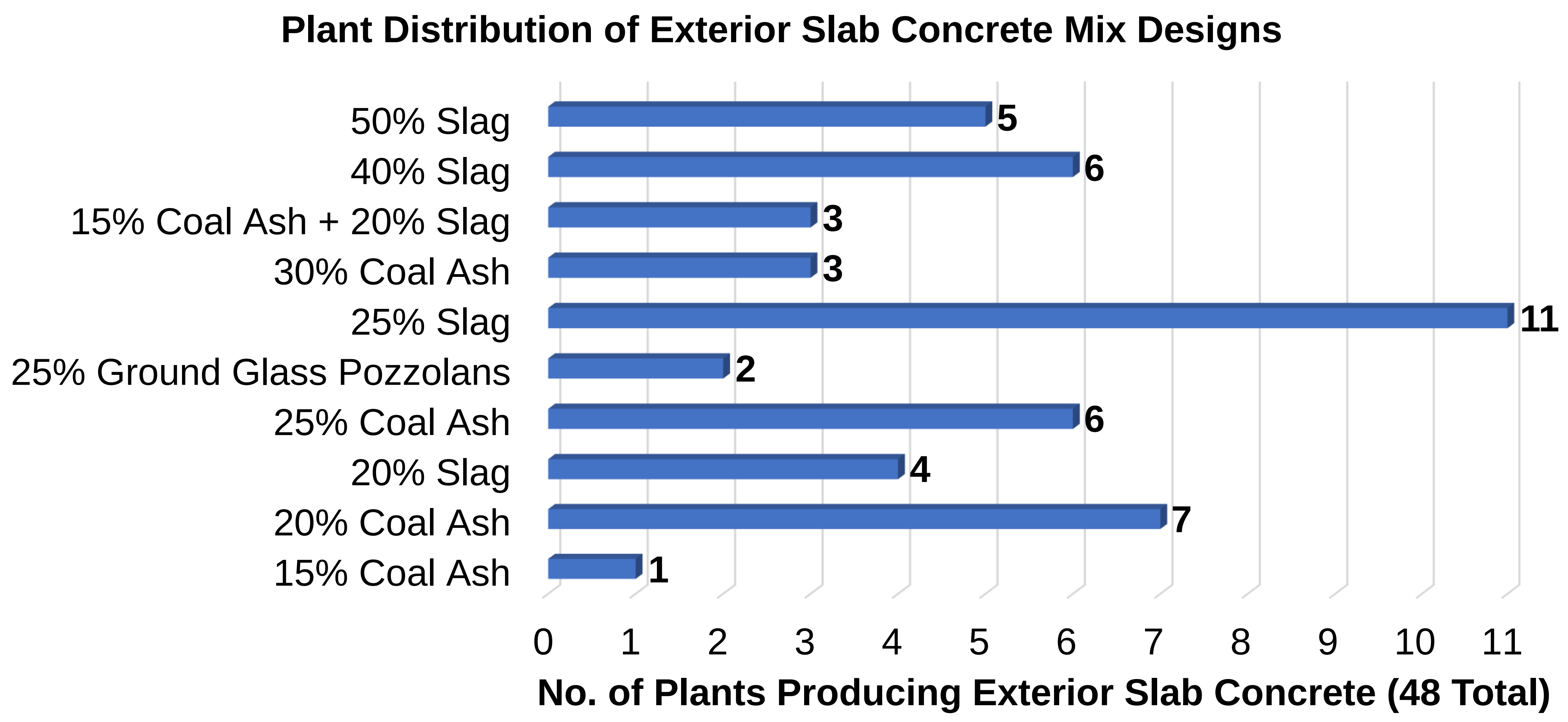
Uncovering the mystery behind surface deterioration.

Massachusetts Department of Transportation Highway Division

Current State of Things

- **MassDOT, municipal, commercial, and residential exterior slab concrete exhibiting scaling**
- **All types of mix designs are exhibiting scaling…**
  - 100% Type I/II cement
  - Type I/II cement and SCMs
  - 100% Type IL cement
  - Type IL cement and SCMs
- **as well as NO scaling…**

Current State of Things



massDOT Massachusetts Department of Transportation Highway Division

Materials and Construction Best Practices

Observations During Construction

Non-Conforming Activities

Mixing and Delivery

- **Hold-Back Water**
  - >10% of the approved total water design
- **Retempering**
  - After discharging of the first 1/3 of the load, multiple times

ORDERED: 50.00 DELIVERED: 10.00 SLUMP: 5.00

MAX WATER ALLOWED: 329.52 gl WATER ADDED ALLOWED ON SITE: 34.01 gl

[AT PLANT] W/C RATIO: 0.41 WATER ADDED: .00 gl TOTAL AGGR WATER: 54.66 gl

BATCHED WATER: 240.85 gl LOA

[ON SITE] W/C RATIO: 0.41 WATER ADDED: 0.00 gl

= 13.5% Hold-Back
(Spec. Limit ≤ 10%

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Field Investigations and Petrographic Examination

Observations During Construction

Non-Conforming Activities

Finishing

- **Dormancy (Placed)**
  - No screeding and no bull floating. Use of roller tampers and steel fresnos.
- **At Initial Set (Stiffened), After Bleed**
  - Final floating and texturing took place well before initial set and while bleed water was present. Blessed concrete. Worked in liquid-applied evaporation reducers and bleed water. Pushing of the broom. Did not remove water and paste from broom. Use of steel fresnos.
- **Cold Conditions (< 40°F)**
  - No QC Plan and therefore no cold conditions planning or execution.
- **Hot Conditions (Evaporation > Bleed)**
  - No QC Plan and therefore no hot conditions planning or execution. Worked in liquid-applied evaporation reducers and added water to the surface to compensate.

Field Investigations and Petrographic Examination

Observations During Construction

Use of roller tamper in lieu of screed and bull float.

Pushing broom. Use of walking floats.

Use of steel fresno in lieu of magnesium bull float.

Finishing in evaporation reducers. Use of inadequate bull float.

Field Investigations and Petrographic Examination

Observations During Construction

Observations During Construction

Non-Conforming Activities

Curing

- **At Final Set (Hardened)**
  - Application of Liquid membrane-forming compounds for curing and sealing took place well before final set, in direct conflict with the Manufacturer's TDS. Compounds often not applied per the required equipment, distance from surface, or the required coverage rate. In some cases, no attempt at curing at all…
- **Cold Conditions (< 40°F)**
  - No QC Plan and therefore no cold conditions planning or execution. No Insulating Materials, Heating, and Enclosures.
- **Hot Conditions (Direct Sunlight)**
  - No QC Plan and therefore no hot conditions planning or execution. No Sunshades, canopies, white polyethylene film, and white pigmented curing compounds.

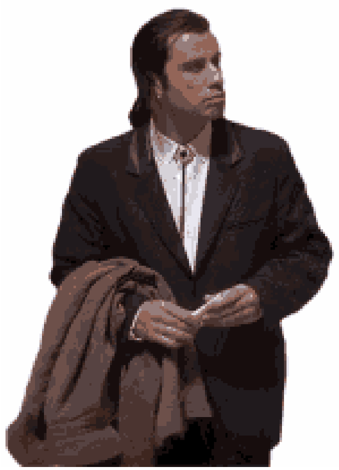
Field Investigations and Petrographic Examination

Observations During Construction

Non-Conforming Activities

Contractor Quality Control (QC)

- **Implementation**
  - Nonexistent or inconsistent. Frontline personnel require NRMCA Flatwork Certification but are in some cases not certified. Frontline personnel, while certified, do not follow the best practices that the course teaches. QC technicians are not on site to conduct inspection.



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Observations Post Construction

No Scaling

Description

The surface remains intact with broomed finish still present.

Observations Post Construction

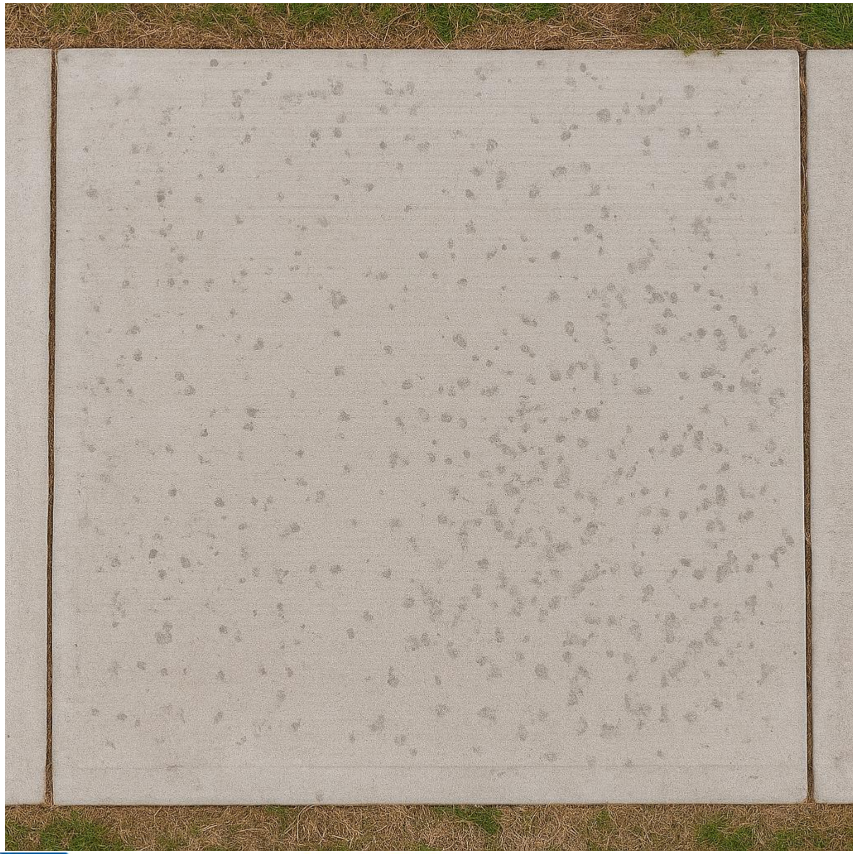
Minor Scaling

Description

Small, isolated scaling spots, with minimal surface flaking. Mortar cover intact. Depth of surface loss is minor (< 1/8 in.).

Observations Post Construction

Moderate Scaling



Description

Small scaling spots and surface flaking are more frequent but remain scattered, not clustered. Depth of surface loss is minor (< 1/8 in.).

Observations Post Construction

Major Scaling

Description

Scaling is clustered in small, isolated patches, with coarse aggregate potentially showing. Small scaling spots and surface flaking may also be scattered. Depth of surface loss is major (1/8 in. – 1/4 in.).

Observations Post Construction

Severe Scaling

Description

Scaling shows larger and more continuous clusters, often covering significant portions of the surface. Coarse aggregate is more commonly exposed. Depth of surface loss is major (1/8 in. – 1/4 in.).

Field Investigations and Petrographic Examination

Observations Post Construction

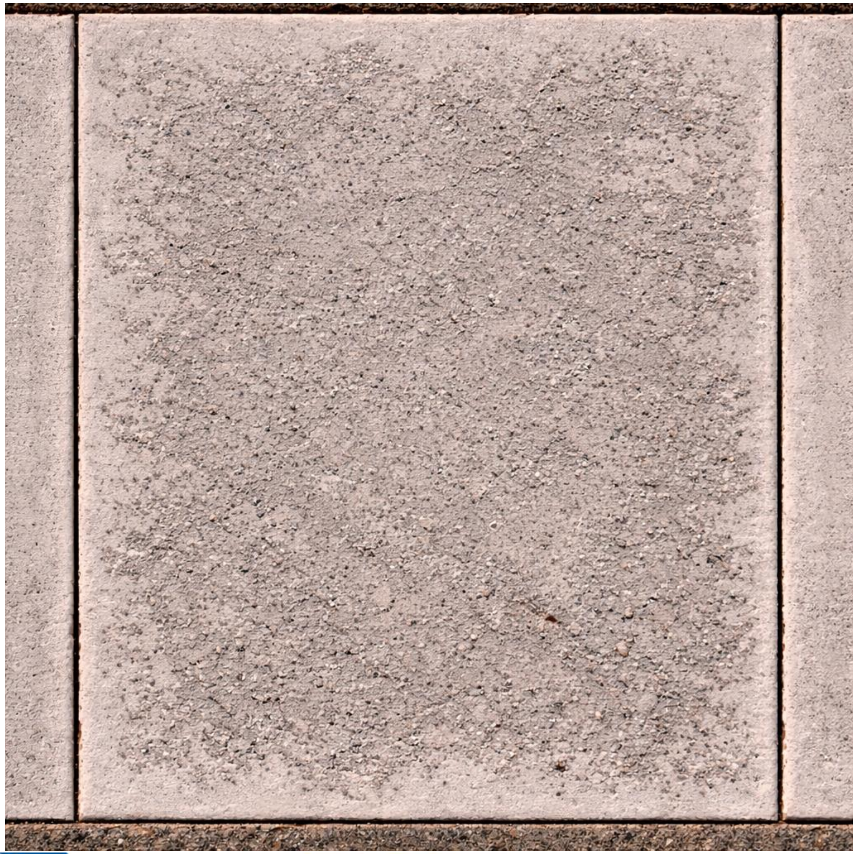
Very Severe Scaling

Description

Prevalent clustering with widespread surface deterioration. Mortar cover is largely gone in areas, with some coarse aggregate exposed and rough surface texture. Depth of surface loss is major (1/8 in. – 1/4 in.).

Observations Post Construction

Extreme Scaling



Description

Extensive surface loss with heavy clustering and broad aggregate exposure. Mortar cover is disintegrated and the surface is deeply deteriorated. Depth of surface loss is extreme (>1/4 in.).

Field Investigations and Petrographic Examination

Petrographic Examination

Coring of Contracts With Scaling

- **Selected 14 Contracts**
- **Examine four (4) panels with scaling per contract**
- **Extract two (2) cores per panel**
  - One (1) core with no scaling as a control with top paste layer intact
  - One (1) core with 1/3 area scaling and 2/3 area no scaling

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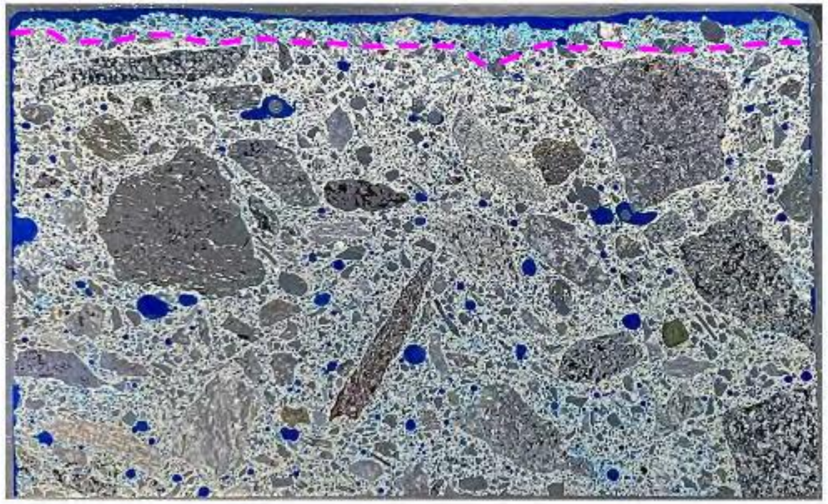
Petrographic Examination

Petrographic Examination

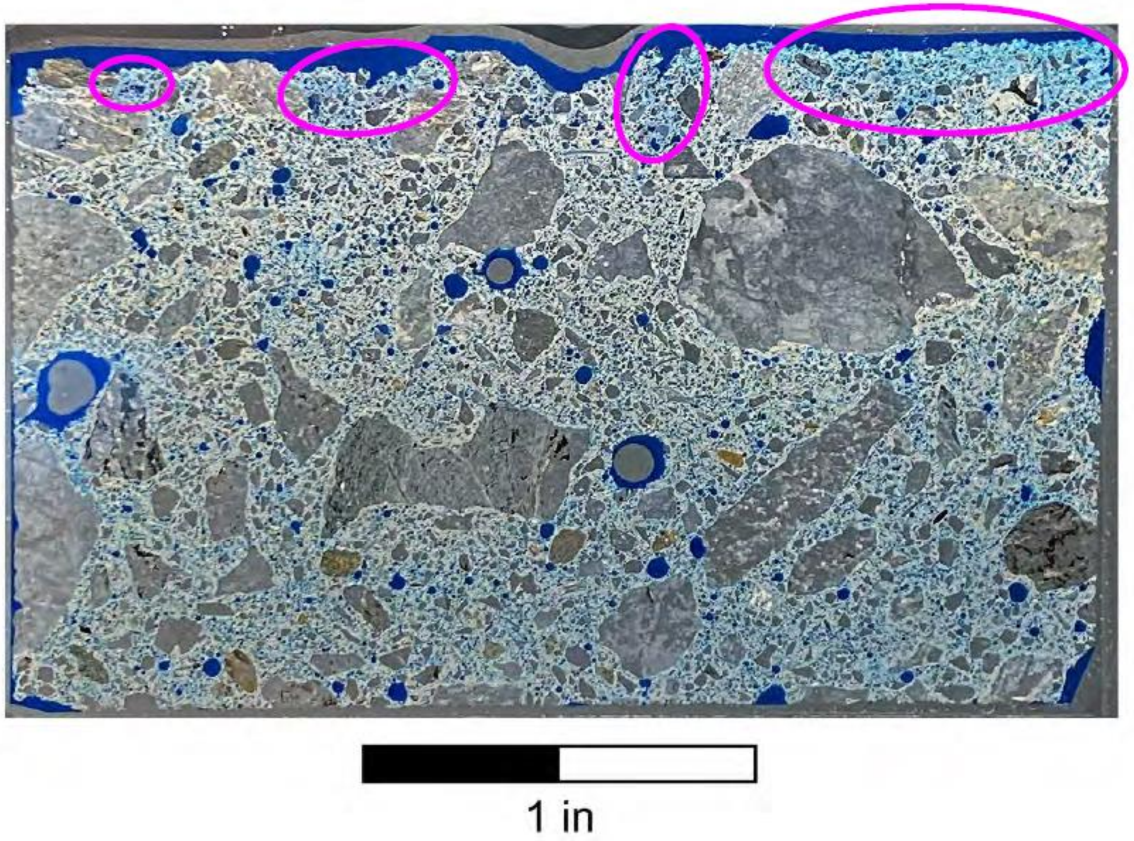
Laboratory Analysis

- ASTM C856 Petrography
- ASTM C457 Air Void System
- ASTM C1218 Chlorides



Field Investigations and Petrographic Examination

Petrographic Examination



Description:

Overview of the Core 2B ultrathin section, oriented with the wearing surface at the top of the image. The sample was impregnated with blue-dyed epoxy, which highlights voids and areas with high levels of porosity in the cementitious paste (a thin layer of blue-dyed epoxy covers the wearing surface). The magenta ovals mark near-surface areas with strong saturation of blue, which are indicative of pockets of highly porous cementitious paste.

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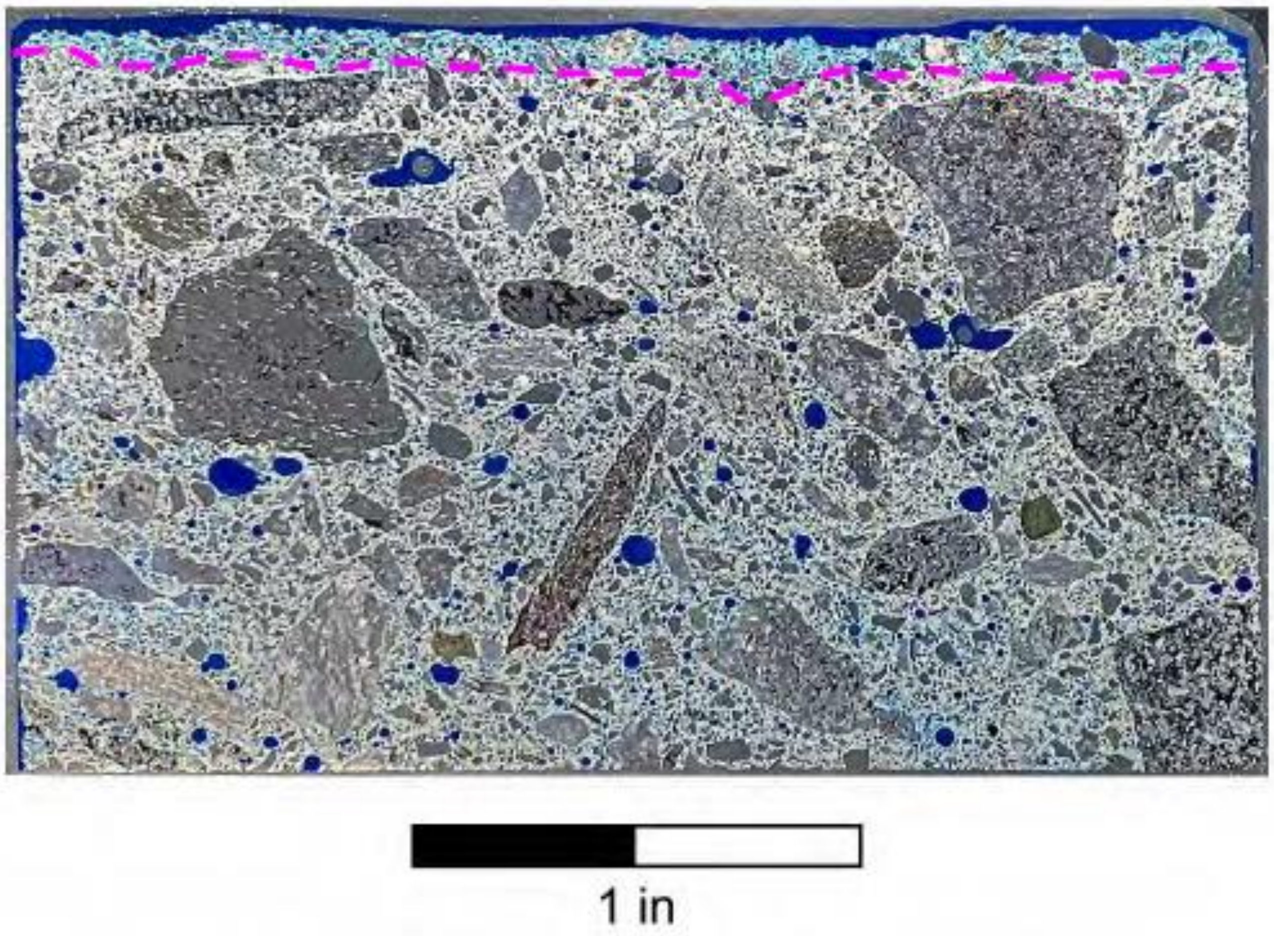
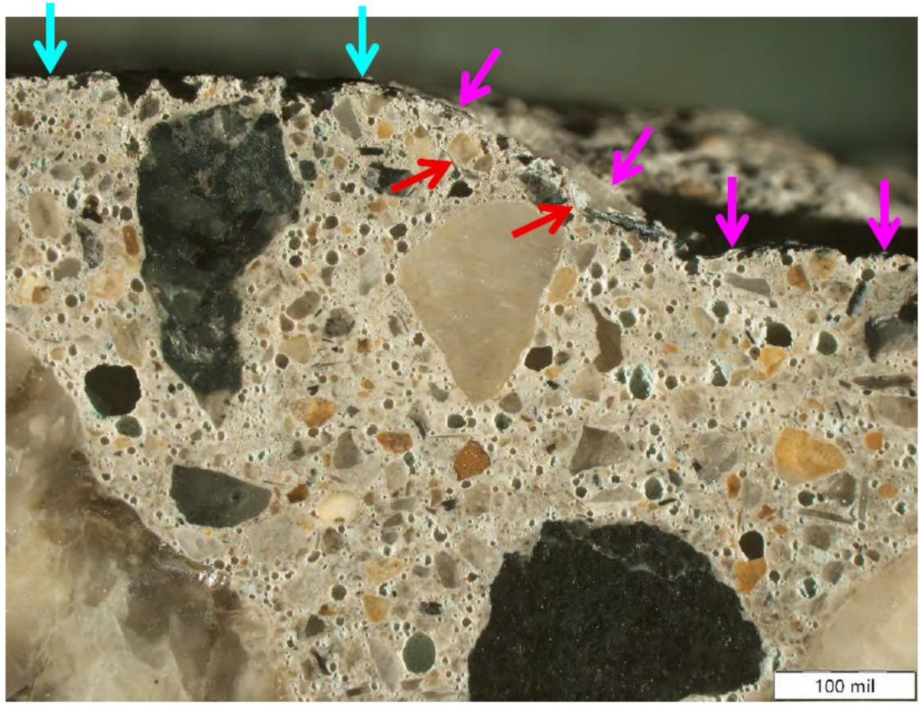
Petrographic Examination

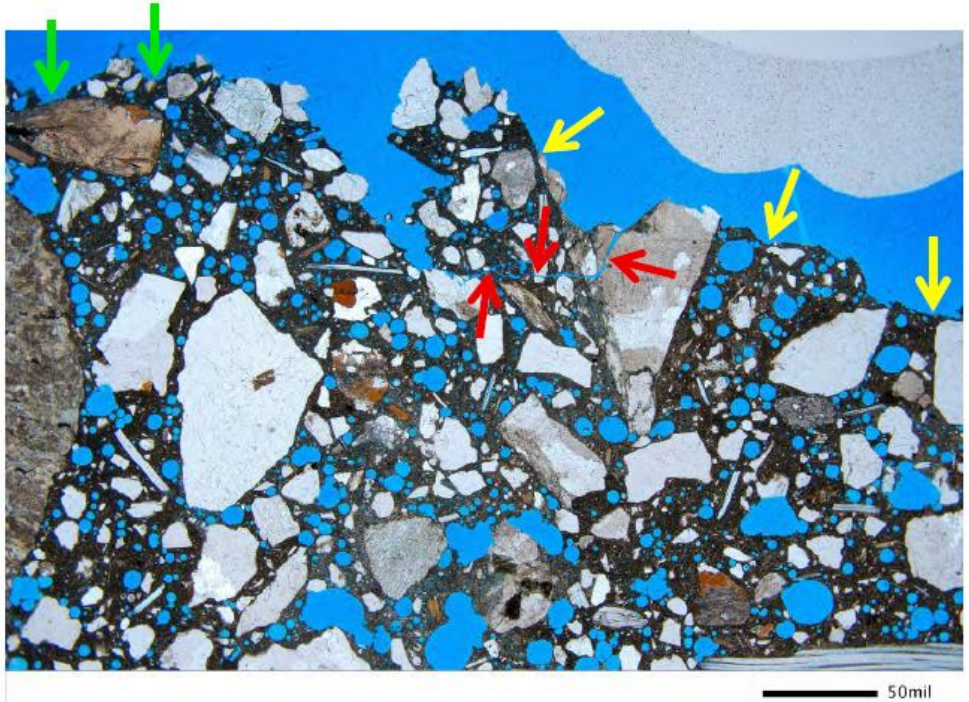


Description:

2G ultrathin section, oriented with the wearing surface at the top of the image. The sample was impregnated with blue-dyed epoxy, which highlights voids and areas with high levels of porosity in the cementitious paste (a thin layer of blue-dyed epoxy covers the wearing surface). Note the strong saturation of blue in the area between the wearing surface and the magenta dashed line, which is indicative of a near-surface zone of highly porous cementitious paste.

Petrographic Examination



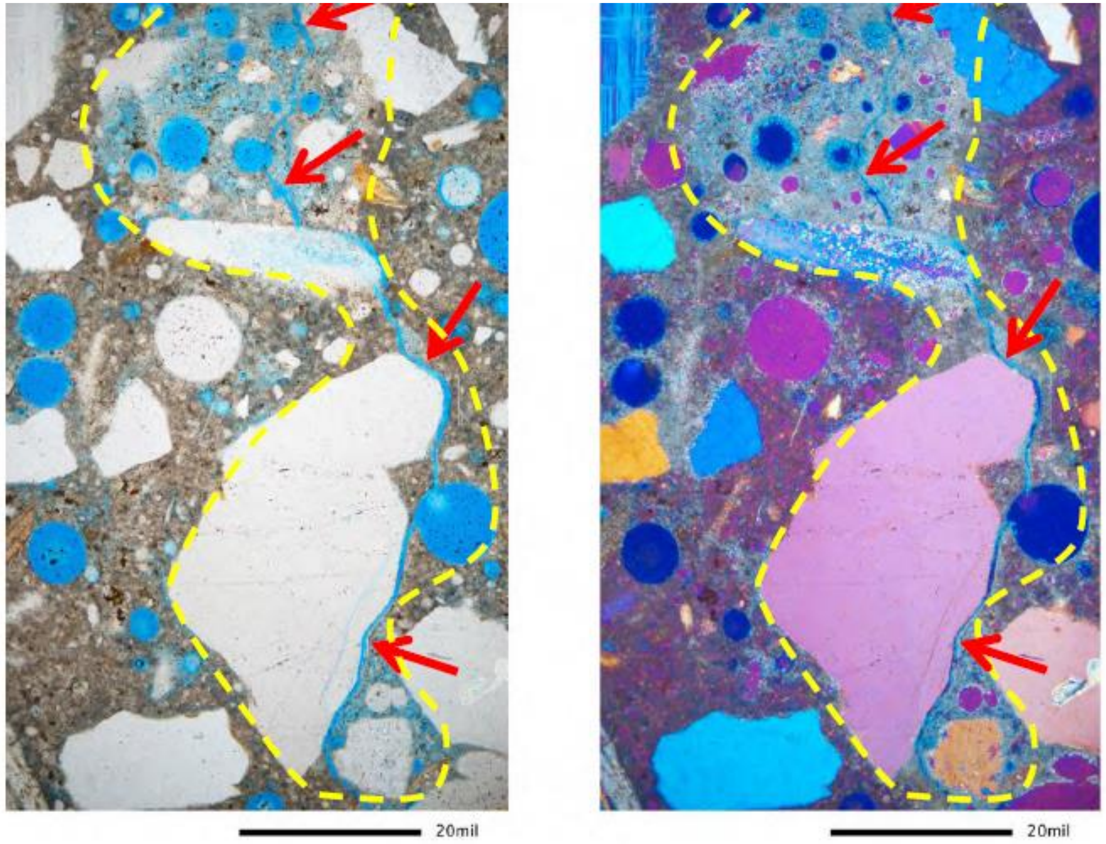


Description:

Photomicrograph of the Core 2B polished section (left) and thin section (right), depicting a transition between an intact portion of the wearing surface and a scaled. The red arrows mark microcracks.

Field Investigations and Petrographic Examination

Petrographic Examination

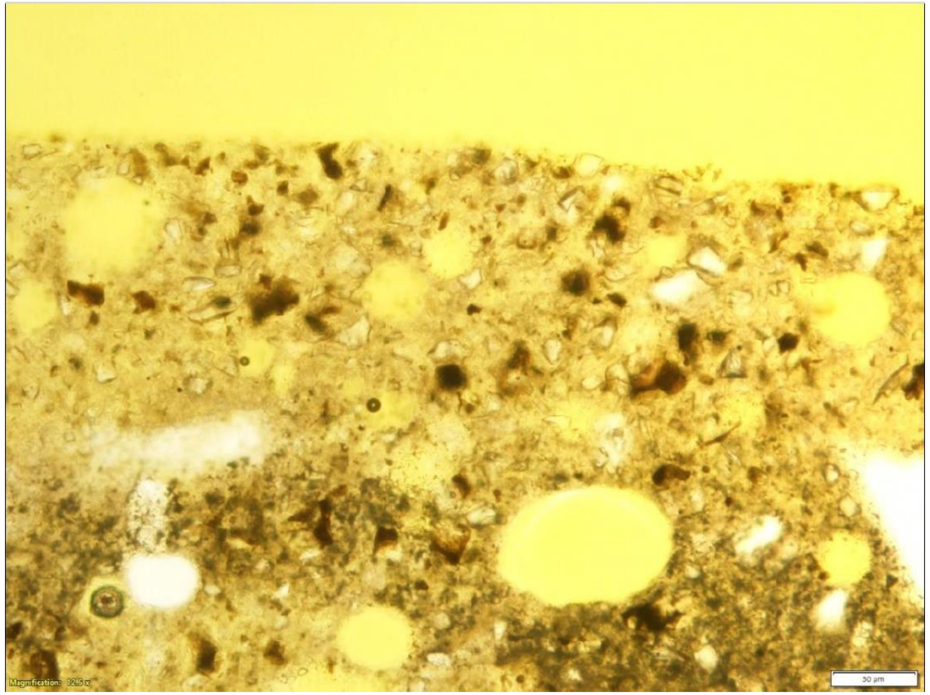


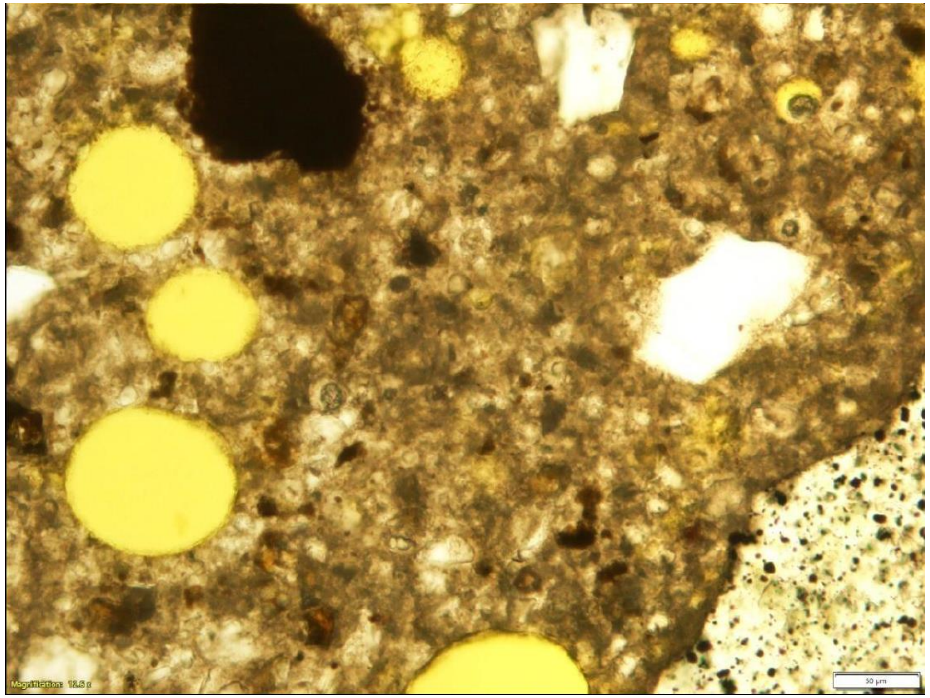
Description:

Photomicrograph mosaics of the Core 2G ultrathin section, depicting bleed-water channels (red arrows) extending through a near-surface zone of highly porous and carbonated cementitious paste (edge and lower boundary marked by yellow dashed lines). The wearing surface is at the top of the image.

(Plane polarized light on left; cross polarized light with full waveplate on right).

Petrographic Examination





Description:

Paste at the surface (Left picture) versus the bottom of core 25-1309A (Right picture), showing a denser, more hydrated paste deeper within the core. PPL, 200X magnification.

Findings

Top Layer (Surface Zone)

- The top layer consists of a high-porosity, low-cohesion cementitious paste
- The presence of a porosity gradient indicates the surface layer is materially different from the bulk concrete
- The shallow depth of deterioration confirms a surface-limited distress mechanism
- Increased porosity and reduced paste integrity make the surface susceptible to environmental exposure and mechanical breakdown

Findings

Underlying Concrete (Body)

- Paste is dense and uniform, typical of properly proportioned concrete
- No evidence of internal cracking or distress mechanisms
- Air content and spacing factor within acceptable limits (Spacing factor within 0.004 - 0.008 in.)
- Estimated w/cm ratio consistent with mix design (0.40 to 0.45)
- No indication of excessive water content in bulk matrix
- Chloride concentrations decreased with depth
- Carbonation is limited to near-surface region

Findings

Potential Causes of Scaling

- Improper finishing practices (inadequate screeding and bull floating, incorrect tools and timing, overworking surface)
- Addition of water at the surface
- Finishing in bleed water and/or evaporation reducers
- Uncontrolled evaporation (evaporation rate exceeding bleed rate)
- Insufficient curing

Emerging Chemical Admixtures and Topical Applications

A supplement for enhanced concrete durability?

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Highway Division

Spring 2026 – National Concrete Consortium

Chemical Admixtures

Colloidal Silica (Type S-CSA)

- Stabilized amorphous silica particles ranging from 1 to 100 nm in diameter, polymerized from soluble silicate under alkaline conditions

Key Results from Research Project [1]

Test Method	Quality Characteristic	Result
AASHTO TP 142	Reduction in ASR from Control (%) [2]	82
AASHTO T 357	Reduction of Chloride Penetration from Control (%) [3]	33

[1] Type S-CSA: E5 Liquid FA / Internal Cure
[2] Control: Very Highly Reactive
[3] Control: High Chloride Penetration

Permeability Reducing (Type S-PRAN)

- Non-hydrostatic conditions; Increases water repellency; Reduces water absorption
- Long-chain fatty acid derivatives, soaps and oils, petroleum derivatives, silanes, and reactive or inert fine particle fillers (colloidal silica, silicates, silicious powders, clay, lime, bentonite, talc)

Permeability Reducing (Type S-PRAH)

- Hydrostatic conditions; Increases resistance to water penetration; Reduces corrosion; Blocks pores and capillaries
- Crystalline hydrophilic polymers that react with moisture and unhydrated cement compounds to form insoluble crystalline structures that block capillary pores

Emerging Chemical Admixtures and Topical Applications

Colloidal Silica Finishing Aids

Specifications

- Currently no AASHTO or ASTM Standards
- Refer to Technical Data Sheet (TDS)

Qualified Construction Materials List

- Five (5) products listed
- Colloidal Silica Finishing Aids* | Mass.gov

Product Claims

"Lubricates the surface for faster, easier finishing. Extends workable time under adverse conditions such as high wind, heat, or low humidity. The amorphous silica reacts during the hydration of concrete to produce more cementitious material, translating into higher density and improved surface performance." – Solomon Colors Day1

Product TDS Specifications

Test Method	Quality Characteristic	Min.	Max.
ASTM C672	Reduction in Scaling (%)	70	–
AASHTO T 161	Reduction of Mass Loss (%)	85	–
ASTM C779	Reduction in Abrasion (%)	35	–
AASHTO T 259 / T 260	Chloride Ion Penetration (%)	95	–

Note: Currently working on developing an AASHTO UP3 Technical Committee for Colloidal Silica Finishing Aids

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Penetrating Colloidal Silica Compounds for Curing and Sealing

Specifications

- Currently no AASHTO or ASTM Standards
- Refer to Technical Data Sheet (TDS)

Qualified Construction Materials List

- One (1) product listed
- Liquid Membrane-Forming (M4.12.4) & Colloidal Silica* Compounds | Mass.gov

Product Claims

“Penetrates into the accessible capillary system, reacting with the available free alkali found within, and primarily forming CSH. Equal to or better than a 28-day moist cure. Applied at final set for curing. Can be applied to existing concrete as a penetrating sealing compound – Spray-Lock P3 Protect

Product TDS Specifications

Test Method	Quality Characteristic	Min.	Max.
ASTM C1556	Reduction in Chloride Diffusion (%)	30	–
AASHTO T 161	Reduction of Mass Loss (%)	40	–
ASTM E96	Reduction in Water Vapor Transmission of Materials (%)	70	–
EN 12390-8	Reduction in Depth of Penetration of Water Under Pressure (%)	70	–

Note: Currently working on developing an AASHTO UP3 Technical Committee for Penetrating Colloidal Silica Compounds for Curing and Sealing

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Case Study – Overview

Project Scope

- Concrete sidewalk with premature deterioration due to scaling
- Remove and replace deteriorated panels
- Place same mix design formulation for new panels
- Place concrete in the same area and implement best construction practices
- Apply Solomon Colors Day1 colloidal silica finishing aids
- Apply ASTM C1315 liquid membrane-forming compounds for curing and sealing
- Apply Spray-Lock P3 penetrating colloidal silica compounds for curing and sealing

Placed: June 10, 2024

Photo: May 8, 2025

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Case Study – Mix Design Formulation

Cementitious: 611 lb. **Type I/II:** 65% **Coal Ash (F):** 15% **Slag (120):** 20%

Mix Design Type: Exterior Slab Concrete (ESC) **Compressive Strength:** 4,500 psi

NMAS: 3/4 in. **Slump:** 6 in. **AC:** 7.0% **PC:** 28.5% **PC + AC / VC:** 1.94

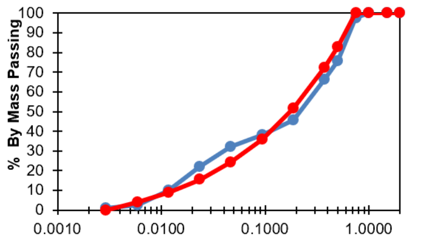
Shilstone: Zone II (Optimum) **Tarantula Curve:** Optimized, Close Conformance

MIX DESIGN FORMULATION

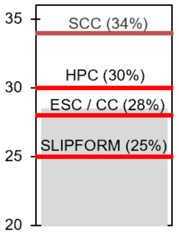
MIX DESIGN ID NO. DOT	PRODUCER	MIX DESIGN TYPE	C (PSI)	NMAS (IN.)	S (IN.)	AC (%)	W/CM RATIO	PC (%)	AGGREGATE (LBS.) FINE	CA1	CA2	CA3	CEMENTITIOUS; PACKAGED; FIBER (LBS.) CEM	SCM1	SCM2	SCM3	PKG	FIBER	WATER (GAL.) W_T	W_{ADMIX}	ADMIXTURES (FL. OZ.) AD1	AD2	AD3	AD4	AD5	AD6	YIELD (CF)	UW (PCF)
11	344034	ESC	4500	3/4	6	7.0	0.45	28.5	1117.0	725.0	1005.0	0.0	397.0	92.0	122.0	0.0	0.0	0.0	32.9	0.2	4.5	30.6	0.0	0.0	0.0	0.0	27.00	138.2

OPTIMIZED COMBINED AGGREGATE AND PASTE SYSTEM ANALYSIS

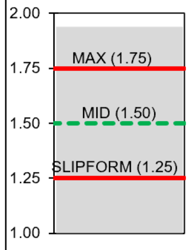
PERCENT BY MASS PASSING (%) 2 IN.	1 1/2 IN.	1 IN.	3/4 IN.	1/2 IN.	3/8 IN.	#4	#8	#16	#30	#50	#100	#200	PERCENT RETAINED BY MASS (%) ON EACH SIEVE TARANTULA CURVE RESULT	SHILSTONE WORKABILITY-COARSENESS FACTOR CF	WF	ZONE	TCM (LBS.)	ECC (LBS.)	THICK (FT.)
100.0	100.0	100.0	97.5	75.6	66.2	45.6	38.0	32.1	22.0	10.0	2.6	0.8	OUTSIDE	54.5	39.3	II: 3/4 - 2 IN.	611.0	565.0	2.5



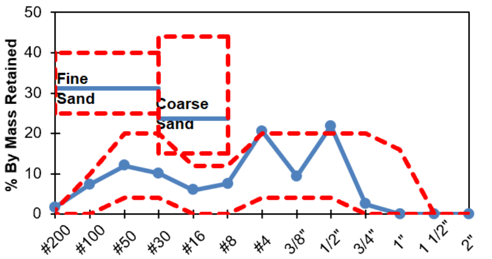
FM	CA (%)	q	E (%)	VC_A (%)
4.86	54.4	0.41	78.3	28.4



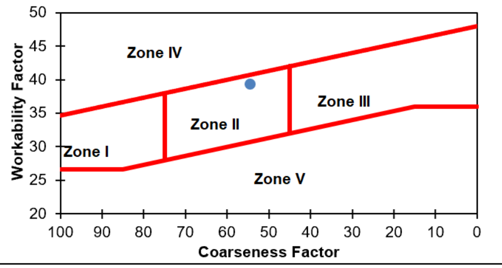
PC (%)
28.5



PC_A (%)	VC_M (%)	RATIO
35.5	18.3	1.94



OUTSIDE: |1/2 IN.||#4| EXCESSIVE COARSE AGGREGATE RESULTING IN DECREASED WORKABILITY AND INCREASED SEGREGATION AND EDGE SLUMPING.



ZONE II (OPTIMUM FOR NMAS 3/4 IN. - 2 IN.): OPTIMIZED WORKABILITY FACTOR AND COARSENESS FACTOR

DEF/Thermal Crack Resistance

T_{MAX} (°F)	T_C (°F)	T_A (°F)
158.00	70	60

SPECIFIC APPLICATION	THICK. (FT.)
DS (SOIL)	9.00
DS (CASING)	9.00
DS (WATER)	9.00
ABUTMENT	1.41
PIER (ABOVE)	1.77
PIER CAP	2.09
PILE CAP	3.18
BRIDGE DECK	9.00
SLAB (GRADE)	9.00

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Case Study – Environmental Conditions

Placement 1 – Scaling Deterioration

$E = (T_c^{2.5} - r * T_a^{2.5})(1 + 0.4V) \times 10^{-6}$

Input	Measurement	0.45 w/cm Bleed Rate
T_c (°F)	77	[redacted]
r (%)	50	[redacted]
T_a (°F)	76	[redacted]
V (mi/hr)	10 to 20	[redacted]
E (lb/ft²/hr)	**0.13 to 0.24**	**≤ 0.15**

EVAPORATIVE CONDITIONS!

Emerging Chemical Admixtures and Topical Applications

Case Study – Environmental Conditions

Placement 2 – No Scaling Deterioration

$E = (T_c^{2.5} - r * T_a^{2.5})(1 + 0.4V) \times 10^{-6}$

Input	Measurement	0.45 w/cm Bleed Rate
T_c (°F)	70	[redacted]
r (%)	75	[redacted]
T_a (°F)	64	[redacted]
V (mi/hr)	0 to 6	[redacted]
E ($lb/ft^2/hr$)	**0.02 to 0.06**	**≤ 0.15**

NO EVAPORATIVE CONDITIONS!

Placed: September 16, 2025

Photo: March 27, 2026

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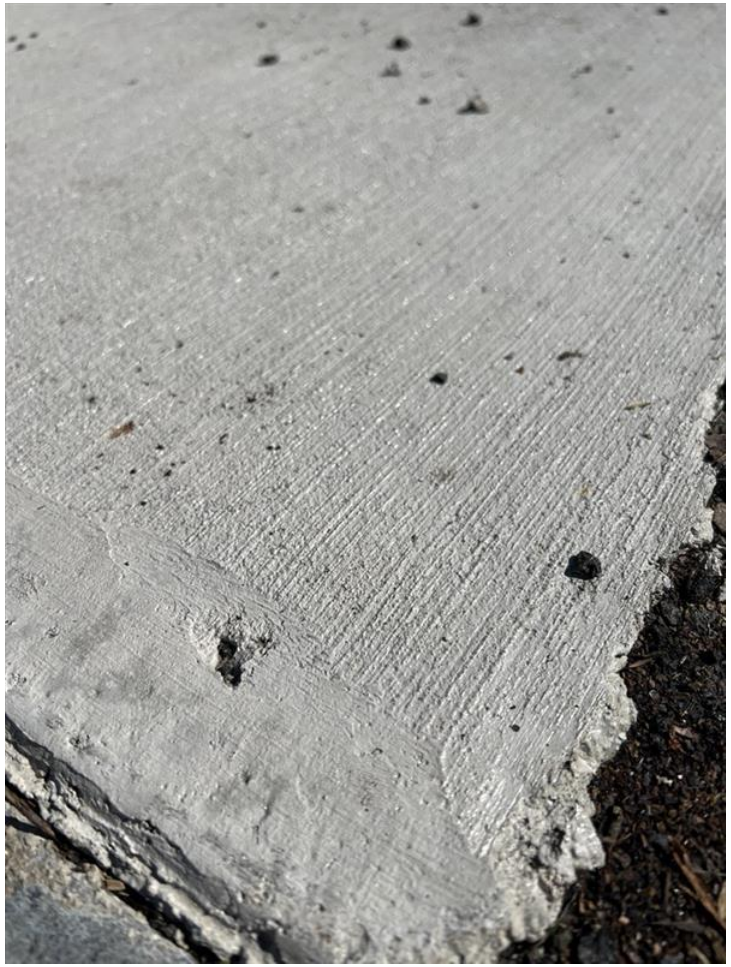
Case Study – Apply Penetrating Colloidal Silica Compounds for Curing and Sealing



Case Study – Findings for Placement 1 (Scaled) vs. Placement 2 (Not Scaled)

Constants

- Mix design formulation (Type I/II, coal ash, and slag)
- Exposure conditions (freezing, thawing, and de-icing)

Variables

- Non-conforming vs. Best Construction Practices
- Evaporative Conditions vs. Ideal Conditions
- Incorrect vs. per TDS application of ASTM C1315 liquid-membrane forming compounds for curing and sealing
- Application of colloidal silica finishing aids and penetrating colloidal silica compounds for curing and sealing

Results

- Best materials and construction practices prevail
- Colloidal silica finishing aids did not damage the surface
- Panels applied with penetrating colloidal silica compounds for curing and sealing exhibited no scaling

Placed: September 16, 2025

Photo: March 27, 2026

Closing Remarks

There are no shortcuts for concrete…

Understand the importance of…

- Best Practices vs. Prohibited Practices
- Acceptable Tools vs. Prohibited Tools
- Contractor Quality Control
- **Initial Set:** Apply final floating and texturing
- **Evaporation Rate > Bleed Rate:** Apply evaporation reducing materials
- **Final Set:** Apply curing

Emerging materials are not silver bullets…They are supplements…

Producers, Contractors, and Agencies all share this burden to get this right!

Research, Specifications, and Webinars

- https://www.mass.gov/lists/current-and-completed-research-projects
- 2021 – Construction and Materials Best Practices for Concrete Sidewalks Subjected to Cold Conditions
- 2023 – Construction and Materials Best Practices for Concrete Sidewalks Subjected to Hot Conditions
- 2025 – Recycled Ground-Glass Pozzolan (RGGP) for Use in Cement Concrete and Comparison with Other Alternative Constituent Materials
- https://www.mass.gov/lists/construction-specifications
- https://vimeo.com/1106214472

Words of Encouragement!

Looks like you were right about the mix.
I know I was skeptical. But I am glad we stuck with the lower cement factor with high range.
It gave us the strength needed and the lower paste factor.
I guess you are never too old to learn.

Norm

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Thank You! Questions?

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