Rapid Setting Materials Synthesis

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Acknowledgments

TPF-5(313) - NCC States
Steve Tritsch
Peter Taylor
Susan Stokke

Acknowledgments

Novel Alternative Cement Binders for Highway Structures and Pavements, FHWA, 2021- PI Kimberly Kurtis

Development of Rapid, Cement-Based Repair Materials for Transportation Structures, TxDOT – 6723, 2015 – PI Kevin Folliard

Optimizing Concrete Pavement Opening to Traffic, FHWA, 2022 - Delatte, Weiss, Taylor

Goal

Provide a DOT engineer with a guide to the use and science of rapid repair materials.

Before report

Synthesis Report

Before report

Synthesis Report

Before report

After report

Part 1 – Choosing Rapid Repair Material – 10 pp.

- Four Questions to Choose a Rapid Setting Material
- Summary of the NCC State Report
- Repair Material Usage
- Research Needs

Part 2 – All the Details! – 40 pp.

Production
Hydration
Admixtures
Durability

Durability Mechanisms Covered

Chemical, Autogenous, Drying Shrinkage
Coefficient of Thermal Expansion
Freeze thaw
Scaling
Permeability
Corrosion
Carbonation
ASR
Sulfate Attack

Appendix

Product	Company	Classification of Repair Material	Description	Product Data Sheet URL
Ardex TRM	Ardex	OPC	Portland cement-based, microsilica-modified, fast setting structural repair mortar	https://www.ardexamericas.com/wp-content/uploads/ARDEX-TRM-Technical-Data.pdf
MasterEmaco T 1060*	BASF Construction Chemical	OPC	One-component, shrinkage-compensated, very rapid-setting, cement-based mortar	https://assets.master-builders-solutions.com/en-us/masteremaco-t-1060-tds.pdf
MasterEmaco T 1061*	BASF Construction Chemical	OPC	One-component, shrinkage-compensated, cement-based mortar	https://assets.master-builders-solutions.com/en-us/masteremaco-t-1061-sds.pdf
MasterEmaco® T 545 HT*	BASF Construction Chemical	MgP	One-component magnesium phosphate-based patching and repair mortar.	https://assets.master-builders-solutions.com/en-us/masteremaco-t-545-t-545-ht-tds.pdf
Pavemend SL	Aquafin*	AA	Rapid setting, semi-leveling, cementitious structural repair concrete.	https://www.aquafin.net/us/en/files/pavemend-sl/TDS%20SL%20071519.pdf

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Let's hit the high points!!!!

Really

The *Really* Fantastic Four Questions

1. How fast do you *really* need it open?
2. What strength do you *really* need?
3. Is reinforcing steel *really* close to the surface?
4. How long do you *really* need it to last?

State Survey Results

How are Rapid Materials tested for approval?
How are Rapid Materials tested for quality control?
What strengths are required for opening of pavements and bridges?
What changes are made to construction specifications?
What materials are used?

Rapid Repair Material	% of States Where Materials are Approved	
	Pavement	Bridge
Accelerated Portland Cement Concrete	71%	63%
Non-Shrink or Shrinkage Compensating Cement (CSA)	69%	77%
Magnesium Phosphate Cement	23%	46%
Polyester Concrete	20%	54%
Calcium Aluminate Cement (CAC)	17%	17%
Ultra-High Performance Concrete (UHPC)	11%	29%
Alkali-Activated (AA) Cement	9%	9%
Other	29%	37%

Source: Masten and Ley 2021, *NCC Spring 2021 State Reports on Fast Setting Patching Materials*

What rapid repair material should I use???

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Usage		Repair Materials
Pavement	No Freeze-Thaw	OPC, CSA-P, CAC, CSA, AA, Polyester
	Freeze-Thaw	OPC, CSA-P, CAC, Polyester

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	Freeze-Thaw	OPC, CSA-P, CAC, Polyester

Why?

Binder	w/cm Ratio	Recommended Air Content
CSA2	0.40	none
CSA2B	0.40	2% to 4%*
CSA2B	0.35	> 2%
CAC2	0.40	none
CACT	0.40	2.5% to 5.5%*
AA	0.40	none
OPC	0.40	> 4%

Lower limit set by ASTM C 666 (bulk freeze thaw)
Upper limit set by ASTM C 672 (scaling)

What rapid repair material should I use???

	Usage	Repair Materials
Structures	**No Freeze-Thaw**	
	< 15 yr service life	OPC, CSA-P, CAC, CSA, AA, Polyester
	≥ 15 yr service life	OPC, CSA-P, CAC, Polyester
	Freeze-Thaw	
	< 15 yr service life	OPC, CSA-P, CAC, Polyester
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Good for carbonation and corrosion

Did you know portland cement naturally protects rebar from corroding?

Portland cement produces calcium hydroxide and this raises the pH of the pore solution.

pH > 13

www.youtube.com/tylerley

Samples are stored in Austin, TX

Repair Material	Carbonation after 11 Months Exposure		Carbonation compared to OPC
	Exposed	Covered	
Rapid Strength OPC	0.01 in.	0.05 in.	
CAC -3	0.13 in.	0.25 in.	5x
CAC -2	0.12 in.	0.14 in.	3x
AA	0.17 in.	0.29 in.	6x
CSA	0.14 in.	0.34 in.	7x

Source: Dornak et al. 2015

Most repair materials have issues with carbonation

If you have rebar within 3” of the surface and you want > 15 y service life then you need to use:

OPC

CAC (commercial products are blends with OPC)

CSA-P (CSA with a pore blocking additive)

Polyester Concrete

Or show that carbonation is not a concern in your environment.

How do I know which commercial material to use???

Which products are OPC, AA, CAC, CSA, etc????

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Go to the appendix!!!

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Summary

- The Rapid Set Materials synthesis outlines:
  - Important questions to ask
  - Current practices by DOTs
  - What materials to choose
  - Material details
  - A comprehensive listing of commercial materials with a description of what they really are.
  - Gives a lot of references.

www.tylerley.com/rapidrepair

Synthesis of Rapid Setting Repair Materials

Final Report
February 2022

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(Part of Intrans Project 15-532)

IOWA STATE UNIVERSITY
Institute for Transportation

National Concrete Pavement Technology Center

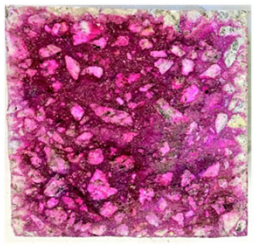
Rebar will corrode in air!
But not in ↑ pH concrete
www.engineeringcivil.com

How do you measure pH?

Place a pH indicator on concrete. The most common one is phenolphthalein.

pH 8 – 12 fuscia

pH < 8 clear



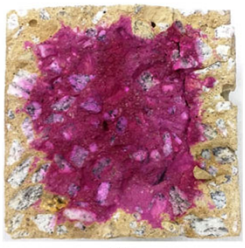
OPC

CAC2

CACT

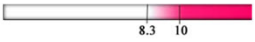
4" x 4"

CSA2

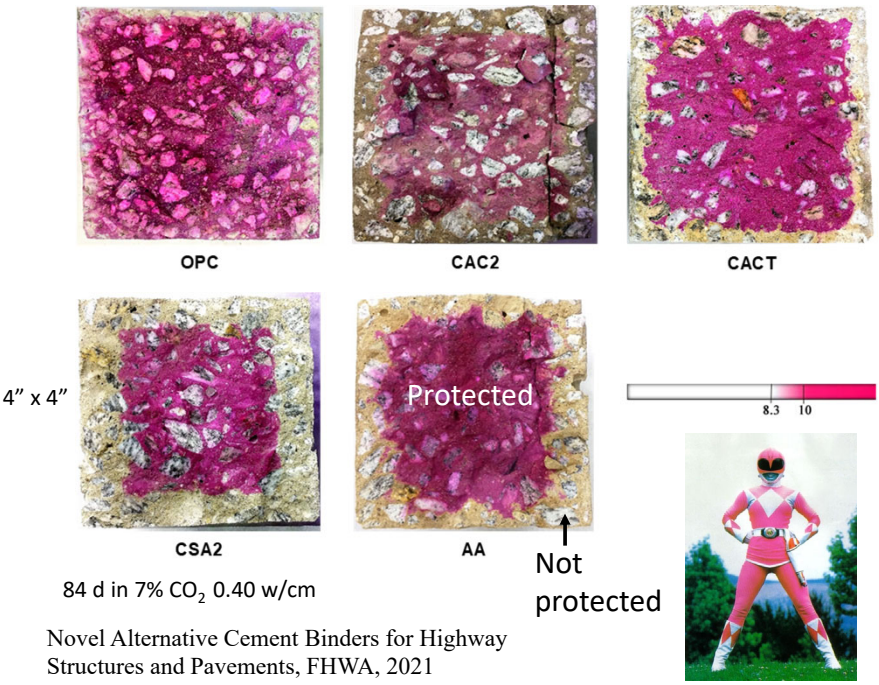


AA

84 d in 7% CO_2 0.40 w/cm



Novel Alternative Cement Binders for Highway Structures and Pavements, FHWA, 2021



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