PAVEMENT AND BRIDGE REHABILITATION USING MATERIAL COMPATIBLE REPAIRS

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CURRENT METHODS OF REPAIR

Concrete Pavements

Partial Depth Repair

Dowel Retrofit

Full Depth Repair

Concrete Bridges

Type 1

Type 2

Type 3

CURRENT PRACTICES

Typical repair materials (Cementitious Materials)

Product	Material Category	Working Time, min	Installation Temp., °F	Time-to-Traffic, hr.	Moisture Conditions		Material Cost Factor
					Repair Surface	Aggregate	
Type III PCC	PCC	20	32 to 109	4 to 6	SSD to dry	1-3% to dry	1
Duracal	gypsum-based	20	32 to 109	1.5	SSD to dry	1-3% to dry	0.7
Set-45	magnesium phosphate	10	32 to 90	1.5	dry	1-3% to dry	3.5
Five Star HP	high alumina	20	32 to 90	1.5	SSD to dry	1-3% to dry	3
Pyrament 505	Hydraulic cement	30	32 to 109	2 to 3	SSD to dry	1-3% to dry	2

THE PROBLEM

Deficiencies in Repair Materials [3] :

- Compressive failure of repair material
- Incompatible stiffness
- Incompatible thermal expansion
- Excessive autogenous shrinkage
- Variability in repair material
- Insufficient consolidation
- Delayed curing

RESEARCH OBJECTIVES

1. Identify critical parameters for compatible repair mixture
2. Develop repair material selection framework
3. Propose new mix designs
4. Experimental evaluation of repair materials (developed and commercially available)

Material Selection Framework

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RESEARCH OBJECTIVES

Improved Performance

1. Improved strength & reduced ε_{repair} » Internal curing
2. Extended durability
3. Structure and Repair deform at the same rate:
   - a.) Applied load » Elastic modulus, $E_{repair} = E_{existing}$
   - b.) Change in temperature » Thermal coefficient, $\alpha_{repair} = \alpha_{existing}$
   - c.) Drying shrinkage » ε_{repair} reduced

Traditional Repair » *Material Compatible Repair*

PROGRESS TO DATE

1. Performed literature review
2. Defined performance criteria
3. Identifying key parameters in material selection framework
4. Identifying materials for use in repair mixes

* Current step

PERFORMANCE CRITERIA

Performance Criteria	
Constructability	Easy to perform, Versatile, etc.
Fresh Concrete	Setting Time Workability (Slump)
Hardened Concrete	Flexural and Compressive Strength Fatigue Performance Stiffness Compatibility Thermal Compatibility Bonding Shrinkages (Autogenous and Total)
Concrete Durability	Freeze/Thaw Deterioration Chloride Permeability (Resistivity)

PERFORMANCE CRITERIA

Performance Criteria		Concrete Pavement		
		Partial Depth	***Dowel Retrofit***	***Full Depth***
Constructability	Easy to perform, Versatile, etc.	✓	✓	✓
Fresh Concrete	Setting Time	✓	✓	✓
	Workability (Slump)	✓	✓	✓
Hardened Concrete	Flexural and Compressive Strength	✓	✓	✓
	Fatigue Performance	✓	✓	✓
	Stiffness Compatibility	✓	✓	✗
	Thermal Compatibility	✓	✓	✗
	Bonding	✓	✓	✗
	Shrinkages (Autogenous and Total)	✓	✓	✗
Concrete Durability	Freeze/Thaw Deterioration	✓	✓	✓
	Chloride Permeability (Resistivity)	✓	✓	✓

PERFORMANCE CRITERIA

Performance Criteria		Concrete Pavement			Concrete Bridges		
		Partial Depth	*Dowel Retrofit*	*Full Depth*	*Type 1*	*Type 2*	*Type 3*
Constructability	Easy to perform, Versatile, etc.	✓	✓	✓	✓	✓	✓
Fresh Concrete	Setting Time	✓	✓	✓	✓	✓	✓
	Workability (Slump)	✓	✓	✓	✓	✓	✓
Hardened Concrete	Flexural and Compressive Strength	✓	✓	✓	✓	✓	✓
	Fatigue Performance	✓	✓	✓	✓	✓	✓
	Stiffness Compatibility	✓	✓	×	✓	✓	×
	Thermal Compatibility	✓	✓	×	✓	✓	×
	Bonding	✓	✓	×	✓	✓	×
	Shrinkages (Autogenous and Total)	✓	✓	×	✓	✓	×
Concrete Durability	Freeze/Thaw Deterioration	✓	✓	✓	✓	✓	✓
	Chloride Permeability (Resistivity)	✓	✓	✓	✓	✓	✓

PERFORMANCE CRITERIA

1. **Fresh Concrete**
   - Workability
   - Set time/high early strength
2. **Hardened Concrete**
   - Flexural and compressive strength compatibility
   - Stiffness compatibility
   - Thermal compatibility
   - Shrinkage (autogenous and total)
   - Bond
   - Fatigue

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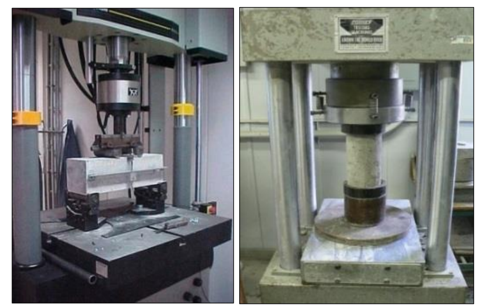
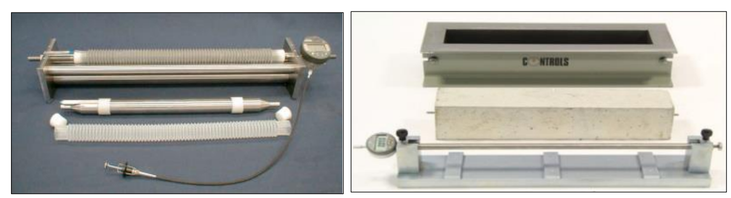
Workability Tests



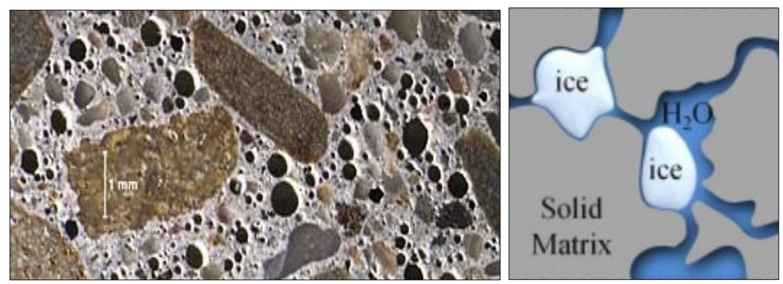
Strength Tests



Shrinkage Tests

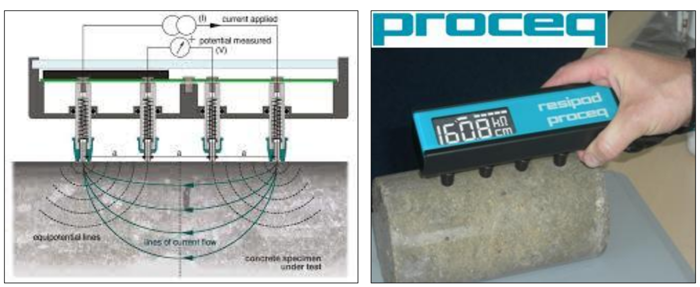
PERFORMANCE CRITERIA

3. **Durability**
   - Freeze/thaw deterioration
   - Chloride permeability
4. **Constructability**
   - Simple to implement
   - Versatile



[10]

Air Voids

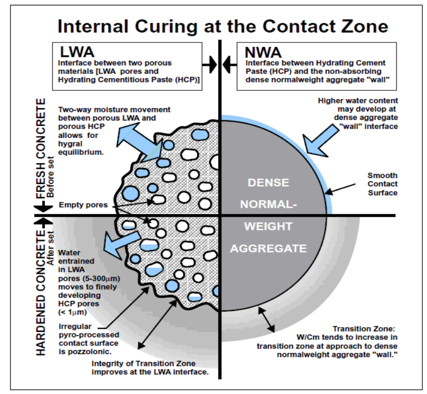


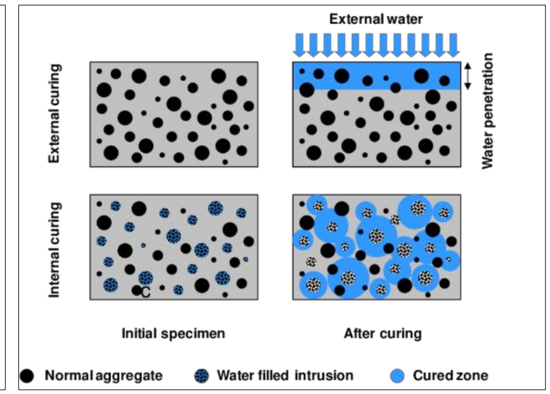
Permeability Test

Super Air Meter Test

INTERNAL CURING

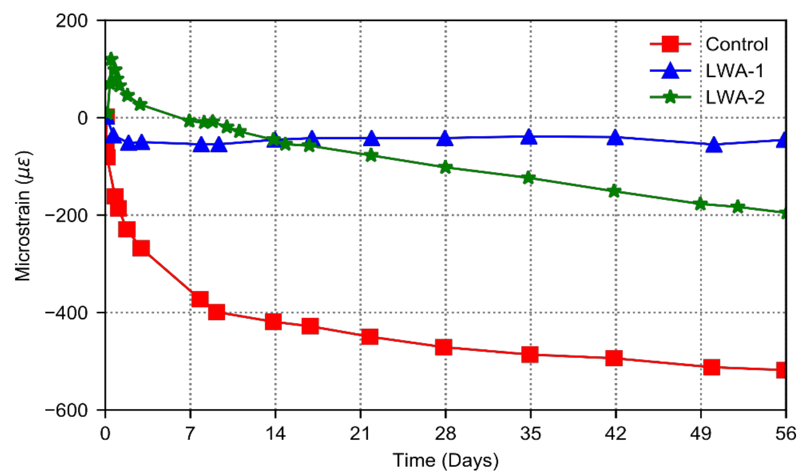
- Saturated porous materials release water as needed to promote longer curing times in surrounding cement paste.





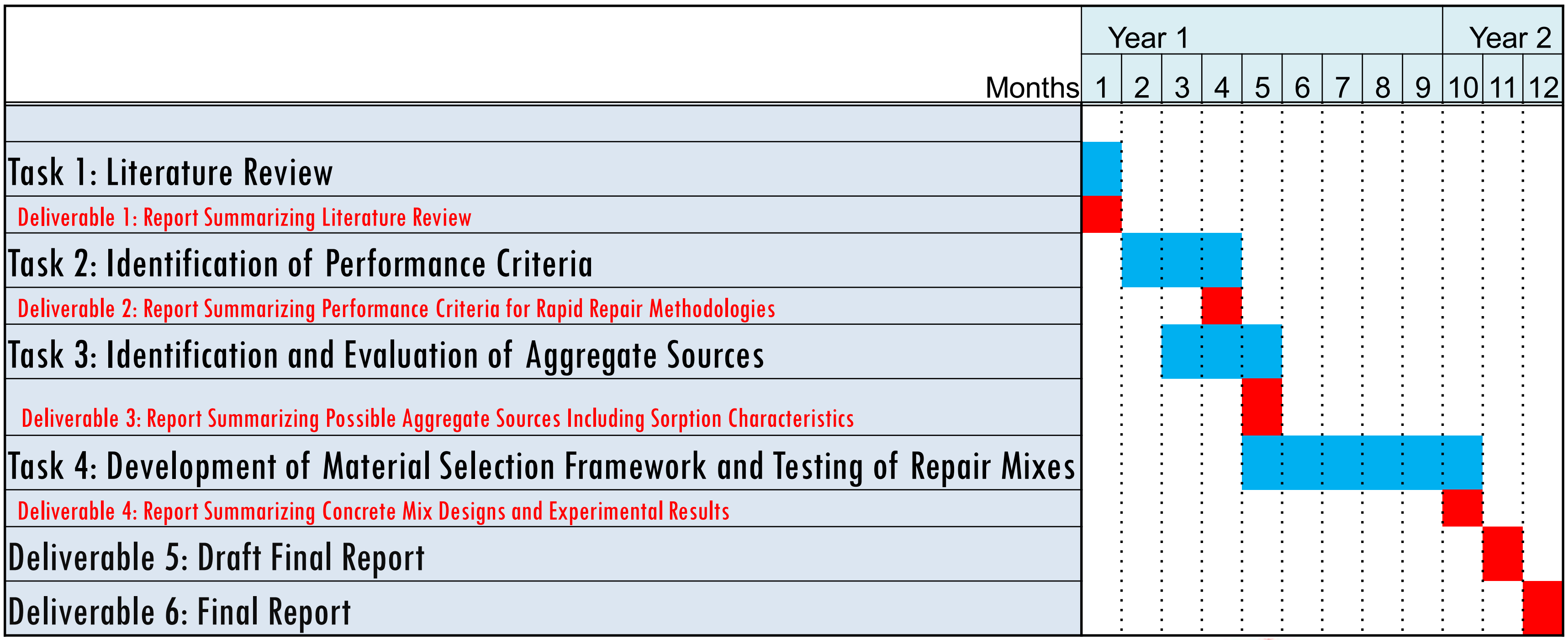
[6, 7]

- Shrinkage can be significantly reduced.
- Improves bond between repair material and existing concrete.



[8]

SCHEDULE


Year 1
Year 2
Months
1
2
3
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5
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12
Task 1: Literature Review
Deliverable 1: Report Summarizing Literature Review
Task 2: Identification of Performance Criteria
Deliverable 2: Report Summarizing Performance Criteria for Rapid Repair Methodologies
Task 3: Identification and Evaluation of Aggregate Sources
Deliverable 3: Report Summarizing Possible Aggregate Sources Including Sorption Characteristics
Task 4: Development of Material Selection Framework and Testing of Repair Mixes
Deliverable 4: Report Summarizing Concrete Mix Designs and Experimental Results
Deliverable 5: Draft Final Report
Deliverable 6: Final Report


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NEXT STEPS

1. **Development of materials selection framework**
    - Characterize in-situ PCC properties
2. **Development of material design procedure**
    - Use in-situ properties with previously identified performance objectives
3. **Experimental evaluation of repair materials**
    - Proprietary repair mixes
    - New repair mixes
4. **Extensive numerical study**
    - Characterize performance threshold resulting from differences in in-situ properties and repair properties

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THANK YOU

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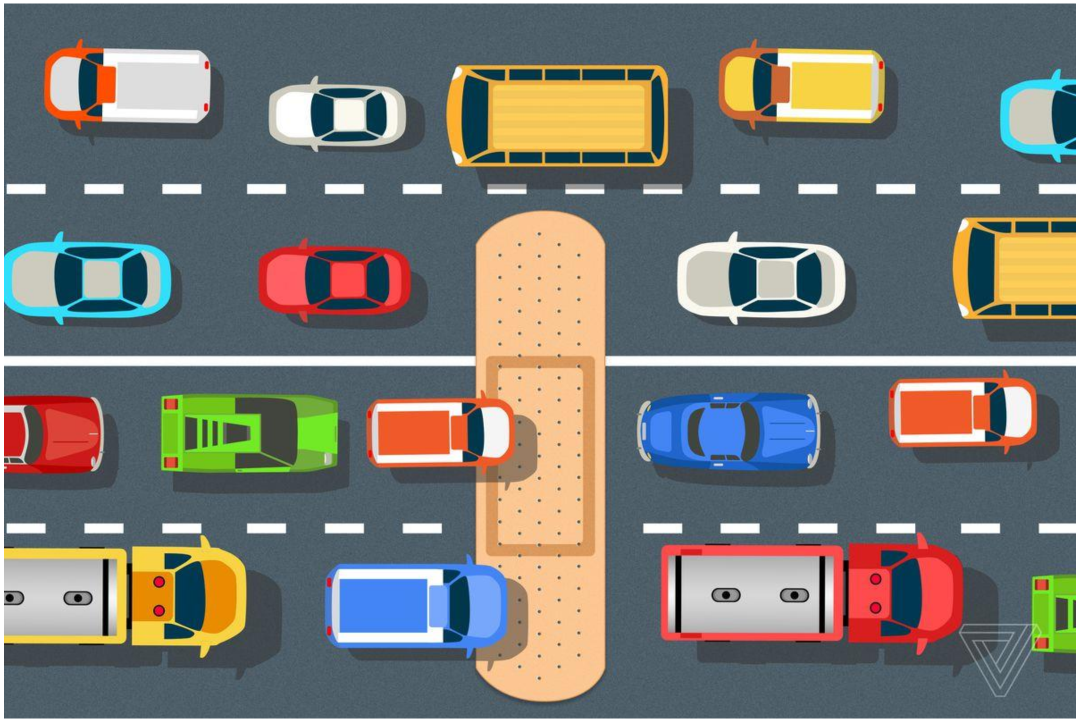

Image courtesy of https://www.theverge.com/2017/5/4/15544156/potholes-self-healing-materials-infrastructure-transportation

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