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16. Abstract

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RESULTS OF A SURVEY ON THE USE OF RAPID-SETTING REPAIR MATERIALS

by

David W. Fowler, George P. Beer,
Alvin H. Meyer, and Donald R. Paul

Research Report Number 311-1

EVALUATION OF FAST-SETTING REPAIR MATERIALS
FOR CONCRETE PAVEMENTS AND BRIDGES

conducted for

State Department of Highways and Public Transportation

in cooperation with the

U.S. Department of Transportation
Federal Highway Administration

by the

CENTER FOR TRANSPORTATION RESEARCH
BUREAU OF ENGINEERING RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

December 1982

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

PREFACE

The authors are indebted to many people for the information presented in this report. Gerald Peck, George Randolph , William Bannister, Donald O'Connor, Billy Neely, and Ralph Banks were very generous with the time they gave to review the questionnaire, suggest evaluation tests, provide information on materials, and review the draft of this report. The districts were very helpful in providing the information on current repair materials being used. And the authors are also appreciative of the information provided by highway officials in other states.

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Donald R. Paul

ABSTRACT

This report summarizes the current state-of-the-art for rapid-setting materials used to repair concrete in Texas and selected other states. Typical specifications used for rapid-setting materials by the Materials and Tests Division (D-9) are included, and a summary of D-9 test results is given. Districts were surveyed for a listing of rapid-setting materials they have used over the past 10 years. Twenty-seven materials were reported. The districts also provided an evaluation of the materials based on their use in different types of repairs, cost, use in different climatic conditions, durability, bond to concrete, and appearance. Nine states were asked to provide the same information requested of districts; eight responses were received. Districts and states were also asked to provide a ranking of material characteristics and properties.

SUMMARY

Current information on the use of rapid-setting repair materials for portland cement concrete in Texas and eight other states is provided.

Districts reported 27 different materials used over the past 10 years. Other states reported many of the same materials plus additional materials. Districts and states provided a rating of each material for different types of repairs, cost, use in different climatic conditions, and appearance. Typical specifications used by the Materials and Tests Division and a summary of these test results are included.

IMPLEMENTATION STATEMENT

The need for rapid-setting repair materials for concrete pavements and bridge decks is well known. This report summarizes the experience of the Materials and Tests Division, districts, and eight other states in the use of rapid-setting materials. The results should be immediately useful to district maintenance personnel in the selection of rapid-setting materials for different types of repairs.

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1.0 INTRODUCTION

1.1 Background

Rapid setting repair materials for portland cement pavements and bridge decks are in great demand. The higher traffic volumes and the advancing age of many pavements and bridges have created serious maintenance problems for state highway forces.

A wide range of repair materials is available (Reference 1). The materials have been categorized as: (1) portland cement; (2) other chemical-setting cements; (3) thermosetting materials; (4) thermoplastics; (5) calcium sulfate; (6) bituminous materials; (7) composites; and (8) additives used to alter mix characteristics (Reference 2).

Many different brands of materials are available, and considerable variation in properties is likely for each category from brand to brand. There is considerable variation in cost per unit weight, and the final in-place cost must take into account the ratio of binder to aggregate. Some materials are designed for temporary repairs and others are designed for permanent repairs. Some are to be used in limited ambient temperature ranges, and some cannot be used in wet weather. Some can be used at feathered edges, but most require a chipped or saw-cut boundary.

There is a pressing need for information on which to base selection of rapid setting materials for different applications. However, there is a serious lack of reliable information from manufacturers and users. Mechanical and durability properties, when available from the manufacturer, are often given without reference to the test method. There is no standard evaluation method for rapid setting repair materials. The fact that new products are continually being introduced and old ones are modified makes the evaluation and selection more difficult. There has been a paucity of performance information from users.

1.2 Scope of Study

Research Study 311, Evaluation of Fast-Setting Repair Materials, was begun in September 1981 with the following objectives: (1) identify

candidate materials; (2) evaluate selected materials in laboratory; (3) determine optimum placement methods; (4) test materials and methods in the field; and (5) disseminate results. This report summarizes the first part of this study, a survey of the Department of Highways and Public Transportation and transportation departments of selected states to determine their experience with rapid setting repair materials. No attempt is made in this report to recommend materials. Future research in this study will provide a basis for methods of evaluation of rapid setting materials.

2.0 USE OF RAPID SETTING REPAIR MATERIALS IN TEXAS

Many rapid setting repair materials have been used by the Department of Highways and Public Transportation. Most districts have used one or more of these materials to repair concrete. The Materials and Tests Division (D-9) has tested many of the materials used by the districts. Each district was asked to provide information on the use of rapid setting materials and D-9 was asked to provide specifications and test results on materials tested. Their response is summarized in this chapter.

2.1 Test Results by Materials and Tests Division

2.1.1 Typical Specifications

The Materials and Tests Division has developed specifications for magnesia phosphate rapid setting mortar and for rapid setting cement mortar. Typical specifications, contained in Appendix A, contain requirements for initial and final set time, compressive strength as a function of time, freeze-thaw durability and length change. These specifications have been modified over the period of time the tests, summarized in 2.1.2, were made.

2.1.2 Test Results

The results of tests performed by the Materials and Tests Division are summarized in Tables 2.1 and 2.2. Table 2.1 includes rapid setting cement mortars and Table 2.2 includes magnesia phosphates and magnesia poly phosphates.

Table 2.1 gives the initial set time and final set time for each material. The percentage of set times and strengths that met the typical specifications (in Appendix A) are given. Durability factors and length changes were not reported. Table 2.2 gives the initial set time, compressive strength, flexural strength, durability factor, and length change for each material. The number of tests and percentages of tests meeting specifications were not available.

TABLE 2.1. TEST RESULTS FOR RAPID SETTING MORTARS

Material	No. of Tests	Initial Set Time, Min.			Final Set Time, Min.			Percent of Tests Meeting Strength Specifications
		Mean	Standard Deviation	Percent of Tests Meeting Specifications	Mean	Standard Deviation	Percent of Tests Meeting Specifications	
Alcrete	72	14.7	5.6	92	25.4	7.1	97	97
All Crete	6	8	5.8	50	157.7	161	50	33
CCC Crete	1	7			10			0
Custom Crete Fast Fix	3	32.5		100	60.0		100	67
Duracal	51	20.5	5.5	96	26.8	6.1	98	100
Duracal Type AG	1	30			39			0
Duracement	31	10.3	2.2	100	18.8	4.2	100	90
Express Repair	13	10.1	5.1	85	24.9	17.5	85	77
Gilcrete	6	33.7	31.4	50	51.8	36.4	50	100
Set Instant	6	16.2	1.2	100	27.3	1.4	100	100
Speed Crete	3	12.0	1.0	100	19.3	1.2	100	0
Zip-Crete	6	9.7	4.3	67	18.2	8.1	67	67

TABLE 2.2. TEST RESULTS FOR MAGNESIUM PHOSPHATE RAPID SETTING MORTAR

Material	Initial Set Time, min.	Compressive Strength, psi		Flexural Strength, psi[a]	Freeze-Thaw Durability Factor[b]	Length Change, percent
		1 hr	3 days			
Set-45	18.5	2410	14,310	715	91.0	- 0.043
Set-45 (Hot Weather)	54.2	206	6,445		58.3	- 0.0124
FX-90	8.0	387	3,556	384	60.0	- 0.009
Neco-Crete	4.0	2612	4,500	559	98.0	0.053
Darex 240	4.5	2210		715	83.5	- 0.027
Bostik 275	18.5	---				- 0.058

[a]Tests were made at an age of 6 hours

[b]Based on ASTM C 666

[c]Same as Horn 240

2.2 Survey of Districts

Each State Department of Highways and Public Transportation District in Texas was sent a questionnaire to obtain their experience with rapid setting repair materials. The questionnaire, shown in Appendix B, asked for: (1) ranking of characteristics and mechanical properties of repair materials in order of performance; and (2) for each repair material used, the volume per year, relative performance for different types of repairs and weather conditions, appeal to workers, and the relative appearance. All but four districts responded to the survey. This section summarizes the materials and their subjective ratings by the districts. The rankings of characteristics and mechanical properties are given in Chapter 4.

2.2.1 Materials Used by District

Table 2.3 summarizes the use of rapid setting materials by district. All materials reported are shown at the top of the table. The amount, if any, reported by each district is shown by a symbol representing the range of the amount in pounds per year. The absence of a symbol indicates that no use of the material was reported by the district. The questionnaire asked for all materials used in the past 10 years to be reported. A total of 27 materials were reported.

2.2.2 Evaluation of Use and Performance of Materials

Districts were asked to rank the materials on a scale from 1 to 5 with 5 indicating highest or best for: (1) performance in different types of repairs; (2) cost, (3) mixing, placing and finishing; (4) durability; (5) appeal to workers; (6) bond to concrete; and (7) appearance. Table 2.4 summarizes the evaluation. The numerical rating is an average of the ratings provided by each district, and is not weighted for the amount of material. From Table 2.3 the quantities of each material can be determined. It should be noted that the evaluations for materials which have been used only in small quantities by one or two districts may not be very meaningful.

TABLE 2.3. MATERIALS USED IN DISTRICTS[a]

District[b]	Alcrete	Bostik 276	Cel-Set	Crylcon	Duracal	B-102 Epoxy	Fast Fix	Ferrolith G	Fondu Calcium Aluminate	Gilco Rapid Patch	Gilcrete	Hub Chem Emulsified Asphalt	Horn 240	Hydraset	Mite 150	Neco-Crete	Plexicrete	Polymer Concrete (UT)[c]	Quik-Crete	Set-45	Set-45 (Hot Weather)	Sikaset	Silikal	Speed Crete	Tapecrete	Tigercrete	Zip-Crete
1														B												
2			A				X							B					X	X				B			
3														B				C		A							A
4					C																						
5		A				A																					A
7																											
8						C												A						C			
9			B			B																B					
10			C																								
11									X								X	X							X		
12																											
13	C			A	C						C																
15																				X			A			X	
16						B																				A	
17																		A									
18				X						A			A					C		B	C		C				
19															B												
20																				B				B			
22																											
23								A										A									
25												A						A		A							
26																B		C		C			C				

[a]Legend: A: 10 to 1000 lbs; B: 1000 to 25,000 lbs; C: More than 25,000 lbs; X: Amount not reported

[b]Questionnaires not received from Districts 6, 14, 21, and 24

[c]UT Polymer Concrete is material developed by Center for Transportation Research

TABLE 2.4. SUMMARY OF MATERIAL EVALUATIONS[a]

Material	Type of Repair					Cost	Mixing, Placing and Finishing				Durability	Appeal to Workers	Bond to Concrete		Appearance
	Wide Cracks	Bridge Deck Spalls	Pier or Abutment Spalls	Pavement Spalls	Punchouts		Normal Temp	Low Temp	High Temp	Use in Wet Weather			Horizontal Surface	Vertical Surface	
Alcrete	NR[b]	2.0	3.0	3.0	3.0	3.0	4.3	2.0	3.3	1.5	2.7	3.7	3.0	3.3	4.0
Bostik 276	NR	5.0	NR	NR	NR	5.0	2.0	NR	NR	NR	5.0	4.0	5.0	NR	2.0
Cel-Set	3.0	NR	5.0	5.0	2.0	3.3	4.7	3.3	4.3	2.0	4.0	4.3	3.7	3.3	4.3
Crylcon	NR	3.0	4.0	5.0	4.5	5.0	4.5	2.5	3.0	1.0	4.5	2.5	5.0	5.0	5.0
Duracal	5.0	4.5	4.0	4.5	3.7	4.3	3.8	2.9	2.7	3.5	4.0	4.2	4.3	4.3	4.5
B-102 Epoxy	3.7	3.3	3.0	4.0	5.0	3.5	3.5	2.7	2.3	1.5	2.5	3.0	3.8	3.0	3.7
Fast Fix	2.0	2.0	NR	2.0	NR	3.0	4.0	3.0	2.0	1.0	3.0	3.0	3.0	NR	NR
Ferrolith-G	NR	3.0	NR	NR	NR	3.0	4.0	2.0	4.0	2.0	4.0	3.0	4.0	NR	3.0
Fondu C_3A	NR	NR	NR	4.0	NR	2.0	5.0	4.0	4.0	5.0	4.0	4.0	4.0	4.0	4.0
Gilco Rapid Patch	NR	NR	NR	NR	4.0	2.0	5.0	NR	NR	5.0	5.0	5.0	3.0	NR	4.0
Gilcrete	NR	NR	NR	2.0	3.0	3.3	3.7	1.7	2.0	1.0	2.3	2.7	2.0	2.7	3.0
Hubchem Emulsified Asphalt	NR	NR	NR	4.0	4.0	3.0	4.0	4.0	4.0	5.0	5.0	5.0	3.0	2.0	3.0
Horn 240	NR	NR	NR	NR	4.0	4.0	4.0	NR	NR	1.0	3.0	4.0	3.0	NR	NR
Hydraset	NR	3.0	NR	3.0	4.5	2.3	4.0	3.7	3.3	2.7	4.7	4.0	4.7	3.7	5.0
Mite 150	NR	NR	NR	5.0	5.0	3.0	2.0	2.0	2.0	NR	5.0	5.0	NR	NR	5.0
Neco-Crete	NR	3.1	3.1	3.1	3.3	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Plexicrete	4.0	NR	NR	4.0	NR	5.0	5.0	4.0	4.0	4.0	5.0	5.0	4.0	4.0	5.0
Polymer Concrete (UT)	3.2	3.7	3.3	3.3	4.3	3.4	4.6	2.5	3.8	1.0	4.3	2.7	3.9	3.8	4.1
Quik-Crete	2.0	2.0	NR	2.0	NR	3.0	4.0	3.0	2.0	1.0	3.0	NR	3.0	NR	NR
Set-45	4.5	4.0	3.0	4.2	3.9	3.7	4.2	4.3	2.8	4.0	4.5	4.8	4.3	3.3	4.3
Set-45 (Hot Weather)	4.0	4.0	NR	NR	4.0	2.0	5.0	5.0	4.0	5.0	4.0	5.0	3.0	NR	5.0
Sikaset	3.0	NR	NR	NR	4.0	5.0	5.0	3.0	2.0	1.0	4.0	5.0	2.0	1.0	4.0
Silikal	3.7	4.2	3.3	4.2	4.4	5.0	4.0	4.0	2.5	1.0	4.5	2.0	4.5	4.0	4.5
Speed Crete	1.0	2.0	2.0	1.5	2.5	2.0	5.0	5.0	5.0	1.7	1.7	4.3	2.0	2.0	3.7
Tapecrete	NR	NR	NR	5.0	NR	3.0	5.0	4.0	4.0	5.0	5.0	5.0	5.0	5.0	5.0
Tigercrete	5.0	3.0	1.0	1.0	NR	4.5	5.0	4.0	4.0	5.0	3.0	4.0	1.0	5.0	4.0
Zip-Crete	NR	2.0	4.0	NR	NR	2.5	4.0	1.0	4.0	NR	3.5	5.0	4.5	3.0	5.0

[a]Evaluations are based on a subjective scale of 1 to 5 with 5 representing the best performance or highest cost

[b]NR indicates no response

3.0 SUMMARY OF OTHER STATES' EXPERIENCE WITH RAPID SETTING MATERIALS

Questionnaires similar to those sent to districts were sent to nine states: California, Florida, Georgia, Illinois, Iowa, Kansas, New York, Oregon and Pennsylvania. Replies were received from all states except Illinois. Names of the persons who provided the information are shown in Appendix C.

Most states did not provide an evaluation of materials. Some provided specifications, lists of approved materials, or general comments. A summary of the response of each of the states is given.

3.1 California

California had one of its eleven highway districts fill out the material evaluation questionnaire. They reported using three materials for bridge deck spalls: Set-45, Horn 240 and Fondu C_3A. Table 3.1 is a summary of the material evaluations.

3.2 Florida

Florida is currently in the process of evaluating five rapid setting materials, although final acceptance or rejection of these products has not yet been made.

3.3 Georgia

Georgia has used seven rapid setting repair materials. They have performed limited testing on these materials, and Table 3.2 summarizes their evaluation.

3.4 Iowa

Iowa has no special provisions for repairs of pavements and bridges except to use concretes with high cement contents and to use calcium chloride as an accelerator.

TABLE 3.1. EVALUATION OF RAPID SETTING MATERIALS BY THE STATE OF CALIFORNIA

Material	Usage lbs/yr	Bridge Deck Spalls	Cost	Mixing, Placing and Finishing				Durability	Appeal to Workers	Bond to Concrete		Appearance
				Normal Temp	Low Temp	High Temp	Use in Wet Weather			Horizontal Surface	Vertical Surface	
Fondu C_3A	15,000	3.0	3.0	4.0	5.0	3.0	NR	3.0	3.0	3.0	NR	2.0
Horn 240[a]	10,000	5.0	4.0	4.0	5.0	2.0	NR	4.0	NR	5.0	NR	4.0
Set-45	25,000	4.0	3.0	4.0	5.0	3.0	NR	4.0	4.0	4.0	NR	5.0

[a]Same as Darex 240

TABLE 3.2. EVALUATION OF RAPID SETTING MATERIALS BY THE STATE OF GEORGIA

Material	Usage lb/yr.	Wide Cracks	Bridge Deck Spalls	Pier or Abutment Spalls	Pavement Spalls	Punchouts	Cost Joint Repairs	Mixing, Placing and Finishing			Use in Wet Weather	Durability	Appeal to Workers	Bond to Surface		Appearance
								Normal Temp.	Low Temp.	High Temp.				Horizontal Surface	Vertical Surface	
Duracal	10,000	NR	3.0	NR	2.0	NR	3.0	3.0	3.0	3.0	3.0	2.0	4.0	2.0	1.0	3.0
Epoxy	NR	2.0	3.0	NR	2.0	3.0	5.0	2.0	2.0	1.0	2.0	3.0	1.0	4.0	4.0	NR
Horn 240	1,000	NR	NR	NR	4.0	NR	4.0	3.0	4.0	1.0	1.0	4.0	3.0	3.0	3.0	3.0
Polymer Concrete	10,000	NR	3.0	NR	4.0	NR	5.0	3.0	3.0	2.0	1.0	5.0	2.0	4.0	4.0	4.0
Roadpatch	1,500	NR	NR	NR	4.0	NR	3.0	3.0	2.0	1.0	3.0	3.0	3.0	3.0	3.0	3.0
Set-45	100,000	NR	NR	NR	3.0	NR	4.0	3.0	5.0	1.0	1.0	2.0	2.0	2.0	2.0	3.0
Speed Crete	NR	NR	NR	NR	1.0	NR	2.0	3.0	2.0	2.0	3.0	1.0	3.0	1.0	1.0	3.0

3.5 Kansas

Kansas has no standard practice for rapid repairs of pavements or bridge decks. They have tested many materials but none has proved entirely satisfactory.

3.6 New York

New York currently uses epoxies for repair of pavements and bridge decks. The New York State Department of Transportation specifications that cover the details of repairs are Section 502-3.15 and Section 555-3.11. The specification that covers the epoxies is Sections 721-01 to 721-05. New York also has made some repairs with polymer concrete, which is covered by special specification Item 18502.0704. The Highway Maintenance Division also has a list of approved products for repairs of pavements and structures. The following is a summary of these materials:

Item 1: Cement Base (2500 psi-1 hr) warm weather
- Duracal
- Hy Speed 500
- Five Star Highway Patch

Item II: Cement Base (2500 psi-1 hr) cold weather
- Duracal

Item III: Cement Base (2500 psi-24 hr) warm weather
- Pike Patch No. 1
- Octocrete
- Pre-Krete
- Five Star Highway Patch
- Speed Crete-Red Line
- Tigercrete
- Thoro System Road Patch

Item IV: Cement Base (2500 psi-24 hr) cold weather
- Pike Patch No. 1

Item V: Catalyzed Resin Base (2500 psi-24 hr) warm weather
- Redgrout H
- Colma Dur
- Preco Gold Label

Item VI: Catalyzed Resin Base (2500 psi-24 hr) cold weather
- Redgrout H

Item VII: Phosphate Base (1000 psi-1 hr) warm weather
- Set-45

Item VIII: Phosphate Base (1000 psi-1 hr) cold weather
None

Item IX: Accelerator Additives Warm Weather
Sikaset C (not for use in deck concrete)

3.7 Oregon

Oregon does not have a standard practice for rapid repair of pavements and bridge decks. They report the use of five separate repair materials of which a summary is given in Table 3.3.

3.8 Pennsylvania

Pennsylvania currently uses a broad range of materials for repair of bridge decks and pavements. They use epoxy mortars, polymer concretes, polymer modified mortars, and magnesia phosphate. These products are covered in Pennsylvania Department of Transportation Item 490-0001 and Items 2590-0001 to 2590-0003 for Indiana and Westmoreland counties. For the rest of the State of Pennsylvania the specification for rapid setting repair materials for concrete pavement spalls is covered in Items 590-0003 to 590-0005. Joint rehabilitation is covered in Item 590-0010, Item 590-0011, and Item 590-0050. The Pennsylvania Department of Transportation also has a list of approved commercial rapid setting materials published in Bulletin 15. The following is a summary of these materials.

B/C Quick Patch No. 2
B/C Non Shrink Mortar (Metallic)
Fast Patch
FX-90
Tigercrete
Hi Speed 500
Gill 33 B&P (Accelerating admixture for pavement only)
Hallemite (surface repairs only)
Horn 240
Fondu
Embeco 411-A Mortar
Metallic Aggregate
Masterpath 200-A (Non-metallic)
Quickdeck
Polyester Resin
Octocrete
Quik Rok (surface repairs only)
Radgrout H-3

TABLE 3.3. EVALUATION OF RAPID SETTING MATERIALS BY THE STATE OF OREGON

Material	Type of Repairs						Mixing, Placing and Finishing				Durability	Appeal to Workers	Bond to Concrete		Appearance	Cost
	Wide Cracks	Bridge Deck Spalls	Pier or Abutment Spalls	Pavement Spalls	Punchouts	Joint Repairs	Normal Temp	Low Temp	High Temp	Use in Wet Weather			Horizontal Surface	Vertical Surface		
Concreassive 2020 Polymer	NR	5.0	NR	NR	NR	5.0	5.0	3.0	2.0	1.0	5.0	5.0	5.0	5.0	5.0	5.0
Crylcon	NR	5.0	NR	NR	NR	5.0	5.0	3.0	2.0	1.0	5.0	5.0	5.0	5.0	5.0	5.0
Niklepoxy Product #4	NR	4.0	NR	1.0	NR	NR	4.0	2.0	2.0	1.0	4.0	3.0	4.0	4.0	3.0	5.0
Type III Portland Cement Concrete (w/c = 0.30)	NR	4.0	NR	3.0	NR	NR	3.0	3.0	3.0	2.0	5.0	3.0	4.0	2.0	5.0	1.0
Set-45	NR	2.0	NR	2.0	NR	NR	5.0	2.0	2.0	3.0	2.0	3.0	3.0	2.0	3.0	3.0

Polymeric Resin
Mirament
Set 45
Set Sustant
Sika top III Self Leveling Mortar (use only 4/5 component "A")
Sika top-122 Repair Mortar
Sika top-121
Thorite
Speed Crete (surface repairs only)
Silikal
Air-entraining Duracal (surface repairs only)
Bostik 276
Five Star Highway Patch

4.0 DESIRED CHARACTERISTICS AND MECHANICAL PROPERTIES

Districts and other states were asked to rank order characteristics and mechanical properties of rapid-setting repair materials. Eight characteristics and eight properties were listed, and other items could be added.

4.1 Response of Districts

Table 4.1 summarizes the ranking of characteristics and properties by districts. Setting time, performance (durability), and working time were rated the top three characteristics. Bond strength to concrete, flexural strength, and shrinkage were rated the top three mechanical properties.

4.2 Response of Other States

Other states ranked performance (durability), ease of mixing and placing, and cost as the top three characteristics. The top three mechanical properties were bond strength to concrete, compressive strength, and shrinkage. The first four mechanical properties were the same for districts as for the other states although the order was slightly different.

TABLE 4.1. SDHPT DISTRICTS' RANKING OF CHARACTERISTICS AND PROPERTIES

CHARACTERISTICS	PROPERTIES
1. Setting Time	1. Bond Strength to Concrete
2. Performance (Durability)	2. Flexural Strength
3. Working Time	3. Shrinkage
4. Ease of Mixing, Placing and Finishing	4. Compressive Strength
5. Use Over Wide Temperature Range	5. Ductility
6. Use in Wet Weather	6. Wear Resistance
7. Cost	7. Coefficient of Thermal Expansion
8. Matches Color of Adjacent Concrete	8. Stiffness (Modulus of Elasticity)
9. Availability	

TABLE 4.2. OTHER STATES' RANKING OF CHARACTERISTICS AND PROPERTIES

CHARACTERISTICS		PROPERTIES
1. Performance (Durability)		1. Bond Strength to Concrete
2. Ease of Mixing, Placing and Finishing		2. Compressive Strength
3. Cost		3. Shrinkage
4. Setting Time	Tie	4. Flexural Strength
5. Working Time	Tie	4. Coefficient of Thermal Expansion
6. Use Over Wide Temperature Range		6. Wear Resistance
7. Use in Wet Weather	Tie	7. Ductility
7. Matches Color of Adjacent Concrete	Tie	8. Stiffness (Modulus of Elasticity)

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

There is an urgent need for dependable rapid setting materials for the repair of concrete pavements and bridge decks. Many types and brands are currently available, but the selection of an appropriate material is complicated by the lack of reliable data from manufacturers and users. There is no standard evaluation procedure for these materials.

This report summarizes the results of tests performed by the Texas Department of Highways and Public Transportation Materials and Test Division on 19 rapid setting materials. Specifications for evaluating magnesia phosphate mortars and rapid setting cement mortars have been developed.

All of the Department of Highways and Public Transportation districts in Texas were surveyed to determine their experience and evaluation of rapid setting repair materials. Quantities of each repair material used per year were obtained. Evaluations of each material were made on the basis of types of repair, cost, climatic conditions, durability, bond to concrete, and appearance. Considerable variation was noted for the 27 materials reported.

Other selected states were surveyed to determine their current experience. Six of the eight states responding listed specific materials that were currently being used. Three states provided an evaluation similar to that provided by the Department of Highways and Public Transportation districts.

The Department of Highways and Public Transportation districts provided a priority order for characteristics and mechanical properties. Setting time, performance (durability), and working time were ranked as the top three characteristics, while bond strength to concrete, flexural strength and shrinkage were rated the top three mechanical properties.

The survey of the other states indicated that bond strength to concrete, compressive strength and shrinkage as the most important mechanical properties. Bond strength to concrete, compressive strength and shrinkage were given as the top mechanical properties.

5.2 Recommendations

It is recommended that further research be conducted to: (1) establish appropriate evaluation procedures for rapid setting repair materials; (2) evaluate the most common materials; and (3) determine the field test performance of different types of repairs.

APPENDIX A

SPECIFICATIONS FOR RAPID SETTING MORTARS

TEXAS STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

Performance Specification for Magnesium Phosphate Rapid Setting Cement Mortar[a]

1. Description

This specification covers a single-package magnesium phosphate type rapid setting patching material which requires only the addition of mixing water to form a mortar suitable for repairing spalled or deteriorated areas on concrete pavement or bridge decks. The mortar must be of such a nature that it can be mixed and placed in a manner similar to that used for conventional portland cement mortar.

2. Screen Analysis

The dry patching material shall comply with the following sieve requirements.

US Standard Screen No.	Percent Retained
4	0
8	2 (Maximum)

3. Packaging

The material shall be packaged in 50-pound multi-wall moisture resistant paper bags.

4. Physical Requirements

For all of the following tests the amount of mixing water used with the dry mix shall be sufficient to obtain a flow of 80 to 95, determined as specified in ASTM Designation: C185. Mixing of the mortar for all tests other than the freeze-thaw requirement shall be done in accordance in ASTM C-305 except that the mixing sequence shall be as follows:

Place water in bowl. Add dry material over 30 second period while mixing at slow speed. Mix 30 additional seconds at slow speed, then change to medium speed and mix one minute.

A. Set Times (ASTM C-266)

Initial - 15 minutes minimum
Final - 30 minutes minimum

[a]This specification is typical of specifications used over the past 10 years, and does not necessarily represent the latest specification.

B. Compressive Strength (ASTM C-109 Modified)

Cure Time	Strength, PSI
1 hour	2000
24 hours	6400
3 days	7000

C. Expansion in Water (ASTM C-157 Modified)

Percent Expansion, Maximum - 0.10

Curing time in water for the specimens shall be six days. They then shall be placed in water maintained at 120 ± 3 degrees F for 21 days after which percent expansion shall be determined.

D. Freeze-Thaw Resistance (ASTM C-666, Method B)

The mortar mix shall be prepared using a 20 quart epicyclic type mixer (Vucan-Hart Model BH-20 or equivalent). The maximum batch size shall be based on 25 pounds of dry material. The proper amount of mixing water, as determined by ASTM C-185, shall be added to the mixer bowl. Start mixer at slow speed. Add dry material and mix at medium speed for 30 seconds. Make test specimens immediately.

The relative modulus of elasticity of the mortar shall be 60 percent minimum after 100 cycles of rapid freezing in air and thawing in water.

5. Sampling and Testing

The material furnished under this specification is subject to sampling and testing to assure conformance with requirements outlined herein. The material furnished will be subject to rejection if requirements of this specification are not met.

TEXAS STATE DEPARTMENT OF HIGHWAYS

AND PUBLIC TRANSPORTATION

Performance Specification for Rapid Setting Cement Mortar[a]

1. Description

This specification covers a single package rapid setting patching material which requires only the addition of mixing water to form a mortar suitable for repairing spalled or deteriorated areas on concrete pavement or bridge decks. The mortar must be of such a nature that it can be mixed and placed in a manner similar to that used for conventional portland cement mortar. Aggregate included in the rapid setting material must all pass the No. 8 sieve (U.S. Standard Screen).

2. Packaging

The material shall be packaged in multi-wall moisture resistant paper bags.

3. Physical Requirements

For all of the following tests the amount of mixing water used with the dry mix shall be sufficient to obtain a flow of 80 to 95, determined as specified in ASTM Designation: C185.

a. Set Times (ASTM Designation: C 266)
   Initial - 15 Minutes Minimum
   Final - 40 Minutes Maximum

b. Compressive Strength (ASTM Designation: C 109 Modified)

Cure Time	Minimum Strength, PSI
2 Hours	2000
24 Hours	3000
14 Days	6000

[a]This specification is typical of specifications used over the past 10 years, and does not necessarily represent the latest specification.

c. Expansion in Water (ASTM Designation: C 157 Modified)
Percent Expansion, Maximum - 0.25
Curing time in water for the specimens shall be 6 days. They then shall be placed in water maintained at 120 ± 3 degrees F for 21 days after which percent expansion shall be determined.

d. Freeze-Thaw Resistance (ASTM Designation: C 666, Method B)
The relative modulus of elasticity of the mortar shall be 60 percent minimum after 100 cycles of rapid freezing in air and thawing in water.

4. Sampling and Testing

The material furnished under this specification is subject to sampling and testing to assure conformance with requirements outlined herein. The material furnished will be subject to rejection if requirements of this specification are not met.

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APPENDIX B

QUESTIONNAIRE TO DISTRICTS AND STATES

RESEARCH STUDY 311

QUESTIONNAIRE ON USE OF RAPID SETTING
MATERIALS FOR REPAIR OF CONCRETE

1. Please give us your opinion on the most important characteristics of rapid setting materials in order of importance with "1" indicating most important. List other characteristics if appropriate.

   _____ Cost

   _____ Working time

   _____ Setting time

   _____ Ease of mixing, placing and finishing

   _____ Use over wide temperature range

   _____ Use in wet weather

   _____ Performance (durability)

   _____ Matches color of adjacent concrete

   _____ _____

   _____ _____

2. In your opinion, what are the most important mechanical properties of rapid setting materials in order of importance.

   _____ Compressive strength

   _____ Flexural strength

   _____ Bond strength to concrete

   _____ Shrinkage

   _____ Wear resistance

   _____ Ductility (ability to deflect without cracking)

   _____ Coefficient of thermal expansion

   _____ Stiffness (modulus of elasticity)

   _____ _____

   _____ _____

3. Please complete an evaluation sheet for <u>each</u> rapid setting material used for repair in your district within the last 10 years, including magnesium phosphates, epoxy concretes, and polymer concretes. You may refer to materials by brand names.

Name of person completing questionnaire Phone number_____

_____ District _____

RETURN THIS PAGE AND EVALUATION SHEETS IN ENCLOSED ENVELOPE OR TO:

David W. Fowler
Center for Transportation Research
ECJ 5.200
The University of Texas at Austin
Austin, TX 78712

MATERIAL EVALUATION SHEET
(Please use separate sheet for each material)

1. Name of material _____

2. Years used in your district: from _____ to _____.

3. Approximate average amount of material used per year during years used:

_____ lbs

4. Uses (Check appropriate blanks)

		Depth		Area		Circle Overall Performance (Poor 1 2 3 4 5 Good)
		Shallow	Deep	Small	Large	
a.	Wide cracks _____					1 2 3 4 5
b.	Bridge Deck Spalls	_____	_____	_____	_____	1 2 3 4 5
c.	Pier or Abutment Spalls	_____	_____	_____	_____	1 2 3 4 5
d.	Pavement Spalls	_____	_____	_____	_____	1 2 3 4 5
e.	Punchouts	_____	_____	_____	_____	1 2 3 4 5
f.	_____	_____	_____	_____	_____	1 2 3 4 5
g.	_____	_____	_____	_____	_____	1 2 3 4 5

5. Evaluation of Material (Circle number)

a. Cost (Low 1 2 3 4 5 High)

b. Mixing, Placing and Finishing

	Difficult				Easy
(1) Normal temp	1	2	3	4	5
(2) Low temp	1	2	3	4	5
(3) High temp	1	2	3	4	5

c. Use in wet weather (Poor 1 2 3 4 5 Good)

d. Durability (Poor 1 2 3 4 5 Good)

e. Appeal to Workers (Dislike 1 2 3 4 5 Like)

f. Bond to Concrete (Poor Good)

(1) horizontal surface	1 2 3 4 5
(2) vertical joints	1 2 3 4 5

g. Appearance 1 2 3 4 5

6. Have you performed any laboratory tests on this material: No _____ Yes _____
(If yes, would you please provide us a copy of test results)

OTHER COMMENTS: _____

_____

APPENDIX C

NAMES OF PERSONS PROVIDING INFORMATION FROM OTHER STATES

CALIFORNIA:
Mr. Bill Neal
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5900 Folsom Boulevard
P.O. Box 19128
Sacramento, California 95819

FLORIDA:
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Florida Department of Transportation
Hayden Burns Building
605 Suwannee Street
Tallahassee, Florida 32301
(904) 488-9605

GEORGIA:
Mr. Jim Gaskill
Georgia Department of Transportation
Office of Materials and Research
15 Kennedy Drive
Forest Park, Georgia 30050
(404) 363-7605

IOWA:
Mr. Ralph A. Britson
Iowa Department of Transportation
Highway Division
800 Lincoln Way
Ames, Iowa 50010
(515) 239-1226

KANSAS:
Mr. J.M. Hemphill, P.E.
Bureau of Materials and Research
Kansas Department of Transportation
State Office Building
Topeka, Kansas 66612

NEW YORK:
Polymer Concrete

Mr. Ron Mediatre
New York State Department of Transportation
Region 10
(516) 979-5055

Rapid-Setting Concretes

Mr. Paul St. John
New York State Department of Transportation
Materials Bureau
1220 Washington Avenue
State Campus
Albany, New York 12232
(518) 457-5956

	Other Information
NEW YORK: (continued)	Mr. F.P. Witte New York State Department of Transportation Materials Bureau 1220 Washington Avenue State Campus Albany, New York 12232
OREGON:	Mr. William J. Quinn Research Coordinator Oregon Department of Transportation Highway Division, Materials Section Salem, Oregon 97310
PENNSYLVANIA:	Mr. Richard Howe, P.E. Pennsylvania Department of Transportation P.O. Box 2926 Harrisburg, Pennsylvania 17120 (717) 787-2489

REFERENCES

1. "Special Product Evaluation List (SPEL)", U.S. Department of Commerce, NTIS, PB-281890, Dec. 77, pp. 115-160.

2. "Rapid-Setting Materials for Patching of Concrete", Report No. 45, Transportation Research Board, National Research Council, Washington, D.C., 1977, 13 pp.