

Project 0-311, Evaluation of Fast-Setting Repair Materials for Concrete Pavements and Bridges [Presentation Slides]

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"Evaluation of Fast-Setting Repair Materials for Concrete Pavements and Bridges"

Sponsoring Agency: Texas Department of Transportation

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Presentation Slides



Slide 1. Title Slide

MATERIALS

RAPID-SETTING MATERIALS

ACCELERATED PORTLAND CEMENT CONCRETE

Slide 2. Materials

CANDIDATE MATERIALS

SOURCES

AUSTIN DIVISION

SURVEY OF DISTRICTS

SURVEY OF OTHER STATES

Slide 3. Candidate Materials

QUESTIONNAIRE ON USE OF RAPID SETTING MATERIALS FOR REPAIR OF CONCRETE

Slide 4. 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.

Use over wide temperature range	Cost
Use in wet weather	Working Time
Performance (durability)	Setting Time
Ease of mixing, placing and finishing	
Matches color of adjacent concrete	

Slide 5. Survey questions [slide 1 of 8]

2. Number your most important mechanical properties of rapid setting materials in order of importance.

Compressive strength

Flexural strength

Bond strength to concrete

Shrinkage

Wear resistance

Ductility

Thermal expansion

Stiffness

Slide 6. Survey questions [slide 2 of 8]

3. Please complete an evaluation sheet for each 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.

Slide 7. Survey questions [slide 3 of 8]

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

1. Name of material _____
2. Years used in your district: _____
3. Approximate average amount of material used per year during years used: _____ lbs

Slide 8. Survey questions [slide 4 of 8]

4. Users were asked to evaluate overall performance of materials in cracks, punchouts, and different sized spalls on a scale of 1 to 5.

Slide 9. Survey questions [slide 5 of 8]

	Low			High	
a. Cost	1	2	3	4	5
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
	Poor				Good
c. Use in wet weather	1	2	3	4	5

Slide 10. Survey questions [slide 6 of 8]

		Poor			Good
d.	Durability	1	2	3	4 5
			Dislike		Like
e.	Appeal to workers		1	2	3 4 5
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

Slide 11. Survey questions [slide 7 of 8]

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: _____

Slide 12. Survey questions [slide 8 of 8]

CTR 3-9-82-311-1

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

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

RESEARCH REPORT 311-1

PROJECT 3-9-82-311

CENTER FOR TRANSPORTATION RESEARCH
BUREAU OF ENGINEERING RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN
DECEMBER 1982

Slide 13. Research Report 311-1 cover page

CHARACTERISTICS

1. SETTING TIME
2. PERFORMANCE (DURABILITY)
3. WORKING TIME
4. EASE OF MIXING, PLACING, AND FINISHING
5. USE OVER WIDE TEMPERATURE RANGE
6. USE IN WET WEATHER
7. COST
8. MATCHES COLOR OF ADJACENT CONCRETE

Slide 14. Characteristics

PROPERTIES

1. BOND STRENGTH TO CONCRETE
2. FLEXURAL STRENGTH
3. SHRINKAGE
4. COMPRESSIVE STRENGTH
5. DUCTILITY
6. WEAR RESISTANCE
7. COEFFICIENT OF THERMAL EXPANSION
8. STIFFNESS (MODULUS OF ELASTICITY)

Slide 15. Properties

RAPID-SETTING MATERIALS

GYPSUM-MODIFIED PORTLAND
CEMENT CONCRETE: DURACAL

MAGNESIA PHOSPHATE: SET-45
(COLD AND HOT WEATHER)

MAGNESIA POLYPHOSPHATE:
NECO-CRETE AND HORN 240

MODIFIED PORTLAND CEMENT CONCRETE:
GILCO HIGHWAY PATCH

Slide 16. Rapid-Setting Materials

MIX PROPORTIONS

Slide 17. Mix Proportions

DURACAL

MORTAR:

50 LB BAG WITH 50 LB FA
AND 1.5 GAL WATER

CONCRETE:

50 LB BAG WITH 50 LB FA,
50 LB CA, AND 1.75 GAL WATER

Slide 18. Duracal

SET-45

(COLD AND HOT WEATHER)

MORTAR:

50 LB PACKAGE AND 0.5 GAL WATER

CONCRETE:

50 LB. PACKAGE, 30 LB CA, AND
0.5 GAL WATER

Slide 19. Set-45 (Cold and Hot Weather)

GILCO HIGHWAY PATCH

MORTAR:

55 LB PACKAGE AND 1.0 GAL WATER

CONCRETE:

55 LB PACKAGE, 30 LB CA AND
1.0 GAL WATER

Slide 20. Gilco Highway Patch

NECO-CRETE

(2 COMPONENT)

MORTAR:

50 LB PACKAGE AND 1.0 GAL LIQUID

CONCRETE:

50 LB PACKAGE, 18.0 LB CA,
AND 1.0 GAL LIQUID

Slide 21. Neco-Crete (2 Component)

**HORN 240
(2 COMPONENT)**

MORTAR:

50 LB PACKAGE AND 1.0 GAL LIQUID

CONCRETE:

**50 LB. PACKAGE, 13.5 LB. CA
AND 1.0 GAL. LIQUID**

Slide 22. Horn 240 (2 Component)

CLASS "K" CONCRETE

7 SKS TYPE III CEMENT

5 1/2 GALS/SK CEMENT (MAX.)

SLUMP: 1 - 3 IN. AIR CONTENT: 3 - 6 %

ADMIXTURES

Slide 23. Class "K" Concrete

ACCELERATORS

CALCIUM CHLORIDE: HYDRASET

CALCIUM NITRATE: ACCELEGUARD 80

SODIUM THIOCYANATE: LA-40

CALCIUM NITRITE: DAREX CORROSION
INHIBITOR

CALCIUM NITRITE AND CALCIUM NITRATE:
DARASET

Slide 24. Accelerators

HYDRASET

CALCIUM CHLORIDE

TYPE C

DOSAGE (MFGR): 1 PT - 2 QTS/BAG CEMENT

RECOMMENDED: 2 QTS (2% CaCl)

Slide 25. Hydraset

ACCELEGUARD 80

CALCIUM NITRATE

TYPE E

DOSAGE (MFGR): 16 - 32 FL. OZ/100 LBS CEMENT

RECOMMENDED: 32 FL. OZ

Slide 26. Acceleguard 80

LA-40

SODIUM THIOCYANATE

TYPE C

DOSAGE (MFGR): 2 - 6 FL. OZ/100 LBS CEMENT

RECOMMENDED: 6 FL. OZ

Slide 27. LA-40

DAREX CORROSION INHIBITOR

CALCIUM NITRITE

TYPE C

DOSAGE (MFGR): 85 – 170 FL. OZ/100 LBS CEMENT

RECOMMENDED: 100 FL. OZ

Slide 28. Darex Corrosion Inhibitor

DARASET

CALCIUM NITRITE AND CALCIUM NITRATE

TYPE C

DOSAGE (MFGR): 100 FL. OZ/100 LBS CEMENT

RECOMMENDED: 100 FL. OZ

Slide 29. Daraset

OTHER ADMIXTURES

AIR ENTRAINMENT

HIGH RANGE WATER REDUCER (HRWR)

Slide 30. Other Admixtures

FIBERS

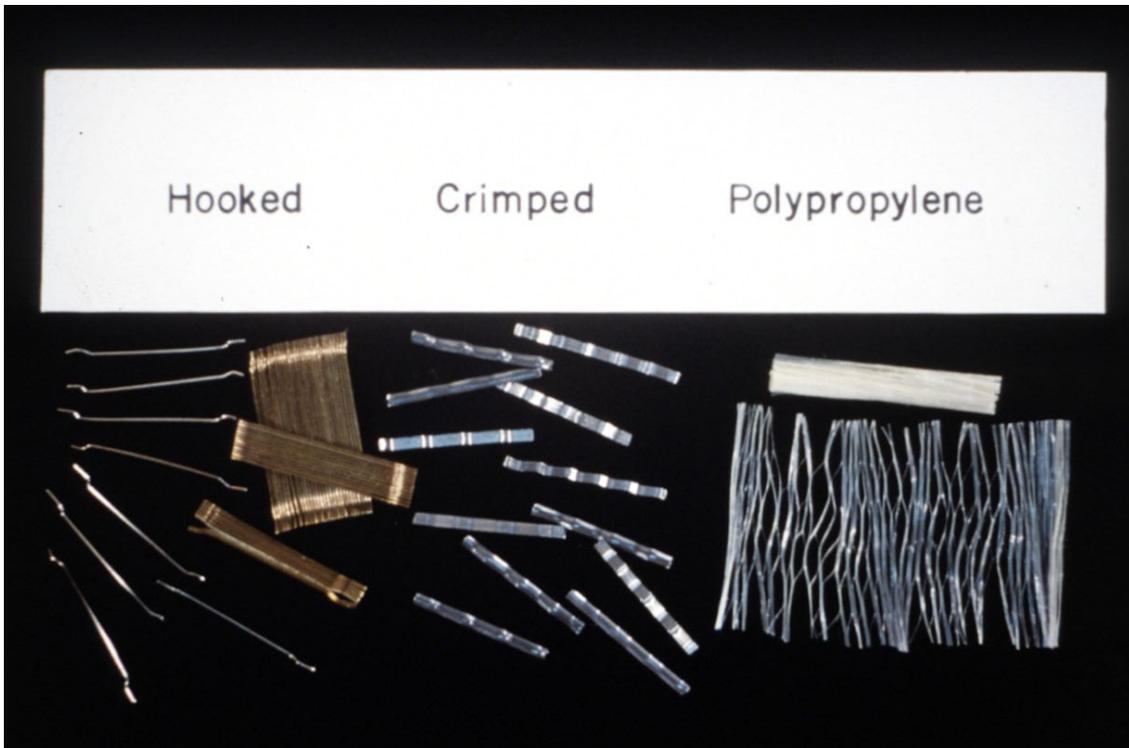
STEEL

HOOKED

CRIMPED

POLYPROPYLENE LATTICE BUNDLES

Slide 31. Fibers



Slide 32. Hooked, crimped, and polypropylene fibers



Slide 33. Material Properties

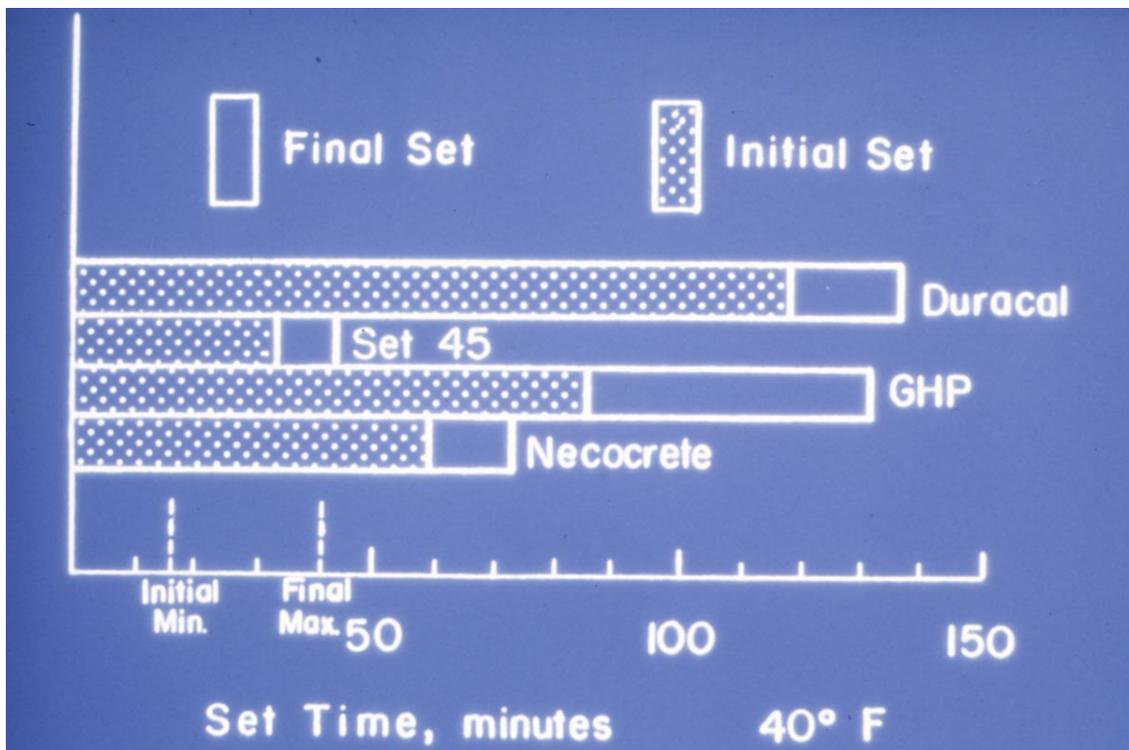
**TSDHPT SPECIFICATIONS FOR
RAPID SETTING CEMENT MORTAR**

- 1. INITIAL SET TIME: 15 MIN. MINIMUM
FINAL SET TIME: 40 MIN. MAXIMUM**
- 2. MINIMUM COMPRESSIVE STRENGTH
2000 PSI AT 2 HRS.
3000 PSI AT 24 HRS.**
- 3. FREEZE-THAW RESISTANCE
RELATIVE DYNAMIC MODULUS 60%
MINIMUM AFTER 100 CYCLES**
- 4. MINIMUM FLEXURAL STRENGTH
100 PSI AT 1 HR.
300 PSI AT 3 HRS.**

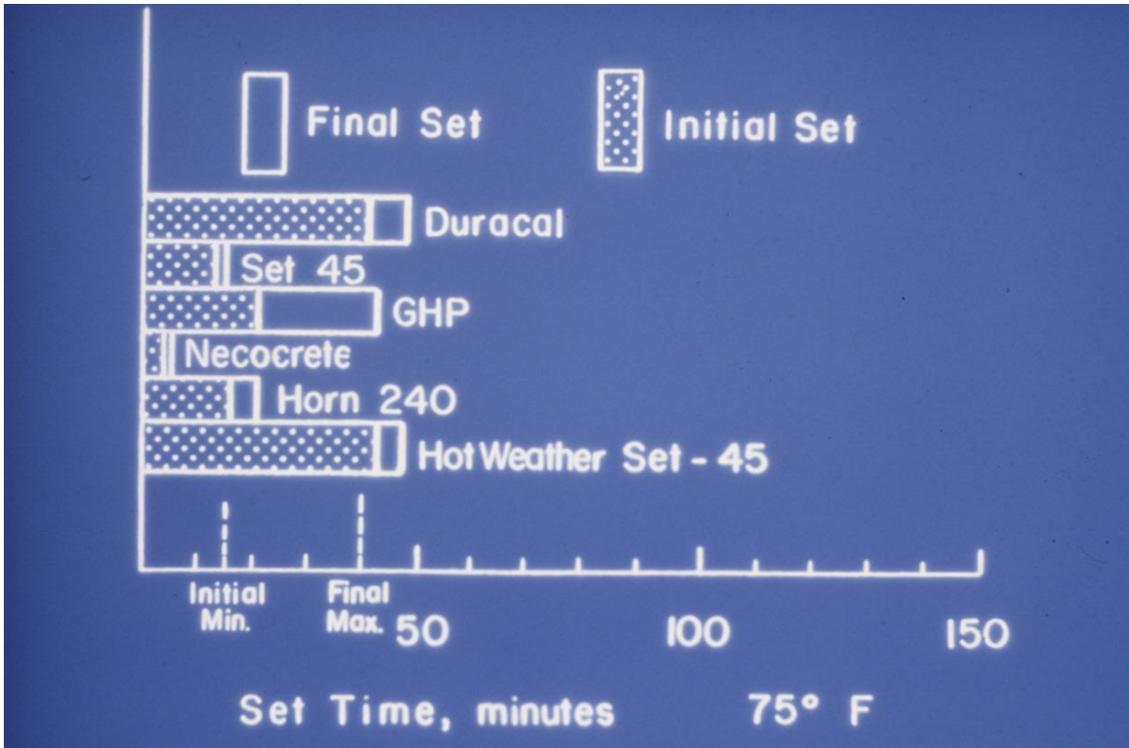
Slide 34. TSDHPT Specifications for Rapid Setting Cement Mortar

PREPACKAGED MATERIALS

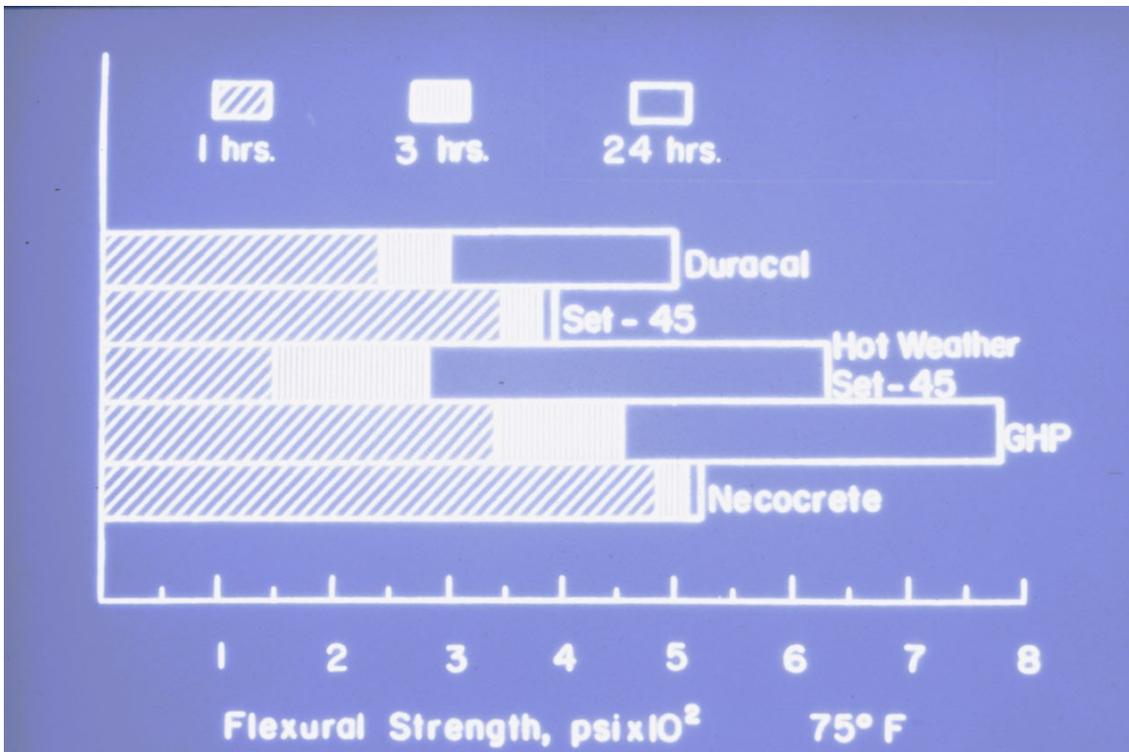
Slide 35. Prepackaged Materials



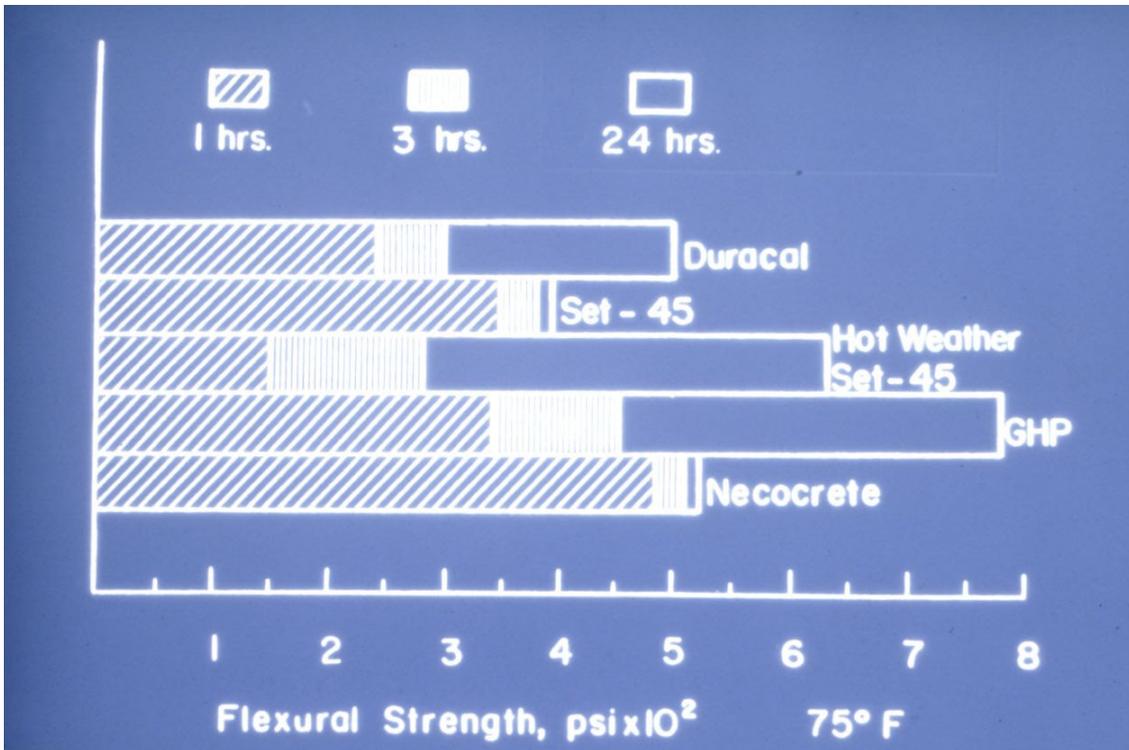
Slide 36. Set Time, minutes – 40°F. Alt text: [Table 1](#)



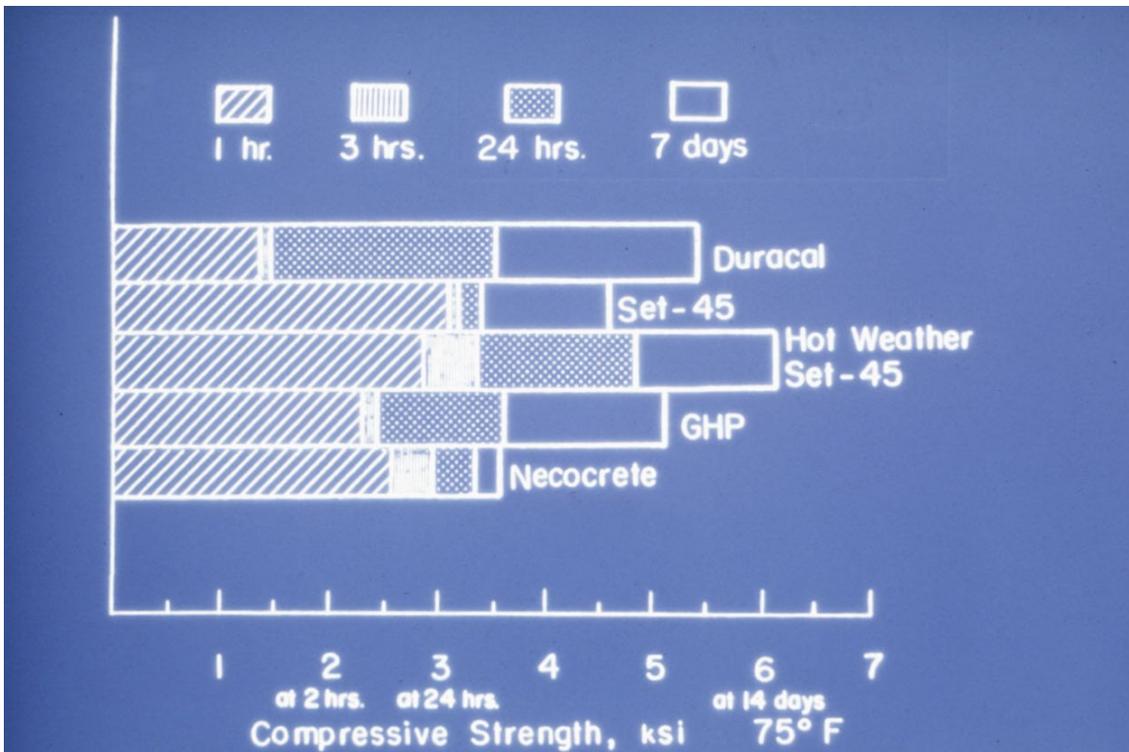
Slide 37. Set Time, minutes – 75° F. Alt text: [Table 2](#)



Slide 38. [Supposed to show Set Time, minutes – 110° F but is a duplicate of Slide 39]



Slide 39. Flexural Strength, psi x 10² – 75°F. Alt text: [Table 3](#)



Slide 40. Compressive Strength, ksi – 75°F. Alt text: [Table 4](#)

**REDUCTION IN COMPRESSIVE STRENGTH
DUE TO ADDITIONAL WATER**

DURACAL (+10% WATER) 26%

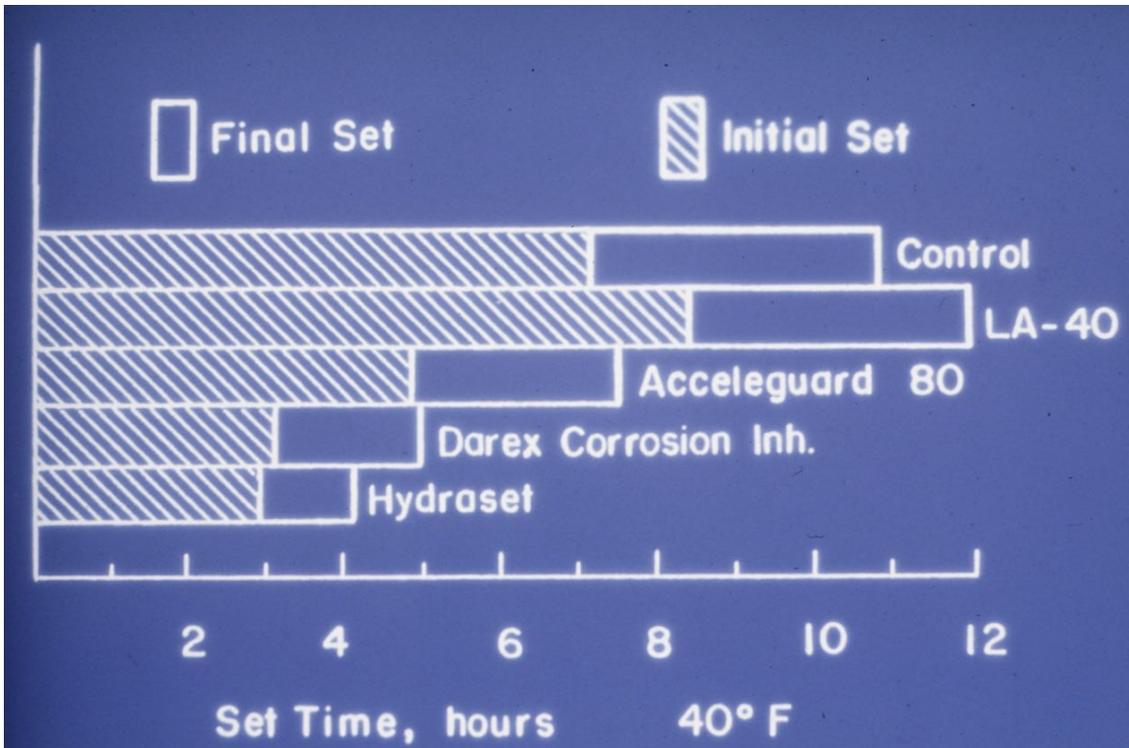
GHP (+6% WATER) 10%

SET-45 (+10% WATER) 14%

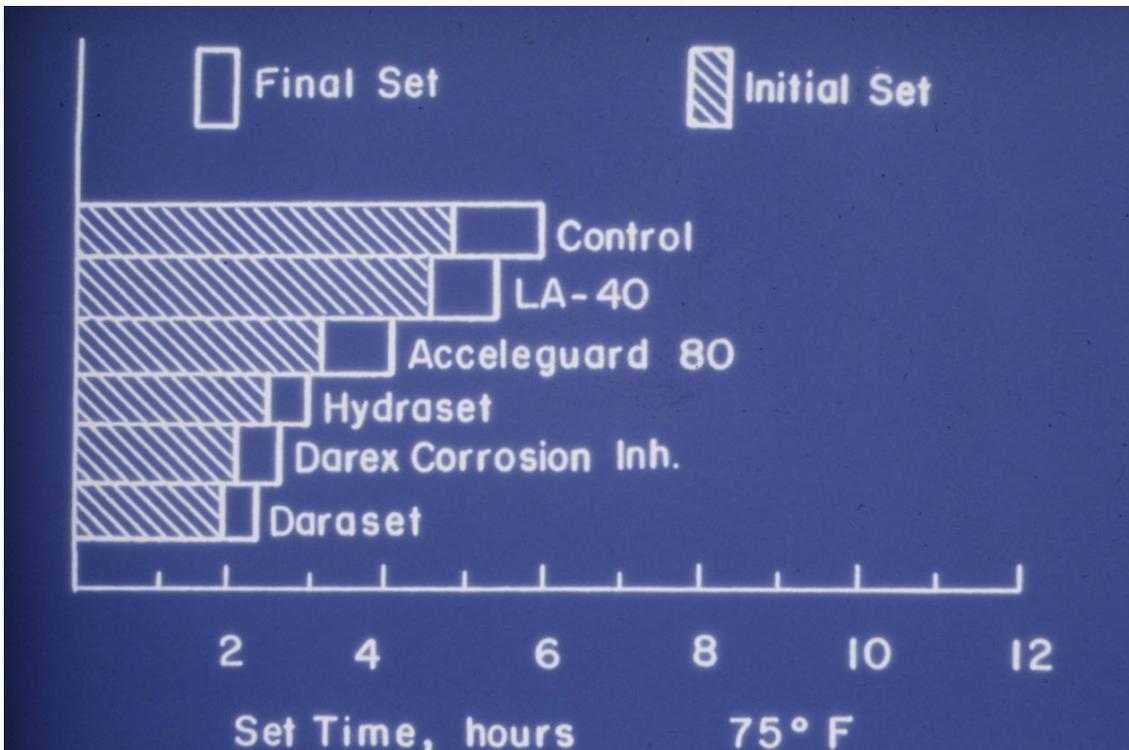
Slide 41. Reduction in Compressive Strength due to Additional Water

CLASS "K" CONCRETE

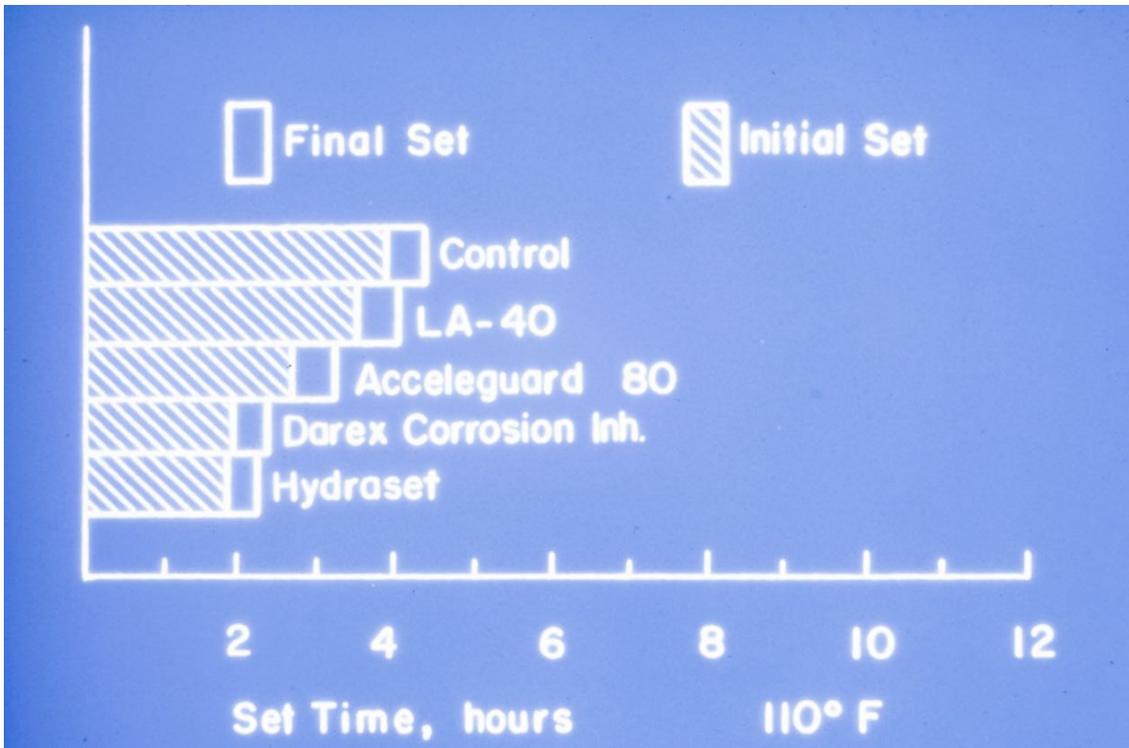
Slide 42. Class "K" Concrete



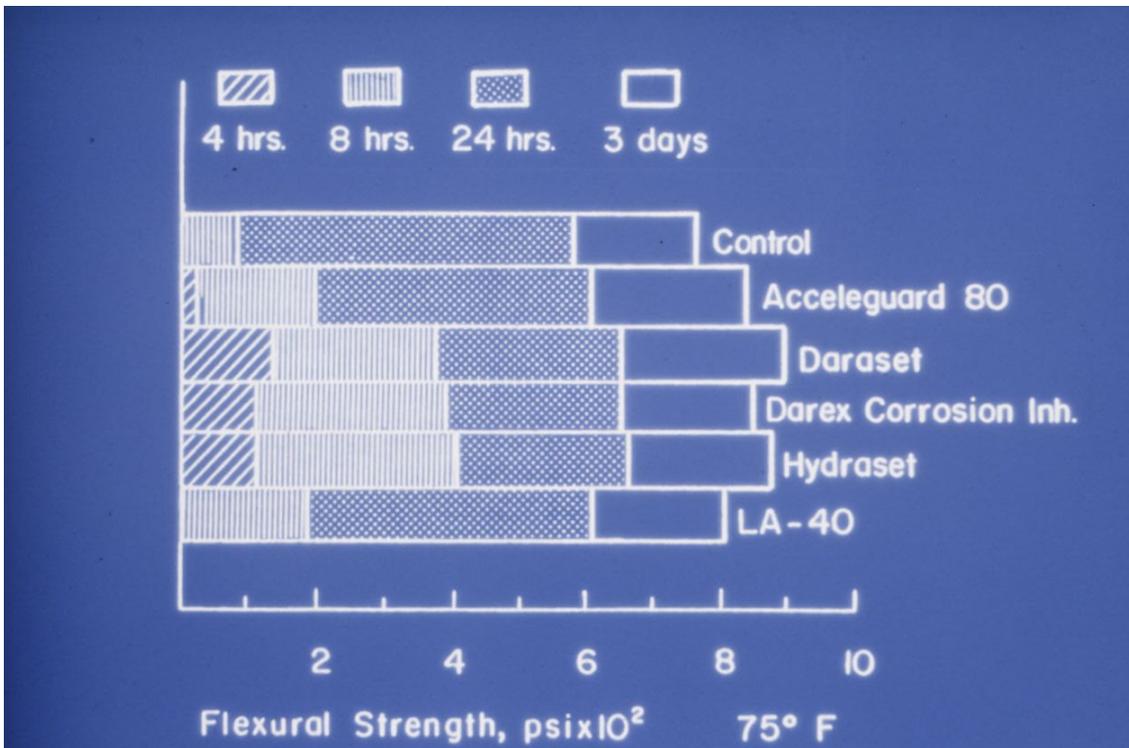
Slide 43. Set Time, hours – 40° F. Alt text: [Table 5](#)



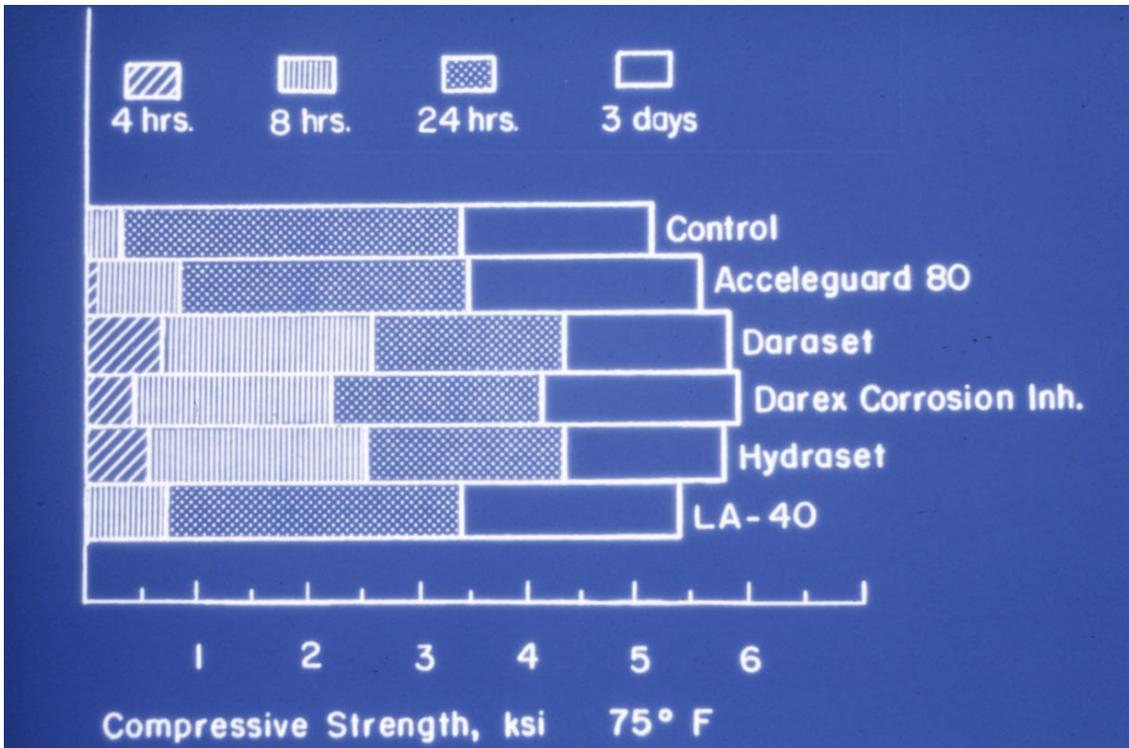
Slide 44. Set Time, hours – 75° F. Alt text: [Table 6](#)



Slide 45. Set Time, hours – 110° F. Alt text: [Table 7](#)



Slide 46. Flexural Strength, $\text{psi} \times 10^2$ – 75° F. Alt text: [Table 8](#)



Slide 47. Compressive Strength, ksi – 75°F. Alt text: [Table 9](#)

RECOMMENDATIONS
FOR USE

Slide 48. Recommendations for Use

MATERIAL	TEMPERATURE RANGE		
	40 - 70 F	71 - 85 F	86 - 100 F
DURACAL		X	X
SET-45			
HOT WEATHER		X	X
COLD WEATHER	X	X	
GHP		X	X
NECO-CRETE	X		
POLYMER CONCRETE	X	X	X

Slide 49. Temperature Range [slide 1 of 2]. Alt text: [Table 10](#)

MATERIAL	TEMPERATURE RANGE		
	40-70 F	71-85 F	86-100 F
DAREX CORROSION INHIBITOR (NON-CHLORIDE)	X	X	X
DARASET (NON-CHLORIDE)	X	X	X
HYDRASET (CHLORIDE)	X	X	X

Slide 50. Temperature Range [slide 2 of 2]. Alt text: [Table 11](#)

MATERIAL	REPAIR SIZE	
	4'x4' OR LESS	4'x4' OR MORE
DURACAL	X	
SET-45	X	
GHP	X	
NECO-CRETE	X	
POLYMER CONCRETE	X	X ^a

^a WITH PRECAST SLAB

Slide 51. Repair Size [slide 1 of 2]. Alt text: [Table 12](#)

MATERIAL	REPAIR SIZE	
	4'x4' OR LESS	4'x4' OR MORE
DAREX CORROSION		X
DARASET		X
HYDRASET		X
CLASS "K"		X

Slide 52. Repair Size [slide 2 of 2]. Alt text: [Table 13](#)

FREEZE - THAW DURABILITY		
MATERIAL	LOW	HIGH
DURACAL		X
SET-45	X	
GHP		X
NECO-CRETE	X	
POLYMER CONCRETE		X

Slide 53. Freeze-Thaw Durability [slide 1 of 2]. Alt text: [Table 14](#)

FREEZE-THAW DURABILITY		
MATERIAL	LOW	HIGH
DAREX CORROSION		X
DARASET		X
HYDRASET		X
CLASS "K"		X

Slide 54. Freeze-Thaw Durability [slide 2 of 2]. Alt text: [Table 15](#)

MATERIAL	INITIAL SET TIME	TIME TO 300 PSI
	at 75 F (MIN.)	FLEXURAL STRENGTH at 75 F (HR.)
DURACAL	40	3.0
SET-45		
HOT WEATHER	40	3.2
COLD WEATHER	10	0.8
GHP	20	1.0
NECO-CRETE	3	0.6
POLYMER CONCRETE	30 - 45	< 1.0

Slide 55. Initial set time and time to achieve 300 psi flexural strength. Alt text: [Table 16](#)

MATERIAL	INITIAL SET TIME	TIME TO 300 PSI
	75 F (HR)	FLEXURAL STRENGTH 75 F (HR)
CLASS K CONTROL	4.8	14.0
DAREX CORROSION		
INHIBITOR	2.0	7.0
DARASET	1.9	7.0
HYDRASET	2.5	7.0

Slide 56. Initial set time and time to achieve 300 psi flexural strength [Class "K" concretes]. Alt text: [Table 17](#)

MATERIAL	RELATIVE COST (Extended Material)
NORMAL PCC	1.0 ^a
DURACAL	5.1
SET-45	18.8
GHP	12.5
NECO-CRETE	18.9
POLYMER CONCRETE	
- CONTRACTOR FORMULATED	8.5
- PREPACKAGED	24

^a ASSUMING \$50/CU YD

Slide 57. Relative costs of rapid-setting materials. Alt text: [Table 18](#)

HIGHWAY REPAIR PROCEDURE

Slide 58. Highway Repair Procedure

TYPES OF REPAIRS POSSIBLE:

SPALLS

PARTIAL AND FULL DEPTH

POTHoles

"BLOW UP" TYPE FAILURES

Slide 59. Types of Repairs Possible



Slide 60. A spall filled with asphalt



Slide 61. A full-depth repair



Slide 62. Preparation of Repair Area

SPALLS

Slide 63. Spalls

- 1) BREAK OUT DAMAGED CONCRETE AT LEAST 1-IN. DEEP. USE LIGHT JACKHAMMER
- 2) SANDBLAST OLD CONCRETE.
- 3) PRESERVE JOINT ACTION (IF APPLICABLE).
- 4) DAMPEN REPAIR AREA (UNLESS NECO-CRETE IS USED).

Slide 64. Procedures for repairing spalls



Slide 65. Spall ready for repair



Slide 66. Full Depth Repairs

- 1) MAKE SAW CUT 1/4 DEPTH OF SLAB
AROUND REPAIR AREA.
- 2) BREAK OUT DAMAGED AREA.
- 3) IF NECESSARY, CUT REINFORCEMENT
NEAR CENTER.
- 4) REPAIR BASE MATERIAL.
- 5) CLEAR DEBRIS FROM REPAIR HOLE.

Slide 67. Procedures for preparing full-depth repairs [slide 1 of 2]

- 6) SANDBLAST REINFORCEMENT AND
EDGES OF OLD CONCRETE.
- 7) IF NECESSARY, SPLICE STEEL
BACK TOGETHER.
- 8) PRESERVE JOINT ACTION
(IF APPLICABLE).
- 9) DAMPEN REPAIR AREA (UNLESS
NECO-CRETE IS USED).

Slide 68. Procedures for preparing full-depth repairs [slide 2 of 2]



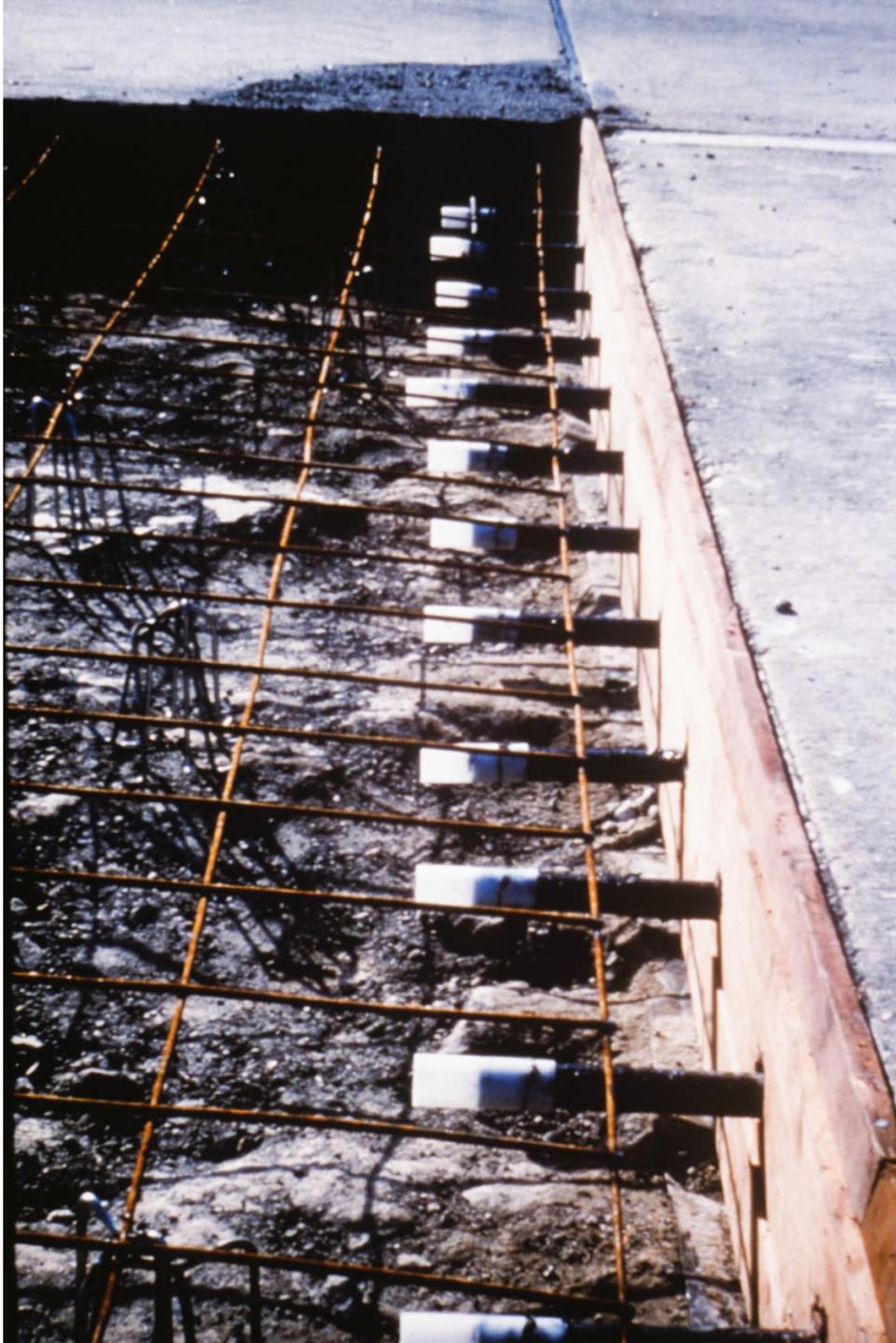
Slide 69. Sawing around repair area



Slide 70. Jack hammer breaking out sawn area



Slide 71. Full-depth repair ready to receive repair materials



Slide 72. Repair area abutting an expansion/contraction joint

PREPACKAGED MATERIALS

Slide 73. Prepackaged Materials

MIXING OF MATERIALS

Slide 74. Mixing of Materials

TYPE OF MIXER:

MORTAR MIXER (MOVING BLADES,
STATIONARY DRUM) GIVES BEST RESULTS

Slide 75. Type of Mixer

MIXING TIMES

DURACAL AND GHP: 3-4 MINUTES

SET-45 AND NECO-CRETE: 2 MINUTES OR LESS

ALWAYS TAKE AIR TEMPERATURE

(SET TIME) INTO CONSIDERATION.

Slide 76. Mixing Times

ORDER TO ADD MATERIALS TO MIXER

Slide 77. Order to Add Materials to Mixer

DURACAL

- 1) ADD 1/2 WATER, ALL F.A. AND C.A.
- 2) IF FIBERS USED, ADD AND MIX FOR 1 MINUTE.
- 3) ADD DURACAL.
- 4) ADD REMAINING WATER.

Slide 78. Duracal

SET-45

- 1) ADD ALL WATER, C.A.
- 2) IF FIBERS USED, ADD AND MIX FOR 1 MINUTE
- 3) ADD SET-45

Slide 79. Set-45

GHP

- 1) ADD ALL WATER, C.A.
- 2) IF USED, ADD FIBERS AND MIX FOR 1 MINUTE.
- 3) ADD GHP.

Slide 80. GHP

NECO-CRETE

- 1) ADD LIQUID SOLUTION, C.A.
- 2) IF USED, ADD FIBERS AND MIX FOR 1 MINUTE.
- 3) ADD NECO-CRETE DRY MATERIAL.

Slide 81. Neco-Crete



Slide 82. Adding coarse aggregate to the mortar mixture



Slide 83. Adding steel fibers to the mix



Slide 84. Adding rapid-setting material

PLACING AND FINISHING

Slide 85. Placing and Finishing

- 1) DUMP MATERIAL INTO REPAIR AREA.
- 2) CONSOLIDATE EACH LIFT.
- 3) QUICKLY SCREED TO PROPER LEVEL.
- 4) APPLY DESIRED FINISH.
- 5) NEVER ATTEMPT TO RETEMPER MATERIAL.

Slide 86. Procedures for placing and finishing the repair material



Slide 87. Placing the material into the repair area



Slide 88. Vibrating the concrete



Slide 89. Consolidating the material with a shovel



Slide 90. Screeding the surface with a 2x4



Slide 91. Finishing screeding the surface



Slide 92. Texturing the surface with a broom



Slide 93. Placing the materials



Slide 94. Completed spall repair



Slide 95. Class "K" Concrete

ORDER TO ADD MATERIALS TO MIXER

Slide 96. Order to Add Materials to Mixer

AT BATCH PLANT

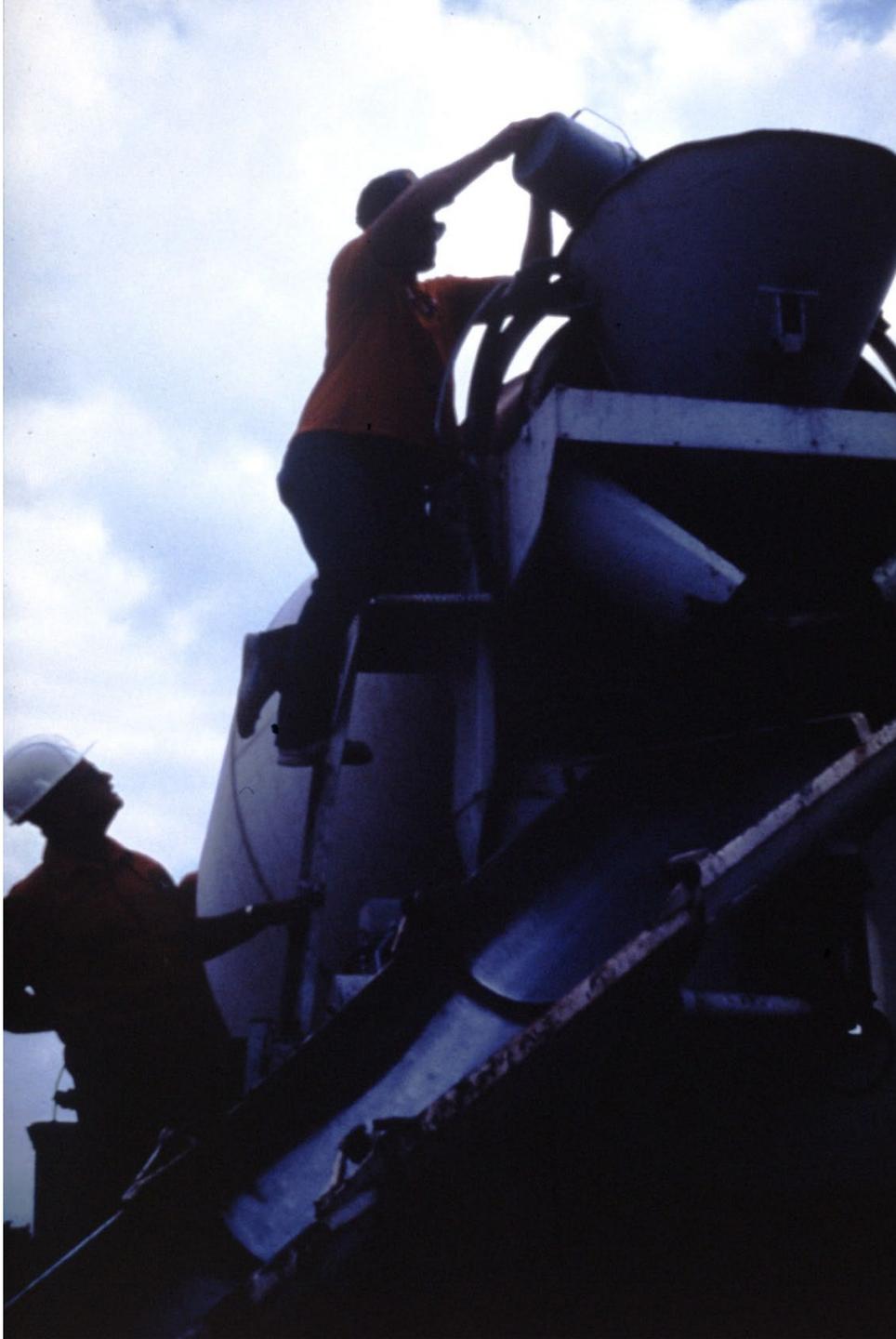
- 1) ADD ALL C.A., F.A., CEMENT,
WATER, AIR ENTRAINMENT.**
- 2) IF USED, ADD 1/2 HRWR.**

Slide 97. At Batch Plant

AT REPAIR SITE

- 1) ADD ACCELERATOR.
- 2) ADD REMAINING HRWR (IF USED).
- 3) MIX AT HIGH SPEED FOR
2 MINUTES.

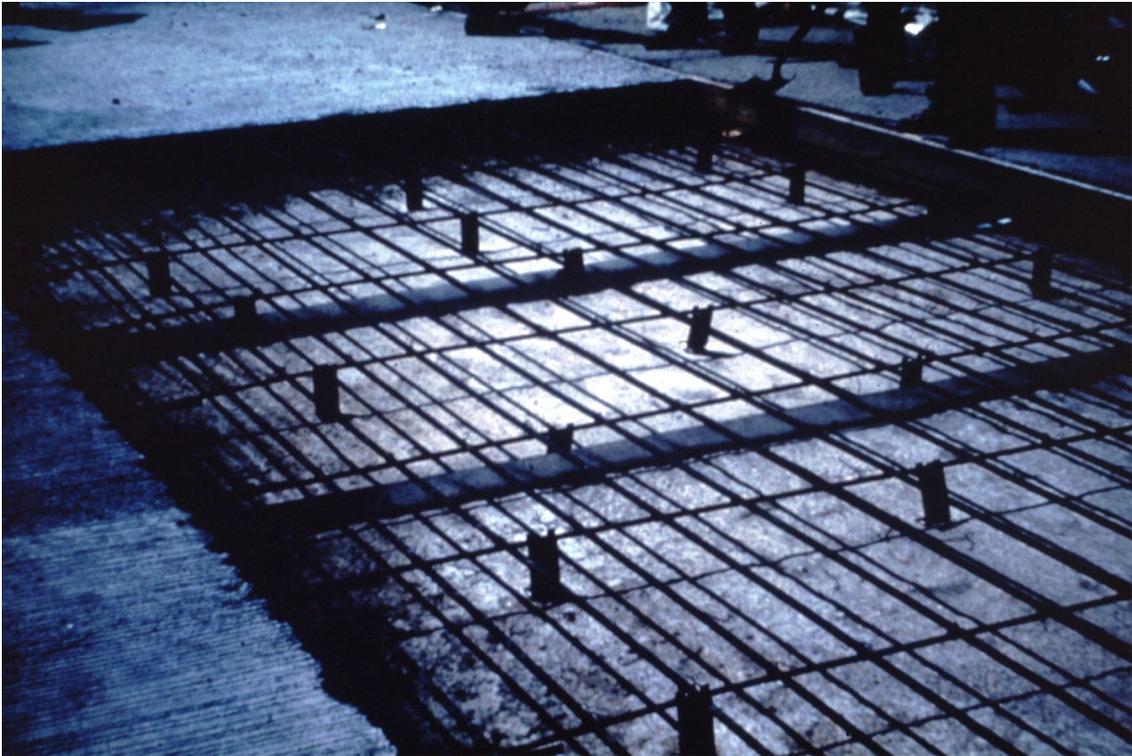
Slide 98. At Repair Site



Slide 99. Adding admixtures

PLACING AND FINISHING

Slide 100. Placing and Finishing



Slide 101. Preparing repair area for concrete



Slide 102. Placing Class "K" concrete



Slide 103. Spreading and consolidating



Slide 104. Screeding and finishing

SUMMARY

Slide 105. Summary

DURACAL:

MEDIUM TO HIGH TEMPERATURE

HIGH FREEZE-THAW DURABILITY

SLOWER STRENGTH GAIN

Slide 106. Duracal

SET-45:

LOW TO MEDIUM TEMPERATURE

LOW FREEZE-THAW DURABILITY

RAPID STRENGTH GAIN

Slide 107. Set-45

GHP:

MEDIUM TO HIGH TEMPERATURE

HIGH FREEZE-THAW DURABILITY

SLOWER STRENGTH GAIN

Slide 108. GHP

NEO-CRETE:

LOW TEMPERATURE

LOW FREEZE-THAW DURABILITY

RAPID STRENGTH GAIN

Slide 109. Neo-Crete

USE MORTAR MIXER

ADD MATERIALS IN SPECIFIED ORDER

DON'T MIX TOO LONG

FINISH MATERIALS QUICKLY

Slide 110. Prepackaged materials instructions

FOR CLASS "K" CONCRETE,

SEE TSDHPT SPECIAL SPECIFICATION

"REPAIRING EXISTING CONCRETE PAVEMENT"

Slide 111. Class "K" Concrete

WHEN NON-CHLORIDE ACCELERATOR REQUIRED:

USE

DAREX CORROSION INHIBITOR

OR

DARASET

Slide 112. When Non-chloride Accelerator Required

FOR FURTHER INFORMATION

CTR REPORT 311-7F

"IMPLEMENTATION MANUAL FOR THE
USE OF RAPID-SETTING CONCRETES "

Slide 113. For Further Information

Appendix A. Slides Script

The following script was prepared by the original authors to accompany the 35mm presentation slides.

PROJECT 311

"Evaluation of Fast-Setting Repair Materials for Concrete Pavements and Bridges" (Implementation)

Slides Script

1. Title
2. Materials included in the study were rapid-setting materials and accelerated portland cement concrete.
3. Candidate materials were selected on the basis of a survey of Austin Division and districts within the state and materials engineers in other state highway departments selected.
4. A questionnaire was developed to obtain the experience of the respondents as to the ideal characteristics and properties of rapid repair materials and on their experiences with available materials for highway repairs.
- 5-12. The next eight slides summarize the questions on the survey form.
13. The results of the survey were summarized in Research Report 311-1.
14. Based on the survey of Texas districts, the desired characteristics are shown in the order of preference. It is interesting to note that costs was no. 7 on the list of eight characteristics.
15. The properties based on the survey of Texas districts are shown in this slide also in order of preference. The survey of other states gave results very similar to the properties shown in this slide.
16. Based on discussions with highway department personnel, four generic types of rapid-setting materials were selected for laboratory and field study: gypsum-modified portland cement concrete: the brand chosen was Duracal; magnesia phosphate: Set-45, both cold and hot weather formulations were used; magnesia polyphosphate: Neco-Crete and Horn 240 were the brands selected; modified portland cement concrete: Gilco Highway Patch was selected.
17. The following slides indicate the manufacturers' recommendations for mix proportions.
18. Duracal, which is a gypsum-modified portland cement concrete, may be produced as a mortar or a concrete. For mortar, 50 lb of fine aggregate and 1.5 gal water must be added to the 50 lb bag. For concrete, 50 lb of fine aggregate, 50 lb of coarse aggregate, and 1.75 gal of water must be added.
19. With Set-45, a magnesia phosphate, in order to produce a mortar, .5 gal of water should be added to the package. For concrete, 30 lb of coarse aggregate, and .5 gal of water are recommended by the manufacturer. However, as will be described later, tests show that 25 lbs of coarse aggregate gave better results.

20. For Gilco Highway Patch, which is a modified portland cement concrete, 1 gal of water is required to produce mortar. To produce concrete, 30 lb of coarse aggregate and 1 gal of water are recommended by the manufacturer. Test results indicated that 15 to 20 percent more water is required to produce the desired workability.
21. Neco-Crete, which is a magnesia polyphosphate, is a two-component system which utilizes 1 gal of liquid with a 50 lb package. To produce concrete, 18 lb of coarse aggregate are recommended to be added to the mortar mix.
22. Horn 240, which is also a magnesia polyphosphate, is very similar to Neco-Crete. The manufacturer recommends, however, that 13.5 lb of coarse aggregate, instead of 18 lb, should be added to the mortar mix to produce concrete.
23. Class "K" Concrete is a special type of rapid-setting portland cement concrete used by the State Department of Highways and Public Transportation. It uses 7 sacks of Type III cement, a maximum of 5-1/2 gal per sack of cement, 3 to 6 percent air content, and various admixtures including accelerators. The slump is in the range of 1 to 3 inches.
24. Based on discussions with highway department personnel, five generic types of accelerators were selected for study. The types and brand names are shown in the slide.
25. Hydraset is a calcium chloride-based Type C accelerator. Based on laboratory tests, it was found that the maximum dosage recommended by the manufacturer, 2 qt per bag of cement, gave the best results.
26. Aceleguard 80 is a calcium nitrate Type E accelerator and tests indicate that 32 fl oz per 100 lb of cement is the desirable dosage.
27. LA-40 is a sodium thiocyanate Type C accelerator. The recommended dosage was found to be 6 fl oz per 100 lb of cement.
28. Darex Corrosion Inhibitor is a calcium nitrite Type C accelerator. Tests indicate that 100 fl oz per 100 lb of cement is the optimum dosage.
29. Daraset is a Type C accelerator containing calcium nitrite and calcium nitrate and 100 fl oz per 100 lb of cement is the recommended dosage.
30. Other admixtures used in the study included air entrainment and high range water reducer (HRWR). The HRWR water reducer permits the use of a lower water-cement ratio but at the same time provides adequate workability.
31. Several types of fibers were used. Two types of steel fibers, hooked and crimped, were investigated. Polypropylene lattice bundles were also used in the study.

32. The three different types of fibers are shown in this slide. The hooked and crimped steel fibers provide better bond to the concrete than straight, smooth fibers. The steel fibers provide considerable toughness to the concrete; that is, after the initial crack, considerable more deflection can be achieved in a concrete slab or beam before failure occurs. Generally, steel fibers are added to the concrete in the range of 60 - 85 lb per cu yd. The hooked fibers should be used in a loose uncollated form for best results. The polypropylene fibers serve to prevent segregation of concrete during placement and to provide some control of shrinkage cracking. The manufacturer recommends the use of 1.6 lb per cu yd. As the polypropylene bundle is dispersed through the concrete, a netlike structure is formed.
33. The results of the test program for determining materials properties will be discussed.
34. The current Texas specification for rapid-setting mortar requires a 15 min. minimum initial set time and 40 min. maximum final set time. The minimum compressive strength is 2000 psi at 2 hr., 3000 psi at 24 hr.. For freeze-thaw resistance, the relative dynamic modulus must be 60 percent minimum after 100 cycles. The minimum flexural strength is 100 psi at 1 hr., 300 psi at 3 hr..
35. Prepackaged materials
36. The next three slides indicate the initial and final set at three different temperatures: 40°, 75°, and 110°F. It can be observed that at a temperature of 40°, only the Set-45 meets the initial set time; none of the materials met the final set time. Duracal and Gilco Highway Patch required nearly 2-1/2 hr. to reach final set. Set-45 exceeded the 40 min. maximum final set time by only a few minutes. All three slides show the initial and final set times required by the Texas specification for rapid-setting mortar as reference points (see slide #34).
37. At 75°F, Neco-Crete set much more rapidly than all the other materials and failed to meet the minimum initial set time. Set-45 and Horn 240 met the set time criteria; Duracal and Hot Weather Set-45 exceeded the maximum set time requirements.
38. For 110°F, Neco-Crete, Gilco Highway Patch, and Cold and Hot Weather Set-45, failed to meet the minimum initial set time. Duracal was the only material which met the initial and final set time requirements.
39. The flexural strength of the materials at 75°F indicate that Neco-Crete gave the highest strength at 1 hr., nearly 500 psi. At 24 hr., Gilco Highway Patch gave the highest strength, almost 800 psi.
40. For compressive strength at 75°F, the Cold Weather Set-45 developed the highest compressive strength, at 1 hr. in excess of 3000 psi. At 24 hr. and 7 days, Hot Weather Set-45 gave the highest strengths. The minimum compressive strengths required by the Texas specifications for rapid-setting mortar at various times are shown as reference points

41. Laboratory tests were performed to determine the effect of adding additional water on the compressive strength of some of the materials. It was found that adding 10 percent more water than recommended resulted in a 26 percent decrease in strength of Duracal. Six percent additional water resulted in a 10 percent decrease in strength for GHP. Ten percent additional water in Set-45 resulted in a 14 percent decrease in strength.
42. The properties of Class "K" concrete will be given for the different accelerators at 40°, 75°, and 110°F.
43. The Darex Corrosion Inhibitor and Hydraset both resulted in initial set times of about 3 hr. The LA-40 proved to provide no advantages in either initial or final set time. Daraset was not included in these tests.
44. At 75°F, the Hydraset, Darex Corrosion Inhibitor, and Daraset all resulted in initial set times of between 2 and 2-1/2 hr. It should be noted that Daraset is a more economical form of Darex Corrosion Inhibitor. Again, LA-40 proved to have very little effect on the set times.
45. At 110°F, the Darex Corrosion Inhibitor and Hydraset again gave the lowest initial set times of about 2 hr. and final set times of less than 2-1/2 hr. Daraset was not included in these tests.
46. Flexural strength at 75°F showed little variation at 24 hr. and 3 days. However, Daraset, Darex Corrosion Inhibitor and Hydraset all resulted in the highest strengths at 4 and 8 hr.
47. Similar results were obtained for compressive strength at 75°F.
48. Recommendations for use
49. This table summarizes the recommended temperature ranges for the rapid-setting materials including polymer concrete. Duracal, Hot Weather Set-45, and Gilco Highway Patch are suitable at the range of 71-100°F. Cold Weather Set-45 is recommended in the range of 40-85°F. Neco-Crete should be used only at the lower temperature range of 40-70°F. Polymer concrete can be used at all temperature ranges by varying the amounts of promoter and initiator. Research Report 246-4F should be consulted for specific recommendations on the use of polymer concrete.
50. Of the six accelerators tested, only three are recommended for use in Class "K" concrete. Darex Corrosion Inhibitor and Daraset, both non-chloride accelerators, and Hydraset, a chloride accelerator, can be used at all temperature ranges. The Daraset would generally be the preferred non-chloride accelerator because of its lower cost.

51. The next two slides give the recommended repair sizes for the different materials. Because of the rapid-setting characteristics, Duracal, Set-45, Gilco Highway Patch and Neco-Crete should be used in repair sizes 4'x4' or less. Polymer concrete should generally be limited to 4'x4' repair sizes except that it has been found to be quite feasible for large repairs in which precast slabs are bonded to the surrounding concrete with polymer concrete. Research Report 246-1 should be consulted for precast slab repairs.
52. Class "K" concrete using accelerators should generally be used for larger size repairs.
53. The freeze-thaw durability has been found to be high for Duracal, GHP, and polymer concrete, but low for Set-45 and Neco-Crete.
54. The Class "K" accelerated concretes were all found to have good freeze-thaw durability.
55. This table summarizes the initial set time and the time to achieve to 300 psi flexural strength.
56. The same information is shown for Class "K" concretes with and without accelerators. It can be seen that the accelerators reduce the initial set time by a factor of 2; the time required to achieve 300 psi flexural strength is also reduced by a factor of 2.
57. Based on a cost of \$50/cu yd for normal portland cement concrete, the relative costs of the rapid-setting materials are shown. The costs are based on the use of coarse aggregate to extend the prepackaged materials. The costs range from about \$250/cu yd for Duracal to about \$1200/cu yd for prepackaged polymer concrete.
58. Highway repair procedures
59. It is possible to use these repair materials on four types of repairs.
60. This slide shows a spall which has been filled with asphalt.
61. A full-depth repair is shown in this slide.
62. The preparation of the repair area is quite important. The procedures will be described for several types of repairs.
63. Spalls
64. These are the procedures recommended for repairing spalls.
65. This slide shows a spall ready for placement of repair materials.
66. Full-depth repairs

67. The next two slides summarize the recommended procedures for preparing for full-depth repairs.
68. This is a continuation of the repair procedure.
69. Sawing around the repair area is shown in this slide. The saw cut should generally be about one-quarter of the depth of the slab. Care should be taken to avoid cutting the reinforcing steel.
70. Jack hammers are shown being used to break out the concrete inside the sawn area. Light jack hammers are preferred to prevent cracking of the concrete outside the saw cut.
71. This slide shows a full-depth repair ready to receive the repair materials. Any broken or badly corroded steel should be replaced.
72. Where the repair area abuts an expansion/contraction joint, care should be taken to maintain the working joint. Dowels should be coated or covered to prevent bonding of the concrete to the dowels.
73. Prepackaged materials
74. The mixing procedures will be discussed for each of the rapid-setting materials.
75. It has been found that a mortar mixer which utilizes moving blades and a stationary drum gives the best results for rapid-setting concretes. Mortar mixers are not suitable for aggregates greater than 1/2" in size.
76. The mixing times for the materials are as follows: 3-4 minutes for Duracal and Gilco Highway Patch and 2 minutes or less for Set-45 and Neco-Crete because of their more rapid setting. However, air temperature should be taken into consideration in determining the precise mixing time. In hotter weather, these recommended mixing times may have to be reduced.
77. The order in which the materials are added in the mixer is important. The following slides describe the recommended order for each material.
78. For Duracal, one-half the water and all the fine and coarse aggregates should be added initially. Fibers, if used, should be added and mixed for one minute. The Duracal is added, followed by the remaining water.
79. For Set-45, all the water and coarse aggregates are first placed in the mixer. Fibers should then be added and mixed for one minute, followed by the addition of all the Set-45.
80. For GHP, the same procedure is used as for Set-45.
81. For Neco-Crete, the same procedure as used for Set-45 and GHP are followed.
82. The coarse aggregate is shown as being added to the mortar mixer.

83. Steel fibers are next added to the mix.
84. The prepackaged rapid-setting material is added.
85. Placing and finishing
86. These are the procedures recommended for placing and finishing the repair material.
87. The material is shown being placed into the repair area.
88. The concrete is being vibrated.
89. Here, a shovel is being used to consolidate the material.
90. A 2x4 is used to screed the surface.
91. Completion of screeding the surface.
92. A broom can be used to texture the surface (Duracal or GHP only).
93. For small spalls, a can or bucket can be used to place the materials.
94. The completed spall repair.
95. Repair procedures for Class "K" concrete.
96. The order in which the materials are added to the mixer will be described.
97. At the batch plant, all the coarse aggregate, fine aggregate, cement and water and air entrainment are added. One-half of the high range water reducer, if used, should be added.
98. At the site, the accelerator and remaining high range water reducer, if used, are added. The material should be mixed at high speed for two minutes.
99. Admixtures are being added at the site.
100. Placing and finishing.
101. Repair area prepared for concrete.
102. Placing Class "K" concrete.
103. Spreading and consolidating.
104. Screeding and finishing.
105. Summary.

106. Duracal is appropriate for use in medium to high temperatures, areas subjected to freeze-thaw, and where lower strength gain can be tolerated.
107. Set-45 is appropriate for low to medium temperature ranges, in areas where freeze-thaw durability is not important, and where rapid strength gains are desired.
108. GHP should be used in medium to high temperatures, in areas where good freeze-thaw durability is required, and where slower strength gains can be tolerated.
109. Neco-Crete should be used at lower temperatures where low freeze-thaw durability is required and rapid strength gain is needed.
110. In using prepackaged materials, use a mortar mixer, add materials in a specified order, avoid overmixing, and place and finish materials quickly.
111. For Class "K" concrete, the specification is spelled out in a special publication, "Repairing Existing Concrete Pavement."
112. The recommended non-chloride accelerators are Darex Corrosion Inhibitor and Daraset.
113. For further information on the use of rapid-setting concretes and accelerated concretes, the Center for Transportation Research Report 311-7F summarizes their use. For additional information on polymer concrete, consult Research Report 246-4F.

*

Appendix B. Accessible Tables

These tables provide accessible versions of data from a selection of previous slides, where scanned images of tables were converted to machine readable tables. The table values listed are the best estimates of library staff and may differ slightly from the values intended to be represented by the original authors.

Material	Initial Set Time (minutes)	Final Set Time (minutes)
Duracal	120	135
Set-45	30	40
GHP	85	130
Neco-Crete	60	70

Table 1. Data from [Slide 36](#). Initial and final set time (minutes) at 40 °F.

Material	Initial Set Time (minutes)	Final Set Time (minutes)
Duracal	40	50
Set-45	10	11
GHP	20	40
Neco-Crete	5	6
Horn 240	15	20
Hot Weather Set-45	40	45

Table 2. Data from [Slide 37](#). Initial and final set time (minutes) at 75 °F.

Material	1 hour	3 hours	24 hours
Duracal	2.5	3.0	5.0
Set-45	3.5	3.8	4.0
Hot Weather Set-45	1.5	2.8	6.3
GHP	3.5	4.5	7.8
Neco-Crete	4.8	5.1	5.3

Table 3. Data from [Slide 39](#). Flexural strength (psi x 10²) of materials at 75 °F.

Material	1 hour	3 hours	24 hours	7 days
Duracal	1.4	1.5	3.5	5.5
Set-45	3.0	3.1	3.4	4.5
Hot Weather Set-45	2.9	3.4	4.9	6.0
GHP	2.4	2.5	3.5	5.0
Neco-Crete	2.5	3.0	3.4	3.5

Table 4. Data from [Slide 40](#). Compressive strength (ksi) of materials at 75 °F.

Material	Initial Set Time (hours)	Final Set Time (hours)
Control	7.0	10.9
LA-40	8.2	12.0
Acceleguard 80	5.0	7.5
Darex Corrosion Inhibitor	3.1	5.0
Hydraset	3.0	4.1

Table 5. Data from [Slide 43](#). Initial and final set time (hours) at 40 °F.

Material	Initial Set Time (hours)	Final Set Time (hours)
Control	5.0	6.0
LA-40	4.5	5.5
Acceleguard 80	3.0	4.0
Hydraset	2.5	3.0
Darex Corrosion Inhibitor	2.1	2.6
Daraset	2.0	2.4

Table 6. Data from [Slide 44](#). Initial and final set time (hours) at 75 °F.

Material	Initial Set Time (hours)	Final Set Time (hours)
Control	4.0	4.4
LA-40	3.5	4.0
Acceleguard 80	2.6	3.2
Darex Corrosion Inhibitor	2.0	2.3
Hydraset	2.0	2.2

Table 7. Data from [Slide 45](#). Initial and final set time (hours) at 110 °F.

Material	4 hours	8 hours	24 hours	3 days
Control	0.0	1.0	5.9	7.6
Acceleguard 80	0.3	2.0	6.0	8.4
Daraset	1.5	3.8	6.5	9.0
Darex Corrosion Inhibitor	1.2	3.9	6.5	8.5
Hydraset	1.2	4.0	6.6	8.7
LA-40	0.0	1.9	6.0	8.0

Table 8. Data from [Slide 46](#). Flexural strength (psi x 10²) of materials at 75 °F.

Material	4 hours	8 hours	24 hours	3 days
Control	0.0	0.3	3.4	5.3
Acceleguard 80	0.2	0.8	3.5	5.6
Daraset	0.7	2.6	4.3	5.8
Darex Corrosion Inhibitor	0.5	2.3	4.2	5.9
Hydraset	0.6	2.5	4.3	5.8
LA-40	0.0	0.8	3.4	5.4

Table 9. Data from [Slide 47](#). Compressive strength (ksi) of materials at 75 °F.

Material	TR: 40–70 °F	TR: 71–85 °F	TR: 86–100 °F
Duracal	No	Yes	Yes
Set-45 (Hot weather)	No	Yes	Yes
Set-45 (Cold weather)	Yes	Yes	No
GHP	No	Yes	Yes
Neco-Crete	Yes	No	No
Polymer Concrete	Yes	Yes	Yes

Table 10. Data from [Slide 49](#). Recommended temperature ranges (TR) for rapid-setting materials.

Material	TR: 40–70°F	TR: 71–85°F	TR: 86–100°F
Darex Corrosion Inhibitor (Non-chloride)	Yes	Yes	Yes
Daraset (Non-chloride)	Yes	Yes	Yes
Hydraset (Chloride)	Yes	Yes	Yes

Table 11. Data from [Slide 50](#). Accelerators recommended for use in Class "K" concrete.

Material	4'x4' or less	4'x4' or more
Duracal	Yes	No
Set-45	Yes	No
GHP	Yes	No
Neco-Crete	Yes	No
Polymer Concrete	Yes	Yes, with precast slab

Table 12. Data from [Slide 51](#). Recommended repair sizes for rapid-setting materials.

Material	4'x4' or less	4'x4' or more
Darex Corrosion Inhibitor	No	Yes
Daraset	No	Yes
Hydraset	No	Yes
Class "K"	No	Yes

Table 13. Data from [Slide 52](#). Recommended repair sizes for Class "K" accelerated concretes.

Material	Low	High
Duracal	No	Yes
Set-45	Yes	No
GHP	No	Yes
Neco-Crete	Yes	No
Polymer Concrete	No	Yes

Table 14. Data from [Slide 53](#). Freeze-thaw durability of rapid-setting materials.

Material	Low	High
Darex Corrosion Inhibitor	No	Yes
Daraset	No	Yes
Hydraset	No	Yes
Class "K"	No	Yes

Table 15. Data from [Slide 54](#). Freeze-thaw durability of Class "K" accelerated concretes.

Material	Initial Set Time (minutes)	Time to 300 psi FS (hours)
Duracal	40	3.0
Set-45 (Hot weather)	40	3.2
Set-45 (Cold weather)	10	0.8
GHP	20	1.0
Neco-Crete	3	0.6
Polymer Concrete	30-45	<1.0

Table 16. Data from [Slide 55](#). Initial set time (minutes) and time to achieve 300 psi flexural strength (FS) at 75 °F.

Material	Initial Set Time (hours)	Time to 300 psi FS (hours)
Class "K" Control	4.8	14.0
Darex Corrosion Inhibitor	2.0	7.0
Daraset	1.9	7.0
Hydraset	2.5	7.0

Table 17. Data from [Slide 56](#). Initial set time (hours) and time to achieve 300 psi FS at 75 °F.

Material	Relative Cost (Extended material)
Normal PCC	1.0
Duracal	5.1
Set-45	18.8
GHP	12.5
Neco-Crete	18.9
Polymer Concrete (Contractor formulated)	8.5
Polymer Concrete (Prepackaged)	24

Table 18. Data from [Slide 57](#). Relative costs of rapid-setting materials, based on a cost of \$50/cu yd for normal portland cement concrete (PCC).