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DEVELOPMENT OF A SPECIFICATION FOR A RAPID-CURING ASPHALTIC PATCHING MIX

By

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ABSTRACT

An end product specification was devised for a rapid-curing asphaltic patching mix. A rapid-curing patching mix was formulated in the laboratory, using this specification as a guide. The mix was packaged and sent out for field trial. Results of the field trial indicated good performance, so the specification was released for use in purchasing rapid-curing cutback asphaltic patching mix.

SUMMARY

In November 1981, the Materials and Tests Laboratory received a sample of a proprietary rapid-curing asphaltic patching mix from the District 21 Maintenance Engineer. This material was reported as being capable of producing a permanent type of repair for concrete, asphaltic concrete, or masonry pavement surfaces. District 21 personnel had used this material successfully for patching potholes in cold, wet weather. The problem was that this mix was very costly and had to be purchased by trade name. The District desired that a specification be developed that would allow this type of material to be purchased by competitive bid.

This paper describes the development of that specification. Tests were run on existing material to determine the types of properties desired and the ingredients required to achieve these properties. An experimental mix was designed that had the appropriate properties. A batch of this material was produced and sent to District 21 to try in the field. Results of the field trial indicated the performance desired was attained; consequently, the specification was prepared for use.

IMPLEMENTATION

The work done in this project has resulted in the development of a specification which will obtain a rapid-curing asphaltic patching mix that will form a durable patch even under adverse weather conditions.

I. Subject

Development of a specification for a rapid-curing asphaltic patching mix to be used for emergency repair of localized areas of deteriorating pavement.

II. Objective

To provide a material that would be easy to use, place, perform well under adverse weather conditions, and produce a durable patch.

III. Background

Several Districts have used a proprietary rapid-curing asphaltic patching mix for emergency pothole patching which has the capability to produce a durable repair in cold, wet weather.

This material consists of a fine-graded mix, similar to an Item 350, Type "FF" gradation, with a rapid-curing cutback asphaltic material as a binder. The mix appears to contain an antistrip agent to achieve a bond to wet surfaces and prevent stripping of the patching mix. The material must be packaged in sealed containers to prevent premature loss of workability before use.

In theory, a maintenance person would see or be notified of the location of a pothole, scoop out as much standing water in the pothole as is possible, open a sealed container of the patching material, fill the pothole with the material, tamp, and use their vehicle to compact the material by driving over it several times. The repaired area can then be turned over to traffic and provide a durable repair in an emergency situation.

In practice, the material functions well and does what the manufacturer claims. The cost of this material has been very high. No specification existed for open bidding and, consequently, the material had to be purchased on a brand name basis.

District 21 contacted the Materials and Tests Division, requesting a generic or competitive specification be written for this type of material. This type of specification would detail the necessary requirements and would enable the Department to buy a rapid-curing patching mix at a lower cost through competitive bidding.

IV. Conclusions and Recommendations

A laboratory-designed patching mix was produced and sent to District 21 for a field trial. The personnel who used the mix in the field indicated that it was placed during a cool (temperature 50-70 F), wet period. Excess water was mopped from the potholes and the material placed, tamped, and compacted. The material formed a patch requiring no further attention.

A specification for a rapid-curing asphaltic patching mix was then written and released for use by the Districts. Based on laboratory tests and field trial results, it is believed that the specification developed will provide for material adequate for the needs of the Department under these conditions. A copy of the specification is attached.

V. Materials and Equipment

Materials and equipment used for this project include all equipment used for testing and designing bituminous mixtures. This includes extraction and Abson recovery equipment, moisture content apparatus, volatiles content apparatus, Hveem stabilometer, cohesiometer, Engler distillation apparatus (conforming to ASTM E 133), and routine asphalt test equipment.

A 50-pound sample of a proprietary rapid-curing asphaltic patching mix was submitted by District 21 for evaluation. Crushed limestone and a field sand from White's Mines (Weatherford, Texas), cutback asphalts from several refineries, and Pave Bond AP antistrip agent were obtained for use in producing trial mixes.

VI. Discussion

In the development of a specification, two ways to proceed were considered. One was to develop a "formulation" specification which would specify to the producers exactly what to put into the patching mix and in what quantities. Another approach was to develop an "end product" specification which would indicate the type of material desired by specifying properties of the finished product. A "formulation" specification would offer no flexibility for producers and could possibly limit competition. An "end product" specification which states the properties desired in a finished product, along with some guidelines as to ingredients, would still allow producers flexibility to achieve the end product properties using their own technologies and provide a material suitable for our needs.

After deciding on an "end product" type specification, a course of action for developing the specification was planned as follows:

1. Plan what tests should be performed on the proprietary mix to determine its components and physical properties. Also determine what properties are desirable in a similar type patching mix.

2. Perform tests on the proprietary mix submitted.

3. Formulate a laboratory mix which should perform similarly.

4. Design, make, and test the patching mix in the laboratory.

5. If properties of the laboratory designed mix are satisfactory, make a larger quantity of mix and package it for field trial.

6. Send this mix to District 21 for field trial and evaluation.

7. Based upon the field evaluation, prepare a specification for a rapid-curing asphaltic patching mix.

The properties considered necessary for a rapid-curing patching mix were ease of placement (workability) in warm or cold weather, ability to bond to wet surfaces, good strength and stability, appropriate rate of cure, proper density range, and stripping resistance.

Tests conducted to determine these properties in the proprietary mix were volatiles content, boiling range of recovered volatiles, moisture content, extraction, Abson recovery, Hveem stability cured and uncured, density cured and uncured, cohesion cured and uncured, split tensile strength cured and uncured, and tests on the residual asphalt (viscosity, penetration, and ductility).

The battery of proposed tests was begun on the proprietary mix on November 16, 1981. A summary of tests and results appear in Tables 1 and 2. All tests used were standard State Department of Highways and Public Transportation test procedures, except for the distillation of volatiles recovered from the proprietary mix which followed ASTM D 86, modified by using a 25 ml flask because of the small sample size.

TABLE 1

TEST RESULTS OF PROPRIETARY PATCHING MIX

Volatiles content: 0.35% (All percents are by weight)

Moisture content: 0.02%

Extraction: Extracted aggregate appears to be 100% limestone

Asphalt content 3.1%

Sieve Analysis

Size	% Retained
+ 3/8"	0
3/8"-No. 4	11.2
No. 4-No. 10	56.5
No. 10-No. 40	24.7
No. 40-No. 80	1.0
No. 80-No. 200	0.5
- No. 200	2.6
Total Loss	3.5
	100.0%

Open Graded

Molded Specimens:

Uncured - molded as received - tested at room temperature

Average Density	2.197 g/cm^3
Hveem Stability	44
Cohesiometer	43
Split Tensile Strength	Value not attainable (Sample disintegrated prior to test)

Cured - molded at 140 F

Average Density	2.142 g/cm^3
Hveem Stability	48 @ 140 F
Cohesiometer	72 @ 140 F
Split Tensile Strength	13.3 psi

TABLE 2

TEST RESULTS ON ASPHALT AND VOLATILES RECOVERED FROM MIX

Residual Asphalt: (Obtained by Abson Recovery)

Viscosity @ 140 F	765 Stokes
Penetration @ 77 F	97
Ductility @ 77 F & 5 cm/min	141+ cm

Engler Distillation of Recovered Volatiles: (ASTM D 86)

Initial Volume = 20.6 ml IBP = 296 F

% Recovered	ml	Temperature (F)
5	1.03	300
10	2.06	302
20	4.12	306
30	6.18	310
40	8.24	316
50	10.3	321
60	12.36	328
70	14.42	337
80	16.48	350
90	18.54	370
95	19.57	-
EP	19.45	390

A rapid curing patching mix was then designed in the laboratory. Based on the properties of the proprietary mix, it was decided that the materials should be readily available and consist of limestone aggregate with a small amount of field sand for workability, a cutback asphalt, and an antistrip agent. Since a rapid cure was desired, an RC cutback would be used. A cutback which would have a residual asphalt with a penetration value of approximately 100 and a cutter solvent approximately equivalent to that of the proprietary mix was desired. The proprietary mix appeared to have an appropriate rate of cure (not too slow or too fast) and would serve as a target for the laboratory-designed mix. Factors contributing to the desired rate of cure were a fairly low initial boiling point and a narrow boiling range. The same solvent characteristics were desired in the cutback used for laboratory design.

An RC-250 (1972 Specification) was selected for investigation, since the distillation residue must have a penetration of 80 to 120. Determining which producer could supply an RC-250 with a solvent approximating the rate of cure needed was the next task.

Several producers are able to make a material which will meet RC-2 and RC-250 specifications concurrently. These were eliminated from consideration because these materials yield higher penetration residue and more volatile solvent than that desired. Cosden, Exxon, and Diamond Shamrock remained as possible suppliers.

After running an Engler distillation on a Cosden RC-250 distillate, this material was ruled out as it had a low boiling range (146-385 F). This might cure out too fast. Exxon, likewise, would be fast curing. The Diamond Shamrock seemed the most promising. The results from standard cutback tests and Engler distillation on recovered solvent are presented in Table 3.

Approximately 80 percent of the Shamrock distillate has the same boiling range as the proprietary mix and the initial boiling point is close.

TABLE 3

SUMMARY OF TESTS ON DIAMOND SHAMROCK RC-250

Standard Cutback Tests

Asphalt Residue % by weight = 77

Initial Boiling Point = 382 F

Temperature	% by Volume of Total Distillate
320 F	0
347 F	0
374 F	0
437 F	42.9
500 F	71.4
600 F	91.1
680 F	100

Penetration (of Residue from Distillation) @ 77 F, 100 g, 5 sec = 99

Ductility @ 77 F & 5 cm/min = 141+ cm

Specific Gravity of Cutback @ 77 F = 0.927

Engler Distillation of Solvent (ASTM D 86)

Initial Volume = 67 ml I.B.P. 276 F

% Recovered	ml	Temp (F)
5	3.35	291
10	6.7	300
20	13.4	316
30	20.1	328
40	26.8	338
50	33.5	348
60	40.2	360
70	46.9	370
80	53.6	382
90	60.3	402
95	63.65	425
EP	-	440

May not cure fast enough

This material was chosen for the laboratory design and experimental work. This cutback was then treated with 0.5 percent Pave Bond antistrip agent to help prevent stripping and promote bond to damp surfaces.

Three aggregates were obtained from White's Mines (Weatherford) to design the laboratory patching mix. An Item 350, Type "FF" gradation was chosen for the laboratory design. The aggregate gradation of the proprietary patching mix did not meet the specification for any mix used by the Department, but it was close to an Item 350, Type "FF" gradation. The proprietary material did not have enough fine material (-40 sieve) to meet the "FF" gradation. It is believed that an "FF", or similar gradation, would result in a more dense, waterproof mix than the gradation used in the proprietary mix. The aggregates obtained from White's Mines consisted of a silicious field sand, limestone screenings, and 1/4 inch limestone coarse aggregate. The gradations of these materials are presented in Table 4, along with the combined design gradation, specification limits, sand equivalent, and specific gravities.

Presented in Table 5, are the results from tests performed on this mix design. This information, when plotted in Figure 1, shows an optimum cutback content of 4.05 percent to achieve 95 percent of theoretical maximum density. Since the mix should be workable at low temperatures, 4.2 percent cutback was chosen to help low temperature workability and to provide a little more asphalt in the mix. This mix had cured and uncured stabilities of 48, volatiles content of .61 percent, and there was less than 10 percent stripping by the boiling stripping test (Tex-530-C).

TABLE 4

MATERIALS AND TESTS DIVISION
BITUMINOUS SECTION
MIX DESIGN SHEET

Date January 18, 1982	District No. Laboratory Mix
Spec. Item No. 350	Material Ident. F82510001 - F82510003
Type "FF"	Design No. -

Sieve Size	F82510001		F82510002		F82510003						Comb. Grad.	1972 T.H.D. Specs.
	Sieve Analysis	12%	Sieve Analysis	19%	Sieve Analysis	69%	Sieve Analysis		Sieve Analysis			
Pass	-	-	-	-	-	-					-	-
Pass	-	-	-	-	-	-					-	-
1 3/4" - 7/8"	-	-	-	-	-	-					-	-
7/8" - 3/8"	-	-	-	-	-	-					-	-
Ret. 3/8"	0	0	0	0	0	0					0	0
3/8" - 1/4"	0	0	0	0	5.9	4.1					4.1	0-5
1/4" - No. 4	-	-	-	-	-	-					-	-
1/4" - No. 10	0	0	12.7	2.4	87.2	60.1					62.5	55-70
No. 4 - No. 10	-	-	-	-	-	-					-	-
Ret. No. 10	-	-	-	-	-	-					-	-
No. 10 - No. 40	6.3	0.8	50.2	9.5	6.5	4.5					14.8	0-25
No. 40 - No. 80	61.6	7.4	15.8	3.0	0.2	0.1					10.5	3-12
No. 80 - No. 200	27.4	3.3	9.3	1.8	0.1	0.1					5.2	2-10
Pass No. 200	4.7	0.5	12.0	2.3	0.1	0.1					2.9	0-6
Total	100	12	100	19	100	69					100	100

SAND EQUIVALENT = 82

Specific Gravities

Size	F82510001	F82510002	F82510003
3/8"-1/4"	-	-	2.601
1/4"-No. 10	-	2.609	2.609
No. 10-No. 80	2.620	2.575	2.623
Pass No. 80	2.657	2.705	-

Average Bulk Specific Gravity = 2.612

Inspector

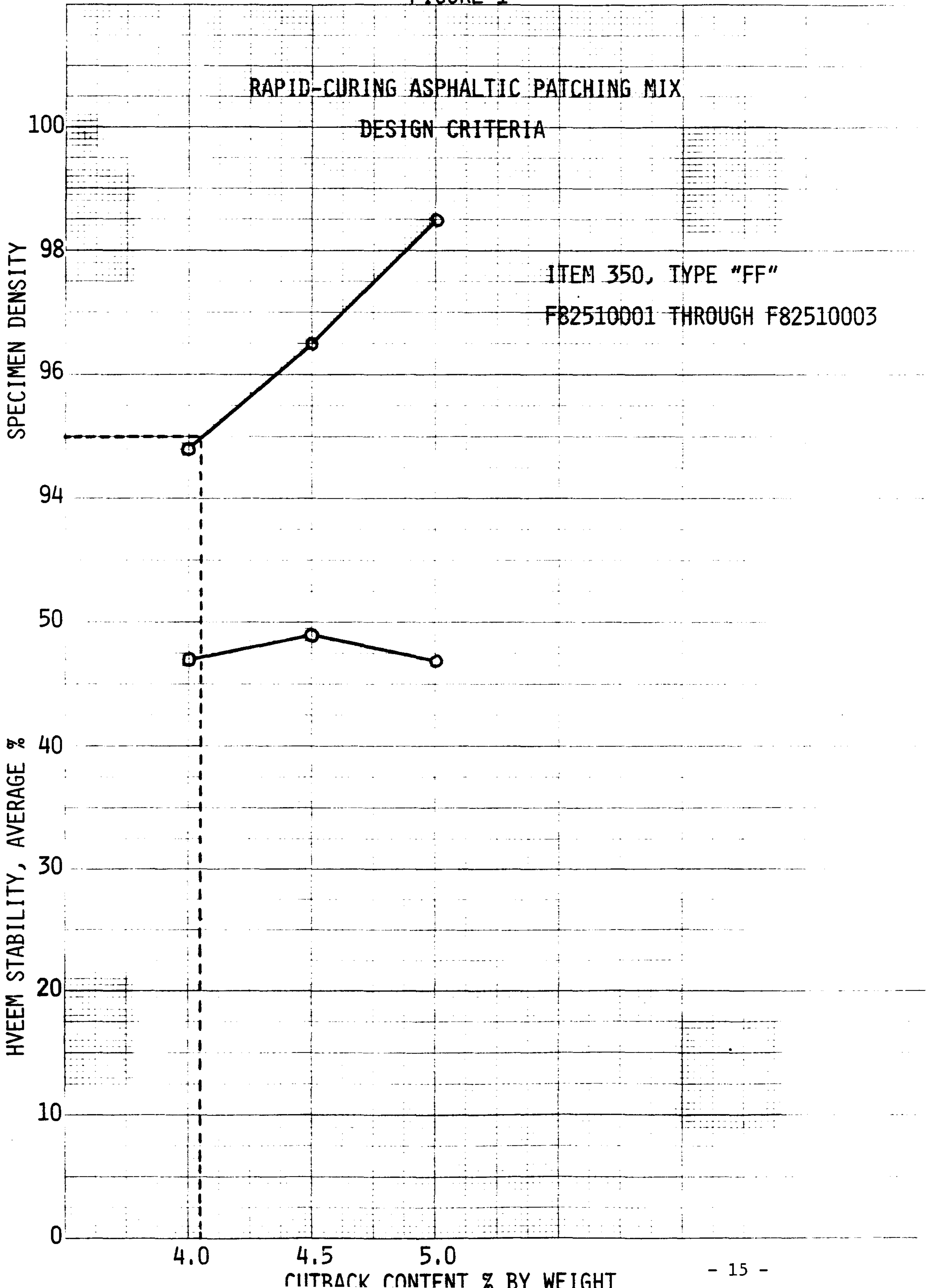
Form No. D-9-F24

TABLE 5

TEST RESULTS ON CURED AND MOLDED SPECIMENS
USED IN STANDARD HVEEM MIX DESIGN

Cutback Asphalt Content (% by weight)	Specimen Density (Avg)	Hveem Stability (Avg)	Cohesiometer Value (Avg)
4.0	94.8	47	59
4.5	96.5	49	55
5.0	98.5	47	71

FIGURE 1


RAPID-CURING ASPHALTIC PATCHING MIX
DESIGN CRITERIA
ITEM 350, TYPE "FF"
F82510001 THROUGH F82510003
SPECIMEN DENSITY
100
98
96
94
HVEEM STABILITY, AVERAGE %
50
40
30
20
10
0
4.0
4.5
5.0
CUTBACK CONTENT % BY WEIGHT

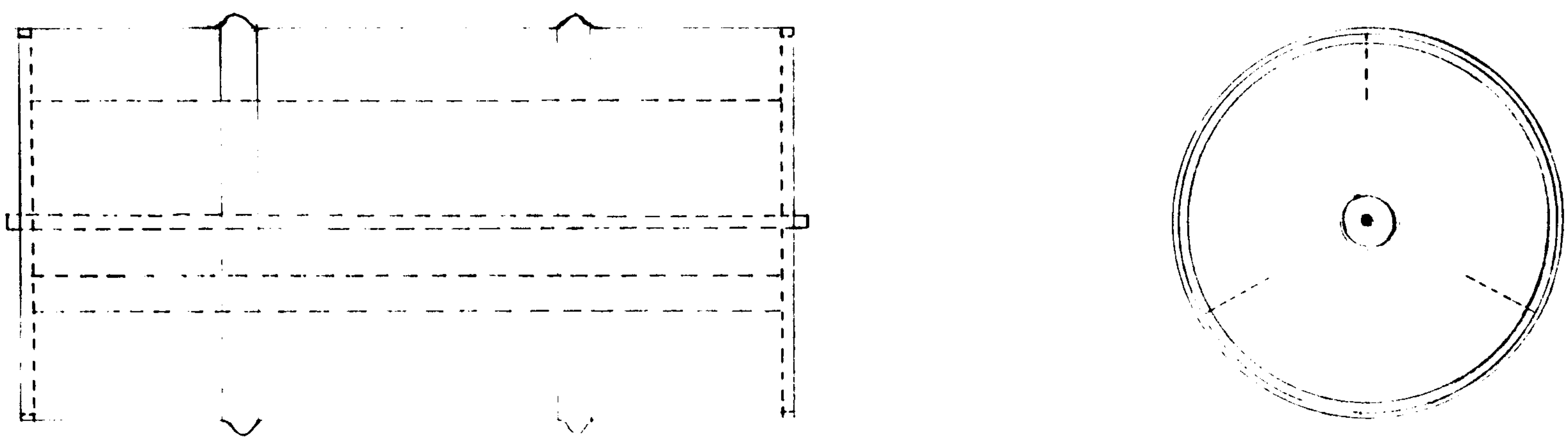
Since the tests performed indicated the laboratory design was satisfactory, the next objective was to produce enough material for a field trial. The danger associated with mixing a material with RC-250 in it, required that a safe method of mixing larger quantities be devised. The method chosen was a drum on a large roller mixer. The roller mixer was designed to mix paint and other products containing solvent to uniform consistency. The mixer consists of two rollers, one of which is chain driven by an electric motor. A cylindrical container placed on the rollers will be rotated, subjecting the contents to a tumbling action.

A mixing drum to roll on the roller mixer was constructed from a 30-gallon drum. Three baffles were welded in the drum at three equidistant points on the interior circumference of the drum. The baffles were three inches wide and ran the length of the drum. A lid to safely enclose the drum and to permit easy access to the drum was fashioned of plywood and a plastic gasket. The lid was held in place by a threaded steel rod running the length of the drum in the center. The baffles were used to provide a better mixing motion and keep the material from riding along the walls of the drum as it rotated. A drawing of the drum construction is presented in Figure 2.

Aggregate was weighed out to produce 100-pound batches of aggregate plus cutback. The aggregate and asphalt were heated in an oven to 150 F for mixing. The initial batch consisted of 25 pounds of material to provide a coating of the mixing drum to minimize losses of the asphaltic material on subsequent batches. This initial batch was then discarded. Three 100-pound batches and one 50-pound batch were mixed and then packaged in five-gallon sealable buckets, each holding approximately 50 pounds.

To assure thorough mixing, the following sequence was used: Load the mixer with all aggregate and treated cutback and then mix on roller mixer 1.5 minutes; shake material to bottom of drum and mix two additional minutes; turn drum around so rotation will be in opposite direction and mix for 1.5 minutes; turn drum around and mix for 1.5 minutes; turn drum around and mix for two minutes. Then mixing was stopped and the mixed batch was loaded into the five-gallon buckets. The mixing schedule could

FIGURE 2



BARREL MIXER

probably have been shortened; however, the above schedule was followed to insure thorough mixing without having to check the operation by opening the mixing barrel several times and losing volatiles. Mixing and packaging took place on Wednesday, February 3, 1982.

On Friday, February 5, 1982, a good opportunity existed for an experimental trial of the patching mix. A cold front had brought freezing temperatures and rain to the Austin area. That afternoon, the laboratory produced rapid-curing asphaltic patching mix, was field-tested by filling a pothole in front of the Materials and Tests Division Laboratory at 38th and Jackson Streets. The pothole filled was approximately 0.75 ft^2 in area and five inches deep. Precipitation turned to sleet. As much water as possible was scooped from the pothole, it was filled with patching mix, and a pickup truck was used to compact the mix.

On Monday, February 8, 1982, approximately 330 pounds of experimental rapid-curing curing asphaltic patching mix was shipped to District 21 for field trial.

VI. Results of Field Trials

When the laboratory-blended patching mix was placed on February 5, 1982, the temperature was 30-32 F, but the material still handled easily. The material displaced some water in the hole and bonded well to the wet base and asphaltic concrete. The patch was observed several days after application and was in very good condition. Two months after placement (April 1982), the patch showed no loss of material or bond; however, the asphalt was rather tender in the warmer weather. After 16 months (last observation), the patch showed no change in appearance and the tenderness had disappeared. In this test of the material, the laboratory rapid-curing asphalt patching mix performed satisfactorily under extreme climatic conditions.

The 300 pounds of experimental rapid-curing cutback asphaltic patching mix was used by District 21 with success. The material was used under wet conditions and at temperatures between 50 and 70 F. Based on reports, the material bonded to wet surfaces of potholes and resulted in durable patches, which have required no further attention. This material has been in place approximately one year.

Before information was obtained from District 21, several other Districts requested a specification for the same type material. A specification was written, a copy of which is attached, which would allow a rapid-curing asphaltic patching mix to be purchased on a bid basis. This specification was written based on laboratory data, incorporating specifications for materials already used by the State (i.e., Item 350, Type "FF"), with minor modifications, and input from the Bituminous Section of the Materials and Tests Division. In the aggregate gradation, an Item 350, Type "FF" using the 1982 specification manual was incorporated with the exception of the material passing the #200 sieve being limited to improve workability. The Pennsylvania Department of Transportation has done some work suggesting that a patching mix is more workable if the amount of material passing the #200 sieve is limited. This work was presented by Prithvi S. Kandhal and Dale B. Mellot in "Rational Approach to Design of Bituminous Stockpile Patching Mixtures," published in <u>Transportation Research Record 821</u>.

In the specification, the amount of material passing the #200 sieve was set at 0 to 4 percent. Suppliers have had problems with the minus #200 sieve material exceeding this requirement. On some projects, the minus #200 mesh requirement has been relaxed to 0 to 6 percent, and it has been reported that the material containing 5 to 6 percent minus #200 material had satisfactory workability. This material was placed in fairly warm weather.

When the rapid-curing asphalt patching mix is to be used in cold weather, limiting the amount of material passing the #200 sieve to four percent will provide a more workable mix.

The laboratory patching mix used in the field trials conformed to the proposed specification, except in the requirement for residual asphalt. The specification follows Standard Item 350 limits of 3.5 to 6.5 percent asphalt; however, the patching mix produced in the laboratory contained 4.2 percent cutback which was 77 percent residual asphalt by weight. This resulted in a mix with 3.23 percent residual asphalt by weight. The particular aggregate combination used, resulted in a mix meeting all other design criteria, with an unusually low asphalt content. The asphalt content of commercially produced mixes has been considerably higher. At present, we do not see a need to change the asphalt content limits in the specification.

SPECIFICATION FOR RAPID-CURING CUTBACK ASPHALT PATCHING MIX

1. Description. This specification covers the properties of a rapid-curing asphalt patching mix for repair of asphaltic concrete pavement.

2. Material. The patching mix shall be designed so that it will have good workability and can be placed at temperatures of 20 to 140 F without addition of heat. It shall have good adhesion to wet surfaces and be resistant to water damage. It shall consist primarily of crushed limestone, rapid-curing cutback asphalt and asphalt additives. The patching mix must be uniform and not require any remixing of the contents of a given container prior to use.

3. Properties. When tested according to standard State Department of Highways and Public Transportation test methods and ASTM procedures indicated, the patching mix shall comply with the following requirements:

Asphalt content, exclusive of volatiles, percent by weight	3.5 minimum 6.5 maximum

Aggregate Gradation:

Sieve	Percent by Weight
Passing 3/8"	100
Passing 1/4"	95 to 100
Passing 1/4", retained on No. 10	58 to 73
Passing No. 10, retained on No. 40	5 to 26
Passing No. 40, retained on No. 80	3 to 12
Passing No. 80, retained on No. 200	2 to 10
Passing No. 200	0 to 4

Hydrocarbon volatile content of the mix, percent by weight	0.4 minimum 0.8 maximum
Moisture content of the mix, percent by weight	0.2 maximum

Distillation range of volatiles recovered from mix:

Distillate, expressed as percent by volume of total volatiles recovered from mix when tested by ASTM D 86.

	Minimum	Maximum
Off at 300 F	-	15
Off at 350 F	50	90
Off at 400 F	85	-
Off at 450 F	95	-

Properties of asphalt extracted from the mix:

Penetration, 77 F, 100 g, 5 sec	70 minimum 130 maximum
Ductility at 77 F, 5 cm/min, cm	100 minimum

Stability of as-received mix (no curing) at 77 ± 2 F, percent, minimum .... (molded at 77 ± 2 F)	35
Stability of cured mix at 140 F, percent, minimum .... (Curing and molding done at 140 F)	40
Density, percent	92 minimum 96 maximum

(Mix cured and molded at 140 F. Percent density shall be the ratio of the compacted specific gravity to the theoretical maximum specific gravity determined by ASTM D 2041.)

Resistance to water damage. The as-received mix shall be evaluated by Test Method Tex-530-C (Boiling Stripping Test). It must not evidence more than 10 percent stripping of the aggregate surfaces.

4. Packaging. The material shall be packaged in airtight pails or drums which can be opened and resealed. The containers must be sufficiently sturdy to withstand the normal handling to which subjected in shipment.