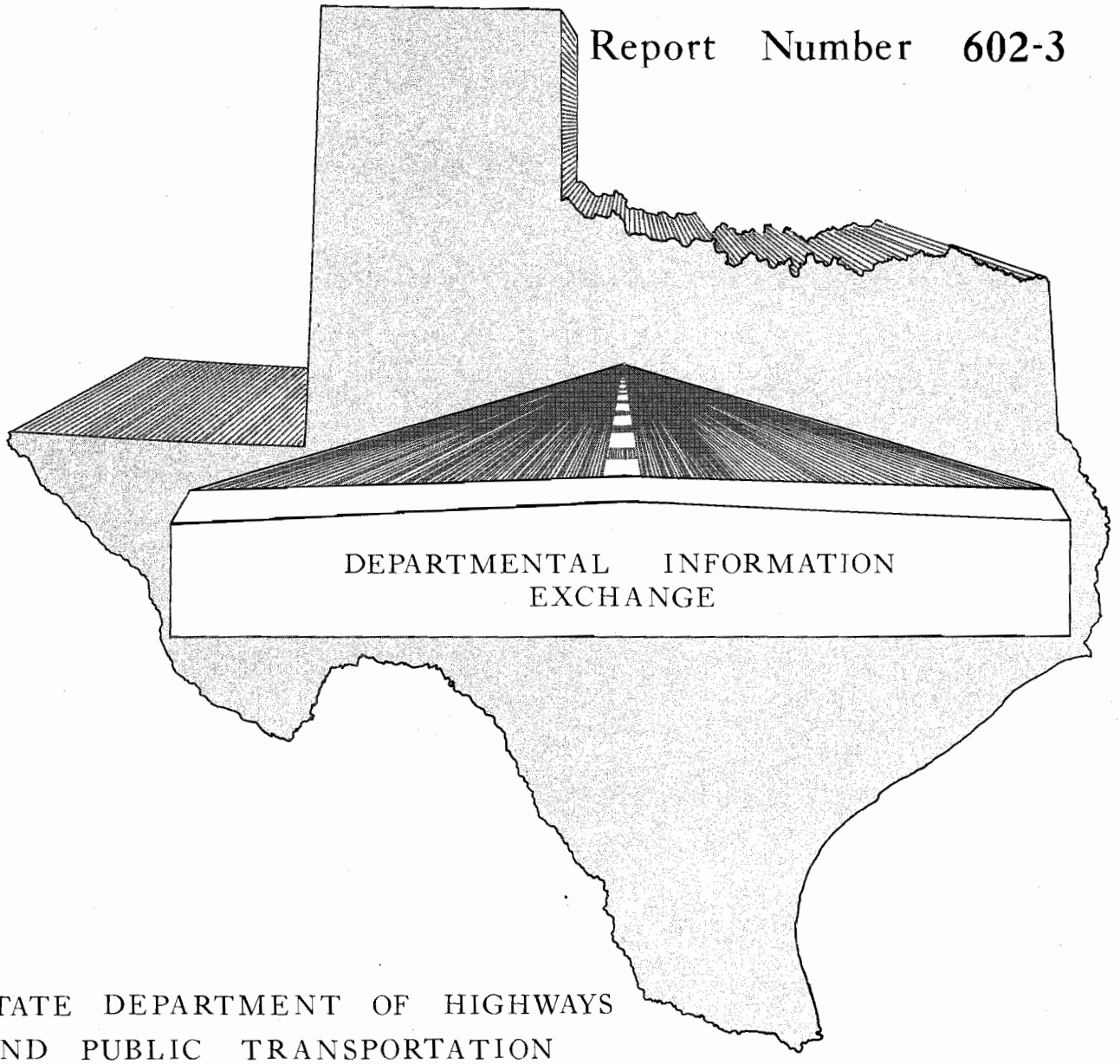
EXPERIMENTAL PROJECTS

OPEN-GRADED ASPHALT FRICTION COURSE

Report Number 602-3



STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

AN OPEN-GRADED ASPHALT FRICTION COURSE

by

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District 18

December 2, 1976

DISCLAIMER STATEMENT

The material contained in this report is experimental in nature and is published for informational purposes only. Any discrepancies with official views or policies of the DHT should be discussed with the appropriate Austin Division prior to implementation of the procedures or results.

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ABSTRACT

Twenty miles of an open-graded asphalt friction course were recently placed on US 175 in Kaufman County. A stable, uniform, open-textured mix with a smooth riding surface and with excellent skid resistance was obtained. This porous mix permits free drainage of water through the mat resulting in a low hydroplaning potential and minimized water spray. Guidelines for designing an open-graded asphalt friction course are presented.

SUMMARY

This report describes the method used in the development and in the placement of an open-graded asphalt friction course. The materials required to produce this mix and an evaluation of a recently completed project are discussed.

A twenty mile section of US 175 in Kaufman County was renovated with two courses of asphaltic concrete. The first course, a level up course, was a fine graded Item 340 Type D mix which was used to restore the centerline crown and seal the existing surface. The purpose of specifying an open-graded asphalt friction course for the surface course, was to obtain a smooth riding surface with a high skid resistance and a low hydroplaning potential.

The 3/4 inch compacted surface course produced a stable, uniform, open-textured mix with a smooth quiet riding surface. The initial skid values, which averaged fifty, should increase as the asphalt film wears off of the aggregate's surface. This porous mix has sufficient voids to permit rapid drainage of water through the mat. The hydroplaning potential and water splatter, common problems on most wet surfaces, have been minimized.

Information obtained from published literature, laboratory trial mixes, and three experimental test sections were used to develope the design and governing specifications. The final design specifications were based upon the performance data obtained from the experimental test sections after they had received several million vehicle passes.

A new design procedure based upon the percent voids in the compacted mix was established.

The design, the specification, and the material required to produce the mix are included.

SPECIFICATION

Special specification, Item 3041, "Plant Mix Friction Course", was used as the governing specification for the open-graded asphalt friction course. A complete copy of this specification and the plan notes are given in the appendix. The modifications from standard hot-mix asphaltic concrete pavement are discussed below. The development of this specification is discussed in this report.

Synthetic aggregate, with a minimum polish value of thirty-seven, was specified for the mineral aggregate. The gradation specification of the mineral aggregate is derived from the gradation recommended by the Federal Highway Administration.*

Sieve Size	% Passing (Volumetric)
3/8	100
4	30-50
10	5-15
200	2-5

The measurement used for payment was tons of asphalt and cubic yards of laboratory-compacted aggregate. The volume of aggregate was calculated from the measured weights of the asphaltic concrete by the following formula:

$$V = \frac{W}{62.4(27)(G_a)}$$

Where:

V = cubic yards of compacted aggregate

W = total weight of asphaltic concrete mixture in pounds

G_a = average actual specific gravity of three molded specimens (see plan notes for molding procedure)

The density and stability requirements normally specified for asphaltic concrete were waived. All of the field operation requirements (mixing, transporting, placing, and compacting) were essentially the same requirements used for hot-mix asphaltic concrete.

* Design of Open-Graded Asphalt Friction Courses
Report No. FHWA-RD-74-2
R.W. Smith, J.M. Rice, and S.R. Spelman

FIELD OPERATIONS

All phases of the field operations (mixing, transporting, placing, and compacting) were completed with standard equipment normally used for the production and placement of hot-mix asphaltic concrete. A flow diagram indicating the sequence of the field operations are shown in Figure 1.

The four materials blended to produce the open-graded asphalt friction course were:

(1) Coarse Light Weight Aggregate (+10 mesh material)

(2) Fine Light Weight Aggregate (-10 mesh material)

(3) Fly Ash (-200 mesh material)

(4) Asphalt (AC-20)

The design, specification, and average plant control gradation are shown in Table 1. A complete design and the specification are given in the appendix.

The two light weight aggregates were proportioned separately from open stockpiles through cold feeder bins onto conveyor belts and carried to the dryer. These aggregates were dried, heated to 260^{o}F and exited into the hot elevator. The fly ash was proportioned by auger feed from a silo directly into the hot elevator. These combined aggregates were separated by screening and collected in three hot bins. Batch weights were used to proportion the hot aggregates and the asphalt into the pug mixer. The completed mix was transported in dump trucks to the project. To prevent surface cooling, the mix was covered with tarpaulins.

The mix was placed with a standard asphaltic concrete lay down machine. Compaction was started immediately after placement using the equipment in the following sequence:

(1) Three wheel break down roller

(2) Three axle tandem roller

(3) Pneumatic roller

One pass with each roller was sufficient to obtain maximum compaction.

A mixing temperature of 260°F was established in the field as the most efficient operating temperature. The placement temperature was approximately 245°F and compaction began with a mat temperature of 240°F.

Traffic was not permitted on the compacted mat until the surface was cool. On bridge surfaces and other areas where it was essential for immediate opening to the traffic, the surfaces were cooled by spraying with water.

In place densities were taken and the percent solids and percent voids were computed. The average results obtained from in place density tests were 68% solids and 32% voids. The average measured depth for the entire project was 0.72 inches.

FLOW DIAGRAM FOR PRODUCTION
OPEN-GRADED ASPHALTIC CONCRETE

STANDARD WEIGHT-BATCH MIXING PLANT

TRANSPORTING, PLACING, COMPACTING

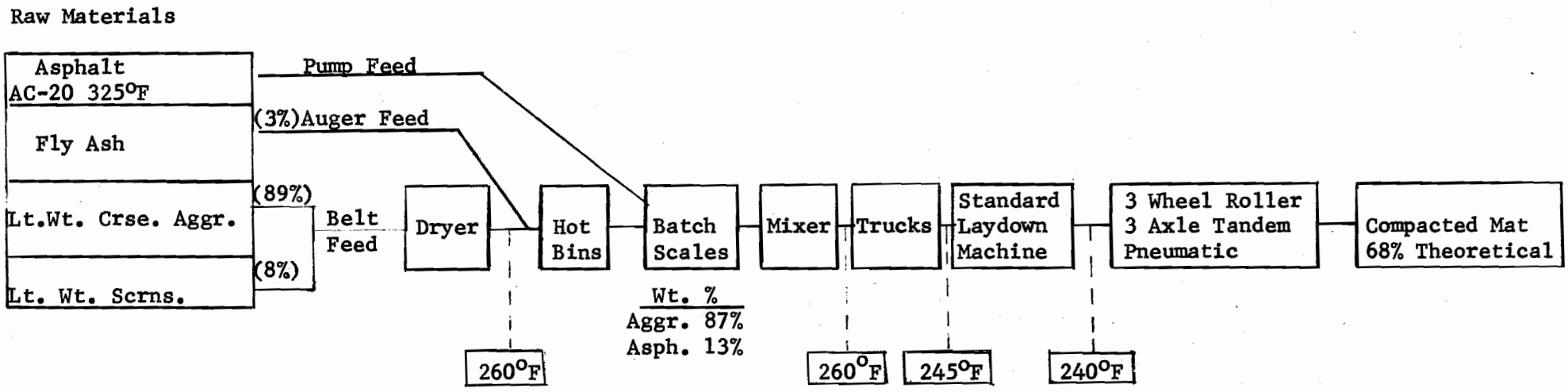

FIGURE 1

Average Gradation Control Data

I. Mineral Aggregate

Sieve Size	Design Gradation (% by Vol.)	Avg. Gradation (% by Vol.)	Specification (% by Vol.)
Passing 3/8"	100.0	100.0	100
Passing No. 4	31.8	33.6	30-50
Passing No. 10	10.6	9.0	5-15
Passing No. 200	2.8	2.4	2-5

II. Plant Control Gradation

Sieve Size	Design Gradation (% by Wt.)	Avg. Gradation (% by Wt.)
+ 3/8	0	0
3/8-4	54.6	54.2
4 - 10	17.2	20.1
+ 10	71.8	74.3
10 - 40	8.1	6.1
40 - 80	1.2	0.9
80 - 200	1.1	1.7
— 200	4.8	4.0
Asphalt	13.0	13.0
Total	100.0	100.0

TABLE I

MATERIALS REQUIRED

A summary of the materials required to produce the open-graded asphalt friction course is shown in Table II. The total square yards of surface area, the total tons of mix, the total cubic yards of compacted mix, and the total tons of asphalt are included in the summary of materials. The quantities for each material were computed based upon the average gradation obtained from the daily extraction reports. As shown, 1.2 cubic yards of coarse aggregate, dry loose unit weight, were used to produce one cubic yard of compacted mix. The average calculated depth, based upon the total surface area paved, was 0.706 inches. The cost per cubic yard was $38.48 and the cost per square yard was $0.75.

SUMMARY OF MATERIALS

I. Total Mix Produced

Controls	Square Yards	Tons of Mix	Cubic Yards of Mix	Tons of Asphalt
197-4-43	81,137	1750.5	1837.4	227.6
197-5-24	122,711	2218.5	2298.9	288.4
197-5-27	93,118	1758.0	1841.0	228.5
Total	304,966	5727.0	5977.3	744.5

II. Dry Loose Unit Weight

Type of Mat'l.	Lbs./C.F.	Lbs./C.Y.	Tons/C.Y.
Lt. Wt. Crse. Aggr.	43.8	1183	0.5915
Lt. Wt. Scrns.	61.6	1663	0.8315
Fly Ash	88.3	2384	1.1920
Asphalt	64.6	1744	.8720

III. Type Materials

Type of Mat'l.	Sieve Size	Avg. Gradation (% by Wt.)	Quantities (Tons)	C.Y. Mat'l. (Dry Loose)	C.Y. Mat'l. C.Y. Mix
Lt. Wt. Crse. Aggr.	3/8-10	74.3	4255.2	7194	1.204
Lt. Wt. Scrns.	10-200	8.7	498.2	599	.100
Fly Ash	-200	4.0	229.1	192	.032
Asphalt	------	13.0	744.5	854	.143
Total		100.0	5727.0	----	------

TABLE II

IV. Average Depth

$$\text{Average Depth} = \frac{(\text{Total Cubic Yards})(36)\ \text{Inches/yard}}{(\text{Total Square Yards})} = 0.706\ \text{Inches}$$

V. Cost Analysis

Materials	Bid Price	Total Quantities	Cost
Aggregate	$28.50/C.Y.	5977.3 C.Y.	$ 170,353.05
Asphalt	$80.10/Ton	744.5 Tons	$ 59,634.45
		Total	$ 229,987.50

Unit Cost

Cost Per Cubic Yard = $ 38.477

Cost Per Ton = $ 40.158

Cost Per Square Yard = $ .754

TABLE II

DEVELOPMENT OF AN OPEN-GRADED ASPHALT FRICTION COURSE

The purpose of an open-graded asphalt friction course is to provide a surface course meeting the following requirements: (1) stable mix, (2) smooth riding surface, (3) high skid resistance, and (4) low hydroplaning potential. An attempt to modify standard specifications to comply with these four requirements was only partially successful. The first three requirements were obtained by requiring a non-polishing coarse aggregate. To reduce the hydroplaning potential to an acceptable tolerance it was necessary to modify gradation requirements, waive the density and stability requirements, and establish a new design procedure. A new specification was developed to meet the requirements of an open-graded mix.

A new procedure was established from trial mixes produced in the laboratory. Small patch-type mixes were hand placed on the road surface for evaluation. Gradation specifications were established from trial mixes which appeared to be performing satisfactorily. Three designs were selected and incorporated into a full-size road test section 1/2 mile in length. Final selection of an open-graded specification was made based upon performance evaluation data after these three test sections received four million vehicle passes. The gradations, evaluation data for the road test sections, and the final design are shown in Table III.

Road Test Section No. 2 was selected as the best design for an open-graded friction course. This section maintained a uniformly open texture with

adequate voids to permit free water drainage. All three test sections showed good skid resistance. Road Test Section No. 1 was rejected due to its low stability since raveling occurred very soon after placement. Design No. 3 initially appeared to be an excellent choice for an open graded mix; however, the open texture closed after a few hundred thousand vehicle passes. This section was rejected due to its inability to reduce the hydroplaning potential. The gradation specification was written with the intention of producing a mix similar to Test Section No. 2.

Light weight aggregate was used in all three road test sections. The light weight aggregate was selected due to its availability in this area. Any non-polishing aggregates meeting the quality tests for surface treatment can be used to produce a satisfactory open-graded asphalt surface course. The fine aggregate (minus 10 mesh material) can be produced from sand, screenings, slag, or other materials meeting the standard hot-mix asphaltic concrete specification.

The density and stability requirements normally specified for asphaltic concrete were waived due to the degradation of the mineral aggregate during the molding of the test specimen. The molded test specimen did not represent the actual road compacted mix. A new method for estimating the percent voids in the road compacted mix is presented in this report. A modified molding procedure, with a lower compactive effort, was used to determine the bulk specific gravity of the compacted mix.

The following conclusions were made based upon actual test data:

1) An open textured surface will not adequately reduce the hydroplaning

potential.

2) The hydroplaning potential is inversely proportional to the percent voids in an open-graded mix.

3) The amount of voids in an open-graded mix is controlled by the gradation of the mineral aggregate.

4) A one-size aggregate produces the most voids, and the size of the aggregate will not appreciably affect the voids of a homogeneous material. The size of the aggregate will affect permability due to surface tension.

5) The largest size aggregate should be the predominate aggregate.

6) Fine aggregate is used to control the void content and to stabilize the coarse aggregate.

7) The stability of the compacted mix is a function of the mineral aggregate gradation, type of asphalt, and amount of asphalt.

8) The optimum asphalt content is the amount of asphalt required to produce the greatest film thickness around the mineral aggregate without separating during the mixing and placing operation.

9) A small quantity of mineral filler (minus 200 mesh material) will help stabilize the asphalt film around the coarse mineral aggregate.

10) Use the most viscous asphalt that will remain ductile at the road surface temperature.

DESIGNS, MIXING TEMPERATURES, COMPACTIONS, SKID VALUES, EVALUATIONS

	Road Test Sections			Project Design
	1	2	3	
Sieve Size	Volume %	Volume %	Volume %	Volume %
+ 3/8	0.0	0.1	0.2	0
3/8-4	47.0	55.1	50.0	58.1
4-10	37.0	19.4	18.6	16.9
+10	84.0	74.6	68.8	75.0
10-40	1.0	3.4	5.3	5.2
40-80	0.0	3.5	6.7	0.8
80-200	0.0	2.4	4.6	0.6
— 200	0.0	.7	1.0	2.3
Asphalt	15.0	15.4	13.6	16.1
Total	100.0	100.0	100.0	100.0
Date Placed	5/72	10/74	10/74	9/76
Mixing Temp.	260	260	275	260
Placement Temp.	245	245	260	250
Road Density				
% Solids	-	74	84	68
% Voids	-	26	16	32
Average Skid Values	53	55	53	50
	Road Performance Evaluation			
Stability	Poor	Good	V. Good	Good
Riding Surface	Excellent	Excellent	Excellent	Excellent
Skid Resist.	Excellent	Excellent	Excellent	Excellent
Porosity	Excellent	Good	Fair	Good

Table III

GUIDELINES FOR DESIGNING AN OPEN-GRADED ASPHALT FRICTION COURSE

A procedure for designing an open-graded asphalt friction course is presented in a separate report. This report is limited to a statement of guidelines used to develope a design procedure. These guidelines are based upon information obtained from laboratory trial mixes, three experimental test sections, and the project described in this report. These guidelines are:

(1) Mineral Aggregate - Use a non-polishing coarse aggregate which will comply with current quality tests for surface treatment. Crushed aggregate will help stabilize the compacted mix.

(2) Gradation - The maximum size of the aggregate should not be larger than one-half the depth of the compacted mix. Make the maximum size aggregate the predominant aggregate. Separate the coarse aggregate (plus 10 mesh material) in 1/8 inch sieve increments. Design with the maximum percent retained between any two sieve sizes as one-third the amount retained between the next larger sizes. Design with five to fifteen percent passing the No. 10 sieve. One to two percent mineral filler (minus 200 mesh material) will help prevent separation during the mixing and placing operation.

(3) Void Content - Design the mix for a minimum of thirty percent voids. Use the procedure shown for estimating the void content.

(4) Asphalt - Use the most viscous asphalt that will remain ductile at the road surface temperature.

(5) Optimum Asphalt - The optimum asphalt content is the amount of asphalt that will produce the greatest film thickness around the mineral aggregate without separating during the mixing and placing operation.

A drainage test is a good indicator in determining the optimum asphalt content. A minimum and maximum asphalt content can be established by visual inspection during trial mixing (optimum asphalt will be near the mid point).

ESTIMATING PERCENT VOIDS

The percent voids in the compacted mix of an open-graded asphaltic concrete may be estimated by the following formula:

$$\% \text{ Voids} = \frac{\% \text{ C.A. } (100)}{\% \text{ Solid C.A.}} - 100$$

C.A. - The mineral aggregate retained on the No. 10 sieve

% C.A. = Percent by volume of the total mix

Note - The actual percent voids in a compacted mix will be 2% to 5% less than the calculated percent voids due to degradation of the coarse aggregate and compaction.

Example:

I. From Design Data:

% C.A. = 75.0%

Unit Weight C.A. = 42.4 PCF

Sp. Gr. C.A. = 1.220

$$\% \text{ Solids of C.A.} = \frac{42.4\ (100)}{(1.220)(62.4)} = 55.7\%$$

$$\% \text{ Voids in Compacted Mix} = \frac{(75.0)(100)}{55.7} - 100 = 34.6\%$$

II. From Plant Control Data:

% C.A. = 74.7%

Unit Weight C.A. = 43.8 PCF

Sp. Gr. C.A. = 1.270

$$\% \text{ Solids of C.A.} = \frac{(43.8)(100)}{(1.270)(62.4)} = 55.3\%$$

$$\% \text{ Voids in Compacted Mix} = \frac{(74.7)(100)}{(55.3)} - 100 = 35.1\%$$

III. Average Measured In Place Density:

% Solids = 68.0%

% Voids = 32.0%

APPENDIX

Control: 197-4-43, etc.
Project: HHS 000S(79), etc.
Highway: U. S. 175
County: Kaufman

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

GOVERNING SPECIFICATIONS AND SPECIAL PROVISIONS

All specifications and special provisions applicable to this project are identified as follows:

STANDARD SPECIFICATIONS: Adopted by the State Highway Department of Texas, January 3, 1972.

Item 1 to 9 Incl., General Requirements and Covenants
Item 330 Cold Mix Limestone Rock Asphalt Pavement (Class A)(213)(300)(500)(501)
Item 340 Hot Mix Asphaltic Concrete Pavement (Class A)
Item 350 Hot Mix-Cold Laid Asphaltic Concrete Pavement (Class A)
Item 560 Metal Beam Guard Fence(360)(421)(492)(502)
Item 580 Structure for Field Office and Laboratory

SPECIAL PROVISIONS: Special provisions will govern and take precedence over the specifications enumerated hereon wherever in conflict therewith.

Required Contract Provisions, Federal-aid Construction Contracts (Form PR-1273, September, 1975)
Wage Rates (Zone 12)
Special Provisions "Important Notice to Contractors" (000--2031)(000---005)(000---779)(000--1982)
Special Provision "Specific Equal-Employment-Opportunity Responsibilities" (000--1968)
Special Provision "Detours, Barricades, Warning Signs, Sequence of Work, Etc."(000--2120)
Special Provision to Item 1 (001---020)
Special Provision to Item 2 (002---009)
Special Provision to Item 7 (007---161)
Special Provisions to Item 8 (008---013)(008---036)
Special Provision to Item 360 (360---012)
Special Provision to Item 421 (421---004)
Special Provision to Item 560 (560---003)
Special Provision to Item 580 (580---001)
Special Provision to Special Specification Item 7249 (7249---003)
SPECIAL SPECIFICATIONS:

Item 3041 Plant Mix-Friction Course
Item 5134 Temporary Erosion, Sediment and Water Pollution Control
Item 7249 Thermoplastic Pavement Markings
Item 7263 Temporary Pavement Markings

GENERAL: The above-listed specification items are those under which payment is to be made. These, together with such other pertinent items, if any, as may be referred to in the above-listed specification items, and including the special provisions listed above, constitute the complete specifications for this project.

F. R. DIV. 6	TEXAS	HHS 000S(79) etc.	SHEET 3
Kaufman	COUNTY	US HWY. 175	CONT. 197-4-43, etc.

GENERAL NOTES AND SPECIFICATION DATA:

BASIS OF ESTIMATE

ITEM	DESCRIPTION	(AV) AREA	RATE	NO. UNITS	RATE	QUANTITY	UNIT
CONTROL 197-4-43							
340	AGGR (TY G) (PRE LEVEL-UP)	9,667SY	153.5#/SY	742	95%	704	TON
340	ASPH (AC) (PRE LEVEL-UP)	9,667SY	153.5#/SY	742	5%	38	TON
340	AGGR (TY G) (LEVEL-UP)	79,138SY	181.3#/SY	7,173	95%	6,814	TON
340	ASPH (AC) (LEVEL-UP)	79,138SY	181.3#/SY	7,173	5%	359	TON
3041	AGGR (GR 4) (SURF)	88,284SY	3/4" DEPTH	1,839	100% VOL	1,839	CY
3041	ASPH (AC) (SURF)	88,284SY	3/4" DEPTH	1,839	15.5% BY WT **	246	TON
CONTROL 197-5-24							
340	AGGR (TY G) (PRE LEVEL-UP)	20,300SY	126.2#/SY	1,281	95%	1,217	TON
340	ASPH (AC) (PRE LEVEL-UP)	20,300SY	126.2#/SY	1,281	5%	64	TON
340	AGGR (TY G) (LEVEL-UP)	122,593SY	118.1#/SY	7,238	95%	6,876	TON
340	ASPH (AC) (LEVEL-UP)	122,593SY	118.1#/SY	7,238	5%	362	TON
3041	AGGR (GR 4) (SURF)	129,620SY	3/4" DEPTH	2,697	100% VOL	2,697	CY
3041	ASPH (AC) (SURF)	129,620SY	3/4" DEPTH	2,697	15.5% BY WT **	361	TON
CONTROL 197-5-27							
340	AGGR (TY G) (LEVEL UP)	78,300 SY	114.1 #/SY	4,466	95%	4,243	TON
340	ASPH (AC) (LEVEL UP)	78,300 SY	114.1 #/SY	4,466	5%	223	TON
3041	AGGR (GR 4) (SURF)	95,431 SY	3/4" DEPTH	1,988	100% VOL	1,988	CY
3041	ASPH (AC) (SURF)	95,431 SY	3/4" DEPTH	1,988	15.5% BY WT **	266	TON

** 1 CY (ASPH) = 0.864 TONS

PAVEMENT MARKING SUMMARY

CONTROL	YELLOW 4 IN	WHITE 4 IN
197-4-44	17,040 LF	61,320 LF
197-5-24	34,008 LF	153,180 LF
197-5-27	29,160 LF	
TOTALS	80,208 LF	214,500 LF

TEMPORARY PAVEMENT MARKINGS SUMMARY

CONTROL	EST. NO. OF 2 FOOT STRIPES (@ 80' SPACING)	EST. NO. OF 1 FOOT STRIPES (@ 40' SPACING)		AMOUNT
197-4-43	287	268		842 LF
197-5-24	460	440		1,360 LF
197-5-27	247	231	*	713 LF
TOTALS	988	939		2,915 LF

* INCLUDES QUANTITIES FOR PRE LEVEL-UP CRSE.

Rev. 4-27-76 Rev 5-4-76

SPECIFICATION DATA

Sheet A

GENERAL NOTES AND SPECIFICATION DATA:

Item 7249 (Continued):

The thermoplastic marking for this project shall be applied so as to constantly maintain a true and acceptable alignment throughout both straight and horizontally curved sections of highway. This alignment shall be in accordance with the plan dimensions and/or as approved by the Engineer.

The equipment for application of the thermoplastic material shall be capable of placing not less than 60,000 linear feet per day of 4-inch stripe. Equipment is subject to prior approval by the Engineer.

Item 3041:

No mineral aggregate shall be used in the production of asphaltic concrete until all quality test requirements have been satisfied.

Prior to ordering asphalt, the Contractor shall designate the source or sources of supply and the Engineer will specify the grade to be used from each source. Only one grade from each source will be required; however, it is not the intent of these specifications to limit the number of sources the Contractor may choose to use.

The "Aggregate Freeze-Thaw Loss" shall not exceed 15 percent.

The aggregate used in this item shall not be introduced into the mixing unit at a temperature in excess of the application and mixing temperature of the asphalt specified in the Item "Asphalts, Oils, and Emulsions".

Mixing Plant - The mineral aggregate will be proportioned separately through bins onto individually controlled variable speed feed belts or other approved methods.

Moisture Content - The moisture content of the completed mix will not exceed one-half of one percent when tested immediately after mixing.

All truck beds will be covered if deemed necessary by the Engineer.

PREPARATION OF THE TEST SPECIMEN SHALL BE MODIFIED AS FOLLOWS:

Molding Hveem Specimen (Tex-206-F)

Gyration shall be continued until one stroke of the pump will produce a pressure of 50 psi.

After gyration is completed, the final applied load will be 1500 psi.

Determination of Specific Gravity of Compacted Bituminuous Mixture (Tex-207-F)

The circumference and the height of the molded Hveem specimen shall be measured. The circumference will be measured to the nearest 0.01 inch and the height will be measured to the nearest 0.001 inch.

F. R. DIV. 6	TEXAS	IHS 000S(79)	SHEET 5
Kaufman	COUNTY	US HWY. 175	CONT. 197-4-43, etc.

NERAL NOTES AND SPECIFICATION DATA:

The volume of the Hveem specimen shall be calculated:

Volume = (Circumference)^2 (Height) (1.304) Cubic Centimeters

Asphaltic concrete pavement shall be laid in accordance with Item 501, "Automatic Screed Controls for Asphalt Concrete Spreading and Finishing Machines", unless otherwise directed by the Engineer.

No asphaltic material or asphaltic concrete pavement shall be placed between November 1 and April 1, except by written permission of the Engineer.

Transverse joints shall be staggered so they fall at least 12" from the adjacent joint.

Laydown operations shall be performed in such sequence that the adjacent lane width will be carried along without excessive distance of lapback, not to exceed one day's operations.

Laydown operations shall be conducted in such sequence that vehicles transporting asphaltic concrete material to this project will not travel over the completed pavement until said pavement shall have been in place for a minimum of twenty-four hours, unless otherwise directed by the Engineer.

The required mixing, placing, and compacting of asphalt pavement shall be completed during daylight hours.

For this project the density and stability requirements of this specification are voided.

SPECIAL SPECIFICATION

ITEM 3041

PLANT-MIX FRICTION COURSE

1. DESCRIPTION

This item shall consist of a wearing surface composed of a compacted mixture of mineral aggregate and asphaltic material, constructed on prepared bases or surface in accordance with these specifications and to the dimensions as shown on the plans.

2. MATERIALS

(1) Asphaltic Materials

(a) Plant-Mix Friction-Course Asphaltic Material shall be asphalt cement and shall meet the requirements of the Item "Asphalts, Oils, and Emulsions". The grade of asphalt used shall be as designated by the Engineer after the design tests have been made using the mineral aggregates that are to be used in the project. The Contractor shall notify the Engineer of the source of his asphaltic material prior to design or production of the surfacing mixture and this source shall not be changed during the course of the project, except on written permission by the Engineer.

(b) The asphaltic material for tack coat shall be determined by the Engineer and shall meet the requirements for emulsified asphalt EA-11 M, or cutback asphalt RC-2. The Engineer may, at his discretion, direct the Contractor to change tack coat materials. Asphaltic materials shall meet the requirements of the Item, "Asphalts, Oils, and Emulsions".

(2) Mineral Aggregate

(a) Description. The mineral aggregate shall be synthetic aggregate composed predominantly of cellular and granular inorganic material produced by fusing raw shale or clay in a rotary kiln under intense heat into predominantly amorphous silicate.

Aggregate shall meet the following requirements: The dry loose unit weight shall be at least 35 pounds per cubic foot when tested in accordance with Test Method Tex-404-A. When shown on the plans the "Aggregate Freeze-Thaw Loss" shall not exceed the percentage shown on the plans when tested in accordance with Test Method Tex-432-A. The "Pressure

Slaking Value" shall not exceed 6 percent when tested in accordance with Test Method Tex-431-A, tentative. If the unit weight of any shipment of synthetic aggregate differs by more than 5 pounds per cubic foot from that of the sample submitted for acceptance tests, the aggregate in that shipment may be rejected.

Aggregate used in the surface or finish course shall have "Polish Value" of not less than 37, unless otherwise indicated on the plans, when subjected to tests as specified in Test Method Tex-438-A. Aggregate from each source shall meet the "Polish Value" test requirement.

(b) Grades. When tested by Test Method Tex-200-F, Part I, the mineral aggregate shall conform to the following gradation limits.

Grade 4:

Sieve Size	Volumetric Percent
Passing 3/8" Sieve	100
Passing #4 Sieve	30-50
Passing #10 Sieve	5-15
Passing #200 Sieve	2-5

Grade 6: As shown on plans

(c) Sampling and Testing. It is the intent of this specification to produce a mixture which when designed and tested in accordance with these specifications and methods outlined in THD Bulletin C-14, will have the following laboratory density and stability unless otherwise shown on the plans.

Density, Percent			Stability, Percent
Min	Max	Optimum	30 Minimum
80	90	85	

Stability and density are control tests. If the laboratory stability and/or density of the mixture produced has a value lower than that specified, and in the opinion of the Engineer is not due to change in source or quality of materials, production may proceed, and the mix shall be changed until the laboratory stability and density falls within the specified limits and as near the optimum value as is practicable. If there is, in the opinion of the Engineer, a fundamental change in any material from that used in the design mixtures, production will be discontinued until a new design mixture is determined by trial mixes. It is the intent of this specification that the mixture will be designed to produce a mixture of optimum density.

3. SURFACING MIXTURE

(1) General. The mixture shall be uniform and consist of mineral aggregate and asphaltic material. The limits of asphalt contained in the mix will be determined by the Engineer.

(2) The completed mix after compaction shall have a minimum air void content of 15%.

4. EQUIPMENT

(1) Mixing Plants. Mixing plants that will not continuously meet all the requirements of this specification shall be condemned.

Mixing plants may be either the weight-batching type or the continuous mixing type. Both types of plants shall be equipped with satisfactory conveyors, power units, aggregate handling equipment, aggregate screens and bins and dust collectors and shall consist of the following essential pieces of equipment:

(a) Weight-Batching Type.

Cold Aggregate Bin and Proportioning Device. The cold aggregate bins or aggregate stockpiles shall be of sufficient number and size to supply the amount of aggregate required to keep the plant in continuous operation. The proportioning device shall be such as will provide a uniform and continuous flow of aggregate in the desired proportion to the plant.

Dryer. The dryer shall be of the type that continually agitates the aggregate during heating and in which the temperature can be so controlled that aggregate will not be injured in the necessary drying and heating operations required to obtain a mixture of the specified temperature.

The burner, or combination of burners, and type of fuel used shall be such that in the process of heating the aggregate to the desired or specified temperatures, no residue from the fuel shall adhere to the heated aggregate. A recording thermometer shall be provided which will record the temperature of the aggregate when it leaves the dryer. The dryer shall be of sufficient size to keep the plant in continuous operation.

Screening and Proportioning. The screening capacity and size of the bins shall be sufficient to screen and store the amount of aggregate required to properly operate the plant and keep the plant in continuous operation at full capacity. Proper provisions shall be made to enable inspection forces to have easy and safe access to the proper location on the mixing plant where accurate representative samples of aggregate may be taken from the bins for testing. **The aggregate shall be separated into at least 3 bins.**

Aggregate Weigh Box and Batching Scales. The aggregate weigh box and batching scales shall be of sufficient capacity to hold and weigh a complete batch of aggregate. The weigh box and scales shall conform to the requirements of the Item, "Weighing and Measuring Equipment".

Asphaltic Material Bucket and Scales. The asphaltic material bucket and scales shall be of sufficient capacity to hold and weigh the necessary asphaltic material for one batch. If the material is measured by weight, the bucket and scales shall conform to the requirements of the Item "Weighing and Measuring Equipment".

If a pressure type flow meter is used to measure the asphaltic material, the requirements of the Item, "Weighing and Measuring Equipment" shall apply.

Mixer. The mixer shall be of the pug mill type and shall have a capacity of not less than 20 cubic feet unless otherwise shown on the plans. The number of blades and the position of same shall be such as to give a uniform and complete circulation of the batch in the mixer. The mixer shall be equipped with an approved spray bar that will distribute the asphaltic material quickly and uniformly throughout the mixer. Any mixer that has a tendency to segregate the mineral aggregate or fails to secure a thorough and uniform mixing with the asphaltic material shall not be used. This shall be determined by mixing the standard batch for the required time, then dumping the mixture and taking samples from its different parts. This will be tested by the extraction test and must show that the batch is uniform throughout. All mixers shall be provided with an automatic time lock that will lock the discharge doors of the mixer for the required mixing period. The dump door or doors and the shaft seals of the mixer shall be tight enough to prevent spilling of aggregate or mixture from the pug mill.

(b) Continuous Mixing Type

Cold Aggregate Bin and Proportioning Device. Same as for weight-batching type of plant.

Dryer. Same as for weight-batching type of plant.

Screening and Proportioning. Same as for weight-batching type of plant.

Aggregate Proportioning Device. The hot aggregate proportioning device shall be so designed that when properly operated a uniform and continuous flow of aggregate into the mixer will be maintained.

Asphaltic Material Spray Bar. The asphaltic material spray bar shall be so designed that the asphalt will spray uniformly and continuously into the mixer.

Asphaltic Material Meter. An accurate asphaltic material recording meter shall be placed in the asphalt line leading to the spray bar so that the cumulative amount of asphalt used can be accurately determined. Provisions of a permanent nature shall be made for checking the accuracy of the meter output. The asphalt meter and line to the meter shall be protected with a jacket of hot oil or other approved means to maintain the temperature of the line and meter near the temperature specified for the asphaltic material.

If a pressure type flow meter is used to measure the asphaltic material, the requirements of the Item "Weighing and Measuring Equipment" shall apply.

Mixer. The mixer shall be of the pug mill continuous type and shall have a capacity of not less than 40 tons of mixture per hour. Any mixer that has a tendency to segregate the aggregate or fails to secure a thorough and uniform mixing of the aggregate with the asphaltic material shall not be used. The dam gate at the discharge end of the pug mill and/or pitch of the mixing paddles shall be so adjusted to maintain a level of mixture in the pug mixer between the paddle shaft and the paddle tips (except at the discharge end).

Truck Scales. A set of standard platform truck scales, conforming to the Item, "Weighing and Measuring Equipment", shall be placed at a location approved by the Engineer.

(2) Asphaltic Material Heating Equipment. Asphaltic material heating equipment shall be adequate to heat the amount of asphaltic material required to the desired temperature. Asphaltic material may be heated by steam coils which shall be absolutely tight. Direct fire heating of asphaltic materi will be permitted, provided the heater used is manufactured by a reputable concern and there is positive circulation of the asphalt throughout the heater. Agitation with steam or air will not be permitted. The heating apparatus shall be equipped with a recording thermometer with a 24-hour chart that will record the temperature of the asphaltic material at the highest temperature.

(3) Spreading and Finishing Machine. The spreading and finishing machine shall be of a type approved by the Engineer, shall be capable of producing a surface that will meet the requirements of the typical cross section and a surface test, when required, and when the mixture is dumped directly into the finishing machine shall have adequate power to propel the delivery vehicles in a satisfactory manner. The finishing machine shall be equipped with a flexible spring and/or hydraulic type hitch sufficient in design and capacity to maintain contact between the rear wheels of the hauling equipment and the pusher rollers of the finishing machine while the mixture is being unloaded.

The use of any vehicle which requires dumping directly into the finishing machine and which the finishing machine cannot push or propel in such a manner as to obtain the desired lines and grades without resorting to hand finishing will not be allowed.

Automatic screed controls, if required, shall meet the requirements of the Item, "Automatic Screed Controls for Asphaltic Concrete Spreading and Finishing Machines".

(4) Pneumatic Tire Rollers. The rollers shall be acceptable medium pneumatic tire rollers conforming to the requirements of the Item "Rolling (Pneumatic Tire)", Type B unless otherwise specified on plans.

The tire pressure of each tire shall be adjusted as directed by the Engineer and this pressure shall not vary by more than 5 pounds per square inch.

(5) Two Axle Tandem Roller. This roller shall be an acceptable power driven tandem roller weighing not less than 8 tons.

(6) Three Wheel Roller. This roller shall be an acceptable power driven three wheel roller weighing not less than 10 tons.

(7) All equipment shall be maintained in good repair and operating condition and shall be approved by the Engineer.

(8) Alternate Equipment. When permitted by the Engineer in writing, equipment other than that specified which will consistently produce satisfactory results may be used.

5. STOCKPILING, STORAGE, PROPORTIONING AND MIXING.

(1) Aggregate Storage. If the mineral aggregates are stored or stockpiled, they shall be handled in such a manner as to prevent segregation, mixing of the various materials or sizes, and contamination with foreign materials. The grading of aggregates proposed for use and as supplied to the mixing plant shall be uniform. Suitable equipment of acceptable size shall be furnished by the Contractor to work the stockpiles and prevent segregation of the aggregates.

(2) Storage and Heating of Asphaltic Materials. The asphaltic material storage shall be ample to meet the requirements of the plant. Asphalt shall not be heated to a temperature in excess of that specified in the Item, "Asphalts, Oils and Emulsions". All equipment used in the storage and handling of asphaltic material shall be kept in a clean condition at all times and shall be operated in such manner that there will be no contamination with foreign matter.

(3) Feeding and Drying of Aggregate. The feeding of various sizes of aggregate to the dryer shall be done through the cold aggregate bin and proportioning device in such a manner that a uniform and constant flow of materials in the required proportions will be maintained. When specified on the plans, the cold aggregate bins shall be charged by use of a clamshell, dragline, shovel or front end loader. The aggregate shall be dried and heated to the temperature necessary to produce a mixture having the specified temperature.

(4) Proportioning. The proportioning of the various materials entering the asphaltic mixture shall be as directed by the Engineer and in accordance with these specifications. Aggregate shall be proportioned by weight using the weigh box and batching scales herein specified when the weight-batch type of plant is used and by volume using the hot aggregate proportioning device when the continuous mixer type of plant is used. The asphaltic material shall be proportioned by weight or by volume based on weight using the specified equipment.

(5) Mixing.

(a) Batch Type Mixer. In the charging of the weigh box and in the charging of the mixer from the weigh box, such methods or devices shall be used as are necessary to secure a uniform asphaltic mixture. In introducing the batch into the mixer, the mineral aggregate shall be introduced first; shall be mixed thoroughly for a period of 5 to 20 seconds, as directed, to uniformly distribute the various sizes throughout the batch before the asphaltic material is added; the asphaltic material shall then be added and the mixing continued for a total mixing period of not less than 30 seconds. This mixing period may be increased, if, in the opinion of the Engineer, the mixture is not uniform.

(b) Continuous Type Mixer. The amount of aggregate and asphaltic material entering the mixer and the rate of travel through the mixer shall be so coordinated that a uniform mixture of the specified grading and asphalt content will be produced. Checks on asphalt used shall be made at lease twice daily by comparing the asphalt used in ten loads of completed mix as shown on the asphalt recording meter and the design amount for these ten loads. The acceptable percent of variation between the asphalt used and the design amount will be as shown on the plans or as determined by the Engineer.

(c) The Mixture produced from each type of mixer shall not vary from the specified mixture by more than the tolerances herein specified.

(d) The Surfacing Mixture from each type of mixer shall be at a temperature between 200 F and 325 F when discharged from the mixer. The Engineer will determine the temperature, within the above limitations, and the mixture when discharged from the mixer shall not vary from the selected temperature by more than 10 F.

6. CONSTRUCTION METHODS.

Tack coat and/or surfacing mixture may be placed when the temperature of the surface to be overlaid is 60 F or more, and the air temperature is above 50 F and rising, but shall not be placed when the air temperature is below 60 F and falling. The air temperature shall be taken in the shade away from artificial heat. All temperatures shall be measured as prescribed by the Engineer. It is further provided that the tack coat or surfacing mixture shall be placed only when the humidity, general weather conditions and moisture condition of the pavement surface, in the opinion of the Engineer, are suitable.

(1) Tack Coat. Before the surfacing mixture is laid, the surface upon which the tack coat is to be placed shall be cleaned thoroughly to the satisfaction of the Engineer. The surface shall be given a uniform application of tack coat using asphaltic materials of this specification. This tack coat shall be applied, as directed by the Engineer, with an approved sprayer at a rate not to exceed 0.10 gallon per square yard of surface. Where the mixture will adhere to the surface on which it is to be placed without the use of a tack coat, the tack coat may be eliminated by the Engineer. The tack coat shall be rolled with a pneumatic tire roller when directed by the Engineer.

(2) Transporting the Surfacing Mixture. The mixture, prepared as specified above, shall be hauled to the work in tight vehicles previously cleaned of all foreign material. The dispatching of vehicles shall be arranged so that all material delivered may be placed, and all rolling shall be completed during daylight hours. In cool weather or for long hauls, canvas covers and insulating of the truck bodies may be required. The inside of the truck body may be given a light coating of oil, lime slurry or other material satisfactory to the Engineer, if necessary, to prevent the mixture from adhering to the body.

(3) Placing. The asphaltic mixture shall be dumped directly into the specified spreading and finishing machine and spread on the approved prepared surface in such a manner that, when properly compacted, the finished surface will be smooth and of uniform texture and density. The spreading and finishing machine shall be operated at a speed satisfactory to the Engineer. If, in the opinion of the Engineer, sporadic delivery of surfacing mixture adversely affects the quality of the work or unduly lengthens the time the traffic is restricted from full use of the through lanes laying operations shall cease and traffic shall be fully restored to the through lanes until acceptable methods of consistent delivery of the mix are provided by the Contractor. During application

of asphaltic material, care shall be taken to prevent splattering of adjacent pavement, curb and gutter and structures.

(4) Compacting. Prior to start of laying operations, the Contractor shall submit for approval by the Engineer, a proposed rolling procedure listing sequence, number of coverages, types and weights of rollers.

(a) As directed by the Engineer, the surface mixture shall be compressed thoroughly and uniformly with the specified rollers and/or other approved rollers.

(b) Immediately following placement of the asphaltic mixture, the surface shall be given complete rolling with a tandem or three wheel roller of such weight as to accomplish good density without excessive breakage of the mineral aggregate. Immediately following initial rolling, the entire surface will be rolled with the pneumatic-tire roller as directed by the Engineer. The motion of the rollers shall be slow enough at all times to avoid displacement of the mixture. If any displacement occurs, it shall be corrected at once by the use of rakes and of fresh mixture where required. To prevent adhesion of the surfacing mixture to the roller, the wheels shall be kept thoroughly moistened with a lime-water solution. Necessary precautions shall be taken to prevent the dropping of gasoline, oil, grease or other foreign matter on the pavement, either when the rollers are in operation or when standing.

7. MEASUREMENT

Asphaltic concrete will be measured separately by the ton of 2,000 pounds of "Asphalt" and by the cubic yard of laboratory-compacted "Aggregate" of the type actually used in the completed and accepted work in accordance with plans and specifications for the project. The volume of aggregate in the compacted mix shall be calculated from the measured weights of the asphaltic concrete by the following formula:

$$V = \frac{W}{62.4\ (27)G_a}$$

Where:
- V = Cubic yards of compacted aggregate
- W = Total weight of asphaltic-concrete mixture in pounds
- G_a = Average actual specific gravity of three molded specimens as prepared by Test Method Tex-206-F and determined in accordance with Test Method Tex-207-F.

The weight "W", if mixing is done by a continuous mixer, will be determined by truck scales. Weight, if mixing is done by a batch mixer, will be determined by batch scales and records of the number of batches, batch designs and weight of asphalt and aggregate shall be kept.

Where surge-storage is used, measurement of material taken from the surge-storage bin will be made on truck scales.

For the first day's production, the average actual specific gravity of specimens molded during laboratory design of the mix shall be used in the volume-computation formula. For each subsequent day's production, the average actual specific gravity of specimens molded from the previous day's production shall be used.

PAYMENT

(1) The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit prices bid for "Asphalt" and "Aggregate", of the types specified, which prices shall be full compensation for quarrying, furnishing all materials, freight involved; for all heating, mixing, hauling, cleaning the existing base course or pavement, tack coat, placing asphaltic concrete mixture, rolling and finishing; and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work except prime coat when required.

(2) The prime coat, performed where required, will be measured and paid for in accordance with the provisions governing the Item, "Prime Coat".

(3) All templates, straightedges, scales and other weighing and measuring devices necessary for the proper construction, measuring and checking of the work shall be furnished, operated and maintained by the Contractor at his expense.

ASPHALTIC CONCRETE BATCH DESIGN

ITEM 3041 TYPE Gr. 4
PLANT-MIX FRICTION COURSE

Highway No. US 175
Project No. HHS 000S(79) Control 197-4-43 Etc. Producer Jagoe-Public
Res. Engr. Albert B. Harlan County Kaufman Date Reported 8-10-76

Volumetric Design

Lab. No.	Materials	Producer	Pit	Sp. Gr.
18-76-1494	3/8"-1/4"(73%)Blend	Superock Inc.	Streetman, Texas	1.201
18-76-1593	4-10 (27%)	Superock Inc.	Streetman, Texas	1.286
18-76-1464	Screenings	Superock Inc.	Streetman, Texas	2.046
18-76-1465	Fly Ash	Trinity Division	Fairfield	2.650
	Asphalt AC-20	American Petrofina	Mt. Pleasant	1.035

Design % Vol. (3.0) (8.0) (89.0)

Sieve Sizes	Fly Ash		Lt. Wt. Scrs		Lt. Wt. Aggr.		Comb. Anal.	Design #18-76-1466	Design Tolerances (Hot Bins)
+ 3/8"					0	0	0	0	0
3/8" - #4			0	0	77.8	69.2	69.2	58.1	50-70
#4 - #10			9.2	0.7	21.9	19.5	20.2	16.9	
+10	0	0	9.2	0.7	99.7	88.7	89.4	75.0	85-95
#10 - #40	0	0	74.2	5.9	0.3	0.3	6.2	5.2	
#40 - #80	3.0	0.1	9.5	0.8	-	-	0.9	0.8	
#80 - #200	10.4	0.3	4.5	0.4	-	-	0.7	0.6	
- #200	86.6	2.6	2.6	0.2	-	-	2.8	2.3	2-5
Total %	100.0	3.0	100.0	8.0	100.0	89.0	100.0	83.9	
							Asph.=	16.1	

MOLDED SPECIMENS RESULTS

Modified Molding Procedure (50 psi End Gyration, 1500 psi applied load)

Asphalt Content Vol.	Asphalt Content Wt.	Actual Sp. Gr.	Theo. Sp. Gr.	% Density	Stability	Cohesio. Value
13.7	11.0	1.090	1.291	84.4	38	106
14.9	12.0	1.101	1.288	85.5	38	114
16.1	13.0	1.101	1.284	85.7	36	106
17.3	14.0	1.106	1.281	86.3	37	111
18.5	15.0	1.121	1.277	87.8	36	114

Design 18-76-1466

ASPHALTIC CONCRETE BATCH DESIGN

ITEM 3041 TYPE Gr. 4
PLANT-MIX FRICTION COURSE

Highway No. US 175
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Lab. No.	Materials	Weight Design Producer	Pit	Sp. Gr.
18-76-1494	3/8"-1/4"(73%)Blend	Superock Inc.	Streetman, Texas	1.201
18-76-1593	4-10 (27%)	Superock Inc.	Streetman, Texas	1.286
18-76-1464	Screenings	Superock Inc.	Streetman, Texas	2.046
18-76-1465	Fly Ash	Trinity Division	Fairfield	2.650
	Asphalt AC-20	American Petrofina	Mt. Pleasant	1.035

Design % Wt. (6.0) (12.3) (81.7)

Sieve Sizes	Fly Ash		Lt. Wt. Scrs		Lt. Wt. Aggr.		Comb. Anal.	Design #	Design Tolerances (Hot-Bins)
+ 3/8"					0	0	0	0	
3/8" - #4			0	0	76.9	62.8	62.8	54.6	44-64
#4 - #10			9.2	1.1	22.8	18.7	19.8	17.2	
+10	0	0	9.2	1.1	99.7	81.5	82.6	71.8	76-91
#10 - #40	0	0	74.2	9.1	0.3	0.2	9.3	8.1	
#40 - #80	3.0	0.2	9.5	1.2	-	-	1.4	1.2	
#80 - #200	10.4	0.6	4.5	0.6	-	-	1.2	1.1	
- #200	86.6	5.2	2.6	0.3	-	-	5.5	4.8	4-9
Total %	100.0	6.0	100.0	12.3	100.0	81.7	100.0	87.0	
							Asph.=	13.0	

MOLDED SPECIMENS RESULTS

Modified Molding Procedure (50 psi End Gyration, 1500 psi applied load)

Asphalt Content	Actual Sp. Gr.	Theo. Sp. Gr.	% Density	Stability	Cohesio. Value
11.0	1.090	1.291	84.4		
12.0	1.101	1.288	85.5		
13.0	1.101	1.284	85.7		
14.0	1.106	1.281	86.3		
15.0	1.121	1.277	87.8		

Vol. 22 SKID RESISTANCE REPORT 1 DATE 09-29-76

District..18, CSN..5017511 - Detail Test Listing
Kaufman County
US 175 South East Bound
Kaufman Southeast City Limits to Henderson County Line

CONSTANTS THIS TEST - (1) TESTED ON 9/21/76 (3) AIR TEMPERATURE AT TEST WAS 79 DEGREES F.
(2) USING TRUCK NO. 42 (4) TRAVELING ***WITH*** THE FROM/TO DESCRIPTION

WARNING - THIS TEST ALONE IS INSUFFICIENT TO ESTABLISH THE SAFE FRICTION VALUE FOR A HIGHWAY

TEST & LANE	SPEED	CUMM. MILES	SN *** A	B	C	D	F & OVER ***	FLUSH	PATCH	INTER-SECT.	STRUC-TURE	R.R. XING	CURVE	CITY LIMIT	DIST. SELECT
1-A	40	0.0	46 *** 46				***								
2-A	42	0.2	** *** **				***					**(Southern Pacific)			
3-A	39	0.5	52 *** 52				***								
4-A	40	1.0	49 *** 49				***								
5-A	39	1.5	49 *** 49				***								
6-A	39	2.0	46 *** 46				***								
7-A	40	2.5	48 *** 48				***								
8-A	39	3.0	47 *** 47				***								
9-A	39	3.5	50 *** 50				***								
10-A	39	4.0	50 *** 50				***								
11-A	39	4.5	48 *** 48				***								
12-A	39	5.0	48 *** 48				***								
13-A	39	5.5	49 *** 49				***								
14-A	39	6.0	47 *** 47				***								
15A	41	6.1	** *** **				***			** (FM 2860)					
16A	39	6.5	51 *** 51				***								
17-A	39	7.0	52 *** 52				***								
18-A	40	7.5	49 *** 49				***								
19-A	39	8.0	49 *** 49				***								
20-A	39	8.5	51 *** 51				***								
21-A	39	9.0	50 *** 50				***								
22-A	40	9.5	51 *** 51				***								
23-A	41	9.9	** *** **				***			** (FM 1895)					
24-A	40	10.0	44 *** 44				***								
25-A	41	10.2	** *** **				***			** (FM 1391)					
26-A	38	10.5	49 *** 49				***								
27-A	41	10.7	** *** **				***			** (SH 274)					
28-A	39	11.0	49 *** 49				***								
29-A	39	11.5	52 *** 52				***								
30-A	41	12.0	46 *** 46				***								
31-A	43	12.5	48 *** 48				***								

Vol. 22

DISTRICT..18, CSN..5017511 - DETAIL TEST LISTING SKID RESISTANCE REPORT 1 DATE 09/29/76 PAGE 20
(CONTINUATION OF RESULTS)

-- GENERAL SKID TEST DATA ---				*** SN BREAKDOWN BY LANE ***							SN BREAKDOWN BY COMMENT						
TEST & LANE	SPEED	CUMM. MILES	SN	***	A	B	C	D	E & OVER	*** FLUSH	PATCH	INTER-SECT.	STRUC-TURE	R.R. XING	CURVE	CITY LIMIT	DIST. SELECT
32-A	39	13.0	48	***	48					***			48 (Cedar Creek Fork)				
33-A	39	13.4	49	***	49					***				(Skid US 175 W.B. Lane)			49
34-A	49	13.5	49	***	49					***							
35-A	39	14.0	38	***	38					***							
36-A	39	14.5	48	***	48					***							
37-A	39	15.0	49	***	49					***							
38-A	41	15.3	**	***	**					***			(Cedar Creek Country Club Road Exit)				**
39-A	41	15.5	49	***	49					***							
40-A	39	16.0	48	***	48					***							
41-A	39	16.5	51	***	51					***							
42-A	39	17.0	48	***	48					***							
43-A	39	17.5	56	***	56					***							
44-A	40	18.0	47	***	47					***							
45-A	40	18.5	44	***	44					***							
46-A	39	19.0	47	***	47					***							
47-A	39	19.2	44	***	44					***							
48-A	40	19.3	**	***	**					***		** (FM 90 & SH 198)					
49-A	38	19.5	45	***	45					***							
50-A	38	20.0	49	***	49					***							
51-A	39	20.4	48	***	48					***							48
52-A	40	20.4	**	***	**					***							**
NUMBER OF TESTS....	44			***	44					***			1				2
SKID NUMBER - LO...	38			***	38					***			48				48
SKID NUMBER - AVG..	48			***	48					***			48				49
SKID NUMBER - HI...	56			***	56					***			48				49