TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
503-1F		

4. Title and Subtitle	5. Report Date
LIGHTWEIGHT HOT-MIX, COLD-LAID MAINTENANCE MIXTURE	December, 1972
	6. Performing Organization Code
7. Author(s) Harrison D. Swilley, Bob M. Gallaway and Jon A. Epps	8. Performing Organization Report No. Research Report 503-1F
9. Performing Organization Name and Address Texas Transportation Institute Texas A&M University College Station, Texas 77843	10. Work Unit No.
	11. Contract or Grant No. Research Study 2-18-71-503
	13. Type of Report and Period Covered Final-January 1972 December 1972
12. Sponsoring Agency Name and Address Texas Highway Department 11th and Brazos Austin, Texas 78701	14. Sponsoring Agency Code

15. Supplementary Notes Research performed in cooperation with the U. S. Department of Transportation, Federal Highway Administration

16. Abstract

Laboratory and field properties of lightweight hot-mix, cold-laid maintenance mixtures are presented. Information collected indicates that conventional mixing, storage and placing operations can be utilized to prepare and place these mixtures. Adequate and prolonged skid resistance is indicated for properly designed mixtures.

17. Key Words	18. Distribution Statement
Maintenance mixtures, mixture design, lightweight aggregates, performance	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	41	

Form DOT F 1700.7 (8-69)

LIGHTWEIGHT HOT-MIX, COLD-LAID MAINTENANCE MIXTURE

by

Harrison D. Swilley, Bob M. Gallaway and Jon A. Epps

Research Report 503-1F

Maintenance Materials for High Friction Pavements-Implementation

Research Study No. 2-18-71-503

Sponsored by
The Texas Highway Department
In Cooperation with the
U. S. Department of Transportation
Federal Highway Administration

December 1972

TEXAS TRANSPORTATION INSTITUTE
Texas A&M University
College Station, Texas

HARRISON D. SWILLEY

DEDICATION

This report is dedicated to Harrison D. Swilley, Supervising Laboratory Engineer, Texas Highway Department, District 2, Fort Worth, Texas in recognition of his sincere concern for the safety of his fellow man.

Harrison D. Swilley was born in Houston, Texas, August 30, 1919. He graduated from Texas A&M University in 1957 with a B. S. degree in Civil Engineering. He had a total of 21 years of service with the Texas Highway Department, seven years in Brownwood and 14 years in Ft. Worth. His last eight years of service were in active charge of the District 2 laboratory where he became concerned with the development of skid resistant overlays for bridge decks. It was in this area that Mr. Swilley made his vital contribution to improved highway safety.

This work began in 1965 and continued until his untimely death on January 10, 1972. He developed a lightweight asphaltic concrete mix which is highly effective for repair of old concrete pavements and bridge decks for improved resistance to the polishing action of traffic, freeze-thaw cycles, and deicing salts. The concept has been widely used in the Fort Worth district and is being adopted by other Texas Highway Department districts to great advantage.

Mr. Swilley's innovative efforts have resulted in improved highway safety with untold savings in lives and property. He practiced the Professional Engineer's Creed and had as his major goal that part of the creed which states

> To place service before profit, the honor and standing of the profession before personal advantage, and the public welfare above all other considerations.

PREFACE

This is the final report issued for Research Study No. 2-18-71-503, "Maintenance Materials for High Friction Pavements-Implementation." This report presents both laboratory and field data defining the behavior of certain lightweight hot-mix cold-laid maintenance materials.

DISCLAIMER

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

ACKNOWLEDGEMENTS

The authors wish to express their appreciation to Texas Highway Department personnel in Districts 2, 17, and 18 as well as representatives of the Maintenance Division for their time and efforts expended in performing the necessary laboratory and field tests to evaluate these maintenance mixtures. In addition, the authors appreciate the use of its field mixing facilities of Young Brothers, in Bryan, Texas, Gifford-Hill, Inc. in Bridgeport, Texas, Texoline Co., U. S. Rubber Reclaiming Co., Vicksburg, Mississippi, and Texas Industries who in part supplied materials utilized in this project.

ABSTRACT

Laboratory and field properties of lightweight hot-mix, cold-laid maintenance mixtures are presented. Information collected indicates that conventional mixing, storage and placing operations can be utilized to prepare and place these mixtures. Adequate and prolonged skid resistance is indicated for properly designed mixtures.

KEY WORDS: Maintenance mixtures, mixture design, lightweight aggregates, performance.

SUMMARY

Based on the laboratory and field data collected in this project and reported herein the following summary statements are warranted:

1. Design and field mixing procedures are available for the preparation of lightweight hot-mix cold-laid maintenance materials. These mixtures should be designed on a volume basis.

2. Mixture specifications have been prepared for lightweight hot-mix, cold-laid maintenance materials.

3. Conventional field storage and placing techniques can be utilized for lightweight hot-mix, cold-laid maintenance materials.

4. Stockpile storage properties and roadway workability characteristics are equal to or superior to normal weight hot-mix, cold-laid mixtures.

5. Skid resistance properties of properly designed lightweight hot-mix, cold-laid maintenance mixtures appear to be superior to most normal weight mixtures utilized in maintenance operations.

6. Mixtures graded to type DD or type FF as designated in the enclosed specification are preferred by field maintenance forces. Primer and water contents of the order of 1.5 percent based on dry weight of aggregate together with asphalts in the 200 to 300 penetration range provide adequate stockpiling and workability characteristics under most conditions. Use of softer asphalts and additional primer should be considered for use at temperatures below freezing.

IMPLEMENTATION STATEMENT

Implementation of the findings of this research began early in the study in the Fort Worth District of the Texas Highway Department. Modifications of the ideas researched in the study have been introduced and practiced in the Dallas, Waco, and Austin Districts of THD.

The use of latex rubber in bituminous binders has also been initiated in the Abilene, Lubbock, and Pharr Districts with marked success. The use of latex in asphalt emulsions is serving two definite purposes, namely improved bond tenacity and practical elimination of the pollution problems associated with the use of cutbacks containing volatile petroleum additives. Conservation of petroleum products also helps minimize the fuel shortage.

The economic advantages of mixtures that will produce prolonged high skid resistance extends into the areas of reduced highway fatalities, injuries and property losses. The paving mixtures developed and service tested in this study have already demonstrated their value in this vital area.

TABLE OF CONTENTS

INTRODUCTION

To perform maintenance activities in an effective manner, engineering and maintenance personnel must develop a workable knowledge in areas of management, materials, equipment, design, and construction. In an attempt to add to this body of knowledge and thereby increase the effectiveness of certain maintenance activities the researchers developed a maintenance mixture containing a synthetic lightweight aggregate. The developed mixture can be mixed at an elevated temperature in a batch or continuous plant and is designed to be placed after the mixture has cooled.

The benefits of lightweight aggregates in bituminous surface courses are well established. Lightweight seal coats have been used in Texas since 1961 and hot mixes containing lightweight aggregates since 1965. The results of this usage indicate that prolonged high skid resistance can be obtained with these materials.

The development of lightweight hot-mix, cold-laid maintenance mixtures has been effected primarily by realizing the beneficial skid resistance properties of such mixtures. The need to minimize color contrast between maintenance patching materials and road surfaces constructed with synthetic aggregate mixtures is also a plus factor. The lightweight nature of the material reduces hauling costs and reduces the work necessary for placement.

Mixture design methods and field construction methods for bituminous mixtures that utilize lightweight aggregates and that are placed at elevated temperatures have been established and are reported (1, 2, 3). Laboratory hot-mix, cold-laid lightweight mixtures have been prepared in the laboratory and small field trials have been conducted as part of previous studies at the Texas Transportation Institute (4, 5). These studies served as guides for

the study reported herein.

Desirable properties of hot-mix, cold-laid or cold-mix, cold-laid mixtures are demanding and include such considerations as stockpile storage and workability, that is, the material must have characteristics such that it can be removed from the stockpile on cold winter days, can be worked in to place, compacted, and when so placed be resistant to loads imposed by traffic. Evidence exists which suggests that mixtures containing lightweight aggregates tolerate high bitumen contents while maintaining adequate stability (6). This observed behavior allows additional bitumen to be used in the mixture to improve workability without sacrificing stability. Additional requirements of this type of mixtures include initial and prolonged skid resistance, stable color, and prolonged durability.

This study has four objectives: i.e., 1) to determine the proper aggregate combination, asphalt content, primer content and water content to produce the desired mixture as described above, 2) to establish the field techniques necessary for the production and utilization of these materials by the Texas Highway Department on a day-to-day basis, 3) to observe the performance of these materials under field conditions in terms of their workability, durability and skid resistance, and 4) to develop specifications to define the materials that prove to be useful.

Review of data published in references 4 and 5 together with field evaluation of stockpiled mixtures and field installations of the materials allowed the selection of aggregate combinations and asphalt, primer and water contents for the initial field trials in District 17 on March 6, 1971.

Results of these field trials served as a basis for preparation of the mixtures in District 18 (Dallas) on August 27, 1971 and District 2 (Fort Worth) on September 1, 1971. Results of the three projects follow.

DISTRICT 17 MIXTURES

Three lightweight hot-mix, cold-laid maintenance mixtures were prepared at a hot-mix plant near Bryan, Texas on March 6, 1971. Four aggregates whose gradations and bulk specific gravity quantities are shown on Table 1 were blended in the proportions shown in Table 2. Extraction and aggregate gradation on the field mixed materials are shown in Table 3. An AC-10 asphalt cement, primer and water were utilized in the proportions shown in Table 2 to produce these mixtures. Mixing temperature ranged from 160 to 190°F.

Specifications for the asphalt and primer used in these mixtures can be found in reference 3 with primer referred to as "special precoat material", Item 300.2.9. Stability, cohesiometer and specific gravity values of laboratory compacted mixtures are shown in Table 4.

The above mentioned mixtures were placed as level-up patches on farm-to-market road 1687 immediately north of State Highway 21, in March of 1971. Bleeding in the wheel path of all three patches was apparent after one week of service and severe stability failures were noted in the patch placed at the intersection of FM 1687 and SH 21 within two months, making it necessary to remove the mixture (Figure 1). The hot-mix, cold-laid normal weight mixture placed at this location also displayed a similar type of distress due to the heavy truck traffic using the roadway.

A distinct odor of primer volatiles was noted in unstable areas

indicating that additional aeration of the mixtures during placement would be beneficial. Skid rests conducted on these sections indicated SN_{40} values in the 30 to 40 range for these over-asphalted mixes.

These materials were successfully used for small pot-hole type patches. Good workability on the roadway and easy removal from the stockpile was noted for all three mixtures. This type of use allowed adequate aeration and minimized the instability problem.

DISTRICT 18 MIXTURE

Materials used on August 27, 1971 at the Gifford-Hill, Bridgeport, Texas, plant to produce the hot-mix, cold-laid mixtures (mixture 18-1, 18-2) for District 18 are shown in Table 5. Mixture 18-3 was produced by Gifford-Hill on April 16, 1971. The gradation of the lightweight aggregates utilized was not available. Mixture design data, field extraction data and mixture property data are shown in Tables 6, 7, and 8, respectively. An OA-230 asphalt cement, primer and water were used in these mixtures that were prepared at 190°F.

Ground rubber, supplied by U. S. Rubber Reclaiming Company, was used in mixture 18-2. Gradation of this devulcanized rubber is shown in Table 9.

Patches made from these materials have been successfully placed in District 18 (Figure 2). No bleeding or shoving has been noticed to date. The materials were easily removed from the stockpiles at temperatures as low as 25°F. The gradation of the mixture was somewhat coarse for maintenance operations which often require featheredging and the use of thin lifts.

Mixtures containing rubber particles had no noticeable beneficial stockpiling, placing or performance characteristics over regular mixes, according to field maintenance personnel. For winter use in the northern part of Texas improvements in these mixtures would consist of softer asphalts such as OA-400 and/or the use of more primer to aid in removal from the stockpile at lower temperatures. The lightweight hot-mix, cold-laid mixtures appeared to have equal or better workability than mixes regularly used in this area.

DISTRICT 2 MIXTURES

Materials used on September 1, 1971, at the Texoline Company plant to produce hot-mix, cold-laid mixtures for District 2 are shown in Table 10 (7). Mixtures were designed by the Texas Highway Department District 2 laboratory. Stability and cohesiometer test results for laboratory prepared mixtures graded to Type DDD* are shown in Figure 3. Mixture design data, field extraction data and mixture property data for materials prepared in the field are shown in Tables 11, 12 and 13, respectively. An OA-230 asphalt cement, primer and water were used in these mixtures. Test sections of these materials were placed on U. S. Highway 180, 12 miles west of Weatherford, Texas, at the intersection with FM 113. In order to observe the storage properties of these materials, several batches (10-18 tons each) were placed in the Parker County maintenance section yard near Weatherford, Texas. Storage properties of the mixes were quite satisfactory.

The placing operation on the road, according to the maintenance personnel, was no different from handling, blading, and compacting normal

*Texas Highway Department designation.

mixtures without lightweight aggregates. A very satisfactory finish was obtained on all field sections.

Initial skid resistance data taken after six months of service indicate values in the 40 to 50 range as shown in Table 14. Based on data collected on hot-mix, hot-laid mixture, these values should increase or maintain this level of skid resistance for a prolonged period.

SPECIFICATIONS

Specifications for lightweight hot-mix cold-laid materials have been prepared based on the present specifications for hot-mix, cold-laid materials as set forth by the Texas Highway Department. These detailed specifications can be found in Appendix A.

REFERENCES

1. Gallaway, B. M. and W. T. Harper, "Final Report on the Use of Lightweight Aggregate in Flexible Pavements", Research Report 51-4F, Texas Transportation Institute, August, 1967.

2. Hargett, E. R., B. M. Gallaway, and W. W. Scott, Jr., "Synthetic Aggregates for Asphalt Concrete Mixes", Texas Transportation Institute, Research Report 110-1F, October, 1969.

3. _____, "1972 Standard Specifications for Construction of Highways, Streets and Bridges", Texas Highway Department, 1972.

4. Hargett, E. R., "A Study of Bituminous Surface Maintenance in Texas", Texas Transportation Institute, Research Report 129-1, August, 1968.

5. Hargett, E. R., "A Study of Winter Maintenance of Bituminous Pavements in Texas", Texas Transportation Institute, Research 129-2F, April, 1970.

6. Epps, J. A. and B. M. Gallaway, "Materials and Mix Designs for Resurfacing Pavements and Maintaining Bridge Decks", Highway Research Board, Special Report 116, 1971.

7. Swilley, H. A. and G. A. Farley, "Report on the Use of Lightweight Synthetic Aggregates", Texas Highway Department, District 2 Report, 1971.

Figure 1

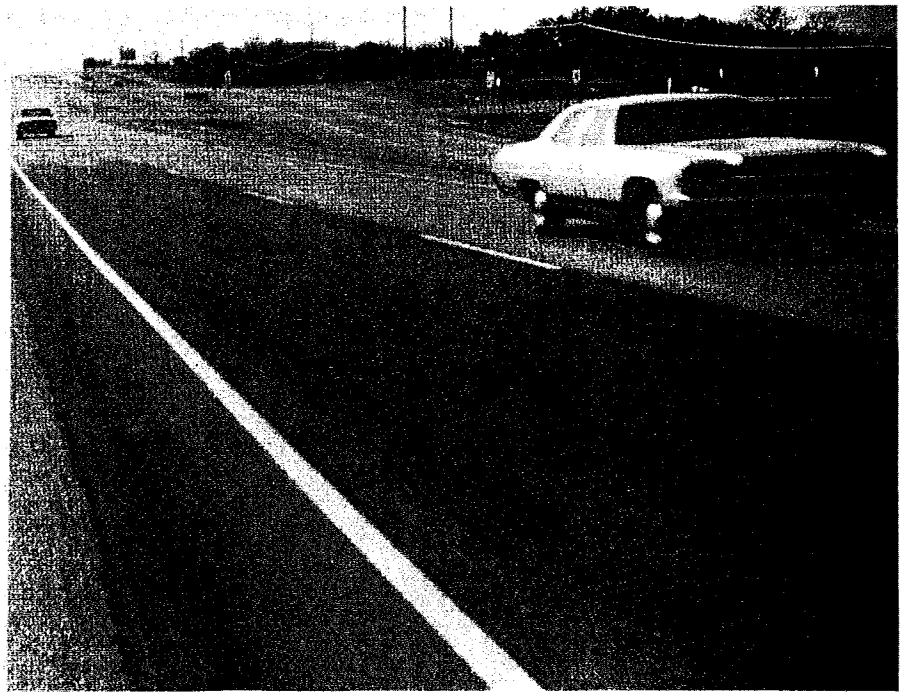

Figure 2

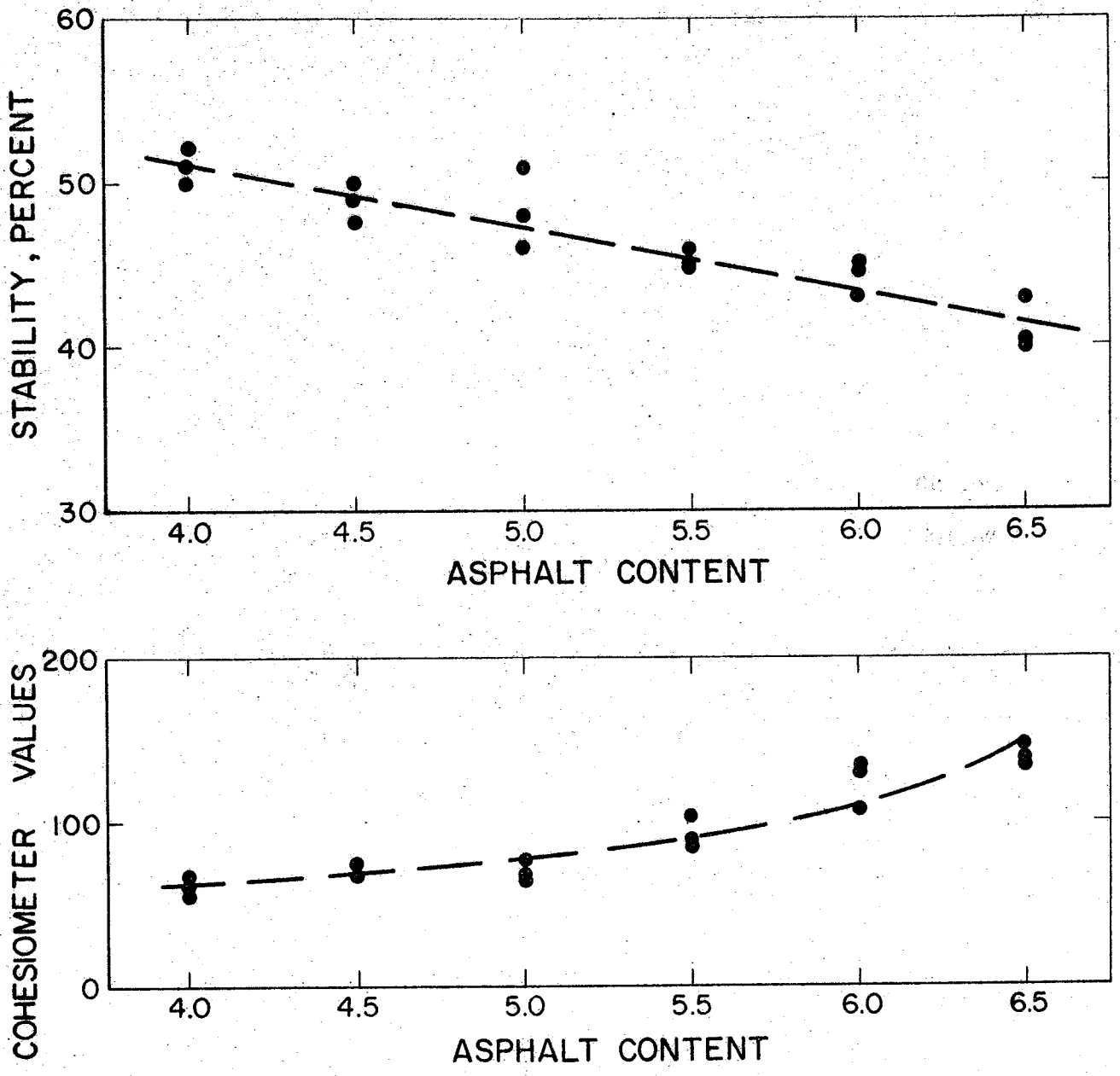

Figure 3. District 2--Laboratory Mixture Design Data(7).

TABLE 1. SIEVE ANALYSIS AND SPECIFIC GRAVITY FOR AGGREGATES UTILIZED IN DISTRICT 17

Sieve Size	ACCUMULATIVE PERCENT PASSING, BY WEIGHT			
	Lightweight A	Lightweight B	Limestone Screenings	Field Sand
5/8	100			
1/2	99	100		
3/8	96	99	100	
No. 4	29	65	99	100
No. 8	5	12	77	99.5
No. 16	2	3	62	99.1
No. 30	2	2	46	98.0
No. 50	0	0	34	81.0
No.100			26	33.6
No.200			20	7.5
Bulk Specific Gravity	1.58	1.72	2.69	2.65

Lightweight Aggregates from Aggregate Producer H.

TABLE 2. DISTRICT 17 LIGHTWEIGHT HOT-MIX, COLD-LAID MIXTURE DESIGN DATA

Material	MIXTURE DESIGNATIONS					
	17-1		17-2		17-3	
	MIXTURE QUANTITIES					
	By Volume	By Weight	By Volume	By Weight	By Volume	By Weight
Lightweight A	45	34	22.5	16		
Lightweight B			22.5	17	45	33
Limestone Screenings	45	54	45	55	45	55
Field Sand	10	12	10	12	10	12
Asphalt Cement* (AC-10)	--	7.9	--	8.5	--	8.5
Primer*	--	2.1	--	2.4	--	2,4
Water*	--	2.8	--	2.8	--	2.8

*Expressed as percent by dry weight of aggregate.

TABLE 3. FIELD EXTRACTION DATA DISTRICT 17

Sieve Size	ACCUMULATIVE PERCENT PASSING, BY WEIGHT MIXTURE DESIGNATION 17-1	17-2	17-3
1/2	100	100	100
3/8	99.5	98.7	99.5
No. 4	74.4	80.6	86.7
No.10	50.7	57.8	63.2
No.40	28.8	33.6	38.4
No.80	12.9	18.5	22.6
No.200	1.7	6.3	6.6
Percent Bituminous Material by Dry Weight of Aggregate *	6.95	7.1	7.65

*Performed according to Test Method TEX-210-F.

TABLE 4. MIXTURE PROPERTIES DISTRICT 17

Mixture Property*	Test Method No.	MIXTURE DESIGNATION 17-1	17-2	17-3
Hveem Stability	Tex-208-F	22,<u>21</u>	<u>26</u>	<u>19</u>
Hveem Cohesiometer Value	Tex-214-F	175	201	261
Laboratory Compacted Mixture Specific Gravity	Tex-207-F	1.92, <u>1.99</u>	1.94, <u>1.98</u>	2.04, <u>1.97</u>

Texas Transportation Values are underlined; Texas Highway Department's are not underlined.
*Mixtures taken immediately after field mixing.

TABLE 5. SIEVE ANALYSIS AND SPECIFIC GRAVITY FOR AGGREGATES UTILIZED IN DISTRICT 18

	ACCUMULATIVE PERCENT PASSING, BY WEIGHT			
Sieve Size	Lightweight C	Lightweight D	Limestone Screenings	Field Sand
1/2	100	100		
3/8	57	99.5	100	100
No. 4	0.3	98.1	99.5	99.8
No. 10		.3	86.4	99.4
No. 40			34.3	91.7
No. 80			21.6	34.7
No. 200			12.3	5.4
Bulk Specific Gravity	1.67*	1.67	2.66	2.62

Lightweight Aggregates from Aggregate Producer D.

*Specific gravity of 1.56 was used for mixture 18-3 produced in April 16, 1971.

TABLE 6. DISTRICT 18 LIGHTWEIGHT HOT-MIX, COLD-LAID MIXTURE DESIGN DATA

Material	MIXTURE DESIGNATIONS					
	18-1		18-2		18-3	
	MIXTURE QUANTITIES					
	By Volume	By Weight	By Volume	By Weight	By Volume***	By Weight
Lightweight Grade C	25	19	25	19	31	25
Lightweight Grade D	25	19	25	19	32	25
Limestone Screenings	30	37	30	37	17	23
Field Sand	20	25	20	25	20	27
Rubber Particles**		--		12		--
Asphalt Cement* (OA-230)		5.5		5.5		6.0
Primer*		1.5		1.5		1.3
Water*		1.7		1.7		1.8

*Expressed as percent by dry weight of aggregate.
**Expressed as percent and by weight of asphalt.
***Gradation of lightweight aggregate was not established for this mixture.

TABLE 7. FIELD EXTRACTION DATA DISTRICT

Sieve Size	ACCUMULATIVE PERCENT PASSING, BY WEIGHT MIXTURE DESIGNATION 18-1	18-2	18-3
1/2	100	100	
3/8	95	91	100
No. 4	75	72	70
No. 10	64	63	51
No. 40	39	36	36
No. 80	16	12	10
No. 200	6	5	2
Percent Bituminous Material by Dry Weight of Aggregates	7.3	7.0	7.3
Moisture Content, Percent	2.0	2.6	---

*Performed according to Test Method Tex-210-F.

TABLE 8. MIXTURE PROPERTIES DISTRICT 18*

Mixture Property	Test Method No.	MIXTURE DESIGNATION 18-1	18-2
Hveem Stability	Tex-208-F	39	30
Compacted Specific Gravity	Tex-207-F	1.96	1.99
Percent Air Voids		3.3	2.5

*Average results of three specimens.

TABLE 9. SIEVE ANALYSIS LIMITS FOR RUBBER ADDITIVE

Sieve Size	RANGE OF SIZE OF MATERIAL	
	Minimum, Percent	Maximum, Percent
Retained No. 4	0	Trace
No. 4-No. 8	8	15
No. 8-No. 12	8	35
No. 12-No. 20	13	31
No. 20-No. 32	13	19
Passing No. 32	24	34

TABLE 10. SIEVE ANALYSIS AND SPECIFIC GRAVITY FOR AGGREGATES UTILIZED IN DISTRICT 2

Sieve Size	ACCUMULATIVE PERCENT PASSING, BY WEIGHT			
	Lightweight E	Limestone Screenings	Crushed Limestone	Field Sand
1/2				
3/8	100	100	100	
4	82.4	99.7	85.5	100
10	2.3	76.3	6.8	99.9
40	.8	37.9	3.8	96.7
80	.7	25.2	3.3	37.6
200	.6	16.8	2.8	8.2
Bulk Specific Gravity	1.62	2.69	2.65	2.64

Lightweight aggregates from producer D.

TABLE 11. DISTRICT 2 LIGHTWEIGHT HOT-MIX, COLD-LAID MIXTURE DESIGN DATA

	MIXTURE DESIGNATIONS						
	2-1		2-2	2-3	2-4	2-5	2-6*
	MIXTURE QUANTITIES						
Material	By Volume	By Weight					
Lightweight E	22.2	14.8	Aggregates were used in the same proportions for all mixtures except mixture 2-6				
Limestone Screenings	27.8	30.8					
Crushed Limestone	22.2	24.2					
Field Sand	27.8	30.2					
Asphalt Cement (OA-230)		5.6	5.4	5.4	5.4	5.4	5.4
Primer		0.5	0.5	0.75	1.00	1.25	0.5
Water		1.5	1.5	1.5	1.5	1.5	1.5

*Type FFF Texas Highway Department Gradation.

TABLE 12. FIELD EXTRACTION DATA DISTRICT 2

Sieve Size	ACCUMULATIVE PERCENT PASSING, BY WEIGHT MIXTURE DESIGNATIONS 2-1	2-2	2-3	2-4	2-5	2-6
1/2						
3/8	100	100	100	100	100	100
No. 4	94.5	94.8	94.8	95.3	92.5	94.6
No. 10	51.5	52.0	53.3	51.8	47.9	31.9
No. 40	34.5	36.8	38.9	37.7	35.6	21.8
No. 80	17.6	17.6	18.8	18.2	18.4	11.1
No. 200	6.7	5.9	6.0	6.8	6.7	4.2
Percent Bituminous Material by Dry Weight of Aggregate*	5.4	5.4	5.1	5.4	5.3	5.4

TABLE 13. MIXTURE PROPERTIES DISTRICT 2

Mixture Property	Test Method No.	MIXTURE DESIGNATIONS 2-1	2-2	2-3	2-4	2-5	2-6
Hveem Stability	Tex-208-F	52	53	55	52	51	47
Hveem Cohesiometer	Tex-214-F	111	93	258	236	142	73
Density, Percent*	Tex-207-F	91.5	91.2	90.6	90.4	91.7	91.3

*Expressed as a percent of maximum theoretical density.

TABLE 14. SKID NUMBERS

Mixture Designations	SKID NUMBERS, SN_{40}	
	Average	Range
2-1	46	41-51
2-2	49	46-63
2-6	50	48-53

APPENDIX A

LIGHTWEIGHT HOT-MIX, COLD-LAID MIXTURE SPECIFICATIONS

TEXAS HIGHWAY DEPARTMENT

SPECIAL SPECIFICATION

TYPE L

HOT-MIX COLD-LAID ASPHALTIC-CONCRETE PAVEMENT
(Volumetric Design)

1. Description. This item shall consist of a leveling-up course, a surface course, or any combination of these courses, as shown on the plans, each to be composed of a compacted mixture of mineral aggregate and asphaltic material.

The pavement shall be constructed on the previously completed and approved subgrade, base, existing pavement, bituminous surface, or in the case of a bridge, on the prepared floor slab, as herein specified and in accordance with the detail shown on the plans.

2. Materials.

(1) Mineral Aggregate. The mineral aggregate shall be composed of a coarse aggregate, a fine aggregate, and if required, a mineral filler. Samples of coarse aggregate, fine aggregate, and mineral filler shall be submitted in accordance with the methods prescribed in the Item Control of Materials of the THD Standard Specifications 1972, and approval of both the material and the source of supply must be obtained from the Engineer prior to delivery.

The combined mineral aggregate, after final processing by the mixing plant and prior to addition of asphalt and mineral filler, shall have a sand equivalent value of not less than 45, unless otherwise shown on plans, when tested in accordance with Test Method Tex-203-F. Mineral aggregate from each source will meet the quality tests specified hereafter unless otherwise specified on the plans.

(a) Coarse Aggregate. The coarse aggregate shall be that part of the aggregate retained on a No. 10 sieve; shall consist of a mixture of clean, tough, durable fragments of stone, crushed blast furnace slag, crushed gravel, crushed limestone rock asphalt and synthetic aggregate (herein defined as aggregate produced by fusing raw shale or clay in a rotary kiln under intense heat into predominately amorphous silicate), or combinations thereof, as hereinafter specified, and of uniform quality throughout.

The combined coarse aggregate shall consist of not less than 60 percent by volume of synthetic aggregate as herein defined.

For all coarse aggregate, the amount of organic matter, clay, loam, or particles coated therewith, or other undesirable materials shown in the plans, when tested in accordance with Test Method Tex-217-F (Part I, Separation of Deleterious Material) shall not exceed 1 percent.

That portion of the coarse aggregate composed of synthetic aggregate shall meet the following requirements: The dry loose unit weight shall be at least 35 pounds per cubic foot, when tested in accordange with Test Method Tex-404-A. The "Aggregate Freeze-Thaw Loss" shall not exceed 15 percent when tested in accordance with Test Method Tex-432-A, Tentative. This requirement may be waived when, in the judgement of the Engineer, the asphaltic concrete will not become exposed to freezing and thawing. The "Pressure Slaking Value" shall not exceed 6 percent when tested in accordance with Test Method Tex-431-A, Tentative.

When it is specified that the coarse aggregate be sampled during delivery to the plant, from the stockpile, or from the cold bins, the material removed when tested in accordance with Test Method Tex-217-F (Part II, Decantation) shall not exceed 2 percent.

> The plasticity index of that part of the fine aggregate contained in the coarse aggregate passing the No. 40 sieve shall not be more than 6 when tested by Test Method Tex-106-E. However, where the coarse aggregate contains less than 5% of fine aggregate and the fine aggregate is of the same or similar material as the coarse aggregate, the P.I. requirement for the material passing the No. 40 sieve may be waived by the Engineer in writing.
>
> Where the fine aggregate in the coarse aggregate is the same or similar material as the coarse aggregate and the P.I. of the material passing the No. 40 sieve exceeds 6, the Contractor may if he so elects use the material, provided the material is processed in a manner satisfactory to the Engineer; and when the coarse aggregate is further sampled from the hot bins and tested in accordance with Test Method Tex-217-F (Part II, Decantation), the amount of material removed shall not exceed 1 percent. The material removed during the processing operation will be disposed of by the Contractor.

When it is specified that the coarse aggregate be sampled from the hot bins and tested in accordance with Test Method Tex-217-F (Part II, Decantation), the amount of material removed shall not exceed 1 percent. Where the fine aggregate in the coarse aggregate is the same or similar material as the coarse aggregate, the P.I. requirement for that part of the fine aggregate in the coarse aggregate passing the No. 40 sieve may be waived by the Engineer in writing.

The point of sampling for Test Method Tex-217-F (Part I and Part II) will be as shown on the plans.

Tests performed as specified herein shall represent material processed or placed until a subsequent test is performed.

The coarse aggregate shall have an abrasion of not more than 40 percent loss by weight, unless otherwise shown on plans, when subjected to the Los Angeles Abrasion Test, Test Method Tex-410-A, except for Type "F" (Non-skid Surface Course) and Type "K" (Differential Wear Surface Course).

The coarse aggregate for Type "F" shall have an abrasion of not more than 35 percent loss by weight when subjected to the Los Angeles Abrasion Test. If gravel is used for Type "F", it shall be so crushed that 90 percent of the particles retained on the No. 4 sieve shall have more than one crushed face, when tested in accordance with Test Method Tex-413-A (Particle Count).

The coarse aggregate for Type "K" shall be composed of two separate materials. One shall have an abrasion of not more than 30 percent and the other shall have an abrasion of not less than 35 percent and not more than 45 percent when subjected to the Los Angeles Abrasion Test. Also, the abrasion of the two different materials shall differ by at least 10 percent. The aggregates shall be combined in such a

manner that the total coarse aggregate including any coarse aggregate contained in the fine aggregate stockpile shall be a mixture of material, 45 to 55 percent (based on volume) of which will have a Los Angeles Abrasion loss of not more than 30 percent, and the remainder will have a Los Angeles Abrasion loss of not less than 30 percent and not more than 40 percent. If gravel is used for Type "K", it shall be so crushed that 90 percent of the particles retained on the No. 4 sieve shall have more than on crushed face.

The selected coarse aggregates supplied from two or more sources shall be tested for compliance with Los Angeles Abrasion requirements prior to being combined with other aggregates.

In addition to the above requirements the coarse aggregate used in the surface or finish course shall have a "Polish Value" of not less than 34 when subjected to tests as specified in the Special Provision "Accelerated Polish Test Method for Coarse Aggregate used in Pavement Surfaces". No "Polish Value" tests will be required for aggregate used in level-up courses. The "Polish Value" test is a quality test for approval of the source and not a job-control test.

(b) Fine Aggregate. The fine aggregate shall be that part of the aggregate passing the No. 10 sieve and shall consist of sand or screenings or a combination of sand and screenings.

Sand shall be composed of durable stone particles free from injurious foreign matter. Screenings shall be of the same or similar material as specified for coarse aggregate. The plasticity index of that part of the fine aggregate passing the No. 40 sieve shall be not more than 6 when tested by Test Method Tex-106-E. Fine aggregate from each source shall meet the P.I. requirement.

Where stone screenings are specified for use, the stone screenings shall meet the following grading requirements, unless otherwise shown on plans:

Passing the 3/8" sieve.....	100% by weight
Passing the No. 200 sieve.....	10- 30% by weight

When authorized by the Engineer, stone screenings containing particles larger than 3/8" may be used, but only that portion of the material passing the 3/8" sieve shall be considered as fulfilling the requirements for screenings when a minimum percentage of stone screenings is specified for a particular mixture.

Where limestone rock asphalt screenings are specified for use, they may be pit run.

(c) Mineral Filler. The mineral filler shall consist of thoroughly dry stone dust, slate dust, portland cement, fly ash, or other mineral dust approved by the Engineer. The mineral filler shall be free from foreign and other injurious matter.

When tested by Test Method Tex-200-F (Part I, Dry Sieve Analysis) it shall meet the following grading requirements, unless otherwise shown on plans:

Passing No. 30 sieve.....	95-100% by weight
Passing No. 80 sieve, not less than	75% by weight
Passing No. 200 sieve, not less than	55% by weight

(2) Asphaltic Material.

(a) Paving Mixture. Asphalt for the paving mixture shall be of the types of oil asphalt or asphaltic cement as determined by the Engineer and shall meet the requirements of the THD Item 300, "Asphalts, Oils and Emulsions".

The grade of asphalt used shall be as designated by the Engineer after design tests have been made using the mineral aggregates that are to be used in the project. If more than one type of asphaltic concrete mixture is specified for the project, only one grade of asphalt will be required for all types of mixtures, unless otherwise shown on plans. The Contractor shall notify the Engineer of the source of his asphaltic material prior to production of the asphaltic mixture and this source shall not be changed during the course of the project except on written permission of the Engineer.

(b) Tack Coat. The asphaltic material for tack coat shall meet the requirements for emulsified asphalt EA-11M, cut-back asphalt RC-2, or shall be a cut-back asphalt made by combining 50 to 70 percent by volume of the asphaltic material as specified for the type of paving mixture with 30 to 50 percent by volume of gasoline and/or kerosene. If RC-2 cut-back asphalt is used, it may upon instructions from the Engineer be diluted by the addition of an approved grade of gasoline and/or kerosene, not to exceed 15 percent by volume. Asphaltic materials shall meet the requirements of the Item, "Asphalts, Oils and Emulsions".

3. Paving Mixtures.

(1) Types. The paving mixtures shall consist of a uniform mixture of coarse aggregate, fine aggregate, and asphaltic material. The grading of each constituent of the mineral aggregate shall be such as to produce, when properly portioned, a mixture which, when tested in accordance with Test Method "Volumetric Sieve Analysis of Fine and Coarse Aggregate" will conform to the limitations for master grading given below for the type specified.

Type "C" (Coarse Graded Surface Course):	Percent by Absolute Volume
Passing 7/8" sieve	100
Passing 5/8" sieve	95 to 100
Passing 5/8" sieve, retained on 3/8" sieve	15 to 40
Passing 3/8" sieve, retained on No. 4 sieve	10 to 35
Passing No. 4 sieve, retained on No. 10 sieve	10 to 30
Total retained on No. 10 sieve	50 to 70
Passing No. 10 sieve, retained on No. 40 sieve	0 to 30
Passing No. 40 sieve, retained on No. 80 sieve	4 to 25
Passing No. 80 sieve, retained on No. 200 sieve	3 to 25
Passing No. 200 sieve	0 to 6

The asphaltic material shall form from 8 to 16 percent of the mixture by volume. (Absolute Volume)

Type "D" (Fine Graded Surface Course):

	Percent by Absolute Volume
Passing 1/2" sieve	100
Passing 3/8" sieve	95 to 100
Passing 3/8" sieve, retained on No. 4 sieve	20 to 50
Passing No. 4 sieve, retained on No. 10 sieve	10 to 30
Total retained on No. 10 sieve	55 to 70
Passing No. 10 sieve, retained on No. 40 sieve	0 to 30
Passing No. 40 sieve, retained on No. 80 sieve	4 to 25
Passing No. 80 sieve, retained on No. 200 sieve	3 to 25
Passing No. 200 sieve	0 to 8

The asphaltic material shall form from 9 to 19 percent of the mixture by volume. (Absolute Volume)

Type "FF" (Non-Skid Surface Course):

	Percent by Absolute Volume
Passing 3/8" sieve	100
Passing 1/4" sieve	95 to 100
Passing 1/4" sieve, retained on No. 10 sieve	55 to 70
Passing No. 10 sieve, retained on No. 40 sieve	0 to 25
Passing No. 40 sieve, retained on No. 80 sieve	3 to 12
Passing No. 80 sieve, retained on No. 200 sieve	2 to 10
Passing No. 200 sieve	0 to 6

The asphaltic material shall form from 8 to 15 percent of the mixture by volume. (Absolute Volume).

Type "KK" (Differential Wear Surface Course):

Passing 1/2" sieve	100
Passing 3/8" sieve	95 to 100
Passing 3/8" sieve, retained on No. 4 sieve	20 to 50
Passing No. 4 sieve, retained on No. 10 sieve	10 to 30
Total retained on No. 10 sieve	55 to 70
Passing No. 10 sieve, retained on No. 40 sieve	0 to 30
Passing No. 40 sieve, retained on No. 80 sieve	4 to 25
Passing No. 80 sieve, retained on No. 200 sieve	3 to 25
Passing No. 200 sieve	0 to 6

The asphaltic material shall form from 9 to 19 percent of the mixture by volume. (Absolute Volume)

Type "MM" (Requirements as shown on plans):

The specification requirements will be shown on the plans for the following:

Type of aggregate
Los Angeles Wear for coarse aggregate
Master grading and range of asphalt content
Density
Stability
Number of hot bins and gradation of aggregates in each bin

Master gradings for the types of mixtures listed above are based on the absolute volume of the aggregate particles within the various sieve sizes and absolute volume of the asphalt at 77 F.

The Engineer will make laboratory mix designs from samples of materials proposed for use by the Contractor. After an acceptable mixture meeting volumetric grading requirements is determined, the Engineer will furnish the Contractor with proportions of each material to be used based on weight.

(2) Tolerances. The Engineer shall designate the weight of each size of aggregate and weight of asphalt which will produce an acceptable mixture within master volumetric grading requirements.

The paving mixture produced shall not vary from the designated grading and asphalt content by more than the tolerances allowed herein and shall remain within the limitations of the master grading specified. The respective tolerances, based on the percent by volume of the mixture, are listed as follows:

	Percent by Absolute Volume
Passing 7/8" sieve, retained on 5/8" sieve.....	plus or minus 5
Passing 5/8" sieve, retained on 3/8" sieve.....	plus or minus 5
Passing 3.8" sieve, retained on No. 4 sieve.....	plus or minus 5
Passing 1/4" sieve, retained on No. 10 sieve.....	plus or minus 5
Passing No. 4 sieve, retained on No. 10 sieve.....	plus or minus 5
Total retained on No. 10 sieve.....	plus or minus 5
Passing No. 10 sieve, retained on No. 40 sieve.....	plus or minus 3
Passing No. 40 sieve, retained on No. 80 sieve.....	plus or minus 3
Passing No. 80 sieve, retained on No. 200 sieve.....	plus or minus 3
Passing No. 200 sieve.....	plus or minus 3
Asphalt Material.....	plus or minus 0.5

The type and amount of the mixture used shall be as specified on the plans.

Should the paving mixture produced vary from the designated grading and asphalt content by more than the above tolerances, proper changes are to be made until it is within these tolerances.

(3) Primer. The use of asphalt primer, when approved by the Engineer, will be permitted. In the event the asphalt primer is used, the hydrocarbon volatile content of the asphaltic concrete, as determined by Test Method-213-F, shall not exceed 0.6 percent of the mixture by weight. The asphalt content of the primer shall be included in the total asphalt content of the paving mixture, unless otherwise specified.

(4) Water. Water in an amount not to exceed 3 percent of the mixture by weight as determined by Test Method Tex-212-F may be used in preparing the mixture. In the event water is used in the mixing operation adequate measuring devices as approved by the Engineer shall be used, the water shall be administered to the mix through an approved spray bar.

(5) Physical Properties of the Mixture. The materials may be mixed on the job or at some central mixing plant and shipped ready for use. Mixtures that do not remain workable a sufficient period of time to permit proper spreading, blading and rolling will not be acceptable.

(6) Extraction Test. Samples of the mixture when tested in accordance with Test Method Tex-210-F shall not vary from the grading proportions of the aggregate and the asphalt content designated by the Engineer by more than the respective tolerances specified above. When limestone rock asphalt screening are used, the extraction requirements related to asphalt content are waived.

(7) 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:

	Density, Percent			
	Minimum	Maximum	Optimum	Stability, Percent
Types C, D, FF	93	96	95	Not less than 30 unless otherwise shown on plans

Stability and density tests 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 equals or exceeds the specified values. If there is, in the opinion of the Engineer, an apparent 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.

4. Equipment.

(1) Mixing Plants. Mixing plants that will not continuously produce a mixture meeting all of the requirements of this specification will 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, hot 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 aggregate bin shall have at least four compartments of sufficient size to store the amount of aggregate required to keep the plant in continuous operation and of proper design to prevent overflow of material of one bin to that of another bin. The proportioning device shall be such as will provide a uniform and continuous flow of aggregate in the desired proportion to the dryer. Each aggregate shall be proportioned in a separate compartment.

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 temperature, 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. Provisions shall be made to enable inspection forces to have easy and safe access to the proper location on the mixing plant where representative samples may be taken from the hot bins for testing. The aggregate shall be separated into at least three bins when producing Type "CC" and Type "KK" mixtures; and at least two bins when producing Type "EE and Type "FF" mixtures. If mineral filler is needed, an additional bin shall be provided. These bins shall contain the following sizes of aggregates which shall be used on "Percent by Volume" when synthetic aggregate is used and "Percent by Weight" when other aggregates are used:

Type "C" (Coarse Graded and Fine Surface Course):

Bin No. 1 ---will contain aggregates of which 85 to 100 percent will pass the No. 10 sieve.

Bin No. 2 ---will contain aggregates of which at least 70 percent will be of such size as to pass the No.4 sieve and be retained on the No. 10 sieve.

Bin No. 3 ---will contain aggregates of which at least 75 percent will be of such size as to pass the 3/8" sieve and be retained on the No.4 sieve.

Type "KK" (Differential Wear Surface Course):

Bin No. 1 ---will contain aggregates of which 85 to 100 percent will pass the No. 10 sieve.

Bin No. 2 ---will contain aggregates of which at least 70 percent will be of such size as to pass the 1/4" sieve and be retained on the No. 10 sieve.

Bin No. 3 ---will contain aggregates of which at least 75 percent will be of such size as to pass the 1/2" sieve and be retained on the 1/4" sieve.

Type "FF" (Non-skid Surface Course):

Bin No. 1 --- will contain aggregates of which 85 to 100 percent will pass the No. 10 sieve.

Bin No. 2 --- will contain aggregates of which at least 75 percent will be of such size as to pass the 3/8" sieve and be retained on the No. 10 sieve.

Aggregate Weight Box and Batching Scales. The aggregate weight box and batching scales shall be of sufficient capacity to hold and weigh a complete batch of aggregate. The weight 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 in a single batch. 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 the 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.

Hot 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 accumulative amount of asphalt used can be accurately determined. Provisions of a permanent nature shall be made for checking the accuracy of the meter output.

Mixer. The mixer shall be of the pug mill continuous type and shall have

a capacity of not less than 30 C.Y. of aggregate 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.

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 and 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 materials 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 when it is 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 the surface test when required; and shall have adequate power to propel the delivery vehicles in a satisfactory manner when the mixture is dumped into the finishing machine. 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

Any vehicle 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 to dump directly into the finishing machine. Vehicles of the semi-trailer type are specifically prohibited from dumping directly into the finishing machine. Vehicles dumping into the finishing machine shall be so designed and equipped that unloading into the finishing machine can be mechanically and/or automatically operated in such a manner that overloading the finishing machine being used cannot occur and the required lines and grades will be obtained without resorting to hand finishing.

Dumping of the asphaltic mixture in a windrow and then placing the mixture in the finishing machine with loading equipment will be permitted provided that the loading equipment is constructed and operated in such manner that substantially all of the mixture deposited on the roadbed is picked up and placed in the finishing machine without contamination by foreign material of the mixture. The loading equipment will be so designed and operated that the finishing machine being loaded will obtain the required line, grade, and surface without resorting to hand finishing. Any operation of the loading equipment resulting in the accumulation of material and the subsequent shedding of this material into the asphaltic mixture will not be permitted.

(4) Forms. The use of forms will not be required except where necessary to support the edges of the pavement during rolling. If the pavement will stand rolling without undue movement, binder twine or small rope may be used to align the edges.

(5) Motor Grader. The motor grader, if used, shall be a self-propelled power motor grader; it shall be equipped with smooth tread pneumatic tired wheels; shall have a blade length of not less than 12 feet; shall have a wheel base of not less than 16 feet; and shall be tight and in good operating condition and approved by the Engineer.

(6) Pneumatic Tire Rollers. The rollers shall be an acceptable medium pneumatic tire roller 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.

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

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

(9) Three Axle Tandem Roller. This roller shall be an acceptable power driven three axle roller weighing not less than 10 tons.

(10) Trench Roller. This roller shall be an acceptable power driven trench roller equipped with sprinkler for keeping the wheels wet and adjustable road wheel so that roller may be kept level during rolling. The drive wheel shall be not less than 20 inches wide.

The roller under working conditions shall produce 325 pounds per linear inch of roller width and be so geared that a speed of 1.8 miles per hour is obtained in low gear.

(11) Straightedges and Templates. When directed by the Engineer, the Contractor shall provide acceptable 10 foot straightedges for surface testing. Satisfactory templates shall be provided as required by the Engineer.

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

5. Stockpiling, Storage, Proportioning and Mixing.

(1) Stockpiling of Aggregates. Prior to stockpiling of aggregates, the area shall be cleaned of trash, weeds and grass and be relatively smooth. Aggregates shall be stockpiled in such a manner as to prevent mixing of one aggregate with another. Coarse aggregates for Type "C" shall be separated into at least two stockpiles of different gradation, such as a large coarse aggregate, and a small coarse aggregate stockpile and such that the grading requirements of the specified type will be met when the piles are combined in the asphaltic mixture.

Coarse aggregates for Type "KK" shall be separated into at least two stockpiles of different abrasion characteristics as herein specified. The two stockpiles may be of the same or similar gradation.

No coarse aggregate stockpile shall contain more than 20 percent by weight of material that will pass a No. 10 sieve except as noted on the plans or provided for by special provision. Fine aggregate stockpiles may contain small coarse aggregate in the amount of up to 30 percent by weight; however, the coarse aggregate shall meet the quality tests specified herein for "Coarse Aggregates". 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. Asphalts shall not be heated to a temperature in excess of 400 F. All equipment used in the storage and handling of asphaltic materials 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. The aggregate shall be dried and heated to the temperature necessary to produce a mixture having the specified temperature. In no case shall the aggregate be introduced into the mixing unit at a temperature of more than 400 F.

(4) Proportioning. The proportioning of the various materials entering into the asphaltic mixture shall be as directed by the Engineer 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, all 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.

(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 asphaltic mixture when placed cold shall be at a temperature between 145 F and 275 F when dumped from the mixer. The Engineer will determine the temperature within the above limitations that the mixture shall be produced.

The asphaltic mixture when placed hot shall be at a temperature between 225 F and 350 F when dumped from the mixer. The Engineer will determine the temperature within the above limitations and the mixture when dumped from the mixer shall not vary from this selected temperature more than 25 F.

6. Construction Methods. When mixture is to be placed cold, the prime coat, tack coat or the asphaltic mixture shall not be placed when the air temperature is below 60 F and is falling, but may be placed when the air temperature is above 50 F and rising.

When the mixture is to be placed hot, the prime coat, tack coat or the asphaltic mixture, when placed with a spreading and finishing machine, shall not be placed when the air temperature is below 50 F and is falling, but it may be placed when the air temperature is above 40 F and is rising. The asphaltic mixture, when placed with a motor grader, shall not be placed when the air temperature is below 60 F and is falling, but may be placed when the air temperature is above 50 F and is rising. The air temperature shall be taken in the shade away from artificial heat. It is further provided that the prime coat, tack coat or asphaltic mixture shall be placed only when the humidity, general weather conditions and temperature and moisture condition of the base, in the opinion of the Engineer, are suitable.

If, where the mixture is to be placed hot, the temperature of the asphaltic mixture of a load or any part of a load becomes 50 F or more less than the temperature selected by the Engineer under Article 5.(5) of this specification after being dumped from the mixer and prior to placing, all or any part of the load may be rejected and payment will not be made for the rejected material.

If the mixture is to be placed with a motor grader, the temperature loss will be based on the temperature of the mixture at the time windrowing of the dumped material with the motor grader is begun.

(1) Prime Coat. If a prime coat is required, it shall be applied and paid for as a separate item conforming to the requirements of the Item, "Prime Coat", except the air temperature at time of application shall be as provided above. The tack coat or asphaltic concrete shall not be applied on a previously primed flexible base until the primed base has completely cured to the satisfaction of the Engineer.

(2) Tack Coat. Before the asphaltic 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 under "Asphaltic Material" 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. All contact surfaces of curbs and structures and all joints shall be painted with a thin uniform coat of the asphaltic material used for the tack coat. The tack coat shall be rolled with a pneumatic tire roller as directed by the Engineer.

(3) Transporting Asphaltic Concrete. The asphaltic mixture, prepared as specified above, shall be hauled to the work in tight vehicles previously cleaned of all foreign material. The dispatching of the 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, if necessary, to prevent mixture from adhering to the body.

(4) Placing.

(a) Generally the asphaltic mixture shall be dumped and spread on the approved prepared surface with the specified spreading and finishing machine, in such manner that when properly compacted the finished pavement will be smooth, of uniform density and will meet the requirements of the typical cross sections and the surface tests. During the application of asphaltic material, care shall be taken to prevent splattering of adjacent pavement, curb and gutter and structures.

(b) In placing a level-up course with the spreading and finishing machine, the forms, binder twine or cord shall be set to line and grade established by the Engineer. When directed by the Engineer, level-up courses shall be spread with the specified motor grader.

(c) When the asphaltic mixture is placed in a narrow strip along the edge of an existing pavement, or used to level up small areas of an existing pavement or placed in small irregular areas where the use of a finishing machine is not practical, the finishing machine may be eliminated when authorized by the Engineer, provided a satisfactory surface can be obtained by other approved methods.

(d) Flush Structures. Adjacent to flush curbs, gutters, liners and structures, the surface shall be finished uniformly high so that when compacted, it will be slightly above the edge of the curb and flush structure.

(e) Curing Time. Where more than one course of pavement is to be placed and the material is to be laid cold, no succeeding course shall be placed until the preceding course has been in place for a sufficient period of time for the preceding course to dry and cure out. The drying and curing period shall be not less than 45 days in any case, unless a variation is authorized by the Engineer in writing.

(5) Compacting.

(a) As directed by the Engineer, the pavement shall be compressed thoroughly and uniformly with the specified rollers.

(b) Rolling with the three wheel and tandem rollers shall start longitudinally at the sides and proceed toward the center of the pavement, overlapping on successive trips by at least half the width of the rear wheels, unless otherwise directed by the Engineer. Alternate trips of the roller shall be slightly different in length. On super-elevated curves, rolling shall begin at the low side and progress toward the high side, unless otherwise directed by the Engineer. Rolling shall be continued until no further compression can be obtained and all roller marks are eliminated. One tandem roller, one pneumatic roller, and at least one three wheel roller, as specified above, shall be provided for each job. If the Contractor elects, he may substitute the three axle tandem roller for the two axle tandem roller and/or the three wheel roller; but in no case shall less than three rollers be in use on each job. Additional rollers shall be provided if needed. The motion of the roller 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. The roller shall not be allowed to stand on pavement which has not been fully compacted. To prevent adhesion of the surface mixture to the roller, the wheels shall be kept thoroughly moistened with water, but an excess of water will not be permitted. All rollers must be in good mechanical condition. 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.

(c) Hand Tamping. The edges of the pavement along curbs, headers and similar structures, and all places not accessible to the roller, or in such positions as will not allow thorough compaction with the roller, shall be thoroughly compacted with lightly oiled tamps.

(d) Rolling with the trench type roller will be required on widening areas in trenches and other limited areas where satisfactory compaction cannot be obtained with the three wheel and tandem rollers.

(6) Surface Tests. The surface of the pavement, after compression, shall be smooth and true to the established line, grade and cross section and, when tested with a 10 foot straightedge placed parallel to the centerline of the roadway or by other equivalent and acceptable methods, the maximum deviation shall not exceed 1/8-inch to 10 feet, except as provided herein, and any point in the surface not meeting this requirement shall be corrected as directed by the Engineer. When the pavement is placed on existing surfaces, the 1/8-inch deviation in 10 feet requirement may be waived by the Engineer.

(7) Opening to Traffic. The pavement shall be opened to traffic when directed by the Engineer. All construction traffic allowed on the pavement shall comply with the State laws governing traffic on highways.

7. Measurement.

(1) Asphaltic Concrete. 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:

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

V = Cubic Yards of compacted aggregate
W = Total weight of asphaltic concrete in pounds
Ga = 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.

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.

(2) Tack Coat. Tack coat will be measured at the point of application on the road in gallons at the applied temperature. When gasoline and/or kerosene is added to the cut-back asphalt for tack coat, as ordered, measurement will be made after mixing.

8. 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 each be full compensation for quarrying, furnishing all materials, freight involved; for all heating, mixing, hauling, cleaning of the existing base course or pavement, placing asphaltic concrete mixture, rolling and finishing; and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work, except tack coat and prime coat when required.

(2) The tack coat, measured as provided under "Measurement" will be paid for at the unit price bid for "Tack Coat", which price shall be full compensation for furnishing, preparing, hauling and placing the asphaltic materials of the grade used; and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work.

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

(4) 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.