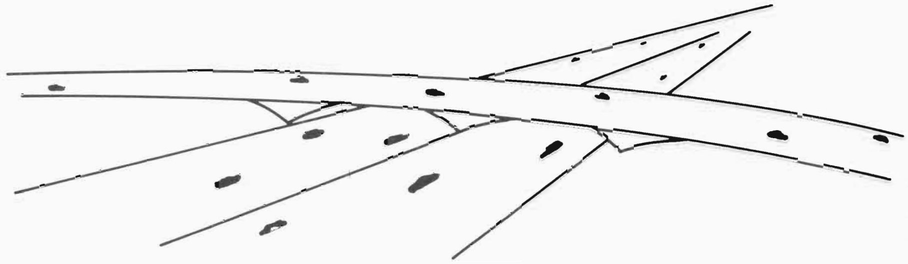

DEPARTMENTAL RESEARCH

Report Number: SS 15.4

VOLUMETRIC DESIGN OF ASPHALTIC CONCRETE PAVEMENT

TEXAS HIGHWAY DEPARTMENT

VOLUMETRIC DESIGN
OF ASPHALTIC CONCRETE
PAVEMENT

by

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Research Report SS 15.4
Texas Highway Department
District Seventeen

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VOLUMETRIC DESIGN OF ASPHALTIC CONCRETE PAVEMENT

Preface

"Design and Construction of Asphaltic Concrete Pavement Using Volumetric Design Specifications" was published in January, 1971, as Research Report SS 15.2.

General interest in volumetric design specifications has indicated a need for publishing additional data on the subject. This report incorporates all material contained in Research Report SS 15.2. Also, construction experience on the second contract project, completed subsequent to the initial report, is included. Skid test results of completed pavements are reported to give further data on pavement performance under traffic. The latest skid tests included in this report were made in July, 1971.

The portion of the report dealing with initial development of the volumetric design specification has been expanded. Curves illustrating the factors considered in specification development have been included in the text.

VOLUMETRIC DESIGN
OF ASPHALTIC CONCRETE
PAVEMENT

Abstract

Plans and specifications for two asphaltic concrete overlay projects in District Seventeen have been prepared on the basis of volumetric design of the paving mixture rather than the usual practice of weight design. The specifications also required a polish test for coarse aggregate. Both projects have been completed and the comments, observations, conclusions, and recommendations in this report are based on the experience gained during their construction. This report contains a description of the factors considered in preparation of the specifications, an analysis of bids received on the two projects, an evaluation of the use of the volumetric specification and a summary of skid testing of the completed pavements. Recommendations are also presented for future use of the volumetric design specification and polish test for aggregates.

VOLUMETRIC DESIGN OF ASPHALTIC CONCRETE PAVEMENT

Introduction

In District Seventeen, as in most other areas of the State, asphaltic concrete overlays have been used as a part of a continuing program of maintenance and improvement of the highway system. These overlays have proved to be effective in improving the riding surface, strengthening the pavement structure and extending the service life of the highway. In past years, most of the overlays in District Seventeen have been a fine graded asphaltic concrete with aggregates consisting of a combination of Rockdale slag aggregate and crushed stone screenings. This material has many advantages in that it is economical, provides a good riding surface, provides a good color and texture contrast with surfaced shoulders, has a good resistance to reflection cracking and has fairly good skid resistance. However, the fine texture of this pavement leads to problems of hydroplaning with even extremely thin films of water on the pavement surface. For this reason, modification of overlay practices to produce a pavement with better surface drainage characteristics and a somewhat more open texture to minimize hydroplaning appears to be worthy of consideration.

This report covers two contracts for asphaltic concrete overlays in District Seventeen. These projects were authorized under the

1969 State Highway Safety and Betterment Program and the 1970 State Highway Safety and Betterment Program. Within this report, these are identified as the 1969 Project and the 1970 Project.

Both of these projects covered several individual sections of highway, each of which had a separate project identification. For purposes of reference, the 1969 Project and 1970 Project were identified as C 49-14-2, etc., and C 49-8-29, etc., respectively.

For these projects, new specifications were drafted. This was done in an attempt to achieve a goal of a pavement with good surface drainage characteristics and skid resistance, making maximum utilization of aggregates which are readily available. This report covers the preparation of plans and specifications and experience gained during construction under the two contracts. Results of skid tests on completed pavements are also reported.

SPECIFICATION DEVELOPMENT (1969 PROJECT)

Factors Considered

The 1969 State Highway Safety and Betterment Program included funding for asphaltic concrete overlays on several highways in District Seventeen. For this project, it was decided that a mix would be specified with a maximum size aggregate of approximately ½". This aggregate size was selected with the intent of producing a pavement with good surface drainage characteristics, which would minimize problems of hydroplaning. Specifications in current use within the Texas Highway Department were reviewed to ascertain practices in other areas of the

State. It was found that most specifications were written to allow the use of certain locally available materials or were written for the use of a single specified type of aggregate with the exclusion of all others. As it appeared that no current specification met all the needs for the District Seventeen project, it was determined that it would be desirable to prepare a new specification.

In drafting a new specification, the following items were given consideration:

(1) The specification should be a general specification which could be used for many different projects and for various types of pavement with gradations ranging from a fine textured surface course to a coarse graded base course.

(2) The specification should be written to allow the contractor a maximum degree of latitude in selecting materials.

(3) The specification should be prepared in such a manner that a maximum number of material suppliers could furnish aggregate for the project at a competitive price.

(4) The specification should allow the use of the most economical mix designs which would produce the desired qualities in the finished pavement.

(5) As several experimental projects had indicated that the use of synthetic aggregates would produce a surface with very good skid resistance, the specification should be drafted in such a manner to encourage the use of synthetic aggregates.

(6) Field measurement for pay quantities should be simplified as much as possible to facilitate keeping job records.

(7) The time and effort required for job control testing should not be greatly increased over that required for current specifications.

(8) The specification should be specific enough in regard to types of material required so the contractor would have sufficient information to prepare his bids with a reasonable degree of certainty.

(9) A specification for hot mix asphaltic concrete should be written in such a manner that compatible companion specifications could be prepared for alternate materials (Hot Mix Cold Laid Asphaltic Concrete and Limestone Rock Asphalt Pavement.)

Paving Quantities

It had been noted on some projects in the past that the usual practice of setting paving rates based on units of pounds per square yard resulted in considerable variation from plan rates to secure the desired thickness of pavement. This is due to the fact that plan rates were based upon an assumed unit weight of paving material which might be considerably different from the unit weight of material actually produced. The variations in unit weight are a direct result of variations in specific gravity of aggregates from different sources. When lightweight or synthetic aggregates are considered, the problems of correlating thickness or volume of completed pavement with weight of paving material are greatly increased.

On previous projects where synthetic aggregates had been specified with payment based on weight, it was necessary to specify a minimum percentage of the total aggregate to be composed of synthetic aggregates. As a result, most synthetic aggregate specifications have limited application in that they have been tailored to fit specific material sources and have little meaning when the wide range of specific gravities of available materials are considered. Even when the specification is restricted to synthetic aggregates, there is still a considerable problem in specifying the weights of the various aggregate portions of the mix, as synthetic aggregates are available with bulk unit weights from 35 to 65 pounds per cubic foot. A design based upon one particular type of aggregate would give entirely different results if aggregate with a different unit weight were substituted in the design.

Figure I illustrates the possible range of volume that could be produced from one ton of paving mixture. The mix proportioning assumed for this example is comparable to mixes in general use. It was assumed that the fine aggregate portion of the mix would have a constant specific gravity of 2.60, but the specific gravity of the coarse aggregate could vary over the broad range which could be attained with the use of the lighter synthetic aggregates, natural aggregates, or combinations of synthetic and natural aggregates. It is apparent that when synthetic aggregates are used, the weight-volume relationship can vary greatly.

Measurement and Payment

In the initial consideration of the new specification, it became evident that some method would be needed to provide an equitable method of measurement and payment. For the paving mixture considered in Figure I, an analysis was made of equivalent costs per ton of aggregate. It was found that as the specific gravity of the coarse aggregate varied, there was a wide range in price per ton of aggregate to result in an equal cost for a given volume of pavement.

MIX VOLUME

FOR

VARYING SPECIFIC GRAVITY COARSE AGGREGATE

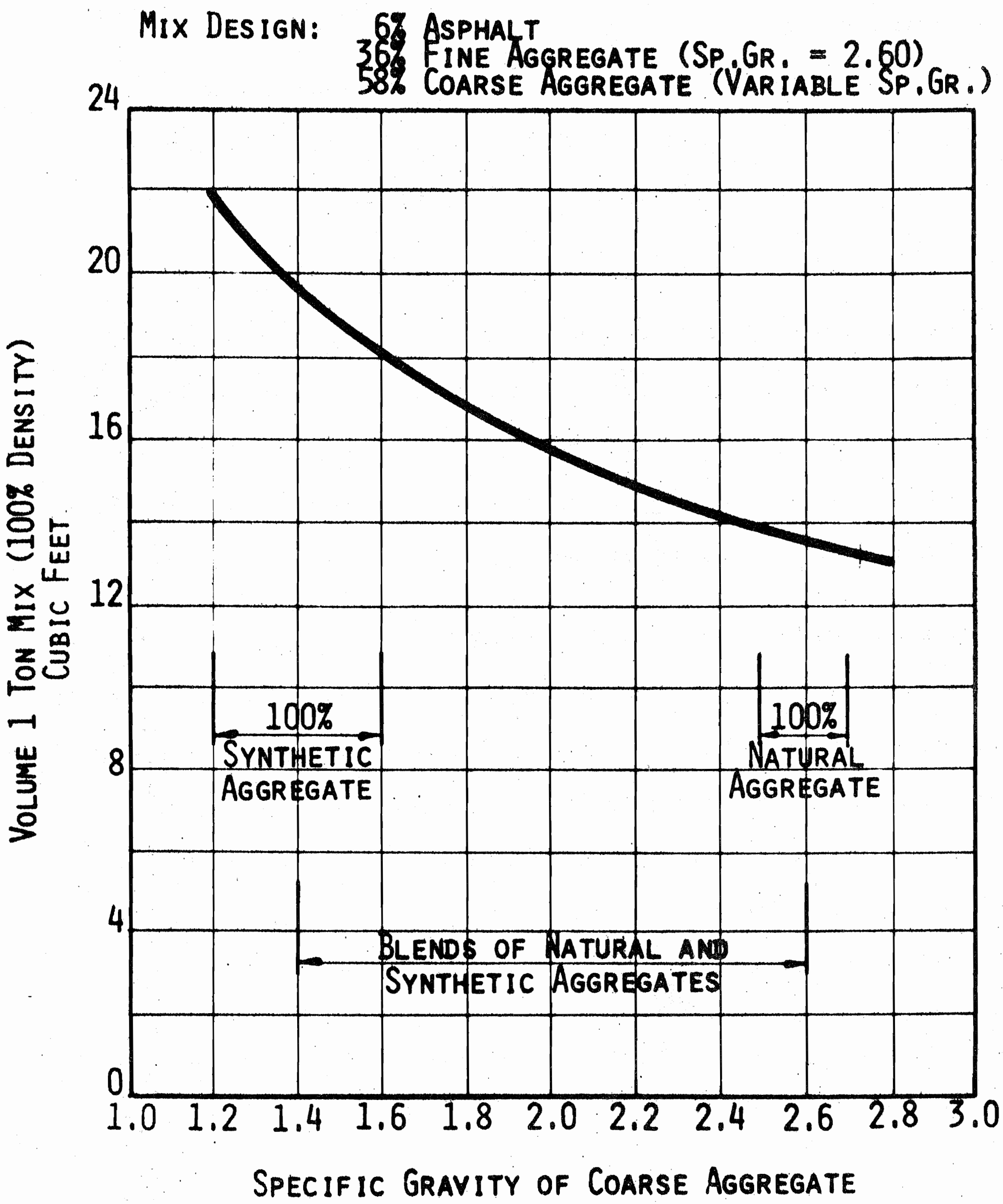


FIGURE I

In Figure II, three curves show the variation in equivalent aggregate prices per ton to result in an equal cost for equal volume of total aggregate. Additional curves could be drawn for other base prices of aggregate. Generally, any pavement design method used will be based on a determination of required thickness or volume of paving courses, without regard to weight of paving material. It is evident from Figure II that basing payment upon tons of aggregate furnished would not be an equitable method of payment.

Consideration was given to a specification whereby measurement would be based upon rodded unit weight of the combined aggregates sampled from the hot bins of the paving plant. Apparently, this method would be workable for hot mix or hot mix cold laid asphaltic concrete; however, it has no direct application to the limestone rock asphalt.

In order to develop a truly usable specification, it was decided that the method of measurement and payment should be based upon some method which could be applied equally to all three of these paving materials. As all aggregates, including natural aggregates, have varying specific gravities; it was considered advisable to base payment upon volume of completed pavement produced, regardless of the unit weight of the particular aggregates the contractor elected to use.

The method finally selected was in accordance with recommendations made by the Highway Design Division and a Statewide Specification

EQUIVALENT AGGREGATE PRICES

FOR

CONSTANT COST-VOLUME RATIO

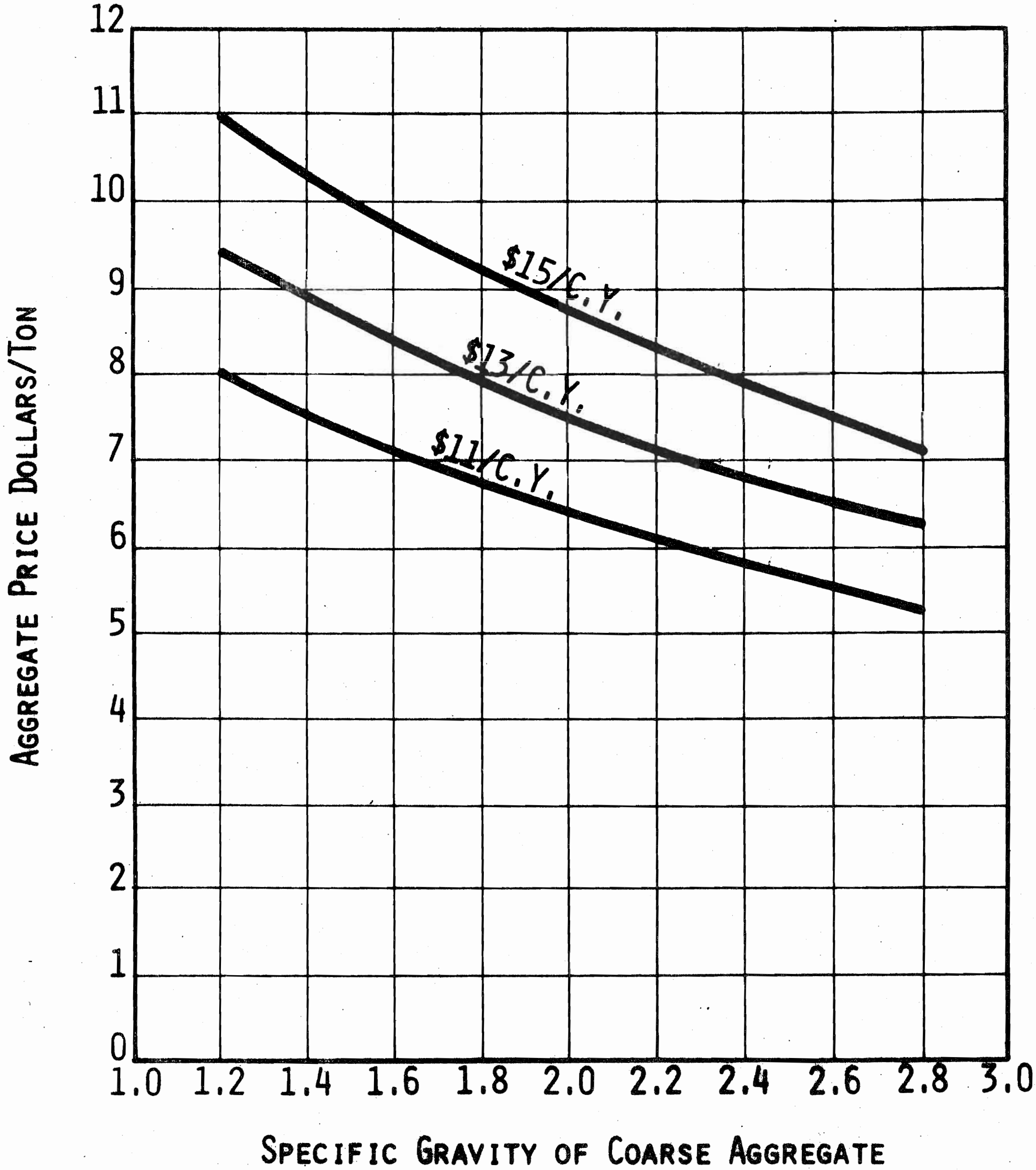


FIGURE II

Committee. The basis of measurement was the unit weights of the laboratory specimens molded for density and stability tests. The advantage of this method is that no additional sampling and measuring procedures would be required other than those necessary to meet existing test requirements. The computation of pay quantities would be a fairly simple mathematical procedure using data from the usual plant laboratory tests. As all asphaltic concrete plants are equipped with batch scales or truck scales to measure the weight of material produced, scale weights were retained in the measurement method. This would allow the contractor to use his plant equipment in the same manner in which it had been used in past projects under other specifications. It was decided to continue to pay for asphalt on a weight basis, as asphalt is measured by weight in the mixing plant and it is a fairly simple procedure to determine the total weight of asphalt used on a project. The measurement for aggregate was to be made on a compacted volume basis 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

G_a = Average specific gravity of three molded specimens as prepared by Test Method Tex-206-F and determined in accordance with Test Method Tex-207-F.

This formula may be considered as a measure of either the cubic yards of compacted aggregate or the cubic yards of compacted asphaltic concrete mix as the asphalt is considered to only fill a portion of the air voids in the aggregate and does not add to the volume of the compacted mix until 100% density is reached. As the intent of the specification is to produce a mix with less than 100% laboratory density, this formula is valid within the range of densities to be produced under the specification. The first impression received by some observers is that as the factor "W" includes weight of asphalt, the weight of asphalt used in the mix is included in the measurement term "V" and double payment is made for asphalt. This, however, is not the case as the weight of asphalt in the specimen is also included in the term "G_a", which cancels the effect of asphalt weight and makes "V" a true expression of volume of compacted aggregate.

Mix Proportioning

After the method of measurement and payment had been determined, it was apparent that the body of the specification should contain limits for master gradation of the aggregate and asphalt content on a volume basis. Asphaltic concrete pavement mix design is based upon a particle size distribution and an asphalt content which will produce a compacted pavement with the desired surface texture, aggregate interlock for strength and stability, and the desired asphalt content for cohesion, impermeability and resistance to oxidation.

These properties of a completed pavement are all volume relationships rather than weight relationships. In practice, experienced engineers and inspectors make a visual judgment of pavement texture based upon the apparent proportions of aggregate particles of each size visible in the pavement surface. This is definitely a judgment of volume of aggregate particles of each size, and the weight of the aggregate particles has no bearing on this evaluation. The basic purpose of specifying a range of gradation and asphalt content for a bituminous mixture is to establish limits which have been proved through experience to produce the desired end product. In previous asphaltic concrete specifications, these requirements have been on the basis of percentage by weight of the aggregate particles retained on specified sieve sizes and a percent by weight of asphalt in the total mix. The requirements in specifications in general usage are valid for natural aggregates in that specific gravity of the aggregate particles of various sizes may differ, but the variation is not critical to the degree that a satisfactory mixture cannot be produced within the limits of master gradation. However, when synthetic aggregates having specific gravities which may be less than half those of natural aggregates are introduced into the mix, different criteria for proportioning of the aggregates must be developed. It is logical to establish these criteria on a volume relationship between all of the components of the completed mix. By this method, the desired texture and particle size distribution can be attained regardless of the specific gravities of the individual aggregate particles.

Figure III illustrates the volume relationship of asphalt, fine aggregate and coarse aggregate in the paving mixture proportioned by weight. The mixture used for this analysis is the same as that used earlier where the fine aggregate is assumed to have a constant specific gravity of 2.60 and the specific gravity of the coarse aggregate varies over a broad range. When the coarse aggregate has a low specific gravity, the volume of coarse aggregate is greatly increased and the volume of asphalt and fine aggregate is not sufficient to fill the voids of the coarse aggregate. Thus, a poorly proportioned mix will result.

SPECIFIC GRAVITY-VOLUME RELATIONSHIP

MIX PROPORTIONING BY WEIGHT

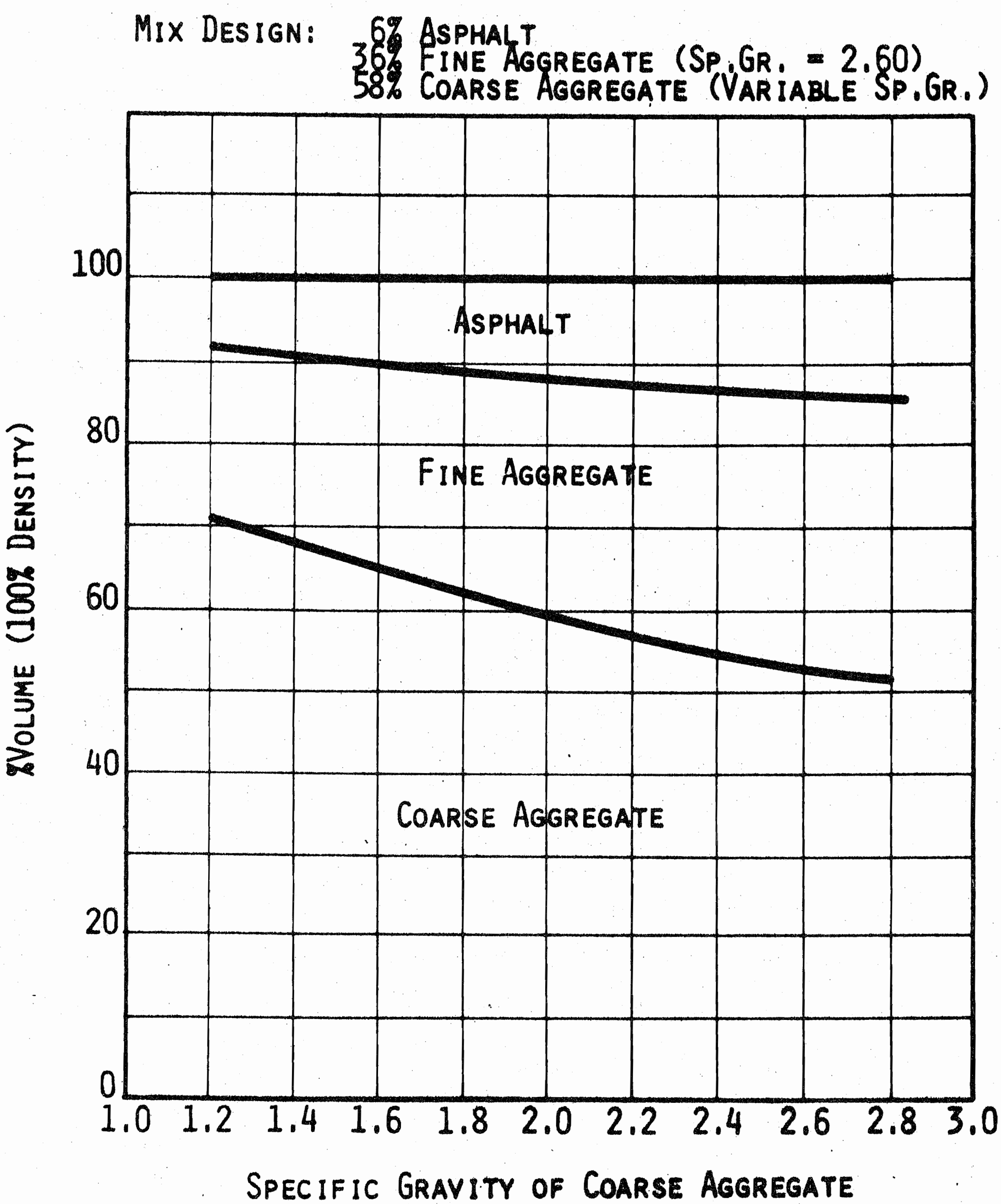


FIGURE III

In order to provide a paving mixture with the desired proportions of asphalt, fine aggregate, and coarse aggregate by volume, the weights of each of these materials must be varied as the specific gravity of aggregates varies, as shown in Figure IV. This figure illustrates the proportions by weight of each of the three components of the paving mix for varying specific gravities of the coarse aggregate. Each mix in this figure would have the same volume of asphalt, fine aggregate, and coarse aggregate, as would a mix proportioned by weight of 6% asphalt, 36% fine aggregate, and 58% coarse aggregate when the specific gravities of both the fine aggregate and coarse aggregate are 2.60. Usual specification limits would allow a band of coarse aggregate of from 50 to 70% of the total weight of the paving mixture. To provide for a wide range of specific gravity for the coarse aggregate, a specification limit based upon weight would have to be in the range of 30 to 70% by weight for coarse aggregate. This limit is too broad to have any real meaning and would serve little purpose in a specification.

From this analysis, it was decided that a specification permitting the use of synthetic aggregates and combinations of natural and synthetic aggregates should be prepared on a volume basis. It was concluded that, if the volume of aggregate of each sieve size and the volume of asphalt were specified, a satisfactory mixture could be produced, regardless of the weights of the various materials.

PROPORTIONS OF ASPHALT AND AGGREGATES
FOR CONSTANT VOLUME RELATIONSHIP
MIX PROPORTIONING BY WEIGHT

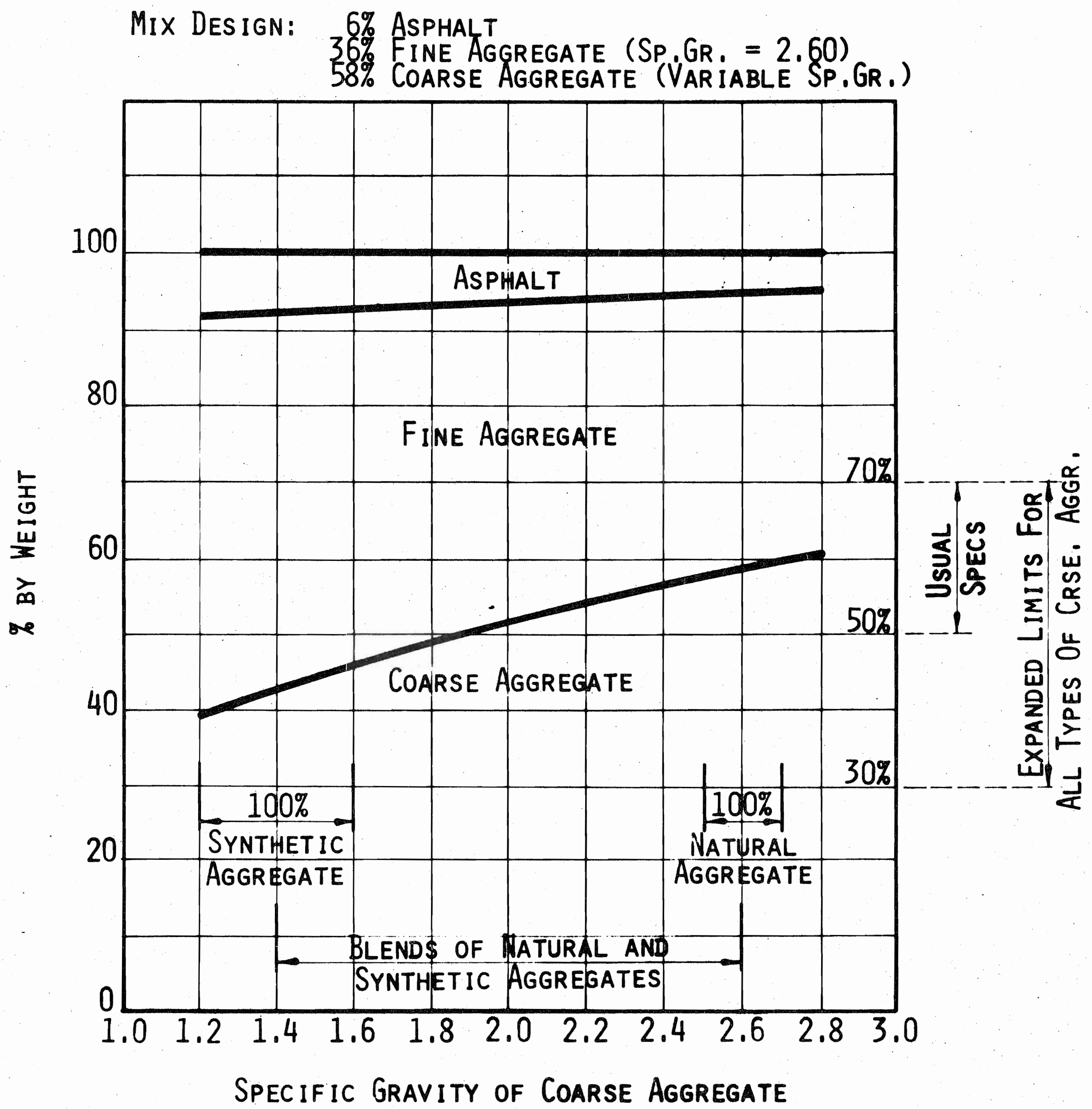


FIGURE IV

Selection of Master Gradation

A volumetric design specification was prepared in accordance with the above considerations. It was assumed that the aggregate gradation as specified in Item 340 of the Standard Specifications and Special Provisions thereto, had been proved to be generally satisfactory for natural aggregates normally used in asphaltic concrete pavements throughout the State. The assumption was also made that these gradation requirements had been developed on the basis of approximately equal specific gravities for all aggregate particles in the mix and therefore, for natural aggregates of uniform specific gravity, also expressed a volume relationship of the various particle sizes.

In the volumetric specification, the same limits of master gradation were used except that the proportions were expressed as a percentage of volume, rather than weight. Fundamentally, this approach to the design specification is based upon the premise that if aggregate particles of a particular size were removed from a satisfactory mix and replaced by an equal volume of aggregate particles with similar shape, size, and absorptive quality, but with considerably higher or lower specific gravity, the characteristics of the total mix would not be significantly altered.

Aggregate Requirements

Past experience and information available from suppliers indicated that in some areas, natural aggregates and synthetic aggregates could be supplied by the contractor for approximately equal costs per cubic yard.

In general, the cost at the source would be higher for the synthetic aggregate than for natural aggregates; however, for projects located a considerable distance from the source, the saving on freight due to the lighter weight of the synthetic aggregates would tend to offset the higher cost at the source so that they could be furnished at the project site for about the same cost as natural aggregates. The new specification was prepared allowing the use of all types of aggregate which had been used previously in asphaltic concrete pavements with satisfactory results. The use of synthetic aggregates was permitted, but this was not a mandatory requirement. The specification, in effect, was written to allow the use of natural, synthetic, or combinations of these aggregates to make materials from many different sources economically competitive.

Format

The format of the volumetric design specification and the testing required for components of the mix and the completed mix were patterned after specifications in current usage. It was necessary to make minor changes in wording throughout the specification so that all requirements would be compatible with the volumetric method of design.

Test Procedures

Upon completion of the volumetric design specification, it was apparent that no established procedures had been developed for preliminary design and job control testing of the bituminous mix to be produced under this specification. The established method for design of bituminous mixtures is given in Construction Manual C-14. The methods outlined in this manual were not directly applicable to a volumetric design; however, the format of Manual C-14 was followed to prepare a design procedure for the volumetric design specification. This procedure included the determination of bulk specific gravity of synthetic aggregates in accordance with a test method developed by J. S. Bryant and described in the Thesis entitled, "Determination of the Moisture Absorption Characteristics of Lightweight Concrete Aggregates". Prior to making trial laboratory mixes and subjecting specimens to density and stability tests, it is necessary to make a sieve analysis of aggregates proposed for use, assume proportions of the various materials to be blended, and check the resulting blended materials against specification requirements. Manual C-14 describes methods whereby this analysis can be done through calculation, and physical blending of the materials is not necessary until a proportioning meeting specification requirements has been determined. A similar procedure for the volumetric design was needed, and methods suggested by Bob M. Gallaway and E. R. Hargett, as a result of their research for the Texas Transportation Institute, were incorporated in the design procedure. This provided a simple, straightforward procedure whereby a proportioning of the various materials could be selected for the purpose of making laboratory trial mixes. The procedure included instructions and examples for converting volume measurements to weight measurements to facilitate the proportioning and blending of the materials.

The new specification included requirements for aggregate proportioning based upon volume of individual particle sizes. However, no test procedure had been established for use as a job control test to insure specification compliance. To meet this need, a test method "Volumetric Sieve Analysis of Fine and Coarse Aggregates" was prepared. This test procedure provides for the measurement of volume of aggregate particles by submerging them in a liquid and measuring the volume of liquid displaced. The liquid specified for use is one of the types of solvent used in asphalt laboratories for the extraction test. The type of liquid is not critical except that a liquid with good wetting properties is needed so that the fine aggregate particles do not tend to float on the liquid.

Some modification was needed in Test Method Tex-210-F. This test method is based upon a weight relationship of asphalt and aggregate and it was necessary to prepare an addendum to correlate with the volumetric specification.

Polish Test

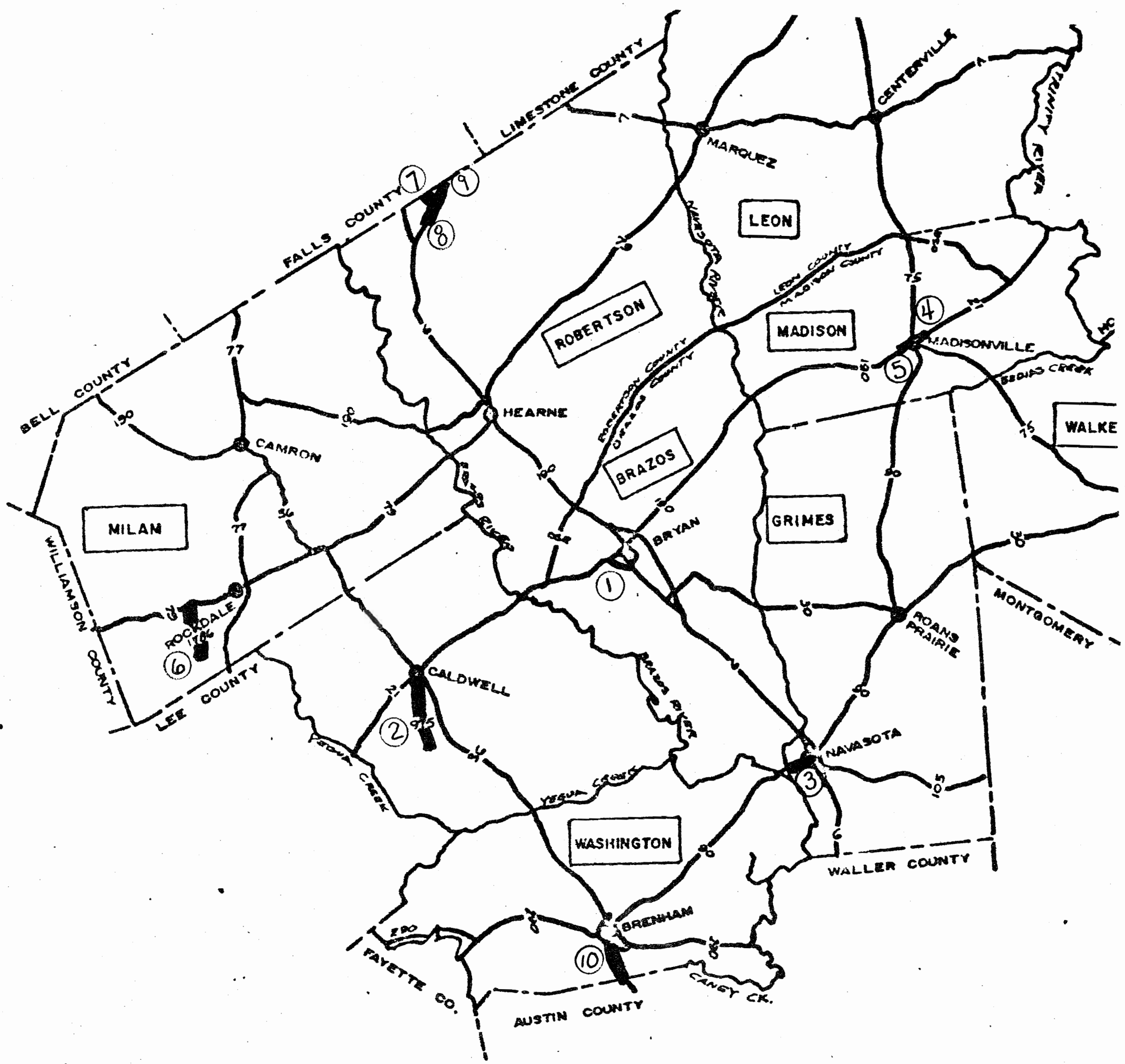
For this project, it was desired to use a coarse aggregate with high resistance to polishing under traffic so that the pavement surface would retain a good skid resistance throughout its life. The Accelerated Polish Test as developed by the Highway Design Division Research Section was adopted as a specification requirement for coarse aggregate. The plans provided that all coarse aggregate would have a polish value of not less than 29 when subjected to the Accelerated Polish Test.

The specification was interpreted to mean that aggregate from each source proposed for use would be tested individually, and if the contractor elected to use two or more coarse aggregates, each would be required to meet the polish test requirements. The minimum polish test value of 29 was selected as prior research had indicated that this was the minimum value which would provide an aggregate that would retain the desired skid resistance.

<u>Project Description, Plans, and Specifications</u>

After final approval of specifications, the plans were completed and processed for letting. As this was considered to be an experimental project, the plans provided for hot mix asphaltic concrete without alternates. This project was considered experimental in that it was intended to provide an evaluation of the volumetric specification and job control procedures under actual construction conditions. Also, the project was intended to furnish additional data on the effect of the polish value test for coarse aggregate on the types of aggregates which the contractor would furnish and the bid prices for the work. Also, in an effort to obtain additional data relative to construction of non-skid pavements, it was planned to make skid tests of the completed pavement immediately after construction and at intervals to determine changes in frictional factors of the pavement under traffic.

The construction plans included ten individual projects to be covered by a single contract. In addition to asphaltic concrete overlay, the plans also provided for some asphalt surface treatment work, primarily on shoulders. The locations and descriptions of the individual projects are shown by Figure V. For convenience in keeping project records, each individual project was identified by a reference number.



1969 DISTRICT LEVEL UP
PROJECT C-49-14-2, Etc.

REF. PROJ.	HWY	LIMITS
1	FM 2818	SH 21 SE to FM 2513
2	FM 975	SH 21 South
3	SH 90	8th St. in Navasota to Navasota River B
4	US 190	SH 90 West
5	US 190	SH 90 East
6	FM 1786	US 79 South
7	FM 46	Falls C/L to SH 14
8	SH 14	FM 46 to FM 1373
9	SH 14	Falls C/L to FM 46
10	SH 36	US 290 South to Austin C/L

FIGURE V

The specification for this project included:

Special Specification 1961, Hot Mix Asphaltic Concrete Pavement (Volumetric Design)

Design of Bituminous Mixtures (Volumetric Design)

Excerpt from "The Determination of the Moisture Absorption Characteristics of Lightweight Concrete Aggregates"

Test Method Volumetric Analysis of Fine and Coarse Aggregates

Addendum to Test Method Tex-210-F

Special Provision to Item 6, Control of Materials

These documents are included in this report as Appendix I through Appendix VI.

Bid Analysis

On August 19, 1969, three bids were received on this project. Low bidder was Young Brothers, Inc., Contractors of Waco, Texas. Table I shows the bids received and unit prices bid.

The low bid was approximately 46% over the programmed funds; however, it was decided to award the contract to the low bidder as this was an experimental project and it was recognized from its inception that the cost might be higher than other similar work.

TABLE I

Quantity		Items	1 Young Bros.	2 Ashland	3 Gaylord
32.	Hr	Roll (Flat Wheel)	$ 6.00	$10.00	$10.00
80.	Hr	Roll (Lt Pneum Tire)	$ 6.00	$10.00	$10.00
566.	CY	Aggr Ty A Gr 4 Mod	$10.00	$ 9.00	$10.00
951.	CY	Aggr Ty D Gr 4 Mod	$10.00	$11.50	$12.00
50,088.	Gal	Asph AC 10	$ .20	$ .20	$ .22
10,472.	CY	Aggr Ty D	$22.50	$23.00	$25.15
1,047.2	Ton	Asphalt (AC)	$22.50	$27.00	$27.00
13,938.	Gal	Tack Coat	$ .15	$ .15	$ .20

BIDDER		TOTAL BID
1	YOUNG BROTHERS INCORPORATED, CONTRACTORS	$287,132.30
2	ASHLAND OIL AND REFINING COMPANY	$298,389.20
3	GAYLORD CONSTRUCTION COMPANY	$323,644.16

Discussion with bidders and material suppliers indicated there were several factors which influenced the contractors' bids resulting in unit prices considerably higher than usual asphaltic concrete projects. These factors are:

(1) Material suppliers were not sure of the expense which would be involved in supplying aggregates meeting the new polish test requirement, and there was a question as to whether some sources of aggregate would meet the test.

(2) The contract covered small individual projects in several locations in District Seventeen, and the contractors had to consider, in their bids, a relatively high moving cost from project to project.

(3) The work should be started late in the asphalt season, and it could be anticipated that delays would be experienced due to unfavorable weather conditions.

(4) The contractors were totally unfamiliar with a volumetric specification and had no previous experience in converting operating costs from a tonnage basis to a volume basis. As is generally the case, it appeared that the bidders increased the unit prices due to an unfamiliar specification.

(5) As this was an experimental project, the bidders anticipated possible lost time for mix design and testing, possibly resulting in low rates of production, and offset this risk by increased bid prices.

SPECIFICATION DEVELOPMENT (1970 PROJECT)

Updating of Specifications

Another asphaltic concrete level up and overlay project was authorized for District Seventeen in 1970 Highway Safety and Betterment Program. Based upon experiences on the 1969 project, it was decided to proceed with the same general specifications for the 1970 job. Some modifications were made in the specification requirements. These were:

(1) There was some change in format for the asphaltic concrete specification, but these changes were for the purposes of improving the readability of the specification and making a more convenient agreement of the text, but did not materially alter any requirements.

(2) The tolerance for asphalt content as reflected by the extraction tests was broadened to more nearly reflect the accuracy obtainable through this test.

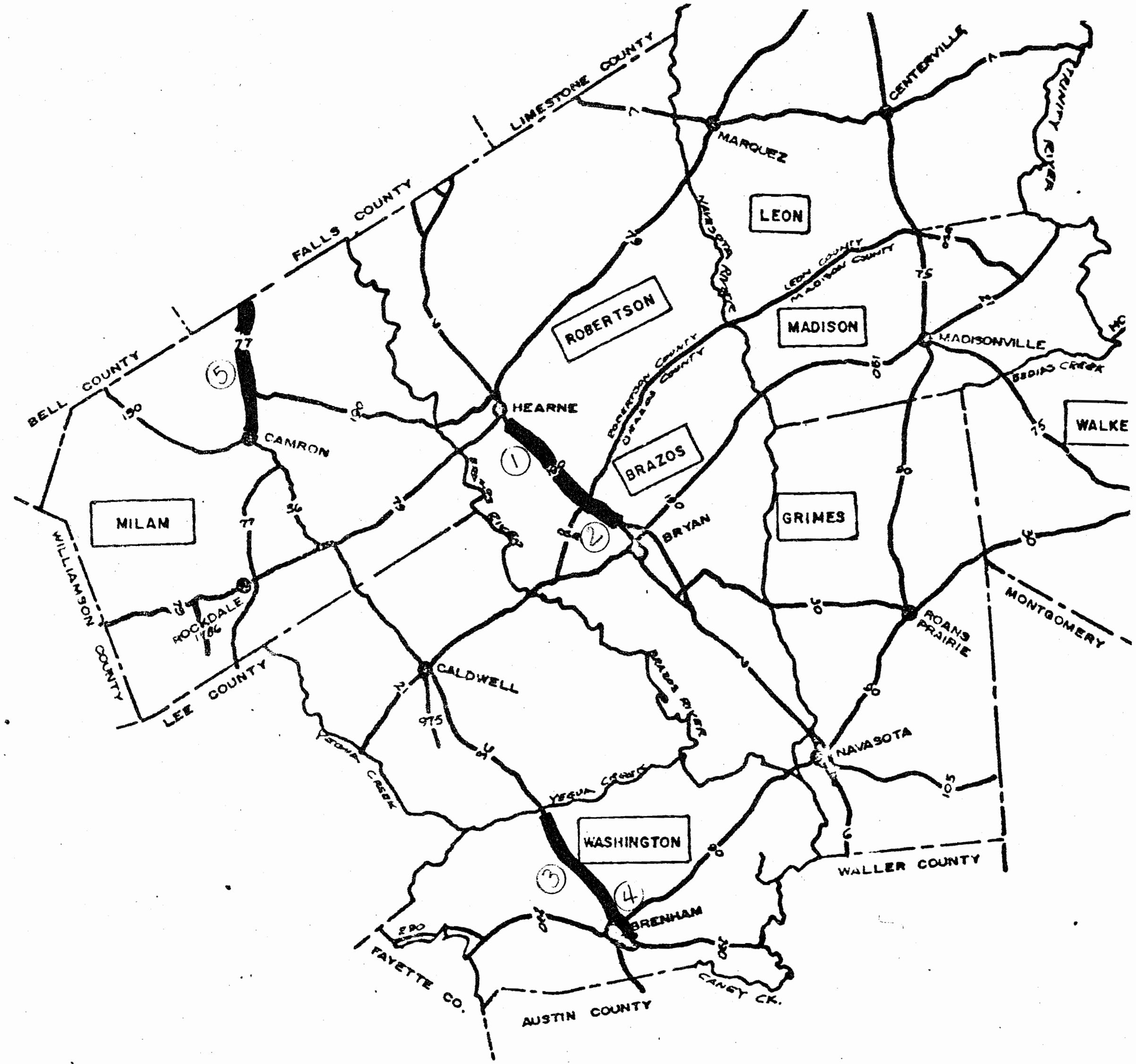
(3) The polish value test requirement was incorporated in the asphaltic concrete specifications rather than as a special provision to Item No. 6 as on the previous project.

(4) The polish value requirement was raised to a minimum value of 34 in order to secure aggregates with slightly better polish resistance than those which had been used on the 1969 project. Also, this change in polish test requirements was based upon experience that indicated that the minimum requirement should be raised somewhat in order to more nearly correspond with the reproducibility of results from the tests and insure a satisfactory quality of aggregate.

(5) In keeping with general Departmental policy, the plans provided for a base bid of hot mix asphaltic concrete pavement with alternate bids for hot mix cold laid asphaltic concrete pavement and limestone rock asphalt.

The 1970 project provided for a spot level up course and a finish course. Approximately 30% of the total material was to be used for the level up course. The plans provided that the polish value test requirement would apply only to coarse aggregate to be used in the finish course. This, in effect, allowed the use of locally available uncrushed siliceous gravel in the level up course.

The locations and descriptions of the individual projects are shown by Figure VI.



1970 DISTRICT LEVEL UP
PROJECT C-49-8-29,Etc.

REF. PROJ.	HWY	LIMITS
1	SH 6	0.5 Mi S of Hearne to Brazos C/L
2	SH 6	Benchley to 3.7 Mi. N of SH 21
3	SH 36	0.3 Mi S of Yegua Cr. to Brenham
4	SH 36	Loop 283 N of Brenham to FM 577 S of Brenham
5	US 77	Falls C/L to Cameron

FIGURE VI

Bid Analysis

Bids were received on the 1970 contract in November, 1970. Seven bids were received with the low bidder being Jones G. Finke, Inc., of Sealy, Texas. The second bidder was extremely close to the low bidder. A tabulation of bids received is shown in Table II.

TABLE II

Quantity		Items	1 Finke	2 Allan	3 Jarbet	4 Freeland	5 Gaylord	6 Robertson	7 Young
13.	Hr	Roll Flat Wheel (210)	9.00	9.00	12.50	8.25	8.00	10.00	7.00
21.	Hr	Roll Lt Pneum Tire(213)	9.00	9.00	12.50	8.25	8.00	8.00	7.00
1,013.	CY	Aggr Ty D Gr 4 Mod (316)	9.00	8.50	10.00	10.52	9.60	12.00	8.00
31,898.	Gal	Asph AC 10 RC-5 or EA-HVRS	.24	.20	.20	.30	.19	.21	.20
*46,127.	CY	Aggr Ty D (2103)	13.20	12.37	NB	NB	15.75	17.20	18.30
* 5,230.5	Ton	Asphalt AC (2103)	20.08	26.00	NB	NB	26.55	26.50	35.00
*55,285.	Gal	Tack Coat (2103)	.00001	.175	NB	NB	.01	.15	.10
ALTERNATE 1A									
46,127.	CY	Cold Mix LRAP (Ty C)(330)	NB	NB	16.25	16.45	NB	NB	NB
55,285.	Gal	Tack Coat RC-2 (330)	NB	NB	.20	.20	NB	NB	NB
ALTERNATE 1B									
46,127.	CY	HM CL ACP (Ty DD)(2104)	NO BIDS ON ALT. 1B						
55,285.	Gal	Tack Coat RC-2 (2104)							

	BIDDER	TOTAL BID
1	JONES G. FINKE, INC.	$730,983.91
2	ALLAN CONSTRUCTION COMPANY, INC.	$731,554.97
3	THE JARBET COMPANY	$777,555.35
4	H. L. FREELAND, INC. GEO. M. AMTHOR	$790,352.81
5	GAYLORD CONSTRUCTION COMPANY	$881,980.30
6	ROBERTSON CONSTRUCTION COMPANY	$959,437.98
7	YOUNG BROTHERS, INC. CONTRACTORS	$1,047,441.70

The bids for this project were much more favorable than those received for the 1969 project. This can be attributed to several factors.

(1) The 1970 project included a greater quantity of material and fewer construction sites which tended to decrease the unit cost of production.

(2) Several other projects had been let in the State with measurement and payment based upon volume. These projects did not include volumetric design and job control testing, but they did allow the contractors to become more familiar with the methods of measurement and payment.

(3) Bidders were more familiar with the volumetric design concept than they had been when bids were received on the 1969 project.

(4) The Residency personnel who showed the project to prospective bidders had assembled considerable data showing methods of converting from a tonnage basis to a volume basis for design, plant control, and measurement and payment. Also, a special effort had been made to thoroughly acquaint Residency personnel with all aspects of this relatively new specification and they were in a position to thoroughly discuss the specification requirements with prospective bidders.

(5) The Residency personnel had secured samples of aggregates from several commercial sources which were within a reasonable haul distance of this project and furnished the prospective bidders with tentative designs showing the percentages of various aggregates which would be required to meet gradation specifications. This information was furnished to the bidders with a clear understanding that it was for their information only and that this, in no way, relieved the contractor from furnishing aggregates which would meet the specification requirements and blending them in proportions which would meet all other test requirements.

It appears that the bid prices received on the 1970 asphaltic concrete project compare favorably with prices received for similar work under the standard asphaltic concrete specifications based upon tonnage measurement and payment. Also, it appears that the requirement for the polish value test for coarse aggregate did not contribute significantly to increased bid prices on this contract. The low bidder advised that he planned to furnish uncrushed siliceous gravel from a source near Hearne for the level up course and to furnish synthetic coarse aggregate from Texas Industries, Clodine plant, for the finish course. These aggregates would be combined with local fine aggregates and field sand to produce the required gradation. Preliminary tests on the Clodine material indicated no problems in meeting the polish value requirement.

One other factor noted in the bids received was that two of the bidders elected to bid the alternate for limestone rock asphalt. The specification requirements for this material were no more stringent than the usual specification for the rock asphalt alternate and the preliminary tests indicate that the rock asphalt easily meets the polish test requirements. Therefore, it can be concluded that the volumetric design for hot mix asphaltic concrete is economically competitive with the alternate paving materials.

The specifications for the 1970 project included:

Important Notice to Contractors, Accelerated Polish Test Method for Coarse Aggregate Used in Pavement Surfaces

Special Provision 026 to Item 330

Special Specification, Hot Mix Asphaltic Concrete Pavement (Volumetric Design)(2103.000)

Special Specification, Hot Mix Cold-Laid Asphaltic Concrete Pavement (Volumetric Design)(2104.000)

The documents are included in this report as Appendix VII through Appendix X.

CONSTRUCTION OPERATIONS AND JOB CONTROL TESTING (1969 PROJECT)

Plant Location

Hot Mix Asphaltic Concrete for the 1969 project was produced from three different plants. These were permanent or semi-permanent plants and no plant was set up specifically for this project. The plant locations were at Feld, near Georgetown; at Waco; and at Texas A & M University Research Annex, near Bryan. In general, the contractor produced material for the individual sections of highway from the plant which would result in a minimum amount of material haul expense; however, in a few instances, in order to coordinate with other work, material was produced from a plant other than the one nearest a particular project.

Construction Sequence

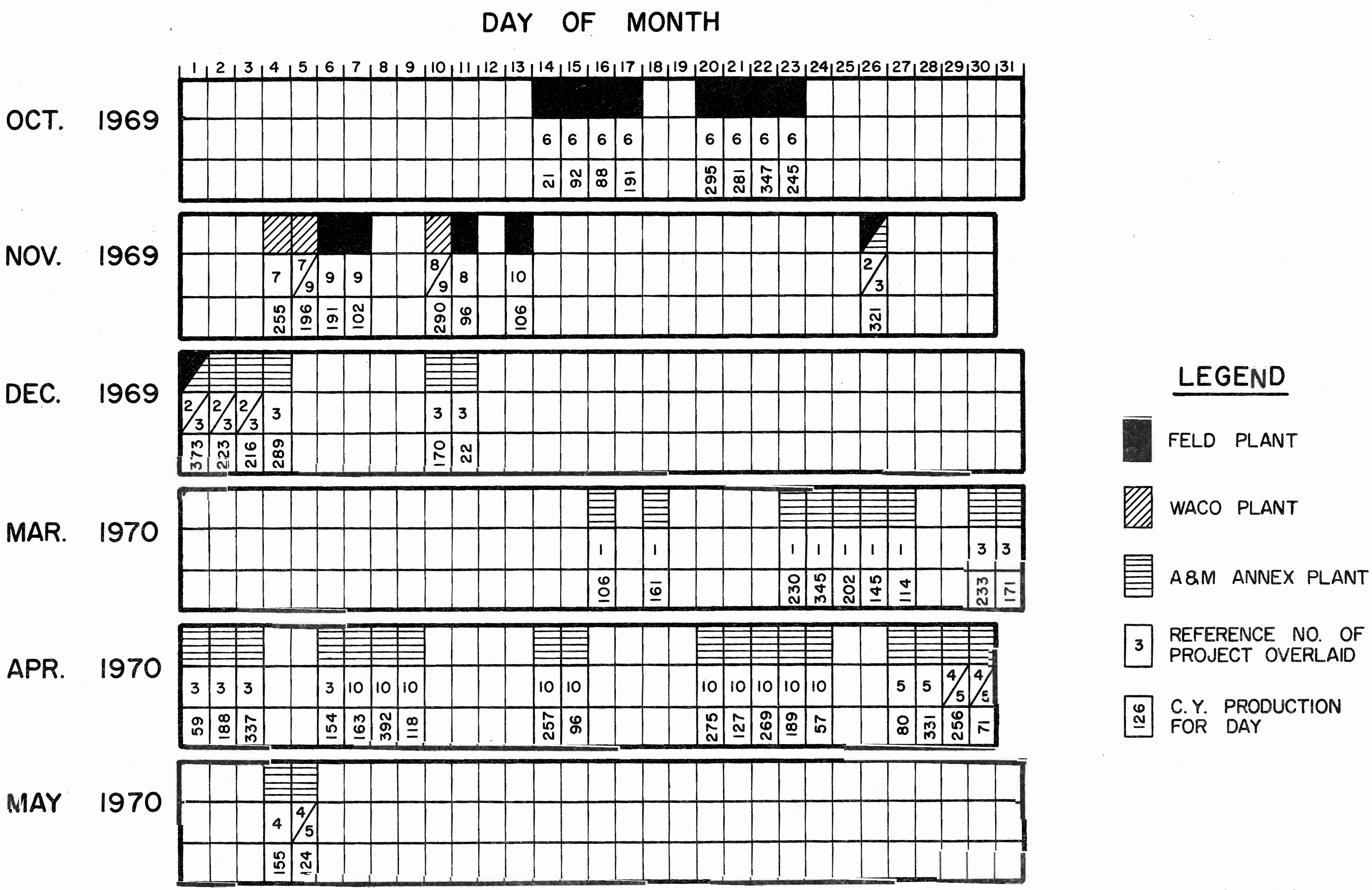
Construction of the asphaltic concrete pavement was started on October 14, 1969, and was completed on May 5, 1970. Progress was very slow on this contract and numerous delays were experienced due to unfavorable weather. The contractor's operations were also hampered by a shortage of personnel and equipment. Mechanical failures at the mixing plant also contributed to the slow rate of progress. At no time during the construction period did the contractor achieve a rate of production approaching the rated capacity of the plant.

The record of production of asphaltic concrete is shown in Figure VII. This table shows the plant used, the individual project where pavement was laid, and the quantity of material produced for each day's operation. The average production was 185 cubic yards per day, but on ten days, the total production was less than 100 cubic yards. The low rate of production and the start-and-stop operation at the plant created problems in job control and testing. With this type of operation, it is extremely difficult to stabilize the quality of material produced and secure samples of material which are truly representative.

Material Sources

The contractor submitted samples of aggregate proposed for use on this project, as required by the specifications. These aggregates were tested for the polish value and other aggregate quality tests and preliminary mix designs were made in the District Seventeen Laboratory. Two sources of coarse aggregate were used for this contract; one being a crushed limestone from Texas Crushed Stone Plant at Feld. This material had a polish value of 32 to 33.

The second coarse aggregate used was from a source at Waco, owned by Young Brothers. This was a crushed gravel aggregate. It was estimated that approximately 60% of the aggregate particles were a limestone type gravel and 40% were a siliceous gravel. This material had a polish value of 29, which was at the lower limit of the specification. The contractor also submitted samples of a third



RECORD OF ASPHALTIC CONCRETE PRODUCTION

Figure VII

coarse aggregate which was a crushed siliceous gravel. This material had a polish value of 24.5 and was not approved for use. The accelerated polish test reports are shown in Appendix XI.

After approval of aggregate sources, based upon the polish value test, additional tests were made during the period of construction. These tests were made as new stockpiles of aggregate were produced to insure that the material was comparable to the sample used for the initial approval of source.

When the plans were prepared, it was assumed that some suppliers who usually furnish aggregates for asphaltic concrete pavement in District Seventeen would be unable to furnish aggregates for this project, due to the polish value test requirement. If the polish test requirement had not been included in the plans, the plans would have been prepared in such way to require the use of a crushed aggregate which would have precluded the use of uncrushed siliceous gravel which is available in the Bryan-Hearne area. Preliminary tests indicated that this material would not meet the polish test requirement and, therefore, no provision was made in the plans specifically requiring a crushed aggregate. Actually, the polish test requirement had little bearing on the sources of aggregates used on this project as the contractor was able to use the same sources which had been used on previous projects within District Seventeen where a crushed aggregate was required but no polish value was specified. From past experience, it appears that the materials which meet the minimum polish requirement of 29 are questionable in relation to their polish characteristics under traffic, and that possibly the value of 29 is too low to insure what could be termed as a non-polishing aggregate.

Job Control Testing

This contract was under the supervision of the Brazos-Burleson County Residency. Personnel from this office performed plant and road inspection. They were assisted in plant inspection by personnel from the District Seventeen Laboratory. Preliminary designs were made by the District Laboratory. These reports are included in Appendix XII. Job control testing was performed in accordance with procedures outlined in the specifications. Also, job control sieve analysis at the plant was performed in a manner prescribed by Construction Manual C-14 to provide a correlation between the two test methods.

During the construction period, plant control by the volumetric specification was evaluated. It was found that the test procedures under this specification did not materially increase the work load for plant inspection personnel, and in fact, as inspection personnel became familiar with the procedures, it was found that approximately the same degree of effort was required for plant control under this specification as under the procedures as specified in Construction Manual C-14. One indication of the amount of time and effort required was that the same number of technicians were assigned to plant inspection as was the usual practice for projects under Manual C-14, and the inspection force was able to run tests as specified by the volumetric specification and also perform check tests in accordance with Manual C-14.

As all aggregates used in this project were natural aggregates, it was assumed that there should be a correlation between the sieve analysis by weight and the sieve analysis by volume. However, this did not prove to be the case. It was noted that the percentage by volume and percentage by weight of a particular size of aggregate might vary as much as 5%; however, further analysis of the test results indicated that this variation should be expected as there was a difference in specific gravities of the various sized particles in the aggregate and that this variation was great enough to result in the apparent discrepancy between sieve analysis by volume and by weight. The experience in job control testing on this project indicated that the prescribed methods of testing were sufficiently accurate to furnish a true representation of the gradation of the aggregate based upon volume.

The test procedures could be performed within a reasonable period of time and technicians familiar with asphalt laboratory work had no difficulty in performing the new test procedures.

In connection with this project, short test sections of pavements were constructed on FM 2818 utilizing synthetic aggregates. This work was done in cooperation with Texas Transportation Institute and Texas A & M University. The information relative to these test sections is contained in a paper by Jerry G. Rose entitled, "Design, Construction, and Analysis of Lightweight Aggregate Hot Mix Asphalt Test Sections on FM 2818, Brazos County, Texas", and these sections are not included within the scope of this report.

CONSTRUCTION OPERATIONS AND JOB CONTROL TESTING (1970 PROJECT)

Plant Location

For this project, the contractor used a portable batching plant. The plant was set up at Hearne for the Brazos, Robertson, and Milam County projects. After these projects, the plant was moved to Brenham for the remainder of the work.

Construction Sequence

Construction of the asphaltic concrete pavement was started on January 18, 1971, and completed on July 2, 1971. The contractor maintained a good rate of daily progress throughout the period of construction. During this period, the plant was in operation for a total of 95 days. The average daily production was approximately 485 cubic yards per day. This rate was considerably higher than on the previous project.

Material Sources

The plans provided for a level-up course of pavement to be laid in sections prior to the finish course. As this material would not be subjected to traffic other than for a short period during construction, there was no polish value requirement on the coarse aggregate. The contractor elected to use an uncrushed siliceous gravel for this paving course. In order to comply with the minimum polish value requirement of 34, the contractor furnished a synthetic coarse aggregate produced by Texas Industries, Clodine, Texas. The polish value for this aggregate was 59.4.

Job Control Testing

Work on this contract was under the supervision of the Robertson County Residency located in Hearne. Personnel from this office performed plant and road inspection. They were assisted in plant inspection by personnel from the District 17 Laboratory and the Washington County Residency. Preliminary mix designs were made by both the District Laboratory and Residency personnel. The designs used are included in Appendix XIII.

In performing laboratory tests for job control, some difficulty was experienced in the sieve analysis of synthetic aggregates. The lighter particles tended to float on the surface of the solvent. The particles had to be forced into the solvent before an accurate reading could be obtained. The laboratory technicians on the project developed a tool consisting of a plastic disc with approximately the same inside diameter as the flask attached to a wooden rod. This tool was used to force all aggregate particles below the surface of the solvent. For each reading, including the initial reading of solvent level, the tool was inserted to a predetermined mark. This procedure gave good results and overcame the problem of floating aggregates.

The recommended laboratory procedure developed for this project specified that aggregate particles of the various sizes would be successively placed in the solvent starting with the largest coarse aggregate. It was found that with an absorptive aggregate, better results could be obtained by introducing the finest sizes first and then adding the larger sized aggregates.

SKID TESTING OF 1969 PROJECT

Test Results

Soon after the construction of the 1969 project, skid tests were made with the Texas Highway Department skid trailer. The tests were repeated at intervals with the most recent test being made in July, 1971. Coefficients of friction measured in October, 1970, for individual test sites on each project are indicated in Appendix XIV. Some tests were made on the synthetic aggregate sections on FM 2818, but those were not considered in this report.

The coefficients of friction obtained by skid tests on the pavements constructed in the 1969 overlay project are generally within the range considered to be satisfactory. Quite a few of the sections of roadway had friction coefficients above .60 immediately after construction; however, it was also noted that there was a considerable variation in coefficients of friction between sites and between sections of pavement constructed on different dates. A portion of this variation can be attributed to changes in aggregate sources; however, this does not fully explain the wide variation between some sections of pavement. Based upon experience on other projects, it was assumed that the pavements with crushed limestone coarse aggregates would have a higher frictional coefficient than pavements constructed with crushed gravel aggregates. This did not prove to be true in all cases. While the highest coefficients were obtained on pavements with the crushed limestone coarse aggregate, other sections where this same aggregate was used exhibited frictional values considerably lower than expected.

Several possible reasons for this variation in coefficients of friction were:

(1) Aggregate gradation

(2) Asphalt content

(3) Source of asphalt

(4) Type and source of coarse aggregate

(5) Type and source of fine aggregate

(6) Weather conditions during construction

(7) Volume and character of traffic

(8) Methods of compaction

(9) Temperature of mixing and laying

Analysis of Skid Tests

A thorough analysis was made of data available to determine which variables in materials and construction operations may have influenced the coefficient of friction of the completed surface. This evaluation did not reveal any single variable to which the variation in friction factor could be attributed. No direct relationship between friction factor and the variables considered could be found. It is highly probable that the interaction of these variables did contribute directly to the variations in skid resistance, but insufficient data is available to indicate the extent to which each variable affected the completed pavement.

Skid tests made on a newly constructed pavement measure the coefficients of friction of the surface which consists of a matrix of fine aggregate and asphalt. The size and shape of the fine aggregate particles, the thickness of the asphalt film, and the overall texture of the surface, i.e., open graded or dense graded, are the variables which probably affect the frictional values of a newly constructed pavement to the greatest degree. At this stage in the life of the pavement, the coarse aggregate does not influence the friction values as little, if any, of the coarse aggregate is in direct contact with the tire of the skid trailer. As the matrix of fine aggregate and asphalt is worn away from the surface due to traffic and weathering, and as more of the coarse aggregate is exposed, the characteristics of the coarse aggregate begin to affect the coefficients of friction. Most of the sections of roadway for which skid tests have been made have only moderate traffic volumes and the characteristics of the coarse aggregate particles have had only a limited influence on the friction values obtained during the period of testing. Curves have been plotted as shown in Appendix XVI, correlating change in coefficient of friction and traffic applications. For most projects, there has been a decrease in friction values since completion of the pavement. Several projects have exhibited an early decrease in coefficient of friction followed by either a leveling off or a slight increase in friction values. This could possibly indicate that the fine aggregate and asphalt matrix is being worn away from the surface, due to the action of traffic and weather and that the skid tests are beginning to indicate a coefficient of friction for the coarse aggregate particles.

One section of pavement constructed under this contract is worthy of particular consideration. This is the south bound lane of SH 14 in Bremond - from Station 21+70 on Project No. 9 to the end of Project No. 9 and the entire south bound lane on Project No. 8. This section of pavement represents a single day's production from the plant located in Waco. The aggregates used were crushed gravel and Needham sand from Waco. The pavement was laid on November 10, 1969. The laydown machine was traveling from north to south. A visual inspection of this pavement indicates that the pavement laid early in the day has a relatively open texture and that as laying progressed, the texture became more densely graded so that the pavement laid near the end of the day has a dense surface. Skid tests made on this section of pavement correlate with the appearance of the pavement in that friction values of .45 were reported for the open graded portion of the pavement and the coefficients obtained on the more densely graded sections were an average of .35. A review of the tests made on aggregate sampled from the plant does not indicate a change in aggregate gradation corresponding to the change in surface texture appearance and coefficients of friction. A review of the project diary does not indicate any changes in construction procedures that can be correlated with the changes in pavement texture. From the data available, it is not possible to isolate those variables which resulted in the variation in pavement texture on this section of roadway. It is possible, however, that a close visual inspection at the time of construction would have revealed indications of factors which did contribute to the variation in surface texture.

SKID TESTING OF THE 1970 PROJECT

Test Results

As previously noted, the pavements constructed on the 1969 project had a considerable variation in surface texture. This was not the case for the 1970 project. The pavements produced had a very uniform texture and little difference in pavement texture could be observed on the various sections of the project. This was primarily due to strict plant control. The road inspectors paid particular attention to the texture of the pavement as it was placed. It was their intent to produce a finished surface with a fairly open texture. If the pavement being laid varied from the texture desired, immediate steps were taken to change the mix proportions at the plant. These changes were generally very minor adjustments in the cold feed to increase or decrease the proportion of field sand in the mix. These adjustments of the cold feed did not make a significant change in the aggregate sieve analysis. Experience on this project indicates that visual control of the pavement texture is extremely important and that a trained road inspector can note changes in the mix affecting texture that are not readily apparent from the sieve analysis.

Skid tests made with the Texas Highway Department skid trailer are reported in Appendix XV. No significant variation in individual friction values was noted as had been the case for the 1969 project. The coefficients of friction on all sites tested were uniformly high. Also, where a series of tests have been run on the same section of road, no change in coefficient friction has been noted.

CONCLUSIONS

Several conclusions may be drawn from the experiences on the two projects covered in this report.

(1) The volumetric specification for asphaltic concrete pavement is a workable approach to design of asphaltic concrete pavements.

(2) The test procedure developed for design and job control testing of bituminous mixes by the volumetric method is subject to refinement, but is usable and accomplishes an adequate degree of control with a reasonable expenditure of time and effort.

(3) Satisfactory bid prices can be realized on projects utilizing the volumetric design specification if the specification requirements are adequately explained to prospective bidders.

(4) The volumetric specification is a method of encouraging the use of synthetic aggregates and makes these aggregates economically competitive with natural aggregates.

(5) The polish test requirement for coarse aggregate has little, if any, effect on the coefficient of friction of the newly completed pavement.

(6) Although a considerable period of time and a high number of vehicle applications are needed to evaluate whether or not the accelerated polish test gives a true indication of polishing characteristics of aggregates under traffic, it does appear that the required

polish test value of 34 does necessitate the use of aggregates which have proved to be satisfactory in the past from the standpoint of non-polishing characteristics.

(7) The coefficient of friction of a finished pavement is dependent upon variables in addition to aggregate qualities and gradation as reflected by usual test procedures and these variables most probably involve construction procedures.

(8) As it appears to be extremely difficult, from available data, to define and set limits for construction procedures and other factors which affect the coefficient of friction of a completed pavement, it would probably be inadvisable to propose an end product specification requiring the contractor to produce a pavement with a specified coefficient of friction. Further studies resulting in positive correlation between pavement skid resistance and factors of materials, design, and construction procedures may make an end product specification feasible at some time in the future.

(9) The construction of a pavement with a desirable surface texture may require adjustments in material proportioning and construction procedures during the construction period. All of the needed adjustments may not be indicated by the specified test procedures and the project inspector must rely upon his experience and judgment to produce the best possible end result within the specifications.

(10) The pavements constructed with synthetic coarse aggregate have a very desirable surface texture and extremely good skid resistance. It appears that this skid resistance will be retained under traffic.

RECOMMENDATIONS

Based upon the projects considered in this report, the following recommendations are made:

(1) The specifications for Hot Mix Asphaltic Concrete Pavement (Volumetric Design), Hot Mix Cold Laid Asphaltic Concrete Pavement (Volumetric Design), and Limestone Rock Asphalt as utilized in the 1970 District Seventeen Asphaltic Concrete Project be considered as satisfactory for general use and be made available throughout the Highway Department for use by other Districts, as desired.

(2) The accelerated polish test should be considered as a valid test for quality of coarse aggregate and this test requirement should be retained in specifications for asphaltic concrete surface courses.

(3) The volumetric method of measurement and payment for asphaltic concrete pavement is an equitable method of payment and should be adopted as general practice.

(4) Additional studies should be made to determine the effect of construction practices and job control on the coefficient of friction of the completed pavement.

(5) The volumetric design specifications should be reevaluated as experience is gained with different types of aggregates and mix designs. It is possible that modification of master gradation and other specification limits can be refined to more nearly insure the production of the desired end result.

(6) Some difficulty may be encountered in submerging lightweight aggregates in the liquid as prescribed in the Volumetric Sieve Analysis procedure. This can be corrected by using a plunger to force the aggregate below the liquid surface. This will not affect the test results if the initial and final readings are made with the plunger the same distance below the surface of the liquid.

(7) Paving courses requiring aggregates to meet polish value requirements should be set up as separate bid items from those for which there is no polish test requirement, even if gradation and other requirements are identical. This should more nearly reflect the actual costs of the different types of paving mixtures.

APPENDIX

I. Special Specification 1961, Hot Mix Asphaltic Concrete Pavement (Volumetric Design)

II. Design of Bituminous Mixtures (Volumetric Design)

III. Excerpt from, "The Determination of the Moisture Absorption Characteristics of Lightweight Concrete Aggregates"

IV. Test Method Volumetric Analysis of Fine and Coarse Aggregates

V. Addendum to Test Method Tex-210-F

VI. Special Provision to Item 6, Control of Materials

VII. Important Notice to Contractors - Accelerated Polish Test Method for Coarse Aggregate Used in Pavement Surfaces

VIII. Special Provision 026 to Item 330

IX. Special Specification, Hot Mix Asphaltic Concrete Pavement (Volumetric Design)(2103.000)

X. Special Specification, Hot Mix Cold-Laid Asphaltic Concrete Pavement (Volumetric Design)(2104.000)

XI. Accelerated Polish Test Reports

APPENDIX I.

Special Specification 1961, Hot Mix Asphaltic Concrete Pavement (Volumetric Design)

TEXAS HIGHWAY DEPARTMENT

SPECIAL SPECIFICATION

HOT MIX ASPHALTIC CONCRETE PAVEMENT
(Volumetric Design)

1. Description. This item shall consist of a base course, 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 details 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 Item 6 of the Standard Specifications, 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.

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

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 2 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 accordance 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 judgment 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 30 percent and not more than 40 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 one crushed face.

The requirement for the Los Angeles Abrasion Test shall be waived for slag aggregate produced from burning coal.

Where coarse aggregates are supplied from two or more sources, aggregate from each source shall be tested for compliance with Los Angeles Abrasion requirements prior to being combined with other aggregates.

(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	2 - 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 as determined by the Engineer 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 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" (Attached) will conform to the limitations for master grading given below for the type specified.

Type "A" (Coarse Graded Base Course):

	Percent By Absolute Volume
Passing 2" sieve	100
Passing 1-3/4" sieve	95 to 100
Passing 1-3/4" sieve, retained on 7/8" sieve	15 to 40
Passing 7/8" sieve, retained on 3/8" sieve	15 to 40
Passing 3/8" sieve, retained on No. 4 sieve	10 to 25
Passing No. 4 sieve, retained on No. 10 sieve	5 to 20
Total retained on No. 10 sieve	65 to 80
Passing No. 10 sieve, retained on No. 40 sieve	0 to 20
Passing No. 40 sieve, retained on No. 80 sieve	3 to 15
Passing No. 80 sieve, retained on No. 200 sieve	2 to 15
Passing No. 200 sieve	0 to 6

The asphaltic material shall form from 7 to 14 percent of the mixture by volume. (Absolute Volume)

Type "B" (Fine Graded Base or Leveling-Up Course):

Passing 1" sieve	100
Passing 7/8" sieve	95 to 100
Passing 7/8" sieve, retained on 3/8" sieve	20 to 50
Passing 3/8" sieve, retained on No. 4 sieve	10 to 40
Passing No. 4 sieve, retained on No. 10 sieve	5 to 25
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 20
Passing No. 80 sieve, retained on No. 200 sieve	3 to 20
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 "C" (Coarse Graded Surface Course):

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	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 9 to 19 percent of the mixture by volume. (Absolute Volume)

Type "E" (Sheet Asphalt Surface Course):

Passing No. 4 sieve	100
Passing No. 4 sieve, retained on No. 10 sieve	0 to 5
Passing No. 10 sieve, retained on No. 40 sieve	15 to 40
Passing No. 40 sieve, retained on No. 80 sieve	20 to 45
Passing No. 80 sieve, retained on No. 200 sieve	12 to 32
Passing No. 200 sieve	7 to 20

The asphaltic material shall form from 17 to 28 percent of the mixture by volume. (Absolute Volume)

Type "E" Mod. (Sheet Asphalt Surface Course):

Coarse aggregates for Type "E" Mod. shall be crushed material or a combination of slag aggregate and crushed stone. Fine aggregate shall be as shown elsewhere in this specification.

The master grading for Type "E" Mod. (Sheet Asphalt Surface Course) shall be as follows unless otherwise shown on plans:

	When Slag Aggr. is Used % by Absol. Vol.	When Crushed Material is Used % by Absol. Vol.
Passing 1/2" Sieve	100	100
Passing 3/8" Sieve	95-100	95-100
Passing 3/8" sieve, retained on No. 4 sieve	15- 50	15- 50
Passing No. 4 sieve, retained on No. 10 sieve	10- 30	10- 30
Total Retained on No. 10 sieve	35- 60	50- 70
Passing No. 10 sieve, retained on No. 40 sieve	15- 50	5- 30
Passing No. 200 sieve	2- 10	2- 10

The asphaltic material shall form from 12 to 22 percent of the mixture by volume. (Absolute Volume)

Type "F" (Non-skid Surface Course):	Absol. Vol.
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 "K" (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	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 9 to 19 percent of the mixture by volume. (Absolute Volume)

Type "M" (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. Mix designs will be made following procedures outlined in "Design of Bituminous Mixtures (Volumetric Design)" (Attached). 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 Absol. Vol.
Passing 1-3/4" sieve, retained on 7/8" sieve	plus or minus 5
Passing 7/8" sieve, retained on 3/8" 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) Extraction Test. Samples of the mixture when tested in accordance with Test Method Tex-210-F and attached Addendum 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 screenings are used, the extraction requirements relative to asphalt content are waived.

(4) 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 ASTM D-2041-64T will have the following laboratory density and stability:

	Density, Percent			
	Min.	Max.	Optimum	Stability, Percent
Types A, B, C, D, E, F, K	95	99	97	Not less than 30 unless otherwise shown on plans.
Type E Mod.	92	98	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 four bins when producing Type "A", Type "B", and Type "C" mixtures; at least three bins when producing Type "D" and Type "K" mixtures; and at least two bins when producing Type "E", Type "E" Mod., and Type "F" mixtures. If mineral filler is needed, an additional bin shall be provided. These bins shall contain the following sizes of aggregates which shall be based on "Percent by Volume" when synthetic aggregate is used and "Percent by Weight" when other aggregates are used:

Type "A" (Coarse Graded Base Course):

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

Bin No. 2 --- will contain aggregates of which at least 70 percent by weight will be of such size as to pass the 3/8-inch sieve and be retained on the No. 10 sieve.

Bin No. 3 --- will contain aggregates of which at least 75 percent by weight will be of such size as to pass the 7/8-inch sieve and be retained on the 3/8-inch sieve.

Bin No. 4 --- will contain aggregates of which at least 75 percent by weight will be of such size as to pass the 2-inch sieve and be retained on the 7/8-inch sieve.

Type "B" (Fine Graded Base or Leveling-up Course):

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

Bin No. 2 --- will contain aggregates of which at least 70 percent by weight 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 by weight will be of such size as to pass the 3/8-inch sieve and be retained on the 1/4" sieve.

Bin No. 4 --- will contain aggregates of which at least 75 percent by weight will be of such size as to pass the 1 inch sieve and be retained on the 3/8-inch sieve.

Type "C" (Coarse Graded Surface Course):

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

Bin No. 2 --- will contain aggregates of which at least 70 percent by weight 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 by weight will be of such size as to pass the 3/8" sieve and be retained on the 1/4" sieve.

Bin No. 4 --- will contain aggregates of which at least 75 percent by weight will be of such size as to pass the 7/8" sieve and be retained on the 3/8" sieve.

Type "D" (Fine Graded Surface Course) and
Type "K" (Differential Wear Surface Course):

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

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

Type "E" (Sheet Asphalt Surface Course):

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

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

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

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

Bin No. 2 --- will contain aggregates of which at least 75 percent by weight 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."

Aggregate 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.

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 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; & 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 Types "A", "B", and "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 "K" 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 weight 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 weight box and in the charging of the mixer from the weight 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 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 by more than 25° F.

6. Construction Methods. 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 the temperature of a load of the asphaltic mixture 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.

(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 asphalt 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 of 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.

(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 with pneumatic roller shall be done as 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.

If the surface ravels, it will be the Contractor's responsibility to correct this condition at his expense.

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
G_a = Average 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 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 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.

APPENDIX II.

Design of Bituminous Mixtures (Volumetric Design)

DESIGN OF BITUMINOUS MIXTURES
(VOLUMETRIC DESIGN)

Scope

This procedure provides a means to determine the proper proportions of approved aggregates and asphalt which, when combined, will produce a mixture that will satisfy the specification requirements. An example of a typical design procedure is included in this test method. All references to volumes in this procedure are absolute volumes, i.e. the volume of the mix is the sum of the absolute volumes of the aggregates and the asphalt.

Procedure

1. Obtain and identify representative samples consisting of approximately 50 pounds of each type of material or each size aggregate proposed for use, and dry to constant weight at a temperature of 200° to 230° F.

2. Secure laboratory size sample of each aggregate by carefully reducing the amount of material by quartering as outlined in Test Method Tex-200-F.

3. Determine the sieve analysis as outlined in Test Method Tex-200-F using the sieve sizes as set forth in the specifications for the type mix desired, and the bulk specific gravity of each size aggregate in accordance with Test Methods Tex-201-F or Tex-202-F for natural aggregates. For synthetic aggregates, determine the bulk specific gravity by the Bryant method. This test method was developed by J. S. Bryant and the procedure is described in the thesis titled "The Determination of the Moisture Absorption Characteristics of Lightweight Concrete Aggregates." For purposes of mix design and plant control, it will be assumed that the bulk specific gravity of the portion of the synthetic aggregate passing the 80 mesh sieve is the same as that of the material retained on the 80 mesh sieve.

4. The proper design technique requires that the aggregate proposed for use be combined in such a manner as to approach the average or midpoint of the allowable range set forth in the specifications. However, economy and ratio of production of the aggregate are factors which should be kept in mind in selecting the initial combination to be tested. Only after combinations utilizing the most economical proportions have been determined to be unsatisfactory will other less desirable combinations be tried.

5. After determining the required data in Step 3, assume, on the basis of the aggregate alone, the most satisfactory combination of the available materials which meets the requirements set forth in Step 4. Calculate the gradation by volume of the combined aggregates following the sample procedure outlined under "Typical Application of Procedure." In the event the assumed combination is at any point outside the specified

grading limitations or, in the opinion of the Engineer, too close to these limits for consistent acceptable plant production, other combinations will be tried.

6. After the design gradation has been selected, the necessary asphalt content must be determined which will enable the mixture to satisfy the density (percent compaction), stability values specified and other requirements of the governing specification. Unless previous experience with these aggregates justifies the use of a smaller asphalt range, the method for selecting the proper asphalt content is to prepare five mixtures containing five different asphalt contents which cover the allowable range of the specifications. The percentages of asphalt to be tried are each end-point, the mid-point, and the two quarter-points of the allowable range shown in the specification. A trial specimen should be molded so that any necessary corrections can be made in the amount of material necessary to obtain a standard specimen height of 2.0 $\pm$ 0.06 inches. The asphalt content of the trial specimen should be at the mid-point of the specification range. After calculating the correct weight to produce the trial specimen of standard height, the total weights for specimens containing other percentages of asphalt can be closely approximated in most instances by using the corrected weight of the trial specimen as a base value and changing total weight of specimen to compensate for varying asphalt contents.

7. Combine materials, mix and mold specimens 4 inches in diameter and 2.0 $\pm$ 0.06 inches in height as described in Test Method Tex-205-F and Tex-206-F.

8. When the quality tests include the sand equivalent value, perform this test on the combined materials prior to the addition of asphalt as set forth in Test Method Tex-203-F.

9. Determine the density or percent compaction of the specimen according to Test Method Tex-207-F.

10. Determine the stabilometer value or percent stability of the specimens as described in Test Method Tex-208-F.

11. Plot the test values obtained from the density and stability determinations versus the percent asphalt as illustrated in Figure 1. From this curve the percent asphalt which will provide a mixture that will satisfy the density and stability requirements of the specifications can be determined. If there is not an asphalt content within the allowable range which will provide such a mixture, it will be necessary to assume another combination of aggregates, or possibly, even obtain new materials and perform a new design as outlined herein.

TYPICAL APPLICATION OF PROCEDURE

The blending procedure described herein was prepared for the blending of aggregates having different specific gravities. In brief, the procedure consists of a paper analysis of the grade fractions resulting from a trial or assumed paper blend of the aggregates under consideration. The trial blend ratios reflect units of volume. The procedure for blending aggregates is outlined as follows:

1. Examine the grade fractions reflected in the available aggregate sources. Materials or material combinations that reflect the desired grade fractions are selected for trial blending analyses.

2. Tabulate gradation data for the aggregates selected on an analysis sheet, Form "Aggregate Blending Tabulation." (Analysis sheet must reflect percentages passing a specified sieve size and retained on the next smaller sieve size.)

3. Select trial blend ratios after making a careful study of gradation specifications and the grade fractions available in the materials selected for blending. (Computations are simplified by the use of a total of 10 blend parts.)

4. Multiply the grade fraction percentages by the blend ratios selected.

5. Total the grade fraction percentages in each column and divide by the total number of blend parts.

6. Compare the gradation of the blended aggregate combination with specifications.

7. Repeat Steps 3, 4, and 5 until a material combination is obtained to meet specifications. Materials reflecting other grade fractions may be included if necessary.

An example of volumetric blending by trial and error is included for a further explanation of this procedure.

Problem: Determine the blend ratios to satisfy the special specification for a Type "D" mix. Volume measurements are required for an accurate analysis of the specified grade fractions, whereas weight measurements are required for accurate batching procedures.

Given: (a) Gradation specifications (limits for the Type "D" Mix).

(b) Grade fractions for one synthetic aggregate and two natural aggregates.

(c) Specific gravities for the three aggregates are as follows:

Aggregate A (Synthetic)	Specific Gravity = 1.05
Aggregate B (Limestone Chips)	Specific Gravity = 2.71
Aggregate C (Field Sand)	Specific Gravity = 2.63

The following three tabular sheets show an example of trial analyses and the aggregate blending in order to satisfy gradation specifications. The procedure outlined above was used for the solution of the problem. (Steps 2 through 6).

County BRAZOS Project C123-4-5

Highway SH 6 Cont. 123 Section 4 Job 6

Item No.

AGGREGATE BLENDING TABULATION

VOLUMETRIC DESIGN NUMBER 1

SPECIFICATIONS AND MATERIALS	BLEND PARTS	SIEVE SIZES — % PASSING & RETAINED									
		+ 1/2	1/2 - 3/8	3/8 - 4	4-10	+10	10-40	40-80	80-200	-200	
SPECIFICATIONS TYPE D		0	0-5	20-50	10-30	50-70	0-30	4-25	3-25	0-6	
Synthetic Aggregate Material A		—	5	45	40	90	7	3	—	—	
Limestone Chips Material B		—	4	15	15	34	50	13	1	2	
Field Sand Material C		—	—	—	—	—	15	35	30	20	
Trial No. 1.	Try	1 part A,	1 part B,	1 part C							
A	1	—	5	45	40	90	7	3	—	—	
B	1	—	4	15	15	34	50	13	1	2	
C	1	—	—	—	—	—	15	35	30	20	
Totals	3		9	60	55	124	72	51	31	22	
Divide by 3	1		3	20	18.3	41.3	24	17	10.3	7.3	
Note	variations	from specifications									

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County *BRAZOS* Project *C123-4-5*

Highway *SH6* Cont. *123* Section *4* Job *6*

Item No. ______

AGGREGATE BLENDING TABULATION

VOLUMETRIC DESIGN NUMBER *1*

SPECIFICATIONS AND MATERIALS	BLEND PARTS	SIEVE SIZES — % PASSING & RETAINED									
		+1/2	1/2-3/8	3/8-4	4-10	+10	10-40	40-80	80-200	-200	
SPECIFICATIONS TYPE *"D"*		0	0-5	20-50	10-30	50-70	0-30	4-25	3-25	0-6	
Trial No. 2	*Try*	*2 parts*		*A, 2*	*parts*	*B,*	*1 part C*				
A	2	—	10	90	80	180	14	6	—	—	
B	2	—	8	30	30	68	100	26	2	4	
C	1	—	—	—	—	—	15	35	30	20	
Totals	5	—	18	120	110	248	129	67	32	24	
Divide by 5	1	—	3.6	24.0	22.0	49.6	25.8	13.4	6.4	5.8	
	The	*coarse material must be increased*									
Trial No. 3											
A	4	—	20	180	160	360	28	12	—	—	
B	1	—	4	15	15	34	50	13	1	2	
C	1	—	—	—	—	—	15	35	30	20	
Totals	6		24	195	175	394	93	60	31	22	
Divide by 6	1		4.0	32.5	29.2	65.7	15.5	10	5.2	3.3	
This design meets gradation but must be checked for											

gradation including asphalt. Assume 10% asphalt; then all percentages of aggregate will be reduced to 90% of values shown.

County *BRAZOS* Project *C123-4-5*

Highway *SH 6* Cont. *123* Section *4* Job *6*

Item No. ______

AGGREGATE BLENDING TABULATION

VOLUMETRIC DESIGN NUMBER *1*

SPECIFICATIONS AND MATERIALS	BLEND PARTS	SIEVE SIZES — % PASSING & RETAINED									
		$+\frac{1}{2}$	$\frac{1}{2}-\frac{3}{8}$	$\frac{3}{8}-4$	4-10	+10	10-40	40-80	80-200	-200	
SPECIFICATIONS TYPE *"D"*		0	0.5	20-50	10-30	50-70	0-30	4-25	3-25	0-6	
Multiply by 90%		—	3.6	29.3	26.3	59.1	14.0	9.0	4.7	3.0	
	This design meets specifications and appears satisfactory for making trial laboratory mixes.										

The theoretical blending of 4 parts of synthetic aggregate with 1 part of limestone chips and 1 part of field sand satisfied the gradation requirements for a Type "D" Mix. The blend ratios for volume blending are as follows:

A	-	Synthetic Aggregate	=	66.6%
B	-	Limestone Chips	=	16.7%
C	-	Field Sand	=	16.7%

Since the aggregates for bituminous mixes are frequently batched by weight, the ratios for weight blending are determined as follows:

A	-	Synthetic Aggregate	=	66.6% X 62.4 X 1.05 = 43.64 Lbs.
B	-	Limestone Chips	=	16.7% X 62.4 X 2.71 = 28.24 Lbs.
C	-	Field Sand	=	16.7% X 62.4 X 2.63 = 27.40 Lbs.
				Total 99.28 Lbs.

Then:	A	-	Synthetic Aggregate	=	43.64 ÷ 99.28 = 44.0%
	B	-	Limestone Chips	=	28.24 ÷ 99.28 = 28.4%
	C	-	Field Sand	=	27.40 ÷ 99.28 = 27.6%

Typical sieve analysis of actual blends of synthetic aggregates and natural aggregates are not suitable for field tests and control of the specified grade fractions. Typical gradation analyses are distorted by the weight measurements of the grade fractions of materials having different specific gravities. A volumetric analysis of the various grade fractions must be used for a control test.

8. After a satisfactory proportioning of the aggregates has been determined, the total mix including asphalt must be determined. The specified range of asphalt content is based on volume relationships as the weight relationship is distorted when synthetic aggregates are used in the mix. The combined grading as determined above must be changed to include the volume of asphalt in the mix. The first check is made on an assumed percentage of asphalt; the mid-range of the specifications may be used for a trial. This will indicate if the aggregate gradation will remain in the master grading as the asphalt content is varied from the lower to the upper limits of the specification

9. The volumes of aggregate and asphalt may be converted to weights for convenience in measurement in making trial mixes.

In the sample above, assume that the asphalt has a specific gravity at 77° F. of 1.000. The combined aggregate will have a specific gravity of:

$$\text{Average Specific Gravity: } \frac{100}{\frac{44.0}{1.05} + \frac{28.4}{2.71} + \frac{27.6}{2.63}}$$

= 1.59 or 62.4 X 1.59 = 99.22 Lbs/CF

The asphalt has a unit weight of 62.4 X 1.000 = 62.4 Lbs/CF

To make a trial mix of a given weight, the weight relationship of aggregate and asphalt will be as shown in Table I.

10. After correcting the weights for the design mixes, combine the materials, mix and mold the test specimens, and obtain the percent density and stability values as described in Test Methods Tex-205-F, 206-F, 207-F, and 208-F.

11. The following table shows the average values obtained from the above tests.

Percent Asphalt	Average Percent Density	Average Percent Stability
8.0	92.0	44
10.0	93.9	45
12.0	96.1	40
14.0	97.5	29
16.0	98.3	16

12. To obtain the optimum asphalt content for the design, the above test values are plotted on a sheet of graph paper with the specimen density and stability on the vertical axis and percent asphalt on the horizontal axis. The density and stability curves are drawn by connecting the respective plotted values (Figure 1.) Since the standard specifications specify an optimum density of 97%, a line is drawn vertically down the sheet from the point at which the density curve intersects the 97% density line. This vertical line intersects both the stability curve and the horizontal axis.

The optimum asphalt content, as read from the graph, is 13.3% by volume and the expected laboratory stability of this mixture would be 33%. The above procedure has established a bituminous mixture design based on either stockpile or cold bin aggregates. The design indicates the material should be fed to the plant in the proportions of weight or volume as shown in paragraph 7.

If the materials are carefully proportioned in this manner and the screens of the plant are properly chosen and operate efficiently, the resulting combined hot bin aggregate should closely approximate the design gradation. Experience has proven, however, that this ideal situation rarely exists.

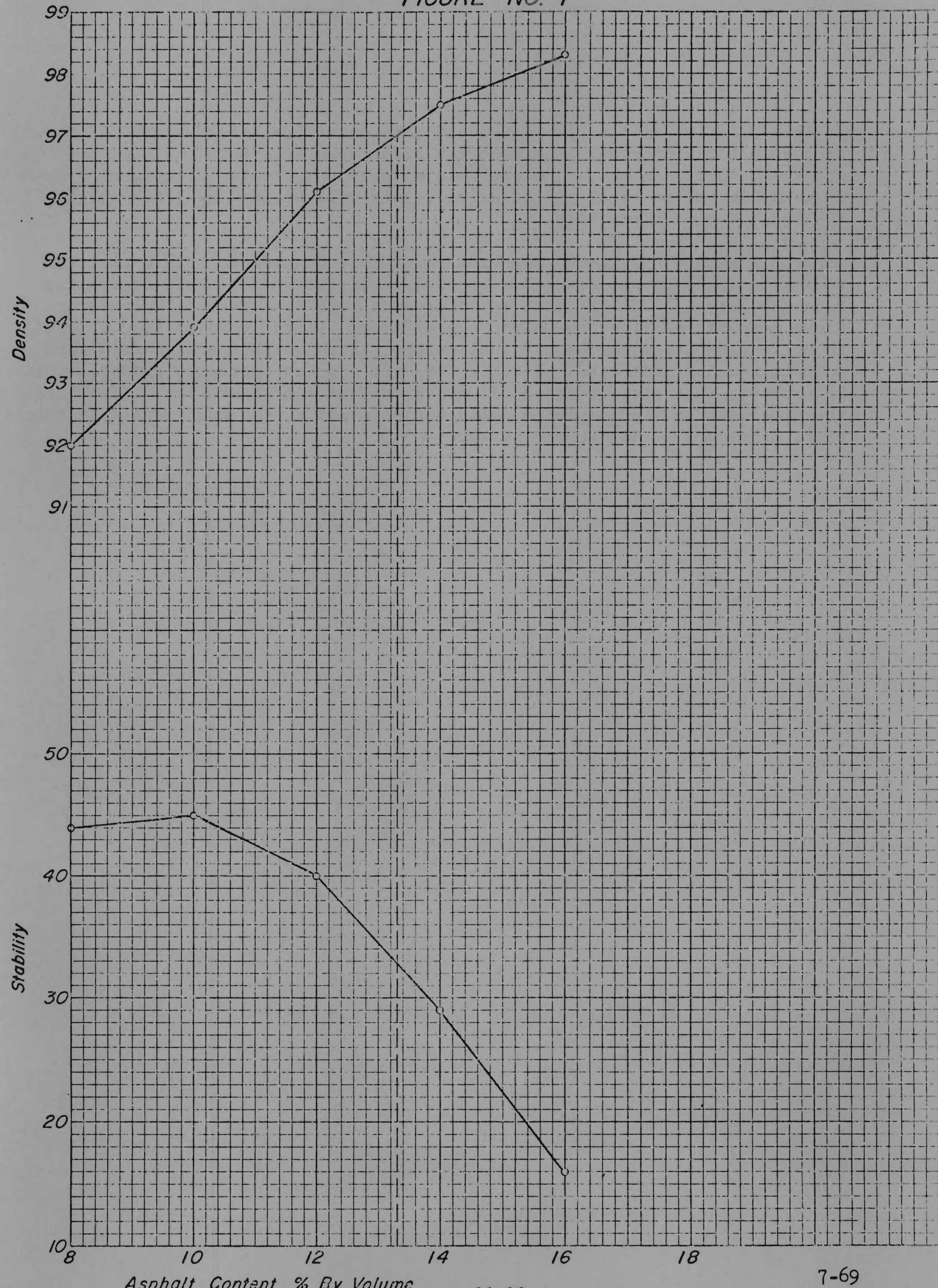
In order to provide the producer with batch weights for plant production, a complete sieve analysis of each hot bin is necessary.

The cold feed should be adjusted to feed the proportions of aggregates from each stockpile as determined in the design procedures. The gradation of the combined aggregates from the hot bins must be checked to determine

TABLE I

% Asphalt By Volume	Weight (In Lbs.) in One C.F. of Mix			Percent of Weight of Total Batch				
	Asphalt	Aggregate	Total	Asphalt	Total Aggregate	Aggregate A	Aggregate B	Aggregate C
9.0	5.62	90.29	95.91	5.86	94.14	41.42	26.74	25.98
10.0	6.24	89.30	95.54	6.53	93.47	41.12	26.55	25.80
11.0	6.86	88.31	95.17	7.21	92.79	40.83	26.35	25.61
12.0	7.49	87.31	94.80	7.90	92.10	40.52	26.16	25.42
13.0	8.11	86.32	94.43	8.59	91.41	40.22	25.96	25.23
14.0	8.74	85.32	94.06	9.29	90.71	39.91	25.76	25.04
15.0	9.36	84.34	93.70	9.99	90.01	39.60	25.56	24.85
16.0	9.98	83.34	93.32	10.69	89.31	39.30	25.36	24.65
17.0	10.61	82.35	92.96	11.90	88.10	38.76	25.02	24.32
18.0	11.23	81.36	92.59	12.13	87.87	38.66	24.96	24.25
19.0	11.86	80.37	92.23	12.86	87.14	38.34	24.75	24.05

FIGURE NO. 1



7-69

if the specified mix is being produced. To determine trial weights of material from each bin, the plant should be run after cold feed settings have been made and the material collected in each bin weighed. The ratio of weight of material in each bin to the total weight of aggregate will be used as batch weights for the beginning of production.

After production is started, control tests must be made to insure that the required mix is being produced. Control tests for gradation of aggregates from the hot bins will be made in accordance with Test Method "Volumetric Sieve Analysis of Fine and Coarse Aggregates". If the results from this test do not correspond with the original design, batch weights and/or cold feed adjustments are indicated. If this does not correct aggregate gradation, it is probable that the gradation of one or more of the stockpiles differs from the gradation of the sample on which the original design was based. In this case, a new design may be necessary.

APPENDIX III.

Excerpt from, "The Determination of the Moisture Absorption Characteristics of Lightweight Concrete Aggregates"

4. Appendix

4.1 Absorption-Time Text (Bryant Method) (5)

EXCERPT FROM

"THE DETERMINATION OF THE MOISTURE ABSORPTION CHARACTERISTICS OF LIGHTWEIGHT CONCRETE AGGREGATES"

A THESIS

BY

JULIAN STEPHEN BRYANT

TEXAS A&M UNIVERSITY

JANUARY 1959

A NEW METHOD OF TEST

The purpose of this research was to devise a simple, reliable method of test that would determine values of absorption, rate of absorption, and specific gravities for both fine and coarse fractions of lightweight aggregates.

The Theory

It was necessary to devise a method of test which did not require handling of the sample or obtaining a saturated, surface-dry condition physically in the sample, and also one which would determine the rate of absorption. The approach was to devise a method that would give the saturated weight of the sample and the surface-dry volume without actually obtaining this condition at the same time.

If the sample is immersed in water in a container of known volume and the water is maintained at a constant level by adding water as the sample absorbs it, then the rate of absorption can be measured by weighing the container at specific time intervals during the test. Then if a rate curve can be established and extrapolated to include zero time, the total amount of absorption can be obtained. Also, the surface-dry volume of the sample can be obtained by subtracting the volume of water at zero time from the volume of the container.

The Test

Scope. This method of test is intended for use in determining the bulk specific gravity, both dry and saturated surface-dry, apparent specific gravity, absorption, and rate of absorption of both the coarse and fine lightweight concrete aggregates. The specific gravity values are as defined in the Standard Definitions of Terms Relating to Specific Gravity (ASTM Designation: E 12) of the American Society for Testing Materials.

Apparatus. The apparatus shall consist of the following:

(a) Balance.—A balance having a capacity of 3 kilograms or more and a sensitivity of 0.1 gram or less.

(b) Container.—A glass Mason jar fitted with a conical brass cap with a hole one-quarter inch in diameter in the top, as illustrated in Fig. 4-1.

Sample. Approximately 400 grams of the aggregate shall be selected by the method of quartering from the sample to be tested.

Procedure. The procedure shall be as follows:

(a) The jar and cap shall be weighed to the nearest 0.1 gram. The jar shall then be filled completely with distilled water and weighed to the nearest 0.1 gram and the temperature of the water recorded. The test shall be conducted in an environment temperature of 72 ± 5° F.

(b) The sample shall be dried in an oven at a temperature of 105°C for 24 hours. It shall then be allowed to cool to room temperature in a dessicator and the weight determined to the nearest 0.1 gram.

(c) After weighing, the sample shall be placed in the Mason jar and the jar filled with distilled water. The cap shall then be placed on the jar and water added to fill the jar and cap completely. The jar with sample and water shall then be weighed to the nearest 0.1 gram and the temperature recorded. With a little practice, this first weighing can be accomplished two minutes after the water is first introduced into the container. Weighings shall then be made at intervals of 2, 4, 6, 8, 10, 20, 30, 60, 90, and 120 minutes from the beginning of the test and each 24 hours thereafter, taking care to agitate the sample by rolling and shaking the jar to remove any air trapped between the particles and refilling the jar so that a constant volume is maintained before each weighing is made.

Calculations. The weight of total water in the container at any time can be obtained by subtracting the weight of the container and the oven-dry weight of the sample from the total weight of the sample, container and water at that time. The weight of total water for each of the time intervals shall be calculated. Then, if the time intervals are represented by t_1, t_2, t_3, . . . t_t and the weights of total water corresponding to those intervals are represented by w_1, w_2, w_3, . . . w_t, a curve can be plotted with time as the abscissa and total water as the ordinate. This curve should be extended to a minimum time of 60 seconds. The total water at zero time shall be referred to as the free water. The curve shall be extended to time zero to determine the amount of free water. For purposes of this test, free water is defined as all water in the container which is not absorbed by

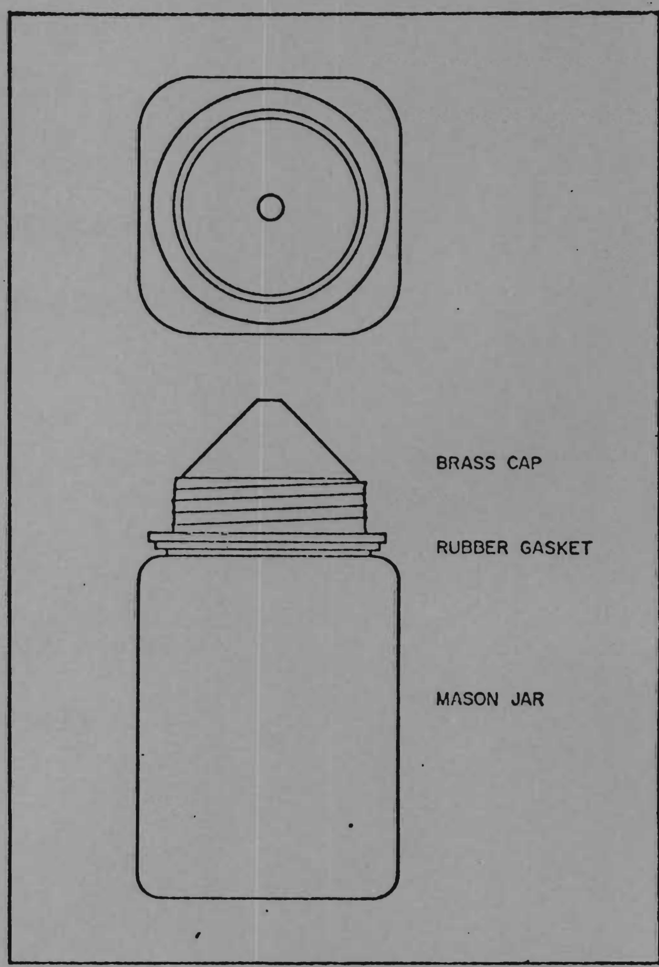


Fig. 4-1. Pycnometer Bottle Used in Tests.

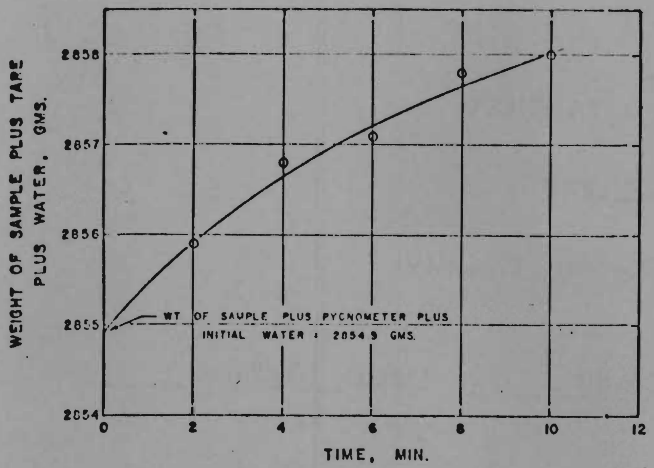


Fig. 4-2. Example Data Plot of Total Water Absorbed Versus Time of Immersion.

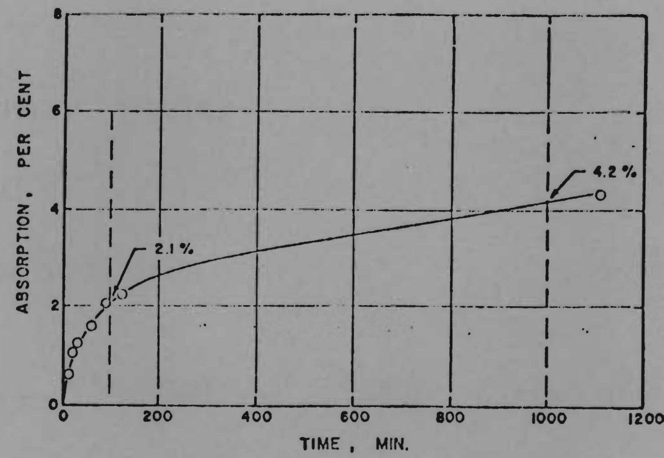


Fig. 4-3. Example Absorption-Time Curve.

the sample. Assuming that the volume of the sample remains constant, then the amount of free water is constant through the test. The volume of free water can then be calculated by dividing the weight of free water by the specific gravity of water at the temperature recorded when the test began. The bulk volume of the sample shall be calculated by subtracting the volume of free water from the volume of the container. The volume of total water at any time, t, shall be calculated by dividing the weight of total water at time, t, by the specific gravity of water at the temperature recorded when the test began. The apparent volume of the sample at any time, t, can then be calculated by subtracting the volume of total water at time, t, from the volume of the container. The absorbed water at any time can be calculated by subtracting the free water from the total water at that time.

Absorption. The percent absorption shall be calculated for each time interval by dividing the weight of absorbed water at each time interval by the oven-dry weight of the sample. The percent absorption versus time shall be plotted on rectangular coordinate graph paper and a smooth curve drawn through these points to establish the rate of absorption.

Bulk Specific Gravity (Dry). The bulk specific gravity shall be calculated by dividing the oven-dry weight of the sample by the bulk volume of the sample.

Bulk Specific Gravity (Saturated Surface-Dry). The bulk specific gravity on a saturated, surface-dry basis at any time, t, shall be calculated by dividing the sum of the oven-dry weight of the sample and the weight of absorbed water at time, t, by the bulk volume of the sample.

TABLE 4-1. EXAMPLE DATA AND CALCULATIONS
ABSORPTION AND SPECIFIC GRAVITY

Date and Time		Time Since Start	Wt. Tare Sample & Water	Weight Total Water	Weight Free Water	Weight Absorbed Water	Percent Absorption
				1660.0	1660.0		
3/2	8:30	2 min	2855.9	1661.0	"	1.0	0.2
	8:32	4	2856.8	1661.9	"	1.9	0.5
	8:34	6	2857.1	1662.2	"	2.2	0.6
	8:36	8	2857.8	1662.9	"	2.9	0.7
	8:38	10	2858.0	1663.1	"	3.1	0.8
	8:48	20	2859.2	1664.3	"	4.3	1.1
	8:58	30	2860.1	1665.2	"	5.2	1.3
	9:28	60	2861.3	1666.4	"	6.4	1.6
	9:58	90	2863.5	1668.6	"	8.6	2.2
	10:28	120	2864.1	1669.2	"	9.2	2.3
3/3	15:00	1110	2872.1	1677.2	"	17.2	4.3
3/4	8:15	2 days	2876.8	1681.9	"	21.9	5.5
3/5	8:17	3	2878.8	1683.9	"	23.9	6.0
3/8	9:00	6	2882.0	1687.1	"	27.9	6.8
3/11	9:07	9	2884.5	1689.6	"	29.6	7.4
3/12	8:10	10	2884.8	1689.9	"	29.9	7.5
3/15	8:40	13	2887.0	1692.1	"	32.1	8.0
3/18	8:26	16	2888.1	1693.2	"	33.2	8.3
3/21	8:30	19	2891.0	1696.1	"	36.1	9.0
3/23	8:12	21	2888.8	1693.9	"	33.9	8.5
3/28	9:17	26	2893.8	1698.9	"	38.9	9.7
3/31	9:00	29	2894.9	1700.0	"	40.0	10.0
4/4	8:05	33	2898.0	1703.1	"	43.1	10.8
4/13	8:20	42	2898.5	1703.6	"	43.6	10.9
4/14	9:00	43	2900.0	1705.1	"	45.1	11.3

TABLE 4-2. TYPICAL DATA SHEET

DATA SHEET

Absorption and Specific Gravity

Project 1081 Aggregate RCA #2 Date 3/2/66

Performed by ______________________

(a) Tare Wt. 795.1 Wt. of Bottle and Water 2723.8

Weight of Water 2723.8 - 795.1 = 1928.7

Temp. of Water 24°C Volume of Bottle $\frac{1928.7}{0.7793}$ = 1933.9

(b) Wt. of bottle & dry sample 1194.9 Wt. Dry Sample 1194.9 - 795.1 = 399.8

(c) Wt. of free water 1660.0 Vol. of Free Water $\frac{1660.0}{0.9973}$ = 1664.5

Bulk Volume of Sample 1933.9 - 1664.5 = 269.4

Wt. Total Water @ 3 days 1683.9 Vol. Total Water $\frac{1683.9}{0.9973}$ = 1688.4

Apparent Vol. Sample 1933.9 - 1688.4 = 245.5

Saturated Wt. Sample 399.8 + 23.9 = 423.7

Absorption (Percent) $\frac{23.9}{399.8}$ = 6.0%

Bulk Specific Gravity (Dry) $\frac{399.8}{269.4}$ = 1.48

Bulk Specific Gravity (SSD) $\frac{423.7}{269.4}$ = 1.57

Apparent Specific Gravity $\frac{399.8}{245.5}$ = 1.63

Aggregate Absorption Factor 4.2 - 2.1 = 2.1

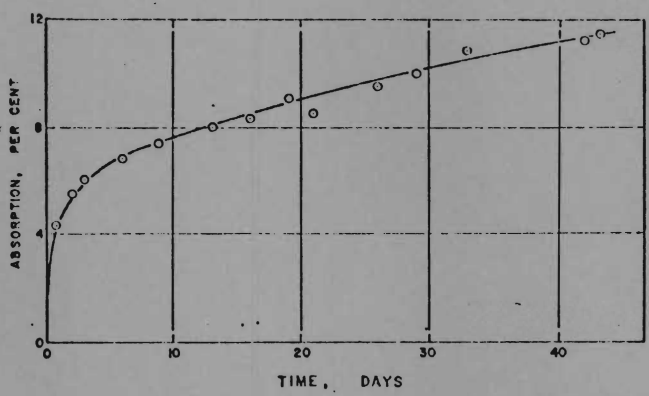


Fig. 4-4. Example Absorption-Time Curve.

Apparent Specific Gravity. The apparent specific gravity at any time, t, shall be calculated by dividing the oven dry weight of the sample by the apparent volume at that time.

4.2 Concrete Mix Design Data

The mix design data for concrete mixes employed in this study are given in Table 4-3.

4.3 References

1. Ledbetter, W. B., "Correlation Studies of Fundamental Aggregate Properties with Freeze-Thaw Durability of Structural Lightweight Concrete," Research Report 81-1, Texas Transportation Institute, Texas A&M University, August, 1965.

2. Kanabar, C. N. and Ledbetter, W. B., "Effects of Degree of Synthetic Lightweight Aggregate Pre-Wetting on the Freeze-Thaw Durability of Lightweight Concrete," Research Report 81-2, Texas Transportation Institute, Texas A&M University, December 1966.

3. Gallaway, Bob M. and Harper, William J., "A Laboratory and Field Investigation of Lightweight Aggregates as Coverstone for Seal Coats and Surface Treatments," Research Report 51-2, Texas Transportation Institute, Texas A&M University, April, 1966.

4. *Standard Specifications for Road and Bridge Construction*, adopted by the State Highway Department of Texas, Item 302, pp. 207, January 2, 1962.

5. Bryant, J. S., "The Determination of the Moisture Absorption Characteristics of Lightweight Concrete Aggregates," M. S. Thesis, Texas A&M University, 1959.

6. Ledbetter, W. B., Hirsch, T. J., and Ivey, Don L., "Selected Durability Studies of Structural Lightweight Concrete," Research Report 35-2, Texas Transportation Institute, Texas A&M University, December, 1964 (Revised April, 1966).

TABLE 4-3. CONCRETE MIX DESIGN DATA

Coarse Aggregate Designator and Lot No.	Concrete Batch Code No.	Cement Factor (sks/cy)	PERCENT ABSOLUTE VOLUME					Slump (in)	Initial Unit Wt (pcf)
			Cement	Water	FA	CA	Air		
R1	5R	5.0	8.7	20.4	34.7	33.7	2.5	3½	118.8
R1	3FTR	4.6	8.2	20.9	34.9	31.7	4.3	4	114.4
R1	4FTR	4.9	8.7	19.0	33.1	33.8	5.4	3	113.2
R2	5FTR	4.9	8.7	18.7	33.0	33.6	6.0	3¾	115.1
C1	5C	4.7	8.4	22.8	35.1	31.7	2.0	4½	115.7
C1	3FTC	4.7	8.3	21.0	34.3	32.1	4.3	3½	117.6
C1	4FTC	4.7	8.4	20.2	34.4	32.2	4.8	4	115.2
E1	5E	4.6	8.2	21.1	36.8	31.8	2.1	3¾	118.0
E4	5E2	4.7	8.3	20.2	37.2	32.3	2.0	4½	128.0
E4	5E3	4.9	8.7	22.0	33.7	33.5	2.1	3	118.2
E4	3FTE	4.7	8.3	17.6	36.0	32.2	5.9	4½	125.2
E4	4FTE	4.7	8.3	17.1	37.4	32.2	5.0	3	120.8
E6	5FTE	4.6	8.2	16.6	37.1	32.1	6.0	3½	117.1
S1	5S	4.9	8.6	23.6	32.7	33.2	1.9	4½	126.8
S1	3FTS	4.9	8.7	20.7	31.7	33.6	5.3	3	116.8
S1	4FTS	4.9	8.7	21.0	32.4	33.6	4.3	3½	118.0
S3	5FTS	5.0	8.8	20.3	32.6	33.8	4.5	3¾	118.2
D1	5D	4.9	8.7	22.9	35.5	30.9	2.0	4¼	118.4
D1	3FTD	5.0	9.0	18.9	35.4	31.9	4.8	3¼	113.6
D1	4FTD	4.9	8.7	19.2	36.2	31.1	4.8	3¾	115.2
D2	5FTD	5.0	8.9	17.8	36.7	31.6	5.0	3¼	116.1

APPENDIX IV.

Test Method Volumetric Analysis of Fine and Coarse Aggregates

TEST METHOD

VOLUMETRIC SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES

Scope:

This test method covers a procedure for the determination of the particle size distribution by volume of fine and coarse aggregate samples, using sieves with square openings. The method is also applicable for use to obtain the sieve analysis of aggregate recovered from bituminous mixtures obtained from plant or roadway.

Apparatus:

1. Sample splitter, quartering cloth, shoveling method on clean surface or quartering machine.

2. Set of Standard U. S. Sieves - woven wire with square openings (A.S.T.M. Designation: E-11).

3. Mechanical Sieve Shaker.

4. Drying oven capable of attaining a temperature of 200°F. or more.

5. Graduate - a glass cylinder with a capacity of 5,000 ml graduated in increments of 5 ml or less.

6. A wide-mouth funnel for transferring aggregates to graduate.

7. Solvent, Benzol, Trichloroethane.

8. Round pans with diameter to fit sieves.

9. Scoop, brass wire brush and hair brush.

Preparation of Sample:

1. Select a representative portion of processed aggregate for test.

2. Place the aggregate in oven and dry to constant weight at a temperature of 140° to 300° F. When drying limestone rock asphalt samples prior to screening, care must be taken to adjust oven temperature so that native bitumen is not fluxed from aggregate. Remove sample from oven and allow to cool to room temperature.

3. To quarter the material, use either the sample splitter, the quartering cloth, quartering machine, or the method of manipulating the aggregate with a large flat scoop or shovel, blending it back and forth on a smooth clean surface until blended and then quartering mechanically with some straight-edge, thus reducing the dry aggregate sample to laboratory testing size. It is permissible for the fine material (major portion passing No. 10 sieve) to thoroughly blend the material and take small portions from several places covering the entire area of the pan to make up the test sample. See Tex-221-F, Table 1 for size of sample.

Procedure:

1. Place the set of sieves, with the largest opening on top, into a pan and pour the aggregate onto the top sieve. Perform a sieve analysis on the aggregate sample by separating the material into a series of particle sizes using such sieves as are necessary to determine compliance with the specifications for the material. The hand sieve operation is done by means of a lateral and vertical motion of the sieves, accompanied by a jarring action so as to keep the material moving continuously over the surface of the sieves. In any case, do not turn or manipulate particles through the openings of the sieves by hand. Continue hand sieving until, by visual observation, no material continues to pass through the sieves in use. When mechanical sieving is used, shaking time should be established that will assure proper sieving of the material without degradation. Check the thoroughness of the sieving by the above described method.

2. Fill the graduate with solvent to a level to cover the entire sample of aggregate. Make an initial reading of the liquid level and record on work sheet. Place the aggregate retained on each sieve size into the graduate, starting with the largest size. After each size of aggregate is placed in the graduate, make a reading of the liquid level and record on the work sheet. For highly absorptive aggregates, each successive size of aggregates should be added at intervals of approximately 30 seconds and the liquid level reading taken approximately 15 seconds after each addition of aggregate. The same timing should be used on each test so that results will be comparable.

Care should be taken to eliminate entrapped air in the graduate, particularly after the fine aggregate is added. This can be done by gently rolling the graduate or stirring the aggregate prior to taking a reading of liquid level. After each test is completed, the solvent may be decanted or filtered and saved for reuse.

By subtracting the liquid reading prior to the addition of each size of aggregate from the liquid reading after the addition of aggregate, the volume of each size of aggregate may be determined. This information is to be entered in Column 3 of the work sheet. The difference in initial and final readings will be the total volume of the aggregate. Divide each volume of aggregate by total aggregate volume to determine percent retained on each sieve and enter in Column 4. This percent will be an expression of each size as a portion of the total aggregate. This is to be corrected to express the portion of each aggregate size as a portion of the total mix including asphalt. The design percent of asphalt (by volume) is subtracted from 100% to give the percent of the mix made up by the aggregate. This percent is to be multiplied by each aggregate fraction in Column 4 to give the percent of each size aggregate in the total mix. These values are to be entered in Column 5.

The gradation shown in Column 5 is the gradation to be entered on Form 404, Revised April 1969. This gradation is to be compared with design gradation and master gradation for compliance with the specifications.

VOLUMETRIC SIEVE ANALYSIS

WORK SHEET

Date 5-5-69 Sample No. 3 Design No. 1-D

Time 1:15 Type D Station No. 1519+00

Spec. Item ______ Project C 123-4-5

% Of Aggregate In Total Mix 90.0 (100% – % Asphalt)

Initial Reading Of Liquid Level 1500 ml.

1	2	3	4	5
Aggregate Size	Reading of Liquid Level After Addition of Aggregate ml.	Volume of Aggregate ml.	Volume of Aggregate % of Total Aggregate	Volume of Aggregate % of Total Mix.
+ 1/2	1500	0	0	0
1/2 - 3/8	1635	135	4.5	4
3/8 - 4	2795	1160	38.7	34
4 - 10	3545	750	25.0	22
+ 10	3545	2045	68.2	60
10 - 40	3885	340	11.4	10
40 - 80	4160	275	9.1	8
80 - 200	4365	205	6.8	6
- 200	4500	135	4.5	4
	Total	3000		

APPENDIX V.

Addendum to Test Method Tex-210-F

ADDENDUM TO

TEST METHOD TEX-210-F

DETERMINATION OF ASPHALT CONTENT
OF BITUMINOUS MIXTURES
BY EXTRACTION

Scope: This addendum gives a method of converting asphalt content determined by Test Method Tex-210-F and expressed as a percentage by weight to a percentage expressed by volume as required by the volumetric design specifications.

Procedure:

1. Complete Test Method Tex-210-F.

2. Perform Test Method "Volumetric Sieve Analysis of Fine and Coarse Aggregates" on samples taken from the hot bins at the same time a sample is taken for the extraction test.

3. Weigh the dry aggregate sample tested in Step 2.

4. By the ratio of asphalt to aggregate weight determined in Step 1, calculate the weight of asphalt required to give the same ratio for the aggregate sample in Step 2.

5. Convert this weight of asphalt to an equivalent volume at 77° F.

6. Add volume of aggregate in Step 2 to asphalt volume in Step 5 to obtain total volume of mix. Determine percentage of asphalt content by dividing asphalt volume by volume of total mix.

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For use on Project
C 49-14-2 etc.

APPENDIX VI.

Special Provision to Item 6, Control of Materials

TEXAS HIGHWAY DEPARTMENT

SPECIAL PROVISION

TO

ITEM 6

CONTROL OF MATERIALS

For this project, Item 6, "Control of Materials", of the Standard Specifications is hereby supplemented with respect to the clauses cited below and no other clauses or requirements of this item are waived or changed hereby.

Article 6.1 Sources of Supply and Quality of Materials is supplemented by the addition of the following requirements:

Coarse aggregate furnished for use in Hot Mix Asphaltic Concrete Pavement shall have a "Polish Value" of not less than 29 when subjected to tests as specified in "Accelerated Polish Test Method for Coarse Aggregate Used in Pavement Surfaces" (attached). This is a quality test for approval of the source and not a job control test.

ACCELERATED POLISH TEST METHOD FOR COARSE AGGREGATE USED IN PAVEMENT SURFACES

Scope:

This test method describes procedures for determining a relative measure of the extent to which different types of aggregate in the wearing surface will polish under traffic.

Definitions:

The "Polish Value" is defined as the state of polish reached by each sample when subjected to accelerated polish by means of a special machine. The test is in two parts:

(1) Samples of stone are subjected to an accelerated polishing action in a special machine.

(2) The state of polish reached by each sample is measured by a British Portable Tester and expressed as the "Polish Value".

Apparatus:

1. Accelerated Polishing Machine:

An accelerated polishing machine shall be mounted on a firm level and non-resiliant base of stone or concrete and shall include:

A. A wheel (referred to as the road wheel) having a flat periphery and of such size and shape as to permit 14 specimens described below to be clamped on the periphery so as to form a continuous surface of stone particles, 1 3/4 inches wide and 16 inches in diameter.

B. A means of rotating the road wheel about its own axis at a speed of 315 to 325 revolutions per minute.

C. A means of bringing the surface of a rubber tired wheel of 8 inch diameter and 2 inch width to bear on the stone surface of the road wheel with a total load of 88 ± one pound. The tire shall be an industrial 8 x 2 pneumatic 4 ply smooth hand truck tire, treated, if necessary, to obtain a true running surface. The tire shall be inflated to a pressure of 45 plus or minus 2 pounds per

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For use on Project
C 49-14-2 etc.

square inch and shall be free to rotate about its own axis, which shall be parallel to the axis of the road wheel. The plane of rotation of the tire shall be in line with that of the road wheel. Before a new tire is used on a test, it shall be given a preliminary run of 6 hours with a 150 grit silicon carbide using dummy specimens on the road wheel.

D. A means to feed the 150 grit silicon carbide at the rates shown in "Accelerated Polish Test Procedure" and in such a way that the silicon carbide grit is continuously and uniformly spread over the surface of the tire and the specimens where they are in contact. The grit shall be fed directly onto the road wheel near the point of contact with the rubber tired wheel.

E. A means to feed the water at the rate shown in "Accelerated Polish Test Procedure" in such a way that the water is continuously and uniformly spread over the surface of the road wheel near the point of contact with the rubber tired wheel.

2. Metal Molds: A number of accurately machine metal molds for preparing specimens of the dimensions specified in No. 4 - "Preparation of Test Specimen".

3. British Portable Tester:

The British Portable Tester used shall conform to ASTM Designation E 303-66T with the following modifications:

A. The slider contact path shall be 3" ± 1/16 inch.

B. The slider width shall be 1 1/2 inches.

C. The rubber which is bonded to the slider shall conform to a 1/4 by 1 by 1 1/2 inch dimension.

D. The rubber shall meet the requirements as specified in ASTM Specification E 249, for Standard Tire for Pavement Tests.

E. The zero adjustment shall be checked before testing the fourteen specimens and after testing the specimens and as often as the operator deems necessary.

F. Calibration procedures of ASTM E 303-66T shall be used, however, after calibration the small slider shall be inserted.

4. A supply of disposable cups and stirring rods for use in molding the specimens.

Materials:

1. Water: A supply of tap water to be spread on the road wheel during testing.

2. Fine Sand: A supply of fine sand for sifting in the aggregate interstices prior to the placement of the polyester bonding agent.

3. Mold Release Agent: A supply of polyester mold release agent used to prevent bond between the mold and polyester.

4. Silicon Carbide Grit: A supply of silicon carbide grit (150 grit size) to be used as the polishing agent.

5. Polyester Bonding Agent: A supply of polyester resin and catalyist.

6. Coarse Aggregate: Approximately a one-half cubic-foot supply of coarse aggregate to be tested. The aggregate shall be normal plant run and laboratory crushed material shall be tested.

Test Record Forms: Record test data on an appropriate work sheet.

Test Control: Four specially selected specimens shall be used for control and only these four specimens shall be used. The specimens shall be selected from those which have been previously polished for 10 hours conforming to the procedure herein established. The friction value (as determined from the British Portable Tester) of the specimens shall be in the following ranges:

Control Specimen #1 - 10-20	Control Specimen #3 - 30-40
Control Specimen #2 - 20-30	Control Specimen #4 - 40-55

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The control specimens shall be tested with the British Portable Tester prior to measuring the "polish value" of the test specimens. Corrections to the polish value will be made on the basis of change in friction values found with the control specimens.

Preparation of Test Specimens:

1. The aggregate to be tested should pass the 1/2 inch sieve and be retained on the #4 sieve.

2. Aggregate shall be clean and free of dust.

3. The mold shall be coated with an application(s) of mold release agent.

4. Each specimen shall consist of a single layer of particles and cover an area of 3.5" x 1.75".

5. The aggregate particles shall be placed as closely as possible in the molds with a flat surface against the bottom of the mold.

6. The interstices between the stones shall be filled with fine sand to 1/4 to 1/2 of the aggregate depth.

7. Weigh the polyester resin and catalyst into a disposable cup, add the resin to the catalyst and mix thoroughly. A mixture of 0.5 to 0.75 grams of catalyst to 50 to 57 grams of polyester resin yields sufficient material for one specimen and remains workable for 10 minutes.

8. The prepared mold is then filled to overflowing with the polyester bonding agent.

9. The consistency of the polyester should be such as to allow it to flow freely between the particles.

10. The mold is then left until the polyester has stiffened sufficiently to be struck off accurately, level with the curved sides of the mold.

11. The specimen is then left in the mold for 3-4 hours to allow sufficient hardening of the polyester in order that the specimen may be removed from the mold.

12. The excess sand is removed from the face of the specimen.

13. The specimen is then replaced in the mold for a curing period of 4 hours with a weight (conforming to the curved sides) on the mold to insure proper curvature of the specimen upon removal.

Accelerated Polish Test Procedure:

1. Determine the friction value of the control specimens for correction purposes as explained in the "Test Control" paragraph.

2. Determine the original friction number of the prepared test specimens as explained in ASTM Designation E 303-66T and modified by paragraph 3 "Apparatus".

3. Fourteen specimens shall be clamped around the periphery of the road wheel using rubber O-rings near the edges of the specimens.

4. The outer surface of the specimens shall then form a continuous strip of particles upon which the pneumatic-tired wheel shall ride freely without bumping or slipping.

5. The road wheel shall then be brought to a speed of 320 ± 5 rev/min, and the pneumatic-tired wheel shall be brought to bear on the surface of the specimen with a total load of 88 ± 1 pound.

6. No. 150 silicon carbide grit shall be continuously fed at at constant rate of 16 ± 4 grams per minute for a testing time of nine hours. Water shall be fed at a rate of 75 ± m.l. per minute.

7. The specimens are then removed from the road wheel and washed thoroughly to remove grit.

8. Determine the friction value of the control specimens for correction purposes as explained in the "Test Control" paragraph.

9. After cleaning, the specimens shall be tested on the British Portable Tester to determine the "polish value", as explained in ASTM Designation E303-66T and modified by paragraph 3 - "Apparatus".

APPENDIX VII.

Important Notice to Contractors - Accelerated Polish Test Method for Coarse Aggregate Used in Pavement Surfaces

TEXAS HIGHWAY DEPARTMENT

SPECIAL PROVISION

IMPORTANT NOTICE TO CONTRACTORS

ACCELERATED POLISH TEST METHOD FOR COARSE AGGREGATE USED IN PAVEMENT SURFACES

Scope:

This test method describes procedures for determining a relative measure of the extent to which different types of aggregate in the wearing surface will polish under traffic.

Definitions:

The "Polish Value" is defined as the state of polish reached by each sample when subjected to accelerated polish by means of a special machine. The test is in two parts:

(1) Samples of stone are subjected to an accelerated polishing action in a special machine.

(2) The state of polish reached by each sample is measured by a British Portable Tester and expressed as the "Polish Value".

Apparatus:

1. Accelerated Polishing Machine:
An accelerated polishing machine shall be mounted on a firm level and non-resilient base of stone or concrete and shall include:

A. A wheel (referred to as the road wheel) having a flat periphery and being of such size and shape as to permit 14 specimens described below to be clamped on the periphery so as to form a continuous surface of stone particles, 1 3/4 inches wide and 16 inches in diameter.

B. A means of rotating the road wheel about its own axis at a speed of 315 to 325 revolutions per minute.

C. A means of bringing the surface of a rubber-tired wheel of 8-inch diameter and 2-inch width to bear on the stone surface of the road wheel with a total load of 88 ± one pound. The tire shall be an industrial 8 x 2 pneumatic 4-ply smooth hand truck tire, treated, if necessary, to obtain a true running surface. The tire shall be inflated to a pressure of 45 plus or minus 2 pounds per square inch and shall be free to rotate about its own axis, which shall be parallel to the axis of the road wheel. The plane of rotation of the tire shall be in line with that of the road wheel. Before a new tire is used on a test, it shall be given a preliminary run of 6 hours with a 150-grit silicon carbide using dummy specimens on the road wheel.

D. A means to feed the 150-grit silicon carbide at the rates shown in "Accelerated Polish Test Procedure" and in such a way that the silicon-carbide grit is continuously and uniformly spread over the surface of the tire and the specimens where they are in contact. The grit shall be fed directly onto the road wheel near the point of contact with the rubber-tired wheel.

E. A means to feed the water at the rate shown in "Accelerated Polish Test Procedure" in such a way that the water is continuously and uniformly spread over the surface of the road wheel near the point of contact with the rubber-tired wheel.

2. Metal Molds:

A number of accurately-machined metal molds for preparing specimens of the dimensions specified in No. 4 - "Preparation of Test Specimen".

3. British Portable Tester:

The British Portable Tester used shall conform to ASTM Disignation E 303-66T with the following modifications:

A. The slider contact path shall be 3" ± 1/16 inch.

B. The slider width shall be 1 1/4 inches.

C. The rubber which is bonded to the slider shall conform to a 1/4 by 1 by 1 1/4 inch dimension.

D. The rubber shall meet the requirements as specified in ASTM Specification E 249, for Standard Tire for Pavement Tests.

E. The zero adjustment shall be checked before testing the fourteen specimens and after testing the specimens and as often as the operator deems necessary.

F. Calibration procedures of ASTM E 303-66T shall be used, however, after calibration the small slider shall be inserted.

4. A supply of disposable cups and stirring rods for use in molding the specimens.

Materials:

1. Water: A supply of tap water to be spread on the road wheel during testing.

2. Fine Sand: A supply of fine sand for sifting in the aggregate interstices prior to the placement of the polyester bonding agent.

3. Mold-Release Agent: A supply of polyester mold-release agent used to preprevent bond between the mold and polyester.

4. Silicon-Carbide Grit: A supply of silicon-carbide grit (150-grit size) to be used as the polishing agent.

5. Polyester Bonding Agent: A supply of polyester resin and catalyst.

6. Coarse Aggregate: Approximately a one-half cubic-foot supply of coarse aggregate to be tested. The aggregate shall be normal plant-run and laboratory crushed material shall be tested.

Test Record Forms: Record test data on an appropriate work sheet.

Test Control: Four specially-selected specimens shall be used for control and only these four specimens shall be used. The specimens shall be selected from those which have been previously polished for 10 hours conforming to the procedure herein established. The friction value (as determined from the British Portable Tester) of the specimens shall be in the following ranges:

Control Specimen #1 -10-20	Control Specimen #3 - 30-40
Control Specimen #2 -20-30	Control Specimen #4 - 40-55

The control specimens shall be tested with the British Portable Tester prior to measuring the "polish value" of the test specimens. Corrections to the polish value will be made on the basis of change in friction values found with the control specimens.

Preparation of Test Specimens:

1. The aggregate to be tested should pass the 3/8-inch sieve and be retained on the #4 sieve.

2. Aggregate shall be clean and free of dust.

3. The mold shall be coated with an application(s) of mold-release agent.

4. Each specimen shall consist of a single layer of particles and cover an area of 3.5" x 1.75".

5. The aggregate particles shall be placed as closely as possible in the molds with a flat surface against the bottom of the mold.

6. The interstices between the stones shall be filled with fine sand from 1/4 to 1/2 of the aggregate depth.

7. Weigh the polyester resin and catalyst into a disposable cup, add the resin to the catalyst and mix thoroughly. A mixture of 0.5 to 0.75 gram of catalyst to 50 to 57 grams of polyester resin yields sufficient material for one specimen and remains workable for 10 minutes.

8. The prepared mold is then filled to overflowing with the polyester bonding agent.

9. The consistency of the polyester should be such as to allow it to flow freely between the particles.

10. The mold is then left until the polyester has stiffened sufficiently to be struck off accurately, level with the curved sides of the mold.

11. The specimen is then left in the mold for 3-4 hours to allow sufficient hardening of the polyester in order that the specimen may be removed from the mold.

12. The excess sand is removed from the face of the specimen.

13. The specimen is then replaced in the mold for a curving period of 4 hours with a weight (conforming to the curved sides) on the mold to insure proper curvature of the specimen upon removal.

Accelerated-Polish-Test Procedure:

1. Determine the friction value of the control specimens for correction purposes as explained in the "Test Control" paragraph.

2. Determine the original friction number of the prepared test specimens as explained in ASTM Designation E 303-66T and modified by paragraph 3 "Apparatus".

3. Fourteen specimens shall be clamped around the periphery of the road wheel using rubber O-rings near the edges of the specimens.

4. The outer surface of the specimens shall then form a continuous strip of particles upon which the pneumatic-tired wheel shall ride freely without bumping or slipping.

5. The road wheel shall then be brought to a speed of 320 $\pm$ 5 rev/min, and the pneumatic-tired wheel shall be brought to bear on the surface of the specimen with a total load of 88 $\pm$ 1 pound.

6. No. 150 silicon-carbide grit shall be continuously fed at constant rate of 16 $\pm$ 4 grams per minute for a testing time of nine hours. Water shall be fed at a rate of 75 $\pm$ m. l. per minute.

7. The specimens are then removed from the road wheel and washed thoroughly to remove grit.

8. Determine the friction value of the control specimens for correction purposes as explained in the "Test Control" paragraph.

9. After cleaning, the specimens shall be tested on the British Portable Tester to determine the "polish value", as explained in ASTM Designation E303-66T and modified by paragraph 3 - "Apparatus".

APPENDIX VIII.

Special Provision 026 to Item 330

TEXAS HIGHWAY DEPARTMENT

SPECIAL PROVISION

TO

ITEM 330

COLD MIX LIMESTONE ROCK ASPHALT PAVEMENT
(Class A)

For this Project, Item 330, "Cold Mix Limestone Rock Asphalt Pavement (Class A)", of the Standard Specifications is hereby amended with respect to the clauses cited below and no other clauses or requirements of this item are waived or changed hereby.

Article 330.2. Materials, Subarticle (1) Rock Asphalt. The fifth paragraph is voided and replaced by the following:

Except for Type D paving mixture the portion of the material retained on the No. 4 sieve shall contain by weight from 20 percent to 35 percent of material with a naturally-impregnated-asphalt content of less than 1 percent. The portion of the material retained on the No. 4 sieve for Type D paving mixture shall contain by weight from 15 percent to 35 percent of the material with a naturally-impregnated-asphalt content of less than 1 percent. This percentage shall be adjusted within the grading limits to obtain an acceptable mixture.

Article 330.2. Materials, Subarticle (1) Rock Asphalt, is supplemented by the following:

The coarse aggregate for use 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 aggregates used in level-up courses. The "Polish Value" test is a quality test for approval of the source and not a job-control test.

Article 330.6. Construction Methods, Subarticle (3) Placing, is supplemented by the following:

Where more than one course of pavement is to be placed, no succeeding course shall be placed until the preceding course has cured to the satisfaction of the Engineer, but shall contain not more than a maximum of 3 percent moisture and 0.2 percent hydrocarbon-volatile content of the mixture by weight as determined by Test Method Tex-212-F and 213-F or test methods included in THD Bulletin C-14.

Article 330.7. Measurement is voided and replaced by the following:

330.7. Measurement. (1) The rock-asphalt mixture will be measured by the cubic yard as actually used in the completed and accepted work in accordance with the plans and specification for the project. The volume of the rock-asphalt mixture will be determined by the following formula:

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

V = Cubic Yards of compacted Aggregate

W = Total weight of rock-asphalt 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

Y = Weight of water in pounds in excess of 4% of total weight of mix at time of wieghing

The weight will be determined on truck scales as provided in the specification. Records will be kept on tare load, total load and net load of rock-asphalt mixture for each load of same.

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

APPENDIX IX.

Special Specification, Hot Mix Asphaltic Concrete Pavement (Volumetric Design) (2103.000)

TEXAS HIGHWAY DEPARTMENT

SPECIAL SPECIFICATION

HOT-MIX ASPHALTIC-CONCRETE PAVEMENT (Volumetric Design)

1. Description. For Project C 49-8-29, Etc, this item shall consist of a base course, 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 details 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 Item 6 of the Standard Specifications, 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.

(a) Coarse Aggregate. The coarse aggregate shall be that part of the aggregate retained on a No. 10 sieve; shall consist of clean, though, durable fragments of stone, crushed blast furnace slag, crushed gravel, gravel, slag aggregate (produced from burning coal), crushed limestone rock asphalt, 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.

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 2 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 accordance 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 be 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 30 percent and not more than 40 percent when subjected to the Los Angeles Abrasion Test. Also, the abrasion of the two different materials shall differ by at least 10 precent. 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 one crushed face.

The requirement for the Los Angeles Abrasion Test shall be waived for slag aggregate produced from burning coal.

Where coarse aggregates are supplied from two or more sources, aggregate from each source 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.

When 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..........	2 - 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 type of asphaltic cement or oil asphalt as determined by the Engineer and shall meet the requirements of the Item, "Asphalts, oils and Emulsions". The grade of asphalt used shall be as designed 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 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 by 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 constiuent 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 "A" (Coarse Graded Base Course):

	Percent By Absolute Volume
Passing 2" sieve	100
Passing 1-3/4" sieve	95 to 100
Passing 1-3/4" sieve, retained on 7/8" sieve	15 to 40
Passing 7/8" sieve, retained on 3/8" sieve	15 to 40
Passing 3/8" sieve, retained on No. 4 sieve	10 to 25
Passing No. 4 sieve, retained on No. 10 sieve	5 to 20
Total retained on No. 10 sieve	65 to 80
Passing No. 10 sieve, retained on No. 40 sieve	0 to 20
Passing No. 40 sieve, retained on No. 80 sieve	3 to 15
Passing No. 80 sieve, retained on No. 200 sieve	2 to 15
Passing No. 200 sieve	0 to 6

The asphaltic material shall form from 7 to 14 percent of the mixture by volume. (Absolute Volume)

Type "B" (Fine Graded Base or Leveling-Up Course):

Passing 1" sieve	100
Passing 7/8" sieve	95 to 100
Passing 7/8" sieve, retained on 3/8" sieve	20 to 50
Passing 3/8" seive, retained on No. 4 sieve	10 to 40
Passing No. 4 sieve, retained on No. 10 sieve	5 to 25
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 20
Passing No. 80 sieve, retained on No. 200 sieve..	3 to 20
Passing No. 200 sieve............................	0 to 6

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

Type "C" (Coarse Graded Surface Course):

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..............................	
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..................	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 9 to 19 percent of the mixture by volume. (Absolute Volume)

Type "E" (Sheet Asphalt Surface Course):

Passing No. 4 sieve............................	100
Passing No. 4 sieve, retained on No. 10 sieve...	0 to 5
Passing No. 10 sieve, retained on No. 40 sieve..	15 to 40
Passing No. 40 sieve, retained on No. 80 sieve..	20 to 45
Passing No. 80 sieve, retained on No. 200 sieve.	12 to 32
Passing No. 200 sieve..........................	7 to 20

The asphaltic material shall form from 17 to 28 percent of the mixture by volume. (Absolute Volume)

Type "E" Mod. (Sheet Asphalt Surface Course):

Coarse aggregates for Type "E" Mod. Shall be crushed material or a combination of slag aggregate and crushed stone. Fine aggregate shall be as shown elsewhere in this specification.

The master grading for Type "E" Mod. (Sheet Asphalt Surface Course) shall be as follows unless otherwise shown on plans:

	When Slag Aggr. is Used % by Absol. Vol.	When Crushed Material is Used % by Absol. Vol.
Passing 1/2" Sieve	100	100
Passing 3/8" Sieve	95-100	95-100
Passing 3/8" sieve, retained on No. 4 sieve	15- 50	15- 50
Passing No. 4 sieve, retained on No. 10 sieve	10- 30	10- 30
Total Retained on No. 10 sieve	35- 60	50- 70
Passing No. 10 sieve, retained on No. 40 sieve	15- 50	5- 30
Passing No. 200 sieve	2- 10	2- 10

The asphaltic material shall form from 12 to 22 percent of the mixture by volume. (Absolute Volume)

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

	Percent by Absol. 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 "K" (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	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 9 to 19 percent of the mixture by volume. (Absolute Volume)

Type "M" (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 Absol. Volume
Passing 1-3/4" sieve, retained on 7/8" sieve	plus or minus 5
Passing 7/8" sieve, retained on 3/8" 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 2.0

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) 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 screenings are used, the extraction requirements relative to asphalt content are waived.

(4) 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 ASTM Designation: D 2041 will have the following laboratory density and stability:

	Density, Percent Min.	Max.	Optimum	Stability, Percent
Types A, B, C, D, E, F, K	95	99	97	Not less than 30 unless otherwise shown on plans.
Type E Mod.	92	98	95	Not less than 30 unless otherwise shown on plans.

Stability and density tests are control tests. If the laborabory 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, and 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 propertioning 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, on 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 four bins when producing Type "A", Type "B", and Type "C" mixtures; at least three bins when producing Type "D" and Type "K" mixtures; and at least two bins when producing Type "E", Type "E" Mod., and Type "F" mixtures. If mineral filler is needed, an additional bin shall be provided. These bins shall contain the following sizes of aggregates which shall be based on "Percent by Volume" when synthetic aggregate is used and "Percent by Weight" when other aggregates are used:

Type "A" (Coarse Graded Base 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 3/8-inch 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 7/8-inch sieve and be retained on the 3/8-inch sieve.

Bin No. 4--- will contain aggregates of which at least 75 percent will be of such size as to pass the 2-inch sieve and be retained on the 7/8-inch sieve.

Type "B" (Fine Graded Base or Leveling-up 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 3/8-inch sieve and be retained on the 1/4" sieve.

Bin No. 4--- will contain aggregates of which at least 75 percent will be of such size as to pass the 1 inch sieve and be retained on the 3/8-inch sieve.

Type "C" (Coarse Graded 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 3/8" sieve and be retained on the 1/4" sieve.

Bin No. 4 --- will contain aggregates of which at least 75 percent will be of such size as to pass the 7/8" sieve and be retained on the 3/8" sieve.

Type "D" (Fine Graded Surface Course) and
Type "K" (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 "E" (Sheet Asphalt 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.

Type "F" (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 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 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 nubmer 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 batching 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.

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 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 will 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 thoroughout 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. 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 Types "A", "B", and "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 "K" 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 be 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 Aggregate". 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 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 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 by more than 25 F.

6. Construction Methods. 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 below 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 the temperature of a load of the asphaltic mixture 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.

(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 tamperature at time of application shall be as provided above. The tack coat or asphalt 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. When 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 asphlatic 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 adhereing 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 section 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.

(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 ans 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 with pneumatic roller shall be done as 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.

If the surface ravels, it will be the Contractor's responsibility to correct this condition at his expense.

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:

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

V = Cubic Yards of compacted aggregate
W = Total weight of asphaltic concrete in pounds
G_a = Average actual specific gravity of three mold 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 to 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.

APPENDIX X.

Special Specification, Hot Mix Cold-Laid Asphaltic Concrete Pavement (Volumetric Design) (2104.000)

TEXAS HIGHWAY DEPARTMENT

SPECIAL SPECIFICATION

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

1. Description. For Project C 49-8-29, etc, this item shall consist of a base course, 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 Item 6 of the Standard Specifications, 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.

(a) Coarse Aggregate. The coarse aggregate shall be that part of the aggregate retained on a No. 10 sieve; shall consist of clean, tough, durable fragments of stone, crushed blast furnace slag, crushed gravel, gravel, slag aggregate (produced from burning coal), crushed limestone rock asphalt, 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.

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 2 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 accordance 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 judgment 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 30 percent and not more than 40 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 requirement for the Los Angeles Abrasion Test shall be waived for slag aggregate produced from burning coal.

Where coarse aggregates are supplied from two or more sources, aggregate from each source 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..................	2 - 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 Item, "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 bv 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 "AA" (Coarse Graded Base Course):

	Percent By Absolute Volume
Passing 2" sieve..............................	100
Passing 1-3/4" sieve..........................	95 to 100
Passing 1-3/4" sieve, retained on 7/8" sieve...	15 to 40
Passing 7/8" sieve, retained on 3/8" sieve.....	15 to 40
Passing 3/8" sieve, retained on No. 4 sieve....	10 to 25
Passing No. 4 sieve, retained on No. 10 sieve..	5 to 20
Total retained on No. 10 sieve.................	65 to 80
Passing No. 10 sieve, retained on No. 40 sieve.	0 to 20
Passing No. 40 sieve, retained on No. 80 sieve.	3 to 15
Passing No. 80 sieve, retained on No. 200 sieve	2 to 15
Passing No. 200 sieve..........................	0 to 6

The asphaltic material shall form from 7 to 14 percent of the mixture by volume. (Absolute Volume)

Type "BB" (Fine Graded Base or Leveling-Up Course):

Passing 1" sieve...............................	100
Passing 7/8" sieve.............................	95 to 100
Passing 7/8" sieve, retained on 3/8" sieve.......	20 to 50
Passing 3/8" sieve, retained on No. 4 sieve......	10 to 40
Passing No. 4 sieve, retained on No. 10 sieve....	5 to 25
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 20
Passing No. 80 sieve, retained on No. 200 sieve...	3 to 20
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 "CC"(Coarse Graded Surface Course):

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 "CC"(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....................	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 9 to 19 percent of the mixture by volume. (Absolute Volume)

Type "DD"(Sheet Asphalt Surface Course):

Passing No. 4 sieve.............................	100
Passing No. 4 sieve, retained on No. 10 sieve......	0 to 5
Passing No. 10 sieve, retained on No. 40 sieve.....	15 to 40
Passing No. 40 sieve, retained on No. 80 sieve.....	20 to 45
Passing No. 80 sieve, retained on No. 200 sieve....	12 to 32
Passing No. 200 sieve...........................	7 to 20

The asphaltic material shall form from 17 to 28 percent of the mixture by volume. (Absolute Volume)

Type "EE" Mod. (Sheet Asphalt Surface Course):

Coarse aggegates for Type "EE" Mod. shall be curshed material or a combination of slag aggregate and crushed stone. Fine aggregate shall be as shown elsewhere in this specification.

The master grading for Type"EE" Mod. (Sheet Asphalt Surface Course) shall be as follows unless otherwise shown on plans:

	When Slag Aggr. is Used % by Absol. Vol.	When Crushed Material is Used % by Absol. Vol.
Passing 1/2" Sieve	100	100
Passing 3/8" Sieve	95-100	95-100
Passing 3/8" sieve, retained on No. 4 seive	15- 50	15- 50
Passing No. 4 sieve, retained on No. 10 sieve	10- 30	10- 30
Total Retained on No. 10 sieve	35- 60	50- 70
Passing No. 10 sieve, retained on No. 40 sieve	15- 50	5- 30
Passing No. 200 sieve	2- 10	2- 10

The asphaltic material shall form from 12 to 22 percent of the mixture by volume. (Absolute Volume)

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

	Percent by Absol. Vol.
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	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 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) Primer. The use of an 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 in accordance with THD Bulletin C-14, 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.

(3) Water. Water in an amount not to exceed 3 percent of the mixture by weight as determined in accordance with THD Bulletin C-14 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.

(4) Central Mixing Plants. 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.

(5) Tolerances. The Engineer shall designated 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 Absol. Vol.
Passing 1-3/4" sieve, retained on 7/8" sieve.............	plus or minus 5
Passing 7/8" sieve, retained on 3/8" 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 2.0

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.

(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 ASTM Designation D 2041 will have the following laboratory density and stability:

	Density, Percent			
	Min.	Max.	Optimum	Stability, Percent
Types AA, BB, CC DD, EE, FF,	95	99	97	Not less than 30 unless otherwise shown on plans.
Type EE Mod.	92	98	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 chermometer 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 inable 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 four bins when producing Type "AA", Type "BB", and Type "CC" mixtures; at least three bins when producing Type "DD" and Type "KK" mixtures; and at least two bins when producing Type "EE", Type "EE" Mod., 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 "AA" (Coarse Graded Base Course):

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

Bin No. 2 --- will contian aggregates of which at least 70 percent will be of such size as to pass the 3/8=inch 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 7/8-inch sieve and be retained on the 3/8-inch sieve.

Bin No. 4 --- will contain aggregates of which at least 75 percent will be of such size as to pass the 2-inch sieve and be retained on the 7/8-inch sieve.

Type "BB" (Fine Graded Base or leveling-up 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 ¼" 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-inch sieve and be retained on the ¼" sieve.

Bin No. 4 --- will contain aggregates of which at least 75 percent will be of such size as to pass the 1 inch sieve and be retained on the 3/8-inch sieve.

Type "CC" (Coarse Graded 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 ¼" 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 ¼" sieve.

Bin No. 4 --- will contain aggregates of which at least 75 percent will be of such size as to pass the 7/8" sieve and be retained on the 3/8" sieve.

Type "DD" (Fine Graded Surface Course) and
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 ¼" 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 ½" sieve and be retained on the ¼" sieve.

Type "EE" (Sheet Asphalt 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 ¼" sieve and be retained on the No. 10 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.

<u>Aggregate Weigh Box and Batching Scales</u>. The aggregate weigh 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.

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 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; & 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 Types "AA", "BB", and "CC" 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 should 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 ares 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.

If the surface ravels, it will be the Contractor's responsibility to correct this condition at his expense.

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.

APPENDIX XI.

Accelerated Polish Test Reports

POLISH VALUE TEST

District	17	Producer	Young Bros.
Highway	F.M. 46	Pit Location	Waco, Texas
Project No.	C-49-14-2 Etc.	Aggregate Type	100% Flint
Data Sampled	10-13-69	Lab Sample No.	
Data Tested	10-17-69	Length of Test Period	9 Hrs.

Before Polish						Average
Specimen 1	40	40	40	40	40	40
Specimen 2	41	41	41	41	41	41
Specimen 3						
Specimen 4						
				Initial Value		

After Polish						Average
Specimen 1	24	24	24	24	24	24
Specimen 2	25	25	25	25	25	25
Specimen 3						
Specimen 4						
				Polish Value		24.5

APPENDIX XI

POLISH VALUE TEST

District 17

Highway F.M. 46

Project No. C-49-14-2 Etc.

Data Sampled 10-13-69

Data Tested 10-17-69

Producer Young Bros.

Pit Location Waco, Texas

Aggregate Type 100% Limestone

Lab Sample No.

Length of Test Period 9 Hrs.

Before Polish						Average
Specimen 1	49	49	49	49	49	49
Specimen 2	49	49	49	49	49	49
Specimen 3						
Specimen 4						
				Initial Value		49

After Polish						Average
Specimen 1	34	33	33	33	33	33
Specimen 2	36	35	35	35	35	35
Specimen 3						
Specimen 4						
				Polish Value		

POLISH VALUE TEST

District 17

Highway F.M. 46

Project No. C-49-14-2 Etc.

Data Sampled 10-13-69

Data Tested 10-17-69

Producer Young Bros.

Pit Location Waco, Texas

Aggregate Type Ty D Crse 60% Lime 40% Flint

Lab Sample No.

Length of Test Period 9 Hrs.

	Before Polish					Average
Specimen 1	52	51	51	51	51	51
Specimen 2	52	51	51	51	51	51
Specimen 3	52	51	51	51	51	51
Specimen 4	53	52	52	52	52	52

Initial Value 51

	After Polish					Average
Specimen 1	29	28	28	28	28	28
Specimen 2	32	31	31	31	31	31
Specimen 3	28	28	28	28	28	28
Specimen 4	30	29	29	29	29	29

Polish Value 29

APPENDIX XI

POLISH VALUE TEST

District 17

Highway F.M. 46

Project No. C-49-14-2 Etc.

Data Sampled 10-13-69

Data Tested 10-17-69

Producer Young Bros

Pit Location Waco, Texas

Aggregate Type Ty D Crse 60% Lime 40% Flint

Lab Sample No.

Length of Test Period 9 Hrs.

Before Polish						Average
Specimen 5	49	48	48	48	48	48
Specimen 6	50	49	49	49	49	49
Specimen 7	53	52	52	52	52	52
Specimen 8	50	49	49	49	49	49

Initial Value 50

After Polish						Average
Specimen 5	29	28	28	28	28	28
Specimen 6	32	31	31	31	31	31
Specimen 7	30	30	30	30	30	30
Specimen 8	30	29	29	29	29	29

Polish Value 30

APPENDIX XI

POLISH VALUE TEST

District 17

Highway F.M. 46

Project No. C 49-14-2 Etc.

Data Sampled 9-22-69

Data Tested 9-26-69

Producer Texas Crushed Stone

Pit Location Feld, Texas

Aggregate Type Ty D T.C.S. 666

Lab Sample No. -

Length of Test Period -

Before Polish						Average
Specimen 1	55	54	54	54	54	54
Specimen 2	55	55	55	55	55	55
Specimen 3	52	51	51	51	51	51
Specimen 4	53	52	52	52	52	52
				Initial Value		53

After Polish						Average
Specimen 1	34	33	33	33	33	33
Specimen 2	33	33	32	32	32	32
Specimen 3	32	31	31	31	31	31
Specimen 4	32	31	31	31	31	31
				Polish Value		32

POLISH VALUE TEST

District 17

Highway F.M. 46

Project No. C-49-14-2 Etc.

Data Sampled 9-22-69

Data Tested 9-26-69

Producer Texas Crushed Stone

Pit Location Feld, Texas

Aggregate Type Ty'D T.C.S. 665

Lab Sample No. -

Length of Test Period 9 hours

Before Polish						Average
Specimen 1	55	54	54	54	54	54
Specimen 2	51	50	50	50	50	50
Specimen 3	57	56	56	56	56	56
Specimen 4	55	54	54	54	54	54
				Initial Value		53

After Polish						Average
Specimen 1	33	32	32	32	32	32
Specimen 2	33	33	32	32	32	32
Specimen 3	35	34	34	34	34	34
Specimen 4	34	33	33	33	33	33
				Polish Value		32

POLISH VALUE TEST

District 17

Highway F.M. 46

Project No. C 49-14-2 Etc.

Data Sampled 9-22-69

Data Tested 9-26-69

Producer Texas Crushed Stone

Pit Location Feld, Texas

Aggregate Type Ty'D T.C.S. 266

Lab Sample No. -

Length of Test Period 9 hours

Before Polish						Average
Specimen 1	55	55	55	55	55	55
Specimen 2	55	55	55	55	55	55
Specimen 3	54	53	53	53	53	53
Specimen 4	56	55	55	55	55	55

Initial Value 54

After Polish						Average
Specimen 1	34	33	33	33	33	33
Specimen 2	34	33	33	33	33	33
Specimen 3	35	34	34	34	34	34
Specimen 4	34	33	33	33	33	33

Polish Value 33

APPENDIX XII.

Laboratory Design Reports

1969 Project

Texas Highway Department
Form 476A

645069-167-25M

SOILS AND BASE MATERIALS TEST REPORT

Laboratory No. Below — C 49-14-2, etc. (Control Number / Section Number / Job Number)
Date Rec'd 9-11-69 Reported 9-26-69
Engineer W. J. Byford — Robertson, etc. (County) / Federal Project No. / FM 46,etc. (Highway No.)
Address Bryan, Texas
Contractor Young Bros.Inc. Contrs. — 17 (District No.) / I.P.E. No. / Req. No. / 9-11-69 (Date Sampled)
Sampler Charlie Young
Sampler's Title
Specification Item No. 1961.000
Sampled From Various Waco Area pits
Material from Property of
Producer Young Bros.
Quantity Represented by Sample
Has been Used on
Proposed for Use as Hot Mix Asphaltic Concrete Pavement

Lab. No.	LL	PI	SL	LS	SR	Class	Soil Binder	L. A. Wear	Decantation	Unit Weight
Specifications		Max. 6								
17-69-1135	22	3								88.6
17-69-1136		1		1						112.9
17-69-1145								30	.66	

PERCENT RETAINED ON

Lab No.	Square Mesh Sieve — Opening in Inches								Sieve Numbers							Grain Diam. in Millimeters			Specific Gravity
	3	2½	2	1¾	1¼	⅞	⅝	⅜	4	10	20	40	60	100	200	.05	.005	.001	
17-69-1135								0	3	14	30	56							

SAMPLE IDENTIFICATION

Lab. No.	Identification Marks	Location—Properties—Station Numbers	Type of Materials
17-69-1135		Needhan Pit	Field Sand
17-69-1136		Young Bros.	Concrete Sand
17-69-1145		Young Bros.	Crushed Stone

Tested in District 17 Laboratory
y: Ron Voss, Chas. McCulloch
On: 9-16,25-69

Texas Highway Department
Form 549

ASPHALTIC CONCRETE STABILITY REPORT

NO CHARGE

Laboratory No. R3-69-1064 thru R3-69-1068
Date Received 9-22-69 Date Reported 9-23-69
Dist. or Res. Engr. W. J. Byford
Address Bryan
Contractor Young Bros. Inc. Contrs.
Sampler C. Young
Sampler's Title --
Sampled from Stockpiles at source
(Design Specimen, Car, Truck, Plant, Road)
Asphalt Producer Amer. Pet.
Type AC-10
Aggr. Producer Cr.Stone & Conc. Sand-Young Bros.
Field Sand-Needhan
Waco area

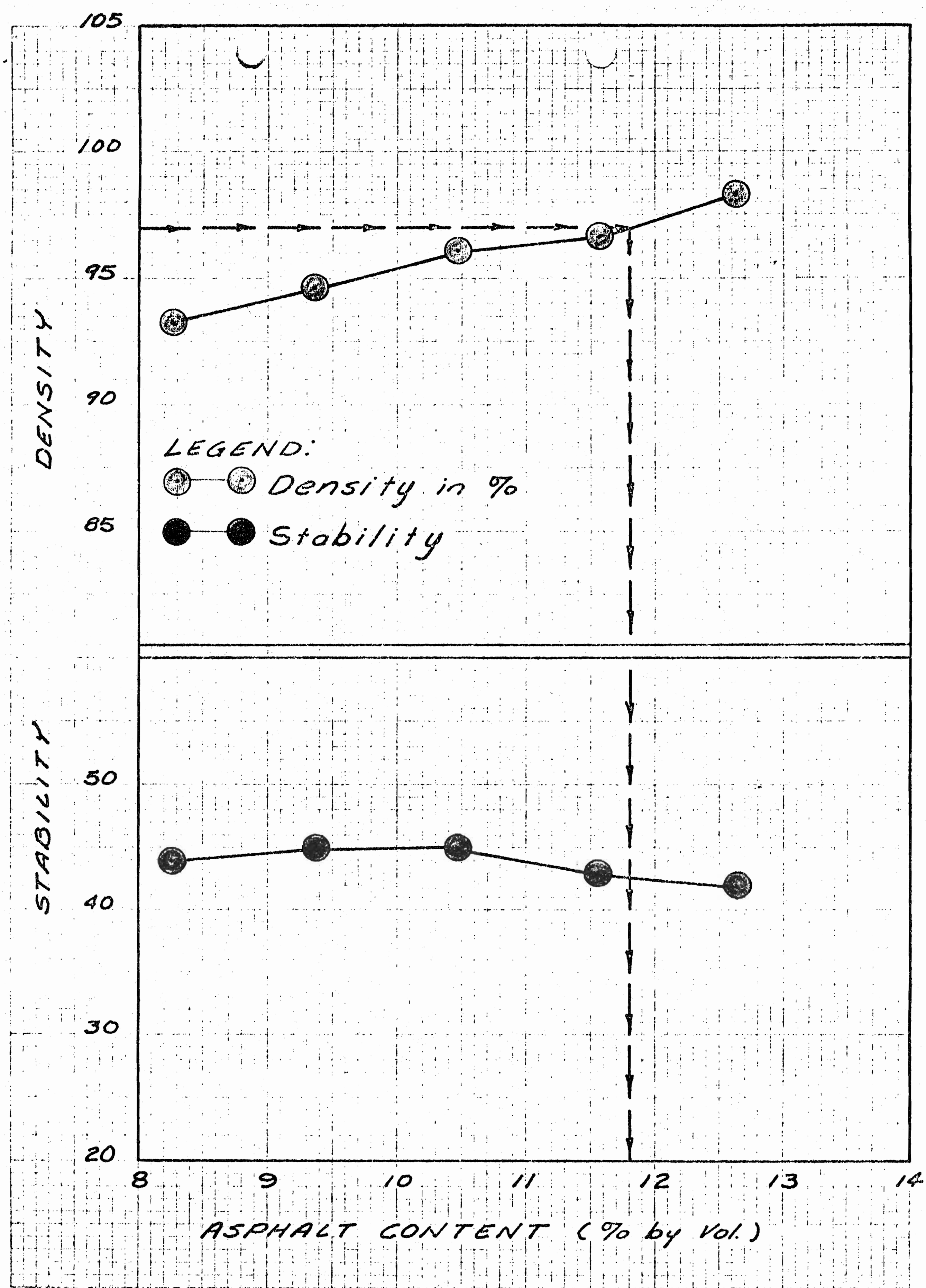
C-2851-1-15, PD 0186 C-49-14-2, PD 0177,etc
Control No. Sect. No. Job No.
Brazos, Robertson,etc. FM 2818,FM46,etc.
County Federal Project No. Hwy. No.
17 --
District No. Req. No. Date Sampled
Specification Item No. 1961
Stencil No. 1961-000,7-69 Type D

REQUESTED DETERMINATION NO. 3568(-)

Laboratory No.	Spec. No.	Identification Marks	Station No.	Asphalt % by volume	Asphalt (% by Wt.)	Specimen Ht. (in.)	Spec. Density (Field) (%)	Hveem Stab. (%)	Hveem St (Avg. %
R3-69-1064	1	17-69-HMAC-23		8.26	3.5	2.04	-- 93.3	43	44
	2					2.03		42	
	3					2.04		46	
R3-69-1065	1	"		9.38	4.0	2.03	-- 94.6	44	45
	2					2.03		44	
	3					2.03		47	
R3-69-1066	1	"		10.48	4.5	2.02	-- 96.1	45	45
	2					2.02		45	
	3					2.02		45	
R3-69-1067	1	"		11.56	5.0	2.04	-- 96.7	42	43
	2					2.03		43	
	3					2.03		43	
R3-69-1068	1	"		12.63	5.5	2.02	-- 98.3	40	42
	2					2.00		43	
	3					2.01		44	

D-9 Remarks: Hveem stability values meet requirements for this project.

ja



No correction for absorption needed - Long.

APPENDIX XII

ounty ROBERTSON Project C 49-14-2, Etc.

ghway FM 46 Co. ______ Section ______ Job ______

m No. 1961.000 DATED 7-69

17-69-HMAC-23

AGGREGATE BLENDING TABULATION

VOLUMETRIC DESIGN NUMBER 1

SPECIFICATIONS AND MATERIALS	BLEND PARTS	SIEVE SIZES — % PASSING & RETAINED									
		+ 1/2	1/2 - 3/8	3/8 - 4	4-10	+ 10	10-40	40-80	80-200	-200	
SPECIFICATIONS TYPE D		0	0-5	20-50	10-30	50-70	0-30	4-25	3-25	0-6	
Type D Waco Crushed Rock: A		0	1.4	64.4	32.5		0.4	0.2	0.4	0.7	
Waco Conc Sand: B			0	0.4	14.0		44.0	36.9	3.8	0.9	
Waco Fld. Sand: C							0.0	17.7	65.5	16.8	
TRIAL NO. 1	TRY 5.5 PARTS A, 3.0 PARTS B, 1.5 PARTS C										
A	5.5	0	8	354	179		2	1	2	4	
B	3.0		0	1	42		132	111	11	3	
C	1.5				0		0	27	98	25	
TOTALS	10		8	355	221		134	139	111	32	
DIVIDE BY 10		0	0.8	35.5	22.1	58.4	13.4	13.9	11.1	3.2	

APPENDIX XII

TABLE NO. III
OLD METHOD'S TEST RESULTS BY ASPHALT CONTENT

Asphalt Content	Hveem Density (Avg. of 3)	Hveem Stability (Avg. of 3)
3.5	94.2	44
4.0	95.4	45
4.5	96.9	45
5.0	97.9	43
5.5	99.3	42

TABLE NO. IV
NEW METHOD'S TEST RESULTS BY ASPHALT CONTENT

	Asphalt Content (% by vol.)	Hveem Density (% by vol.)	Hveem Stability (Avg. of 3)
Specs.	9 to 19	95 to 99	not less than 30
	8.26	93.3	44
	9.38	94.6	45
	10.48	96.1	45
	11.56	96.7	43
	12.63	98.3	42

Charts and graphs are attached giving gradation of aggregates used, asphalt content by weight and volume and Hveem Specimen density by weight and volume.

TEXAS HIGHWAY DEPARTMENT
DISTRICT 17 LABORATORY
BRYAN, TEXAS
October 2, 1969

Robertson Co., etc. C 49-14-2,etc.

The District 17 Laboratory has completed a design for Item 1961.000,"Hot Mix Asphaltic Concrete Pavement"(Volumetric Design), to be used on various jobs in the 1969 Level-Up project. This design used 2.5 parts crushed limestone aggregate, TCS # 665 Type D, from Texas Crushed Stone Company at Feld, Texas, 3.3 parts crushed limestone aggregate # 266, Type F, from Texas Crushed Stone at Feld, Texas, 2.1 parts concrete sand from Texas Crushed Stone Company at Feld, Texas, and 2.1 parts field sand from theSantanna Pit near Austin. Laboratory testing was made under laboratory identification number 17-69-HMAC-24.

The laboratory design grading and specifications are shown on the attached form entitled "Aggregate Blending Tabulation".

The Specifications require that the asphalt material shall form from 9 to 19 percent of the mixture by volume (Absolute). All specimens were made within these limits.

TABLE NO. I
SPECIFIC GRAVITY

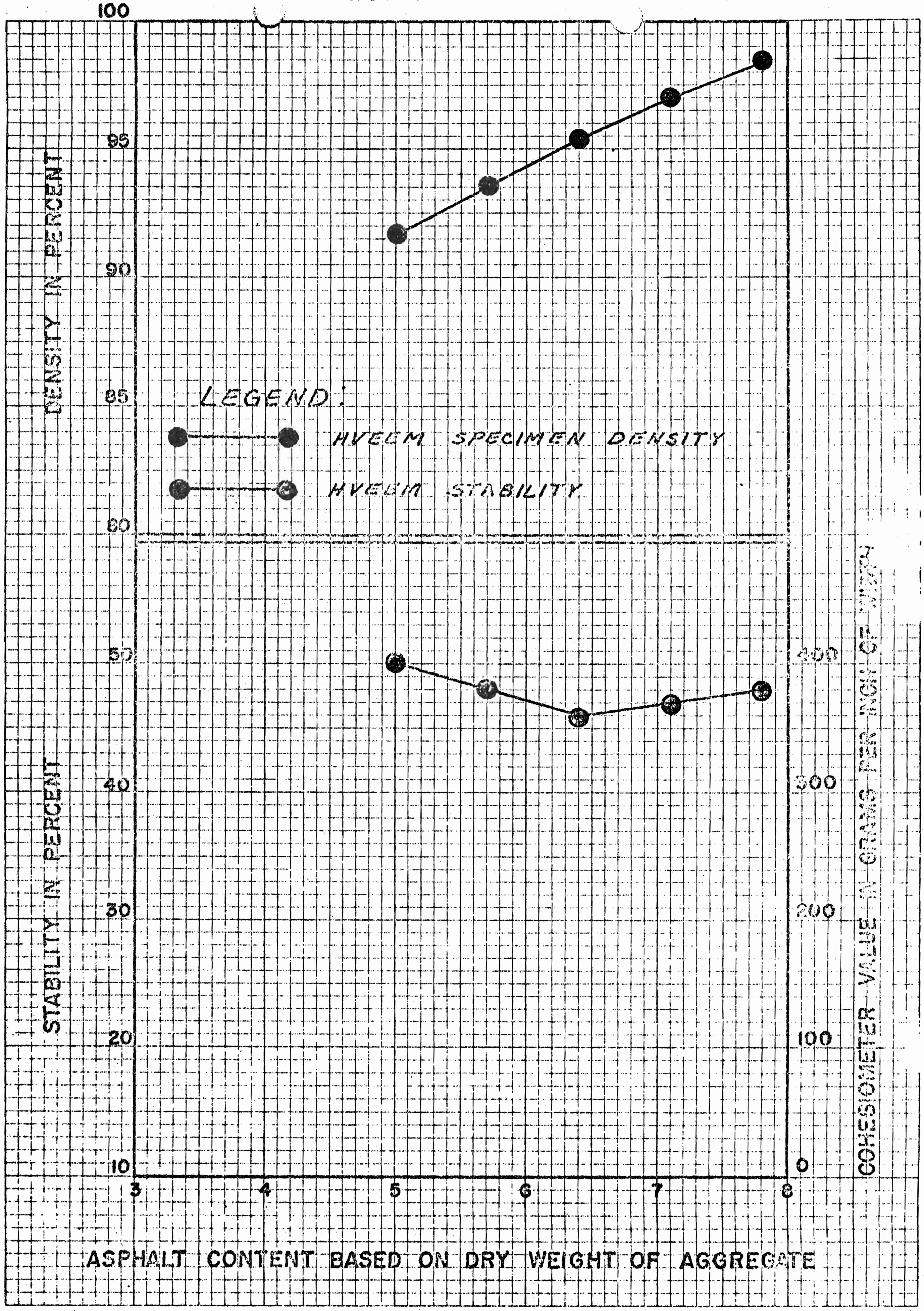
Size Sieve	Crushed Gravel (Type D)	Crushed Gravel (Type F)	Concrete Sand	Field Sand
1/2 - 10	2.345			
3/8 - 10		2.424		
4 - 80				2.575
40 - 80			2.609	
80 - 200			2.746	2.664

Note: 1. Specific gravity of the combined aggregate is 2.483
2. American Petrofina AC-10 asphalt was used in this design. Its specific gravity is 1.019.

TABLE NO. II
PROPORTIONING OF MATERIALS

Crushed Limestone T.C.S. # 665	Crushed Limestone T.C.S. # 266	Limestone Concrete Sand	Santanna Pit Field Sand
25%	33%	21%	21%

APPENDIX XII



100
95
90
85
80
50
40
30
20
10
DENSITY IN PERCENT
STABILITY IN PERCENT
400
300
200
100
0
COHESIOMETER VALUE IN GRAMS PER INCH OF WIDTH
3
4
5
6
7
8
ASPHALT CONTENT BASED ON DRY WEIGHT OF AGGREGATE
LEGEND:
HVEEM SPECIMEN DENSITY
HVEEM STABILITY

ASPHALTIC-CONCRETE STABILITY REPORT

CHARGE $24.00

Laboratory No. 69-6566-H thru 69-6569-H
Date Received 10-10-69 Date Reported 10-13-69
Dist. or Res. Engr. W. J. Byford
Address Bryan
Contractor Young Bros. Inc. Contrs.
Sampler Charlie Young
Sampler's Title Contractor
Sampled from Design
(Design Specimen, Car, Truck, Plant, Road)
Asphalt Producer Amer. Pet. Humble
Type AC-10
Aggr. Producer
20% TCS Type D — 25% TCS Type D
40% TCS #665 — 33% TCS Type F
40% Wehrman Field Sand — 21% TCS Sand
21 % Field Sand

C-2851-1-15, PD 0186 C-49-14-2, PD 0177,etc.
Control No. Sect. No. Job No.
Brazos, Robertson,etc. FM 2818, FM 46,e
County Federal Project No. Hwy. No.
17 --
District No. Req. No. Date Sampled
Specification Item No. 1961
Stencil No. 1961-000,7-69 Type D

REQUESTED DETERMINATION NO. 3560(4)

Laboratory No.	Spec. No.	Identification Marks	Station No.	Cohesiometer Value	Asphalt (% by Wt.)	Specimen Ht. (in.)	Spec. Density (Field) (%)	Hveem Stab. (%)	Hveem S (Avg. %)
69-6566-H	1	17-69-HMAC-24			8.0	2.02	99.3	51	49
	2					2.01		47	
	3					2.00		49	
69-6567-H	1	"			8.7	2.02	102.3	45	43
	2					2.02		40	
	3					2.02		44	
		17-69-HMAC-25							
69-6568-H	1	1			8.5	2.01	102.0	39	39
	2	11				2.01		38	
	3	111				2.01		41	
69-6569-H	1	"			9.2	2.02	100.9	32	30
	2					2.02		28	
	3					2.03		30	

D-9 Remarks: Hveem stability values meet requirements for this project.

ja

APPENDIX XII

Texas Highway Department
Form 549

ASPHALTIC CONCRETE STABILITY REPORT

CHARGE $30.00

Laboratory No. 69-6207-H thru 69-6211-H
Date Received 9-29-69 Date Reported 9-30-69
Dist. or Res. Engr. W. J. Byford
Address Bryan
Contractor Young Bros. Inc. Contrs.
Sampler C. Young
Sampler's Title --
Sampled from Design
(Design Specimen, Car, Truck, Plant, Road)
Asphalt Producer Humble
Type AC-10
Aggr. Producer 20% T[illegible].Cr.[illegible]. Type D
40% [illegible]
40% [illegible] Field Sand

C-2851-1-15, PD 0186 C-49-14-2, PD 0177, etc.
Control No. Sect. No. Job No.

Brazos, Robertson, etc. FM 2818, FM 46, etc.
County Federal Project No. Hwy. No.

17 --
District No. Req. No. Date Sampled

Specification Item No. 1961

Stencil No. 1961-000, 7-69 Type D

REQUESTED DETERMINATION NO. 3568(3)

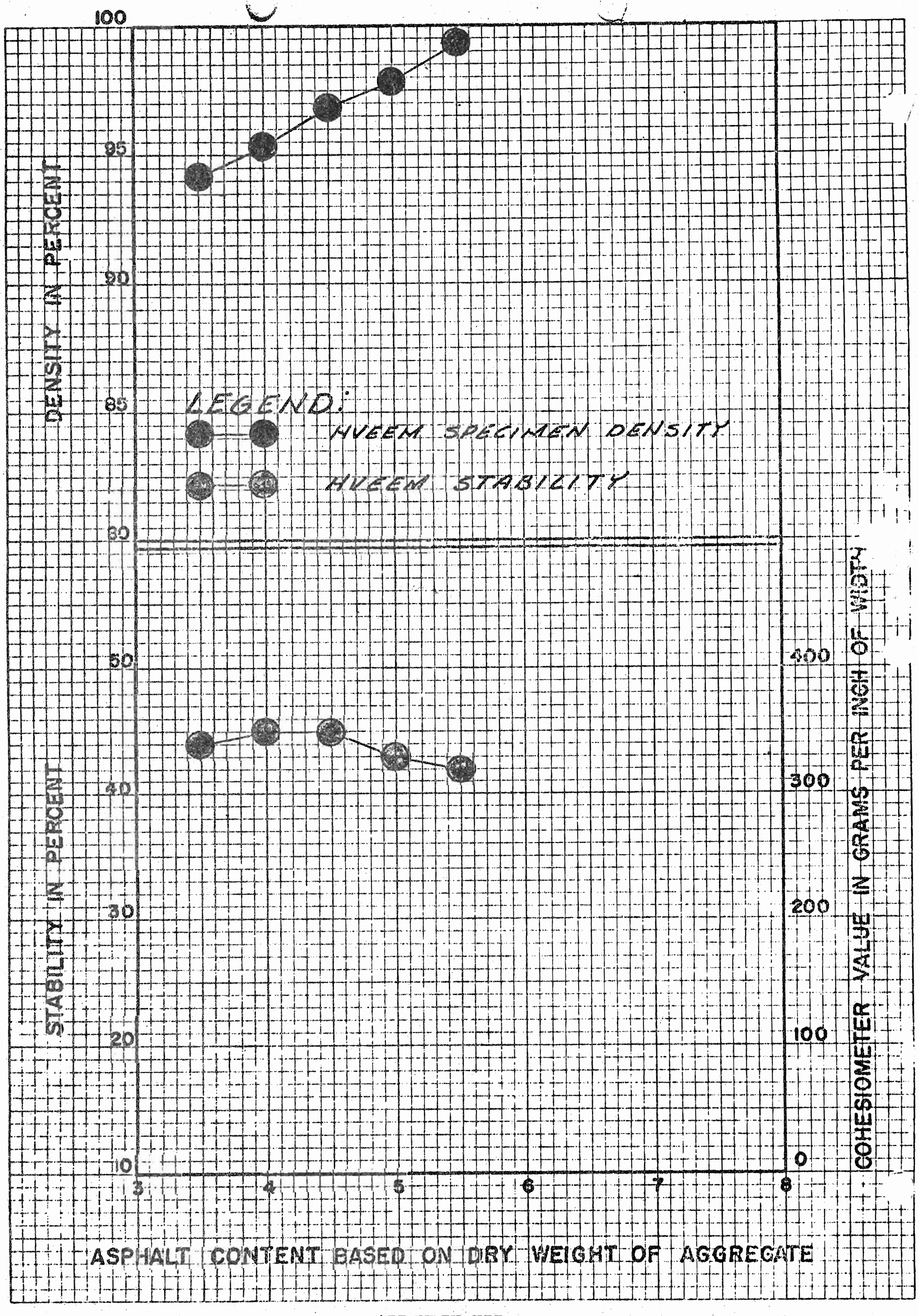
Laboratory No.	Spec. No.	Identification Marks	Density (% Vol.)	Asphalt (% by Vol.)	Asphalt (% by Wt.)	Specimen Ht. (in.)	Spec. Density (Field) (%)	Hveem Stab. (%)	Hveem Stab. (Avg. %)
		17-69-[illegible]-25							
69-6207-H	1	1	91.9	11.41	5.0	2.07**	-91.7	49	50
	2	11				2.04		49	
	3	111				2.02		51	
69-6[illegible]8-H	1	"	93.6	12.89	5.7	2.02	--93.5	47	48
	2					2.00		48	
	3					2.01		48	
69-6209-H	1	"	95.4	14.33	6.4	2.01	--95.3	42	46
	2					2.00		44	
	3					2.00		52	
69-6210-H	1	"	97.0	15.76	7.1	2.02	--97.0	47	47
	2					2.02		48	
	3					2.01		47	
69-6211-H	1	"	98.6	17.15	7.8	2.02	--98.4	48	48
	2					2.01		48	
	3					2.02		48	

D-9 Remarks: Hveem stability values meet requirements for this project.

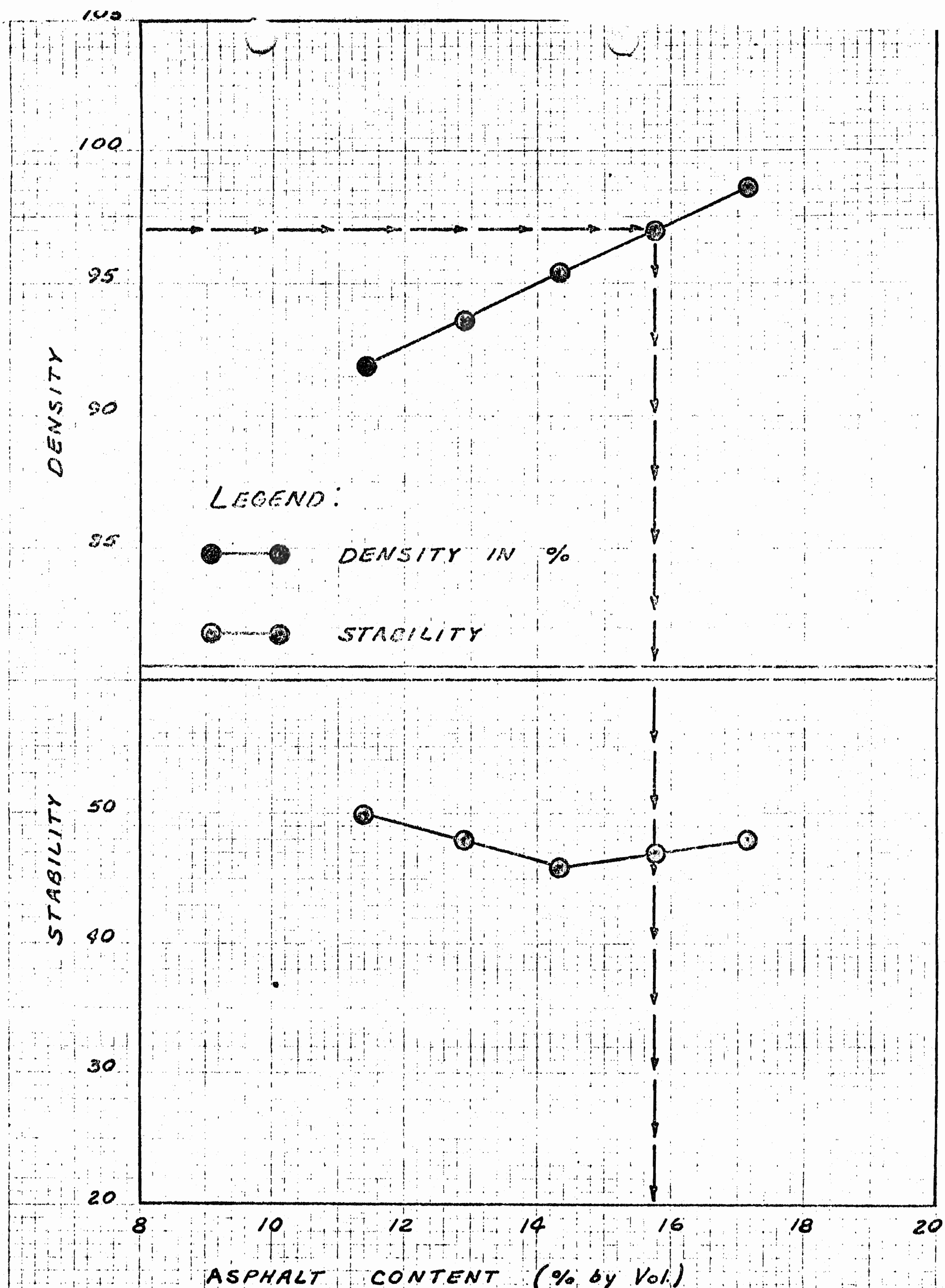
ja

**Does not meet height requirements of Test Method Tex - 206 - F

APPENDIX XII



APPENDIX XII



NOTE: This design must be corrected for an aggregate absorption of 3.2 percent.

County ROBER(T)SON Project C-49-14-2, ck.
Highway FM 46 Cont. ______ Section ______ Job ______
Item No. 1961.000 DATED 7-69
17-69-HMAC-25

AGGREGATE BLENDING TABULATION
VOLUMETRIC DESIGN NUMBER ____

SPECIFICATIONS AND MATERIALS	BLEND PARTS	+1/2	1/2-3/8	3/8-4	4-10	+10	10-40	40-80	80-200	-200
		SIEVE SIZES — % PASSING & RETAINED								
SPECIFICATIONS TYPE D		0	0-5	20-50	10-30	50-70	0-30	4-25	3-25	0-6
CRUSHED LIMESTONE TCS #665: A		0	16.1 15.9	21.3 79.1	8.6 3.5		2.2 0.5	.8 0.1	.2 0.1	[illegible] 0.8
CRUSHED LIMESTONE TCS #666: B			0	33.5 33.1	60.9 57.3		[illegible] 6.9	[illegible] 0.7	[illegible] 0.5	[illegible] 1.5
WEHRMAN FIELD SAND: C					0		13.8	35.0	43.5	7.7
TRIAL NO. 1		Try 2.0 parts A, 4.0 parts B, 4.0 parts C								
A	2.0	0	32	158	7		1	0	0	0.2
B	4.0		0	132	229		28	3	2	6
C	4.0				0		55	140	174	31
TOTALS	10.0		32	290	236		84	143	176	39
DIVIDED by 10		0	3.2	29.0	23.6	55.8	8.4	14.3	17.6	3.9

TABLE NO. III
OLD METHOD'S TEST RESULTS BY ASPHALT CONTENT

Asphalt Content	Hveem Density (Avg. of 3)	Hveem Stability (Avg. of 3)
5.0	91.7	50
5.7	93.5	48
6.4	95.3	46
7.1	97.0	47
7.8	98.4	48

TABLE NO. IV
NEW METHOD'S TEST RESULTS BY ASPHALT CONTENT

	Asphalt Content (% by Vol.)	Hveem Density (% by Vol.)	Hveem Stability (Avg. of 3)
Specs.	9 to 19	95 to 99	Min. 30
	11.41	91.9	50
	12.89	93.6	48
	14.33	95.4	46
	15.76	97.0	47
	17.15	98.6	48

Charts and graphs are attached giving gradation of aggregates used, asphalt content by weight and volume and Hveem Specimen density by weight and volume.

TEXAS HIGHWAY DEPARTMENT
DISTRICT 17 LABORATORY
BRYAN, TEXAS
October 3, 1969

Brazos County, Robertson County, etc. C 49-14-2,etc.

The District 17 Laboratory has completed a design for Item 1961.000, "Hot Mix Asphaltic Concrete Pavement" (Volumetric Design), to be used on various jobs in the 1969 Level-Up project. This design used 2.0 parts crushed limestone aggregate, TCS # 665, from Texas Crushed Stone Company at Feld, Texas, 4.0 parts crushed limestone aggregate, TCS # 666, from Texas Crushed Stone Company at Feld, Texas, and 4.0 parts field sand from the Wehrman's Pit near Bryan. Laboratory testing was made under laboratory identification number 17-69-HMAC-25.

The laboratory design grading and specifications are shown on the attached form entitled "Aggregate Blending Tabulation."

The Specifications require that the asphaltic material shall form from 9 to 19 percent of the mixture by volume (Absolute). All specimens were made within these limits.

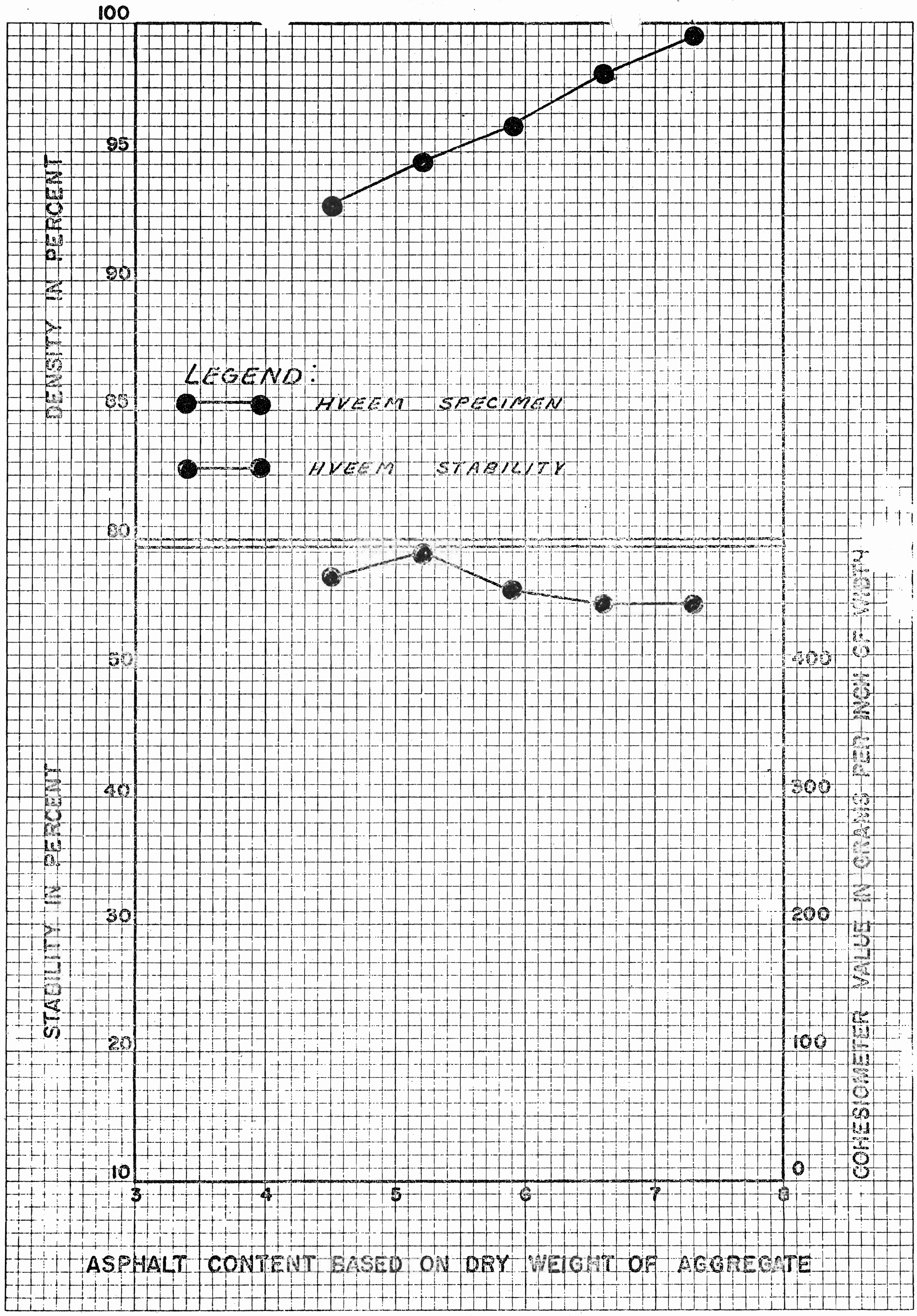
TABLE NO. I
SPECIFIC GRAVITY

Size Sieve	Crush Gravel TCS # 665	Crushed Gravel TCS # 666	Field Sand
3/8 - 4		2.462	
4 - 80		2.473	
+ 10	2.345		
+ 80			2.510
- 80		2.720	2.682

Note: 1. Specific gravity of the combined aggregate is 2.494
2. Humble AC-10 asphalt was used in this design. Its specific gravity is 0.996.

TABLE NO. II
PROPORTIONING OF MATERIALS

TCS # 665 Crushed Gravel	TCS # 666 Crushed Gravel	Wehrman's Field Sand
20%	40%	40%



APPENDIX XII

Texas Highway Department
Form 476A

645069-167-25M

SOILS AND BASE MATERIALS TEST REPORT

Laboratory No. Below
Date Rec'd ______ Reported 10-2-69
Engineer W. J. Byford
Address Bryan, Texas
Contractor Young Brothers
Sampler Charlie Young
Sampler's Title ______
Sampled From Various
Producer Texas Crushed Stone & Needhan Pit
Quantity Represented by Sample ______
Has been Used on ______

C 49-14-2, etc.
Control Number — Section Number — Job Number

Robertson, etc. — FM 46, etc.
County — Federal Project No. — Highway No.

17
District No. — I.P.E. No. — Req. No. — Date Sampled

Specification Item No. 1961.000
Material from Property of ______

Proposed for Use as Hot Mix Asphaltic Concrete Pavement

Lab. No.	LL	PI	SL	LS	SR	Class	Soil Binder	WBM % Loss	XXXXX ~~% Moist.~~ Unit Weight	L. A. Wear
17-69-1177	23	1					99			
17-69-1178	24	1					45		112.6	40

PERCENT RETAINED ON

Lab No.	Square Mesh Sieve															Grain Diam.			Specific Gravity
	Opening in Inches								Sieve Numbers							in Millimeters			
	3	2½	2	1¾	1¼	⅞	⅝	⅜	4	10	20	40	60	100	200	.05	.005	.001	
17-69-1177										0	1	1							
17-69-1178									0	10	46	55							

SAMPLE IDENTIFICATION

Lab. No.	Identification Marks	Location—Properties—Station Numbers	Type of Materials
17-69-1177		Needhan Pit	Field Sand
17-69-1178		Texas Crushed Stone	Concrete Sand

Tested in District 17 Laboratory

QUALITY SAMPLE

By: Ronnie Voss
On: 9-26-69

APPENDIX XII

Texas Highway Department
Form 549

ASPHALTIC CONCRETE STABILITY REPORT

CHARGE $30.00

Laboratory No. 69-6112-H thru 69-6116-H
Date Received 9-25-69 Date Reported 9-26-69
Dist. or Res. Engr. W. J. Byford
Address Bryan
Contractor Young Bros. Inc. Contrs.
Sampler Charlie Young
Sampler's Title Contractor
Sampled from Design
(Design Specimen, Car, Truck, Plant, Road)
Asphalt Producer Amer. Pet.
Type AC-10
Aggr. Producer 21% Field Sand
21% Tex.Cr.St. Sand
33% Tex.Cr.Stone Type F
25% Tex.Cr.Stone Type D

C-2851-1-15,	PD 0186	C-49-14-2, PD 0177,etc.
Control No.	Sect. No.	Job No.
Brazos, Robertson,etc.		FM 2818, FM 46,etc
County	Federal Project No.	Hwy. No.
17		--
District No.	Req. No.	Date Sampled

Specification Item No. 1961

Stencil No. 1961-000,7-69 Type D

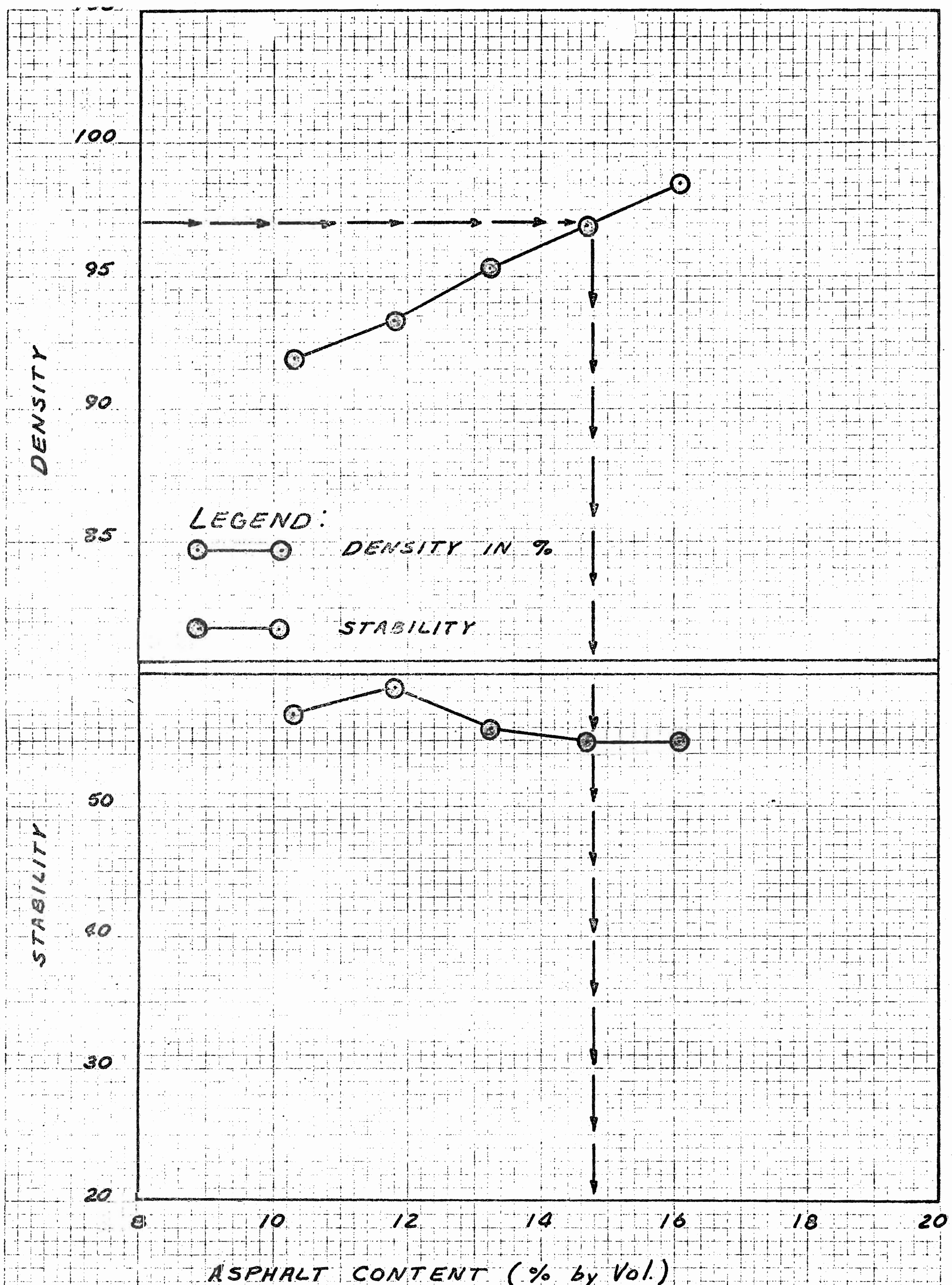
REQUESTED DETERMINATION NO. 3568(2)

Laboratory No.	Spec. No.	Identification Marks	Asphalt (% by Vol.)	Density (% Vol.)	Asphalt (% by Wt.)	Specimen Ht. (in.)	Spec. Density (Field) (%)	Hveem Stab. (%)	Hveem Stab. (Avg. %)
Specs.		17-69-HMAC-24	9-19	95-99					(.30)
69-6112-H	1	I	10.30	91.9	4.5	2.04	-- 92.9	59	57
	2	II				2.01		59	
	3	III				2.02		52	
69-6113-H	1	"	11.79	93.3	5.2	2.03	-- 94.6	56	59
	2					2.03		61	
	3					2.02		60	
69-6114-H	1	"	13.25	95.3	5.9	2.02	-- 96.0	53	56
	2					2.02		61	
	3					2.03		54	
69-6115-H	1	"	14.69	96.9	6.6	2.01	-- 98.0	56	55
	2					2.01		54	
	3					2.00		56	
69-6116-H	1	"	16.10	98.5	7.3	2.00	-- 99.5	57	55
	2					2.01		53	
	3					2.01		57	

D-9 Remarks: Hveem stability values meet requirements for this project.

ja

HW D4-P-3097-F73-1267-86M



Note: This design chart must be corrected for an aggregate absorption of 2.3 percent.

County ROBERTSON Project C-49-14-2 etc.
Highway FM 46 Cont. ______ Section ______ Job ______
Item No. 1961.000 [illegible] 7-69
17-69-HMAC-24

AGGREGATE BLENDING TABULATION
VOLUMETRIC DESIGN NUMBER ____

	SPECIFICATIONS AND MATERIALS	BLEND PARTS	SIEVE SIZES — % PASSING & RETAINED									
			+ 1/2	1/2 - 3/8	3/8 - 4	4 - 10	+10	10-40	40-80	80-200	-200	
	SPECIFICATIONS TYPE D		0	0-5	20-50	10-30	50-70	0-30	4-25	3-25	0-6	
A	CRUSHED L.S. TCS No. 665		0	15.9	79.1	3.5		1.5				
B	CRUSHED L.S. TCS No. 266			0	10.7	80.4		8.3	0.6			
C	L.S. Conc. Sand TCS			0	0.3	9.4		46.9	18.6	10.8	14.0	
D	Santanna Pit Field Sand				0	0.2		3.1	59.3	26.2	11.2	
	TRIAL No. 1											
	Aggr. A	2.5	0	39.8	197.8	8.8		5.8				
	" B	3.3		0	35.3	265.3		27.4	2.0			
	" C	2.1		0	0.6	19.7		98.5	39.1	22.7	29.4	
	" D	2.1			0	0.4		6.5	124.5	55.0	23.5	
	TOTALS	10	0	39.8	233.7	294.2		[illegible]	165.6	77.7	52.9	
	÷ By 10		0	4.0	23.4	29.4	56.8	13.6	16.5	7.8	5.3	

TABLE NO. III
OLD METHOD'S TEST RESULTS BY ASPHALT CONTENT

Asphalt Content	Hveem Density (Avg. of 3)	Hveem Stability (Avg. of 3)
4.5	92.9	57
5.2	94.6	59
5.9	96.0	56
6.6	98.0	55
7.3	99.5	55

TABLE NO. IV
NEW METHOD'S TEST RESULTS BY ASPHALT CONTENT

	Asphalt Content (% by Vol.)	Hveem Density (% by Vol.)	Hveem Stability (Avg. of 3)
Specs.	9 to 19	95 to 99	Min. 30
	10.30	91.9	57
	11.79	93.3	59
	13.25	95.3	56
	14.69	96.9	55
	16.10	98.5	55

Charts and graphs are attached giving gradation of aggregates used, asphalt content by weight and volume and Hveem Specimen density by weight and volume.

Los Angeles Wear from D-9 and polish values from D-8 are contained in test reports from these divisions.

APPENDIX XIII.

Laboratory Design Reports - 1970 Project

TEXAS HIGHWAY DEPARTMENT
DISTRICT 17 LABORATORY
BRYAN, TEXAS
April 16, 1971

C 49-8-29,etc. Robertson County, etc.

The District 17 Laboratory has completed the design for Item 2103, Type D "Hot-Mix Asphaltic Concrete Pavement," to be used on the 1971 Level-up projects in the Washington County area. Material used in this Design was pit run gravel from La Grange, Texas. Humble AC-20 asphalt was used in this design.

This design was made under Laboratory Number 17-71-HMAC-43. Density, stability and cohesiometer values are shown in tabular and graphical form within this report.

TABLE NO. I
ORIGINAL SIEVE ANALYSIS

Sieve Size	Pit Run Gravel (Volumetric)	Pit Run Gravel (By Weight)	Specifications (Volumetric)
3/8	7.9*	5.0	0-5
4	31.6	32.0	20-50
10	25.0	23.2	10-30
+ 10	(64.5)	(60.2)	50-70
10 - 40	14.5	17.4	0-30
40 - 80	7.9	6.2	4-25
80 - 200	7.9	10.2	3-25
- 200	5.2	6.0	0-6

*Exceeded specifications

TABLE NO. II
PROPORTIONING OF MATERIAL

Pit Run Gravel
100%

TABLE NO. III
TEST RESULTS BY ASPHALT CONTENT

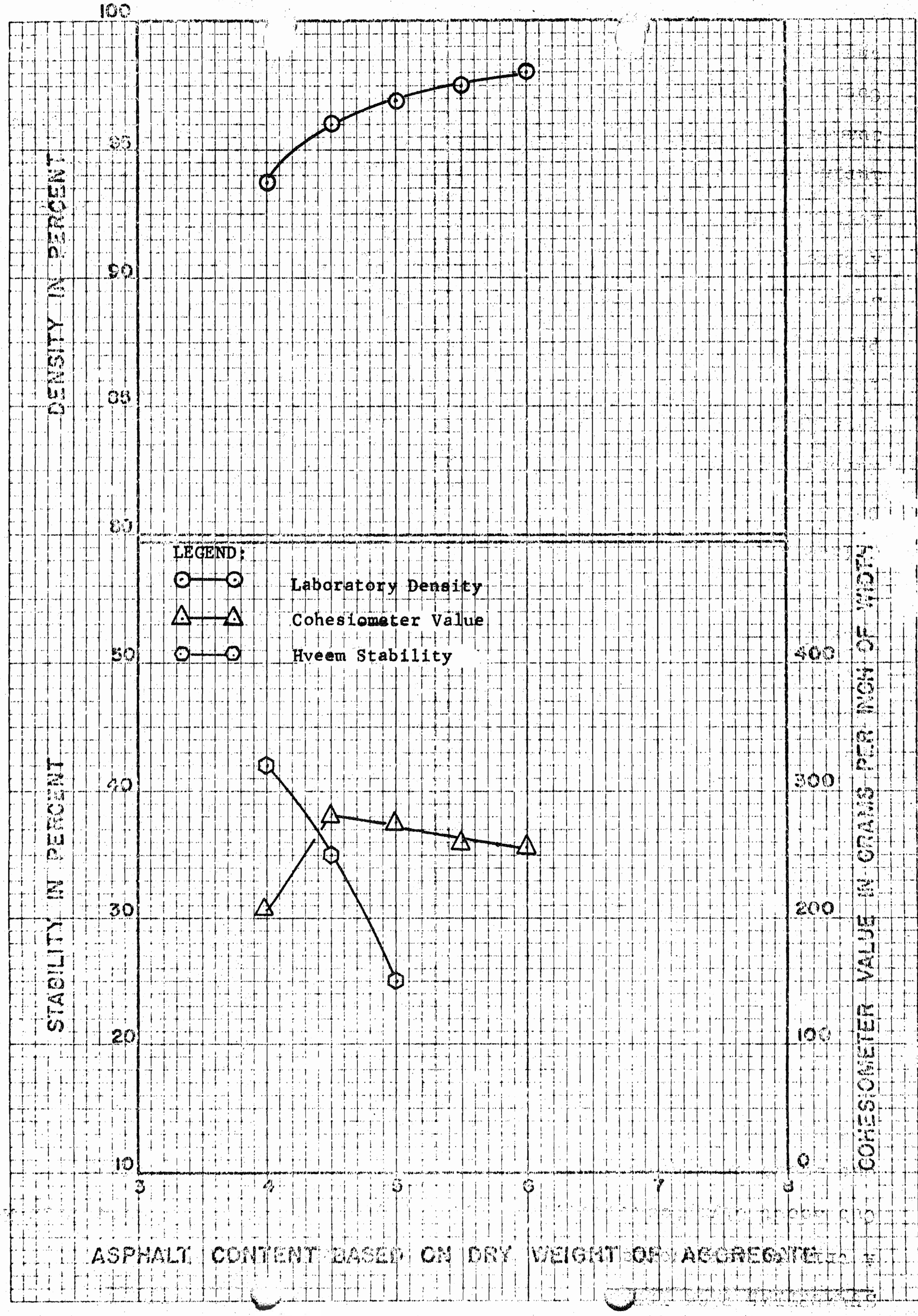
Asphalt Content %	Density (Avg.of 3)	Hveem Stability (Avg. of 3)	Cohesiometer Val. (Avg. of 3)
4.0	93.7	42	207
4.5	96.0	35	282
5.0	96.9	25	276
5.5	97.5	*	261
6.0	98.0	*	258

*Stability too low to calculate

TABLE NO. IV
SPECIFIC GRAVITY

Sieve Size	Pit Run Gravel
1/2 - 4	2.603
10	2.478
10 - 80	2.466
- 80	2.740

The average specific gravity of the combined aggregate is 2.560.
The specific gravity of the Humble AC-20 is 1.026.



100
95
90
85
80
50
40
30
20
10
DENSITY IN PERCENT
STABILITY IN PERCENT
LEGEND:
Laboratory Density
Cohesiometer Value
Hveem Stability
400
300
200
100
0
COHESIOMETER VALUE IN GRAMS PER INCH OF WIDTH
3
4
5
6
7
8
ASPHALT CONTENT BASED ON DRY WEIGHT OF AGGREGATE

Texas Highway Department
Form 549

801796-770-30M

ASPHALTIC CONCRETE STABILITY REPORT

Charge $60.00

Laboratory No. 71-1873-H thru 71-1877-H
Date Received 4-5-71 Date Reported 4-6-71
Dist. or Res. Engr. Delton A. Kittrell
Address Hearne
Contractor Jones G. Finke
Sampler F. J. Shenkir
Sampler's Title Sr. Res. Engr.
Sampled from Design
(Design Specimen, Car, Truck, Plant, Road)
Asphalt Producer Humble
Type AC-20
Aggr. Producer Pit Gravel
La Grange

C-49-8-29, PD 0245, C-49-9-34, PD 0246, etc.
Control No. Sect. No. Job No.

Brazos, Robertson, etc. SH 6, etc.
County Federal Project No. Hwy. No.

17 3-29-71
District No. Req. No. Date Sampled

Specification Item No. 2103

Stencil No. 2103-000,10-70 Type D

REQUESTED DETERMINATION NO. 3803 (38)

Laboratory No.	Spec. No.	Identification Marks	Station No.	Cohesiometer Value	Asphalt (% by Wt.)	Specimen Ht. (in.)	Spec. Density (Field) (%)	Hveem Stab. (%)	Hveem Stab. (Avg. %)
		17-71-HMAC-43							
1-1873-H	1	1		191	4.0	2.05	-	41	42
	2	11		200		2.06	93.7	41	
	3	111		230		2.03		45	
				Avg. 207					
1-1874-H	1	"		302	4.5	2.03	-	36	35
	2			280		2.03	96.0	36	
	3			265		2.06		34	
				Avg. 282					
1-1875-H	1	"		272	5.0	2.02	-	27	25
	2			243		2.04	96.9	23	
	3			314		2.00		25	
				Avg. 276					
1-1876-H	1	"		237	5.5	2.05	-	*	*
	2			259		2.05	97.5	*	
	3			288		2.01		*	
				Avg. 261					
1-1877-H	1	"		235	6.0	2.00	-	*	*
	2			237		2.01	98.0	*	
	3			242		2.03		*	
				Avg. 258					

*Stability too low to calculate.

CAUTION
HVEEM STABILITY VALUES ARE LOWER THAN THOSE SPECIFIED FOR THIS PROJECT
DIVISION OF MATERIALS & TESTS

TEXAS HIGHWAY DEPARTMENT DISTRICT NO. 17 BRYAN, TEXAS
RECEIVED

... MATERIALS & TESTS
... Materials and Tests

1

SOILS AND BASE MATERIALS TEST REPORT

Laboratory No. 17-71-608
Date Rec'd 4-5-71 Reported 4-20-71
Engineer D. A. Kittrell
Address Hearne, Texas
Contractor Jones G.Finke
Sampler F. J. Shenkir
Sampler's Title Sr. Res. Engr.
Sampled From Pit
Producer
Quantity Represented by Sample
Has been Used on

Control Number	Section Number	Job Number
C 49-8-29, etc.		

County	Federal Project No.	Highway No.
Robertson, etc.		SH 6, etc.

District No.	I.P.E. No.	Req. No.	Date Sampled
17			3-29-71

Specification Item No. 2103
Material from Property of
Proposed for Use as HMAC

Lab. No.	LL	PI	SL	LS	SR	Class	Soil Binder	WBM % Loss	% Moist.
Specs.		Max. 6							
17-71-608	19	4							

PERCENT RETAINED ON

Lab No.	Square Mesh Sieve															Grain Diam.			Specific Gravity
	Opening in Inches								Sieve Numbers							in Millimeters			
	3	2½	2	1¾	1¼	⅞	⅝	⅜	4	10	20	40	60	100	200	.05	.005	.001	

SAMPLE IDENTIFICATION

Lab. No.	Identification Marks	Location—Properties—Station Numbers	Type of Materials
17-71-608	17-71-HMAC-43		

Tested in District 17 Laboratory
By: Dean Chaddock
On: 4-20-71

TEXAS HIGHWAY DEPARTMENT
DISTRICT 17 LABORATORY
BRYAN, TEXAS
December 22, 1970

Robertson Co., etc. C 49-8-29, etc.

The District 17 Laboratory has completed a design for Item 2103 Hot Mix Asphaltic Concrete Pavement (Volumetric Design) to be used on various jobs in the 1970-71 Level-up Projects. The design used 3.8 parts Pea Gravel from Gifford Hill, 2.7 parts Gravel Screenings from Gifford Hill, 1.5 parts concrete sand from Gifford Hill and 2.0 parts field sand from the Cotroppa Pit. Laboratory testing was made under Laboratory Identification number 17-70-HMAC-90.

The laboratory design Grading and Specifications are shown on the attached form entitled "Aggregate Blending Tabulation."

The specifications require that the asphalt material shall form from 9 to 19 percent of the mixture by volume (absolute). All specimens were made within these limits.

TABLE NO. I
Specific Gravity

Size	Gifford Hill Gravel	Gifford Hill Gravel Screenings	Gifford Hill Concrete Sand	Cotroppa Field Sand
1/2 - 4	2.595			
3/8 - 10		2.574	2.553	
4 - 10	2.585			
10 - 80		2.626	2.633	2.615
Passing 80		2.615	2.770	2.725

Notes: 1. Specific gravity of the combined aggregates is 2.617.
2. Humble AC-20 asphalt was used in this design. Its specific gravity is 1.026.

TABLE NO. II
PROPORTIONING OF MATERIALS

Brazos River Gravel	Brazos River Gravel Screenings	Brazos River Concrete Sand	Cotroppa Field Sand
38%	27%	15%	20%

TABLE NO. III
OLD METHOD'S TEST RESULTS BY ASPHALT CONTENT

Asphalt Content	Hveem Density (Avg. of 3)	Hveem Stability (Avg. of 3)
4.0	94.7	38
4.5	96.2	37
5.0	97.4	35
5.5	98.8	28
6.0	99.0	(too low to calculate)

TABLE NO. IV
NEW METHOD'S TEST RESULTS BY ASPHALT CONTENT

	Asphalt Content (% vy Vol.)	Hveem Density (% by Vol.)	Hveem Stability (Avg. of 3)
Specs.	9 to 19	95 to 99	MIn. 30
	9.6	94.7	38
	10.7	96.2	37
	11.8	97.4	35
	12.9	98.8	28
	14.0	99.0	(too low to calculate)

Charts and graphs are attached giving gradation of aggregates used, asphalt content by weight and voluem and Hveem Specimen density by weight and volume.

County Robertson etc Project C-49-8-29 etc

Highway SH 6 Cont. ______ Section ______ Job ______

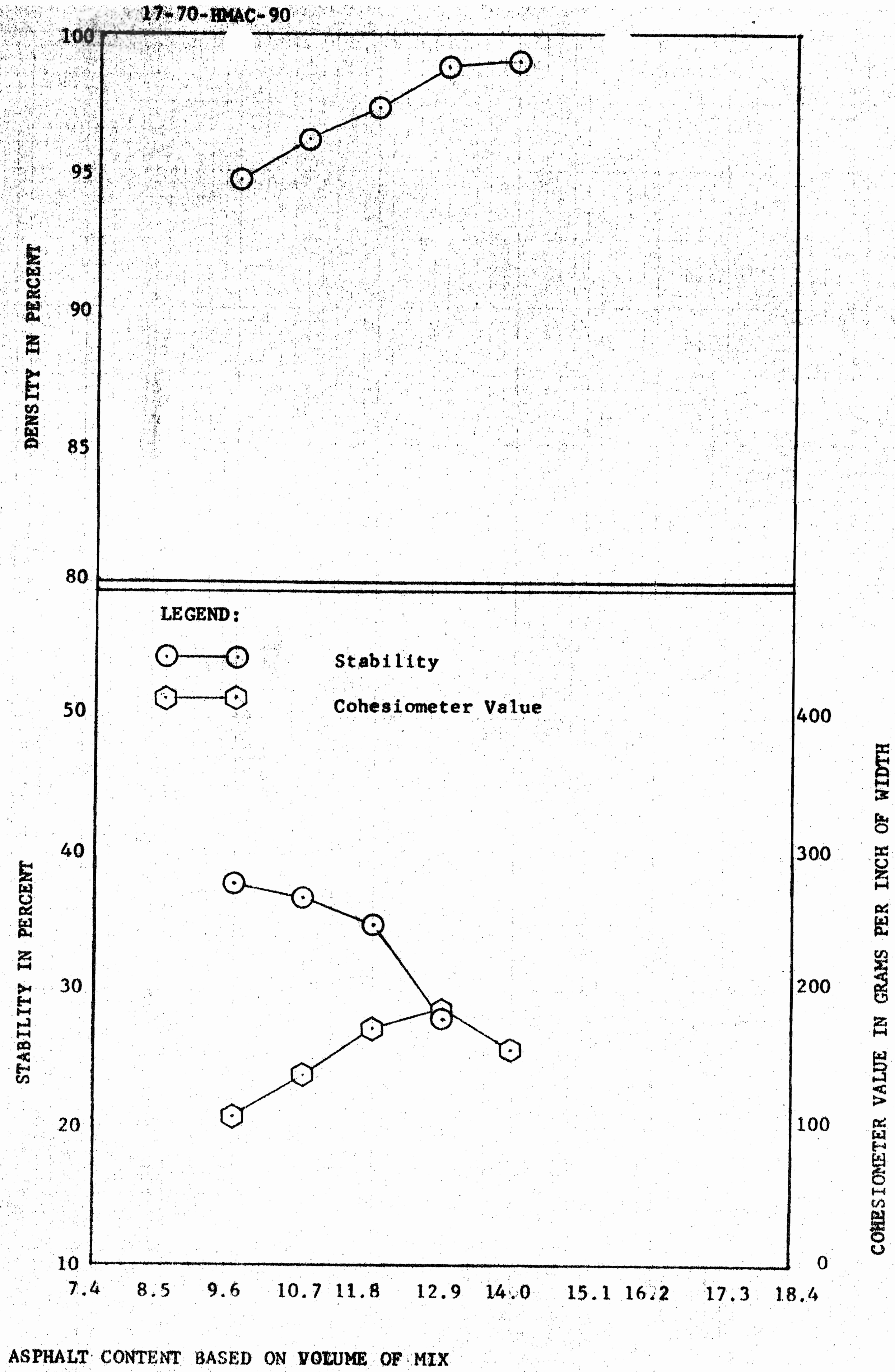
Item No. 2103-000, 10-70

AGGREGATE BLENDING TABULATION

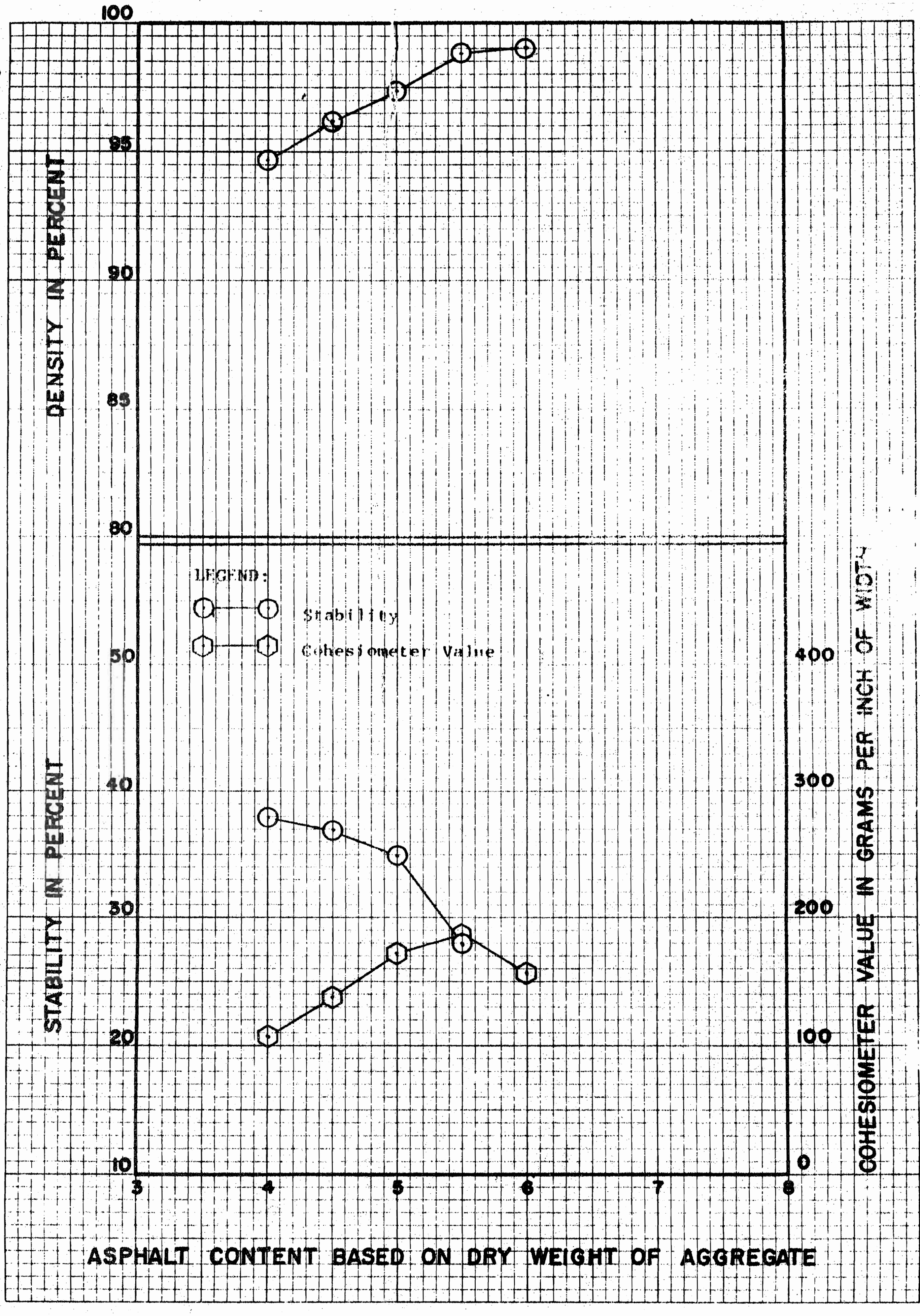
VOLUMETRIC DESIGN NUMBER ____

	SPECIFICATIONS AND MATERIALS	BLEND PARTS	SIEVE SIZES — % PASSING & RETAINED									
			+1/2	1/2-3/8	3/8-4	4-10	+10	10-40	40-80	80-200	-200	
	SPECIFICATIONS TYPE D		0	0-5	20-50	10-30	50-70	0-30	4-25	3-25	0-6	
A	River Gravel		0	5.9	55.5	37.5	98.9	1.1	0	0	0	
B	Conc. Screenings			0	28.5	53.7	82.2	14.6	1.6	0.5	1.1	
C	Conc. Sand			0	0.8	9.4	10.2	42.8	39.0	6.3	1.7	
D	Field Sand				0	0.6	0.6	0.5	20.4	64.3	14.2	
	Trial No. 1											
	Aggr A	3.8	0	22.4	210.9	142.5	375.8	4.2	0	0	0	
	Aggr B	2.7		0	77.0	145.0	221.9	39.4	4.3	1.4	3.0	
	Aggr C	1.5		0	1.2	14.1	15.3	64.2	58.5	9.5	2.6	
	Aggr D	2.0			0	1.2	1.2	1.0	40.8	128.6	28.4	
	TOTALS	10		22.4	289.1	302.8	614.2	108.8	103.6	139.5	34.0	
	÷ By 10			2.2	28.9	30.3*	61.4	10.9	10.4	14.0	3.4	

* May want to reduce screenings and increase conc. sand when running.



17-70-HMAC-90
DENSITY IN PERCENT
100
95
90
85
80
LEGEND:
Stability
Cohesiometer Value
STABILITY IN PERCENT
50
40
30
20
10
COHESIOMETER VALUE IN GRAMS PER INCH OF WIDTH
400
300
200
100
0
7.4
8.5
9.6
10.7
11.8
12.9
14.0
15.1
16.2
17.3
18.4
ASPHALT CONTENT BASED ON VOLUME OF MIX



DENSITY IN PERCENT
STABILITY IN PERCENT
COHESIOMETER VALUE IN GRAMS PER INCH OF WIDTH
LEGEND:
Stability
Cohesiometer Value
100
95
90
85
80
50
40
30
20
10
400
300
200
100
0
3
4
5
6
7
8
ASPHALT CONTENT BASED ON DRY WEIGHT OF AGGREGATE

Form 340

ASPHALTIC CONCRETE STABILITY REPORT

NO CHARGE

Laboratory No. R3-70-1352 thru R3-70-1356
Date Received 12-14-70 Date Reported 12-15-70
Dist. or Res. Engr. Delton A. Kittrell
Address Hearne
Contractor Jones G. Finke
Sampler F. W. Shenkir
Sampler's Title Sr. Res. Engr.
Sampled from Pit Sites
(Design Specimen, Car, Truck, Plant, Road)
Asphalt Producer Humble
Type AC-20
Aggr. Producer Gifford Hill Gravel 3.8 parts
Gravel Scrns. 2.7 parts
Gifford Hill Conc. Sand 1.5 parts
Cotroppa Field Sand 2.0 parts

C-49-8-29, FD 0245, C-49-9-34, FD 0246, etc.
Control No. Sect. No. Job No.

Brazos, Robertson, etc. St. 6, etc.
County Federal Project No. Hwy. No.

17 12-7-70
District No. Req. No. Date Sampled

Specification Item No. 2103

Stencil No. 2103-000, 10-70 Type D

REQUESTED DETERMINATION NO. 3803(-)

Laboratory No.	Spec. No.	Identification Marks	Asphalt (% by Vol.)	Cohesiometer Value	Asphalt (% by Wt.)	Specimen Ht. (in.)	Spec. Density (Field) (%)	Hveem Stab. (%)	Hveem Stab. (Avg. %)
		17-70-HMAC-90							
R3-70-1352	1	1	9.6	112	4.0	2.00	94.7--	37	38
	2	11		116		1.97		39	
	3	111		99		1.96		37	
				Avg. 109					
R3-70-1353	1	"	10.7	129	4.5	1.98	96.2--	38	37
	2			151		1.97		37	
	3			136		1.98		37	
				Avg. 139					
R3-70-1354	1	"	11.8	179	5.0	2.01	97.4--	36	35
	2			169		2.01		35	
	3			168		2.01		35	
				Avg. 172					
R3-70-1355	1	"	12.9	184	5.5	2.01	98.8--	29	28★
	2			195		2.01		27	
	3			188		2.01		27	
				Avg. 189					
R3-70-1356	1	"	14.0	142	6.0	2.03	99.0--	*	★ *
	2			162		2.01		*	
	3			165		2.02		*	
				Avg. 156					

★ CAUTION
HVEEM STABILITY VALUES ARE LOWER THAN THOSE SPECIFIED FOR THIS PROJECT
DIVISION OF MATERIALS & TESTS

ja

*Stability too low to calculate.

DIVISION OF MATERIALS & TESTS

Engineer of Materials and Tests

Texas Highway Department
Form 476A

[illegible]-167-25M

SOILS AND BASE MATERIALS TEST REPORT

Laboratory No. 17-70-1502
Date Rec'd 11-25-70 Reported 12-22-70
Engineer D. A. Kittrell
Address Hearne, Texas
Contractor Jones G. Finke, Inc.
Sampler James W. Starkey
Sampler's Title Engr. Tech. III
Sampled From Stockpile
Producer
Quantity Represented by Sample
Has been Used on

C 49-8-29, etc.
Control Number Section Number Job Number
Robertson, etc. SH 6, etc.
County 17 Federal Project No. Highway No. 11-25-70
District No. I.P.E. No. Req. No. 2103 Date Sampled
Specification Item No.
Material from Property of
Proposed for Use as HMACP

Lab. No.	LL	PI	SL	LS	SR	Class	Soil Binder	WBM % Loss	% Moist.	
Specifications		Max. 6								
17-70-1502	23	3					100			

PERCENT RETAINED ON

Lab No.	Square Mesh Sieve															Grain Diam.			Specific Gravity
	Opening in Inches								Sieve Numbers							in Millimeters			
	3	2½	2	1¾	1¼	⅞	⅝	⅜	4	10	20	40	60	100	200	.05	.005	.001	

SAMPLE IDENTIFICATION

Lab. No.	Identification Marks	Location—Properties—Station Numbers	Type of Materials
17-70-1502	17-70-HMAC-90	Stockpile	

Tested in District 17 Laboratory
By: Dean Chaddock
On: 12-15-70

TEXAS HIGHWAY DEPARTMENT
DISTRICT 17 LABORATORY
BRYAN, TEXAS
December 28, 1970

Robertson County, etc. C 49-8-29, etc.

The District 17 Laboratory has completed a design for Item 2103, "Hot Mix Asphaltic Concrete Pavement (Volumetric Design, to be used on Various projects in the 1970-71 Level-up. The design used 3.1 parts + 4 lightweight aggregate from Clodine, 2.4 parts +10 lightweight aggregate from Clodine, 2.5 parts concrete sand from Gifford Hill, Inc. and 2.0 parts field sand from the Cotroppa pit. Laboratory testing was made under Laboratory Identification number 17-70-HMAC-93.

The laboratory design grading and specifications are shown on the attached form entitled "Aggregate Blending Tabulation."

The specification require that the asphalt material shall form from 9 to 19 percent of the mixture by, volume (absolute).

TABLE NO. I
SPECIFIC GRAVITIES OF THE VARIOUS AGGREGATES

Size	Clodine +4 Mat'l	Clodine +10 Mat'l	Gifford Hill Concrete Sand	Cotroppa Field Sand
½ - 4	1.580			
4 - 10		1.793	2.553	
10 - 80			2.633	2.615
Passing 80			2.770	2.725

NOTES: 1. Specific gravity of the combined aggregates is 2.004.
2. Humble AC-20 asphalt was used in this design. Its specific gravity is 1.026.

TABLE NO. II
PROPORTIONING OF MATERIALS

Clodine +4 Material	Clodine +10 Material	Gifford Hill Concrete Sand	Cotroppa Field Sand
31	24	25	20

TABLE NO. III
OLD METHOD'S TEST RESULTS BY ASPHALT CONTENT

Asphalt Content %	Cohesiometer Value (Avg. of 3)	Hveem Density (Avg. of 3)	Hveem Stability (Avg. of 3)
6.5	117	87.7	49
7.0	110	89.7	46
7.5	129	91.5	46
8.0	138	91.9	47
8.5	144	92.6	47
9.0	185	93.9	47
9.5	212	94.4	47
10.0	233	94.7	45
11.0		97.4	not tested

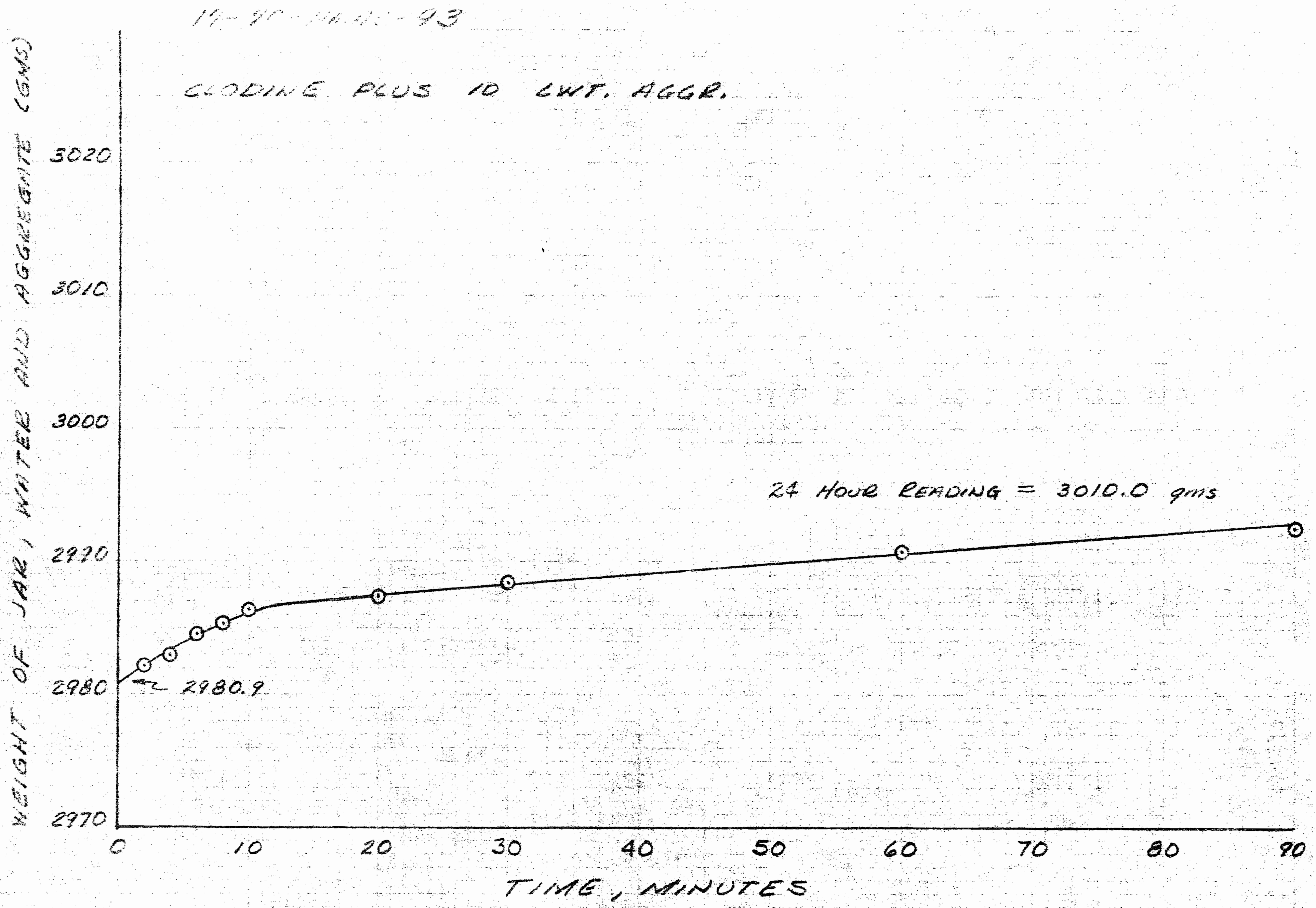
TABLE NO. IV
NEW METHOD'S TEST RESULTS BY ASPHALT CONTENT

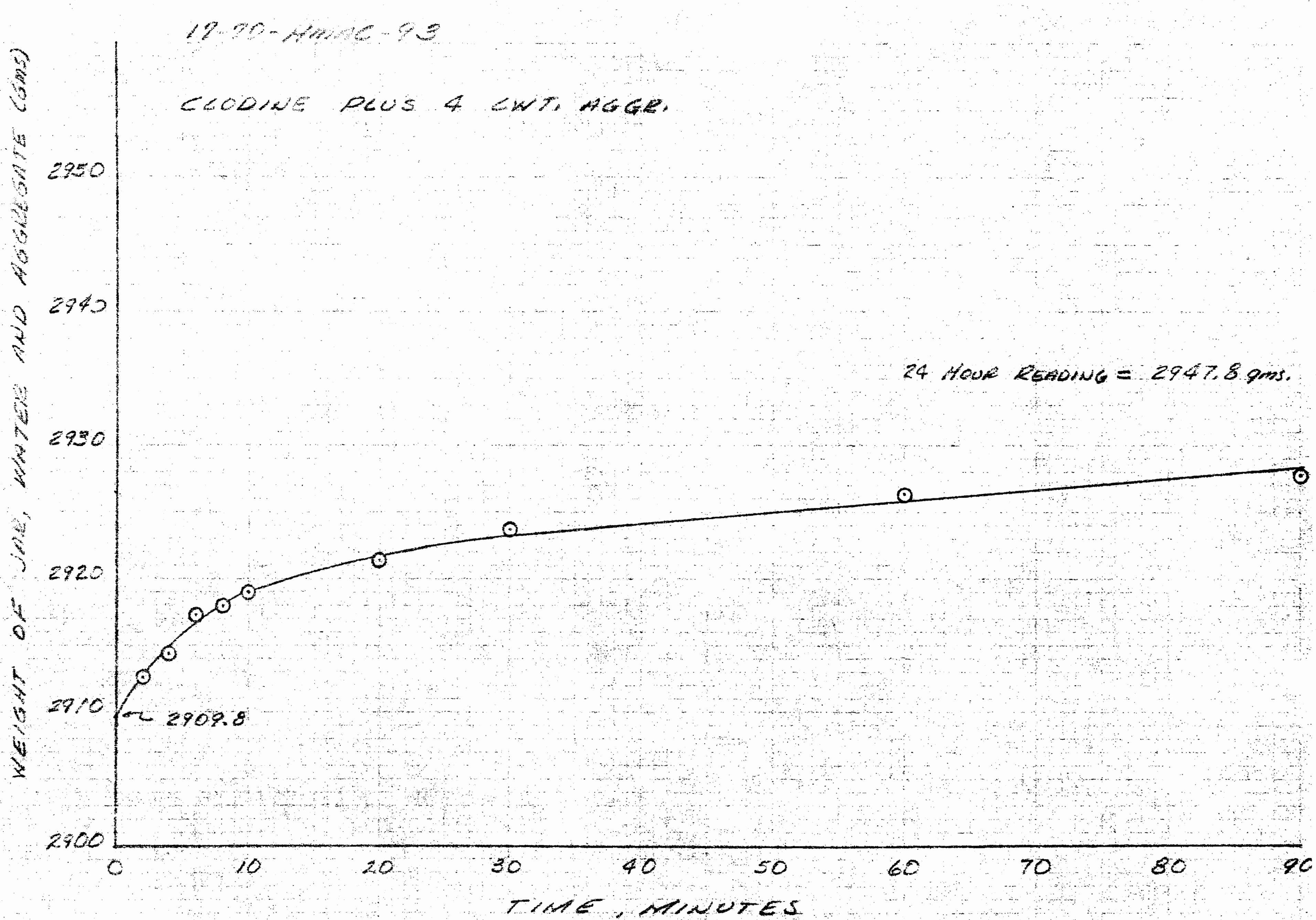
Asphalt Content (Percent by Vol.)	Hveem Density (Percent)	Hveem Stability (Avg. of 3)
12.0	87.7	49
12.8	89.7	46
13.7	91.5	46
14.5	91.9	47
15.4	92.6	47
16.2	93.9	47
17.0	94.4	47
17.8	94.7	45
19.5*	97.4	not tested
21.0*	97.1	" "
22.6*	97.5	" "

* These specimens molded after 4 hours soaking in asphalt binder. Other specimens remained in low temperature oven overnight prior to molding.

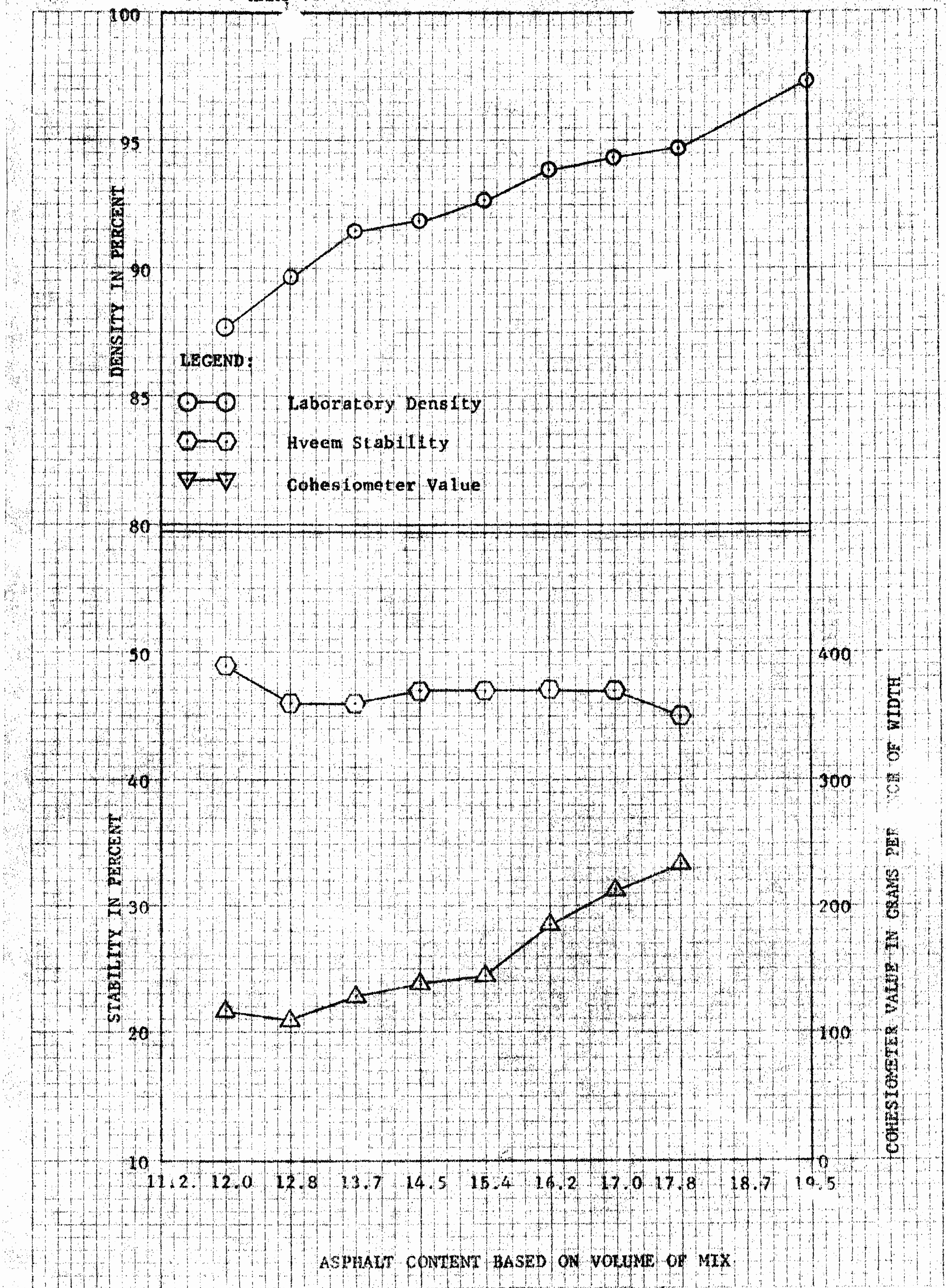
Charts and graphs are attached giving gradation of aggregates used, asphalt contents by weight and volume and Hveem specimen density.

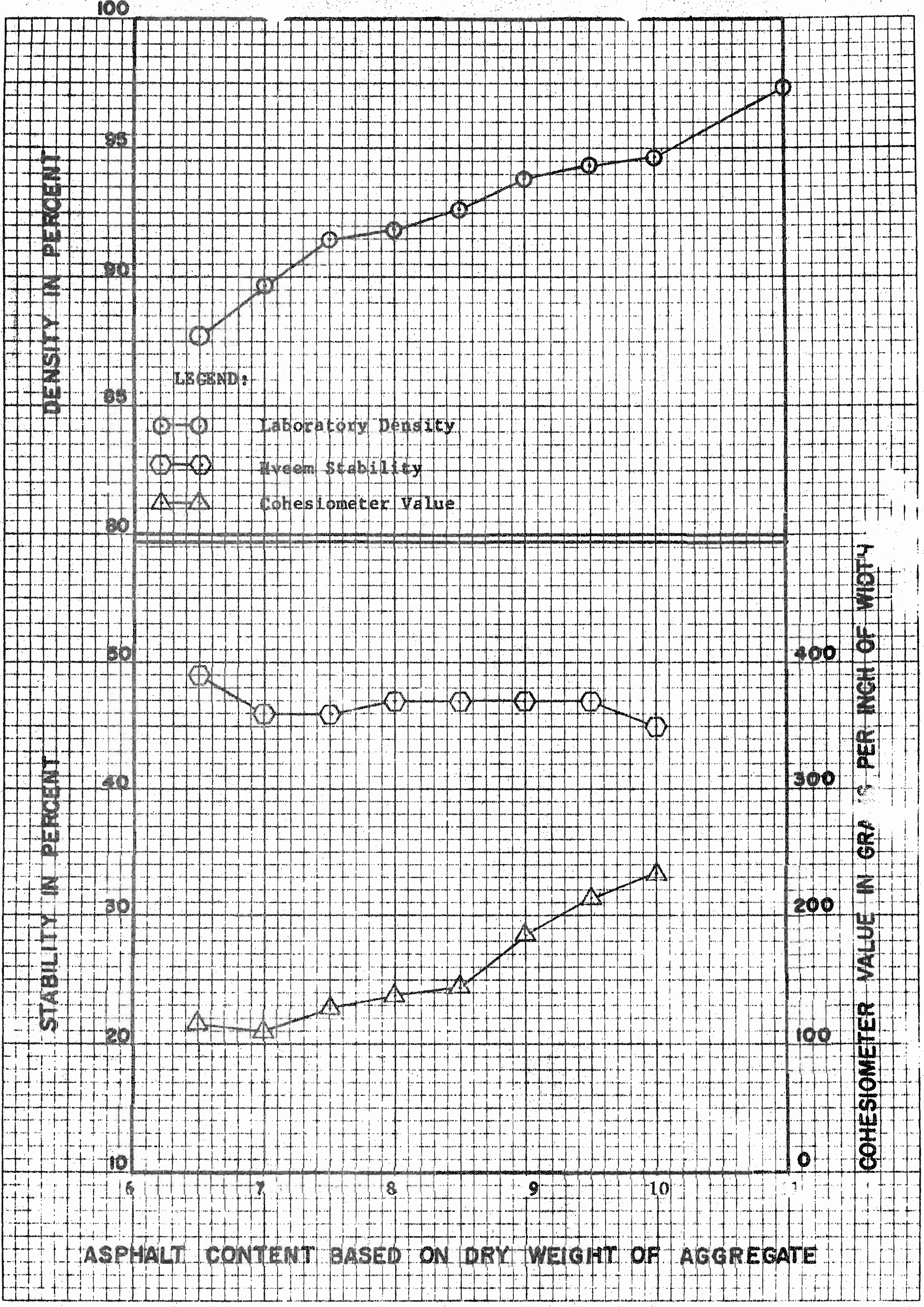
The +4 Clodine aggregate had an absorption of 9.4 percent and the +10 Clodine aggregate had an absorption of 7.2 percent. The District 17 Laboratory recommends starting with 18 percent asphalt by volume if this aggregate gradation is used. This material will need to be dry before adding asphalt at the plant. Some type of protective covering for the stockpiles is suggested.


CLODINE PLUS 10 LWT. AGGR.
24 HOUR READING = 3010.0 gms
2980.9
WEIGHT OF JAR, WATER AND AGGREGATE (GMS)
3020
3010
3000
2990
2980
2970
0
10
20
30
40
50
60
70
80
90
TIME, MINUTES



12-70-HMAC-93
CLODINE PLUS 4 CWT. AGGR.
24 HOUR READING = 2947.8 gms.
WEIGHT OF JAR, WATER AND AGGREGATE (GMS)
2950
2940
2930
2920
2910
2900
2909.8
0
10
20
30
40
50
60
70
80
90
TIME, MINUTES


100
95
90
85
80
DENSITY IN PERCENT
LEGEND:
Laboratory Density
Hveem Stability
Cohesiometer Value
50
40
30
20
10
STABILITY IN PERCENT
400
300
200
100
0
COHESIOMETER VALUE IN GRAMS PER OF WIDTH
11.2
12.0
12.8
13.7
14.5
15.4
16.2
17.0
17.8
18.7
19.5
ASPHALT CONTENT BASED ON VOLUME OF MIX



100
95
90
85
80
DENSITY IN PERCENT
LEGEND:
Laboratory Density
Hveem Stability
Cohesiometer Value
50
40
30
20
10
STABILITY IN PERCENT
400
300
200
100
0
COHESIOMETER VALUE IN GRA PER INCH OF WIDTH
6
7
8
9
10
ASPHALT CONTENT BASED ON DRY WEIGHT OF AGGREGATE

ASPHALTIC CONCRETE STABILITY REPORT

Laboratory No. 70-8611-H thru 70-8618-H
Date Received 12-21-70 Date Reported
Dist. or Res. Engr.
Address
Contractor
Sampler
Sampler's Title
Sampled from
(Design Specimen, Car, Truck, Plant, Road)
Asphalt Producer
Type
Aggr. Producer 3.1 parts +4 Clodine
2.4 parts +10 Clodine
2.5 parts Gifford Hill Conc. Sand
2.0 parts Cotroppa Field Sand
Asphalt*
(% by Volume)

Control No. Sect. No. Job No.
County Federal Project No. Hwy. No.
District No. Req. No. Date Sampled
Specification Item No.
Stencil No. Type

REQUESTED DETERMINATION NO. 3803 (2)

Laboratory No.	Spec. No.	Identification Marks	~~Station No.~~	Cohesiometer Value	Asphalt (% by Wt.)	Specimen Ht. (in.)	Spec. Density* (Field) (%)	Hveem Stab. (%)	Hveem Stab. (Avg. %)
70-8616-H	1	17-70-HMAC-93	16.2	197	9.0	2.03	--- 93.9	47	47
	2			175		2.03		47	
	3			184		2.04		47	
				Avg 185					
70-8617-H	1	17-70-HMAC-93	17.0	220	9.5	1.99	--- 94.4	48	47
	2			193		2.02		47	
	3			223		2.00		47	
				Avg 212					
70-8618-H	1	17-70-HMAC-93	17.8	258	10.0	2.02	--- 94.7	47	45
	2			226		2.02		45	
	3			215		2.02		44	
				Avg 233					

DIVISION OF MATERIALS & TESTS

Engineer of Materials and Tests

n.

ASPHALTIC CONCRETE STABILITY REPORT

Charge $96.00

* Asphalt (% by volume) and Specimen Density (field)(%) columns were filled in by District 17 Laboratory

Laboratory No. 70-8611-H thru 70-8618-H
Date Received 12-21-70 Date Reported 12-28-70
Dist. or Res. Engr. Delton A. Kittrell
Address Hearne
Contractor Jones G. Finke
Sampler F. W. Shenkir
Sampler's Title Sr. Res. Engr.
Sampled from Design
(Design Specimen, Car, Truck, Plant, Road)
Asphalt Producer Humble
Type AC-20
Aggr. Producer 1.2 Gifford Hill Conc. Sand
2.0 Cotroppa Field Sand
3.8 Lt. Wt. Aggr. +4
3.0 Lt. Wt. Aggr. 4-10

C 49-8-29 PD 0245 C 49-9-34 PD 0246, etc.
Control No. Sect. No. Job No.

Brazos, Robertson, etc. SH 6, etc.
County Federal Project No. Hwy. No.

17 12-15-70
District No. Req. No. Date Sampled

Specification Item No. 2103

Stencil No. 2103-000,10-70 Type D

REQUESTED DETERMINATION NO. 3803(2)

Laboratory No.	Spec. No.	Identification Marks	Asphalt* (% by Volume)	Cohesiometer Value	Asphalt (% by Wt.)	Specimen Ht. (in.)	Spec. Density* (Field) (%)	Hveem Stab. (%)	Hveem Stab. (Avg. %)
70-8611-H	1	17-70-HMAC-93	12.0	115	6.5	1.98	--- 87.7	49	49
	2			108		1.98		47	
	3			128		1.98		51	
				Avg 117					
70-8612-H	1	17-70-HMAC-93	12.8	104	7.0	1.98	--- 89.7	46	46
	2			112		1.98		47	
	3			114		1.97		45	
				Avg 110					
70-8613-H	1	17-70-HMAC-93	13.7	128	7.5	1.99	--- 91.5	47	46
	2			129		2.02		46	
	3			131		2.03		46	
				Avg 129					
70-8614-H	1	17-70-HMAC-93	14.5	147	8.0	2.01	--- 91.9	47	47
	2			139		1.99		48	
	3			128		2.02		47	
				Avg 138					
70-8615-H	1	17-70-HMAC-93	15.4	139	8.5	2.00	--- 92.6	47	47
	2			141		2.00		47	
	3			151		1.99		46	
				Avg 144					

D-9 REMARKS: Hveem stability values meet requirements for this project.

Texas Highway Dept. District No. 17 Bryan, Texas

DIVISION OF MATERIALS & TESTS
Engineer of Materials and Tests

County *Robertson, etc* Project *C 49-8-29 etc*
Highway *SH6 etc* Cont. ______ Section ______ Job ______
Item No. *2103*

AGGREGATE BLENDING TABULATION
VOLUMETRIC DESIGN NUMBER ____

SPECIFICATIONS AND MATERIALS	BLEND PARTS	SIEVE SIZES — % PASSING & RETAINED									
		1/2	1/2-3/8	3/8-4	4-10	+10	10-40	40-80	80-200	-200	
SPECIFICATIONS TYPE *D*		0	0-5	20-50	10-30	50-70	0-30	4-25	3-25	0-6	
A *Lwt AGGR +4*			0	87.5	11.2	98.7	1.3				
B *Lwt AGGR 4-10*			0	8.8	85.5	94.3	5.7				
C *Conc Sand*			0	0.8	9.4	10.2	42.8	39.0	6.3	1.7	
D *FLD Sand*				0	0.6	0.6	0.5	20.4	64.3	14.2	
Trial No. 2											
AGGR. A	3.1	0	0	271.3	34.7	306.0	4.0				
AGGR. B	2.4	0	0	21.1	205.2	226.3	13.7				
AGGR. C	2.5	0	0	2.0	23.5	25.5	107.0	97.5	15.8	4.3	
AGGR. D	2.0	0	0	0	1.2	1.2	1.0	40.8	128.6	28.4	
TOTALS	10	0	0	292.4	264.6	559.0	125.7	138.3	144.4	32.7	
÷ 10		0	0	29.2	26.5	55.9	12.6	13.8	14.4	3.3	

TEXAS HIGHWAY DEPARTMENT
DISTRICT 17 LABORATORY
BRYAN, TEXAS
April 5, 1971

Robertson County, etc. C 49-8-29, etc.

The District 17 Laboratory has completed a design for Item 2103, "Hot Mix Asphaltic Concrete Pavement (Volumetric Design) to be used on various projects in the 1970-71 level-up. The design used 2.5 parts + 4 lightweight aggregate from Clodine, 2.9 parts + 10 lightweight aggregate from Clodine, 4.6 parts local field sand. Laboratory testing was made under laboratory identification number 17-71-HMAC-45.

The laboratory design grading and specifications are shown on the attached form entitled "Aggregate Blending Tabulation."

The specification require that the asphalt material shall form from 9 to 19 percent of the mixture by volume (Absolute).

TABLE NO. I
SPECIFIC GRAVITIES OF THE VARIOUS AGGREGATES

Size Sieve	Clodine + 4 Material	Clodine + 10 Material	Local Field Sand
1/2 - 4	1.580		
4 - 10		1.793	
10 - 80			2.552
Passing 80			2.740

NOTES:
1. Specific gravity of the combined aggregates is 2.029.
2. Humble AC-20 asphalt was used in this design. Its specific gravity is 1.026.

TABLE NO. II
PROPORTIONING OF MATERIALS

Clodine + 4	Clodine + 10	Local Field Sand
25	29	46

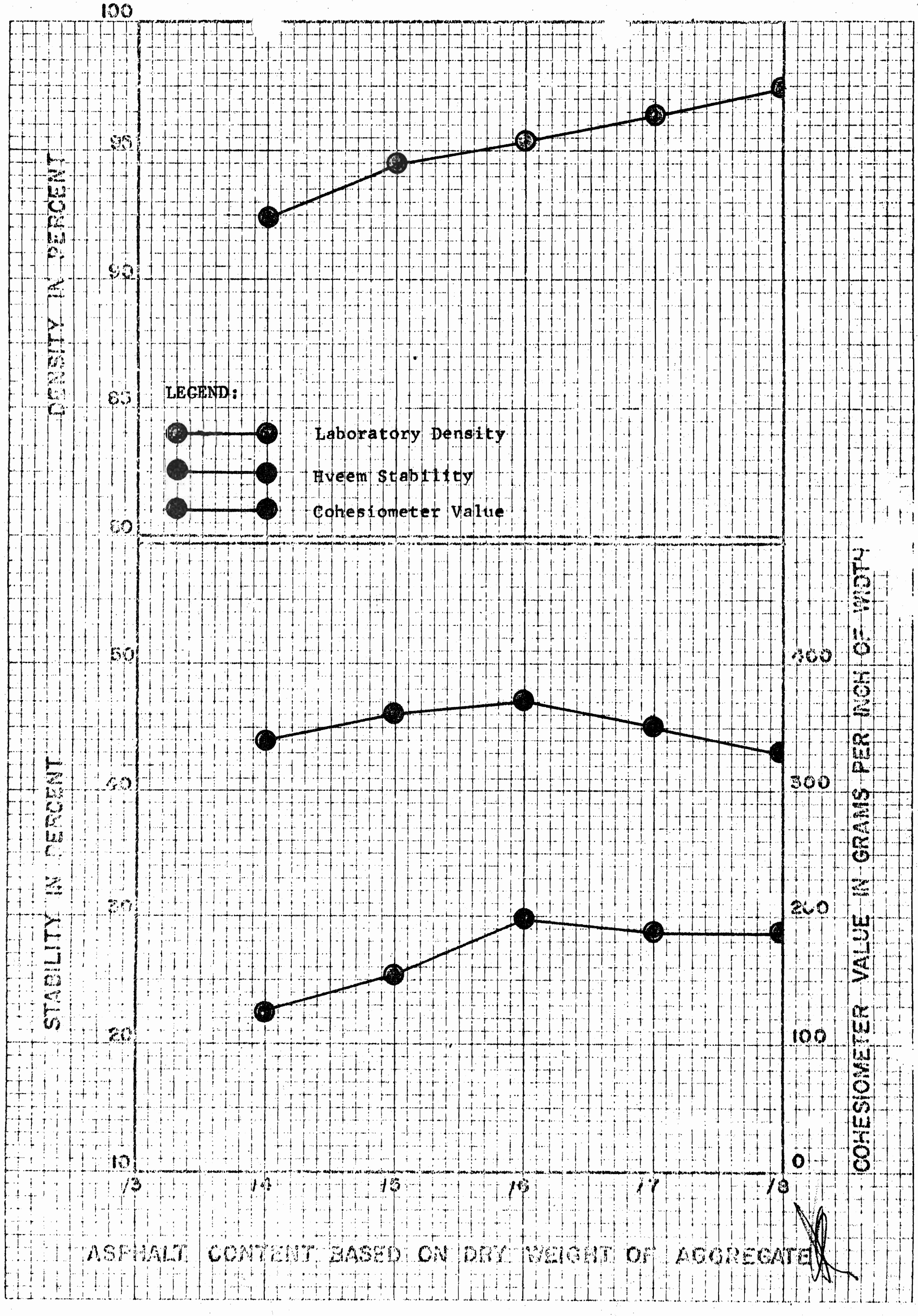
TABLE NO. III
OLD METHOD'S TEST RESULTS BY ASPHALT CONTENT

Asphalt Content (% by wt.)	Cohesiometer Value (Avg. of 3)	Hveem Density (Avg. of 3)	Hveem Stability (Avg. of 3)
8.1	125	92.3	44
8.7	153	94.4	46
9.3	197	95.3	47
10.0	188	96.3	45
10.6	188	97.3	43

TABLE NO. IV
VOLUMETRIC METHOD"S TEST RESULTS BY ASPHALT CONTENT

14	125	92.3	44
15	153	94.4	46
16	197	95.3	47
17	188	96.3	45
18	188	97.3	43

Specimens were molded after 4 hours in the oven at 250° F.
Charts and graphs are attached giving gradation of aggregates used, asphalt contents.



100
95
90
85
80
50
40
30
20
10
DENSITY IN PERCENT
STABILITY IN PERCENT
LEGEND:
Laboratory Density
Hveem Stability
Cohesiometer Value
400
300
200
100
0
COHESIOMETER VALUE IN GRAMS PER INCH OF WIDTH
13
14
15
16
17
18
ASPHALT CONTENT BASED ON DRY WEIGHT OF AGGREGATE

Texas Highway Department
Form 476A

640069-107-25M

SOILS AND BASE MATERIALS TEST REPORT

Laboratory No. 17-71-610
Date Rec'd 4-8-71 Reported 5-5-71
Engineer D. A. Kittrell
Address Hearne, Texas
Contractor Jones G. Finke
Sampler George Perdue
Sampler's Title Engr. Asst. III
Sampled From Stockpile
Producer
Quantity Represented by Sample
Has been Used on

C 49-8-29, etc.
Control Number Section Number Job Number
Robertson, etc. SH 6 etc.
County Federal Project No. Highway No.
17 4-8-71
District No. I.P.E. No. Req. No. Date Sampled
Specification Item No. 2103
Material from Property of

Proposed for Use as HMACP

Lab. No.	LL	PI	SL	LS	SR	Class	Soil Binder	WBM % Loss	% Moist.	
Specification		Max. 6								
17-71-610	21	1								

PERCENT RETAINED ON

Lab No.	Square Mesh Sieve — Opening in Inches								Square Mesh Sieve — Sieve Numbers							Grain Diam. in Millimeters			Specific Gravity
	3	2½	2	1¾	1¼	⅞	⅝	⅜	4	10	20	40	60	100	200	.05	.005	.001	

SAMPLE IDENTIFICATION

Lab. No.	Identification Marks	Location—Properties—Station Numbers	Type of Materials
17-71-610	117-71-HMAC-45	Stockpile	Field Sand

Tested in District 17 Laboratory
By: Dean Chaddock
On: 4-20-71

County ______________ Project ______________

Highway ______ Cont. ______ Section ______ Job ______

Item No. ______________________________

AGGREGATE BLENDING TABULATION

VOLUMETRIC DESIGN NUMBER ____

SPECIFICATIONS AND MATERIALS	BLEND PARTS	SIEVE SIZES — % PASSING & RETAINED									
		1/2-3/8	3/8-4	4 10	(+10)	10-40	40-80	80-200	-200		
SPECIFICATIONS TYPE D											
Lwt Aggr +4		1.8	87.5	10.7	(100)	0	0	0	0		
Lwt Aggr 4-10		0	6.3	85.9	(92.2)	7.8	0	0	0		
Field SAND		0	0	0	0	5.6	55.6	36.0	2.8		
Lwt Aggr +4	2.5	0.5	21.9	2.6							
Lwt Aggr 4-10	2.9	0	1.8	24.9		2.3					
Field SAND	4.6	0	0	0		2.6	25.6	16.5	1.3		
		0.5	23.7	27.5	(51.7)	4.9	25.6	16.5	1.3		
		0-5	20-50	10-30	50-70	0-30	4-25	3-25	0-6		

ASPHALTIC CONCRETE STABILITY REPORT

Charge $60.00

Laboratory No. 71-2439-H thru 71-2443-H
Date Received 4-26-71 Date Reported 4-27-71
Dist. or Res. Engr. Delton A. Kittrell
Address Hearne
Contractor Jones G. Finke
Sampler G. Perdue
Sampler's Title Engr. Asst. III
Sampled from Stockpile
(Design Specimen, Car, Truck, Plant, Road)
Asphalt Producer Humble
Type AC-20
Aggr. Producer Clodine Lightweight
Field Sand

C 49-8-29 PD 0265, C 49-9-34 PD 0266, etc.
Control No. Sect. No. Job No.

Brazos, Robertson, etc. SH 6, etc.
County Federal Project No. Hwy. No.

17 4-8-71
District No. Req. No. Date Sampled

Specification Item No. 2103

Stencil No. 2103-000,10-70 Type D

REQUESTED DETERMINATION NO. 3803 (45)

Laboratory No.	Spec. No.	Identification Marks	Station No.	Cohesiometer Value	Asphalt (% by ~~Wt.~~ Volume)	Specimen Ht. (in.)	LABORATORY Spec. Density (%)	Hveem Stab. (%)	Hveem Stab. (Avg. %)
		HMAC-17-71-45							
71-2439-H	1	1		133	14	2.04	92.3	46	44
	2	11		104		2.02		44	
	3	111		137		2.04		43	
				Avg 125					
71-2440-H	1	"		107	15	2.04	94.4	44	46
	2			174		2.01		47	
	3			178		1.98		47	
				Avg 153					
71-2441-H	1	"		161	16	1.98	95.3	45	47
	2			219		2.02		46	
	3			212		2.05		49	
				Avg 197					
71-2442-H	1	"		170	17	2.02	96.3	45	45
	2			191		2.00		47	
	3			204		2.05		44	
				Avg 188					
71-2443-H	1	"		203	18	2.00	97.6	44	43
	2			180		2.00		44	
	3			182		2.01		42	
				Avg 188					

D-9 REMARKS: Hveem stability values meet requirements for this project.

TEXAS HIGHWAY DEPARTMENT
DISTRICT NO. 17
BRYAN, TEXAS
RECEIVED

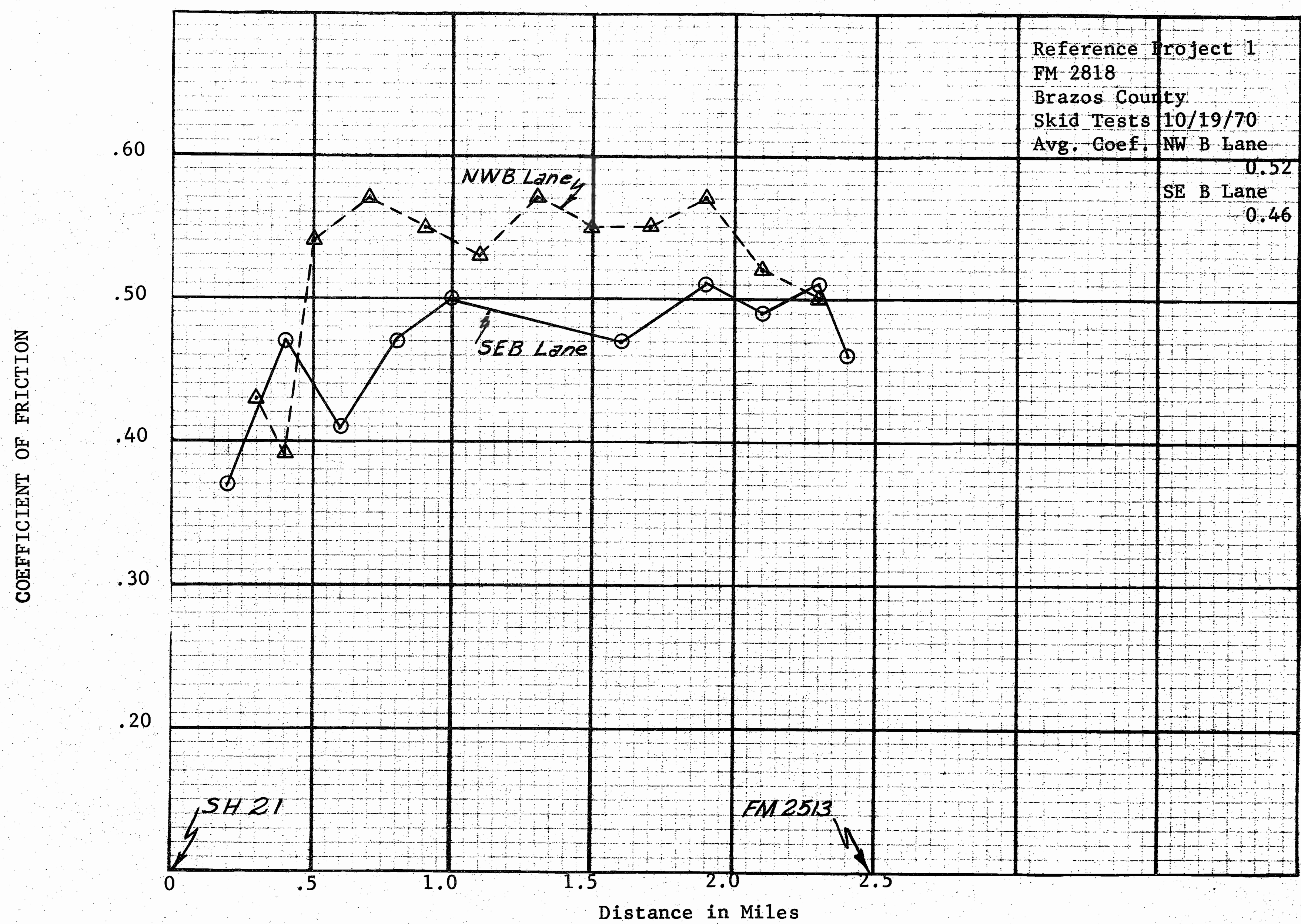
DIVISION OF MATERIALS & TESTS

Engineer of Materials and Tests

D4-P-2130 F-463 6-69 60M

APPENDIX XIV.

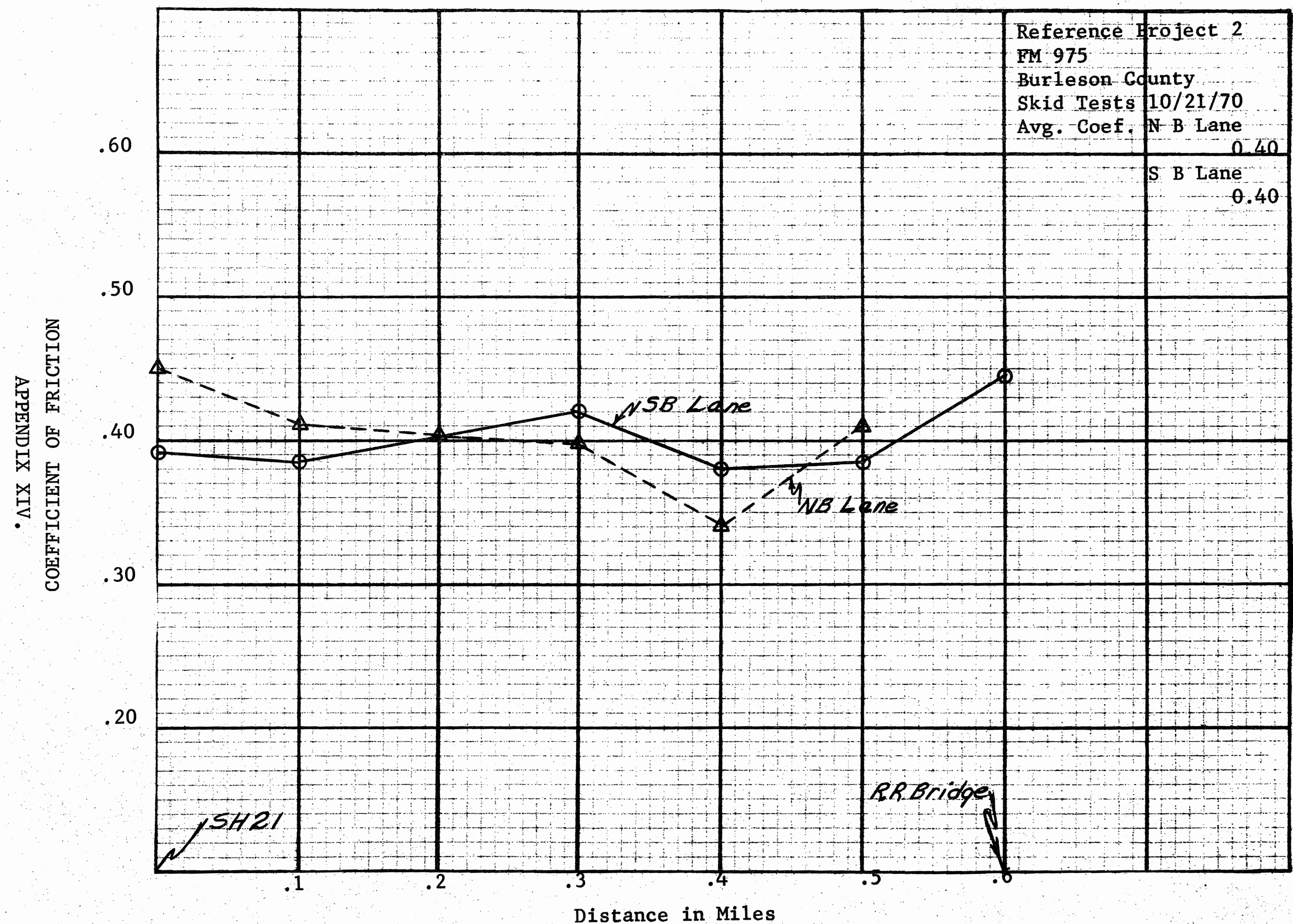
Skid Resistance Results (October 1970)



SUMMARY OF SKID TEST RESULTS (1969 PROJECT)

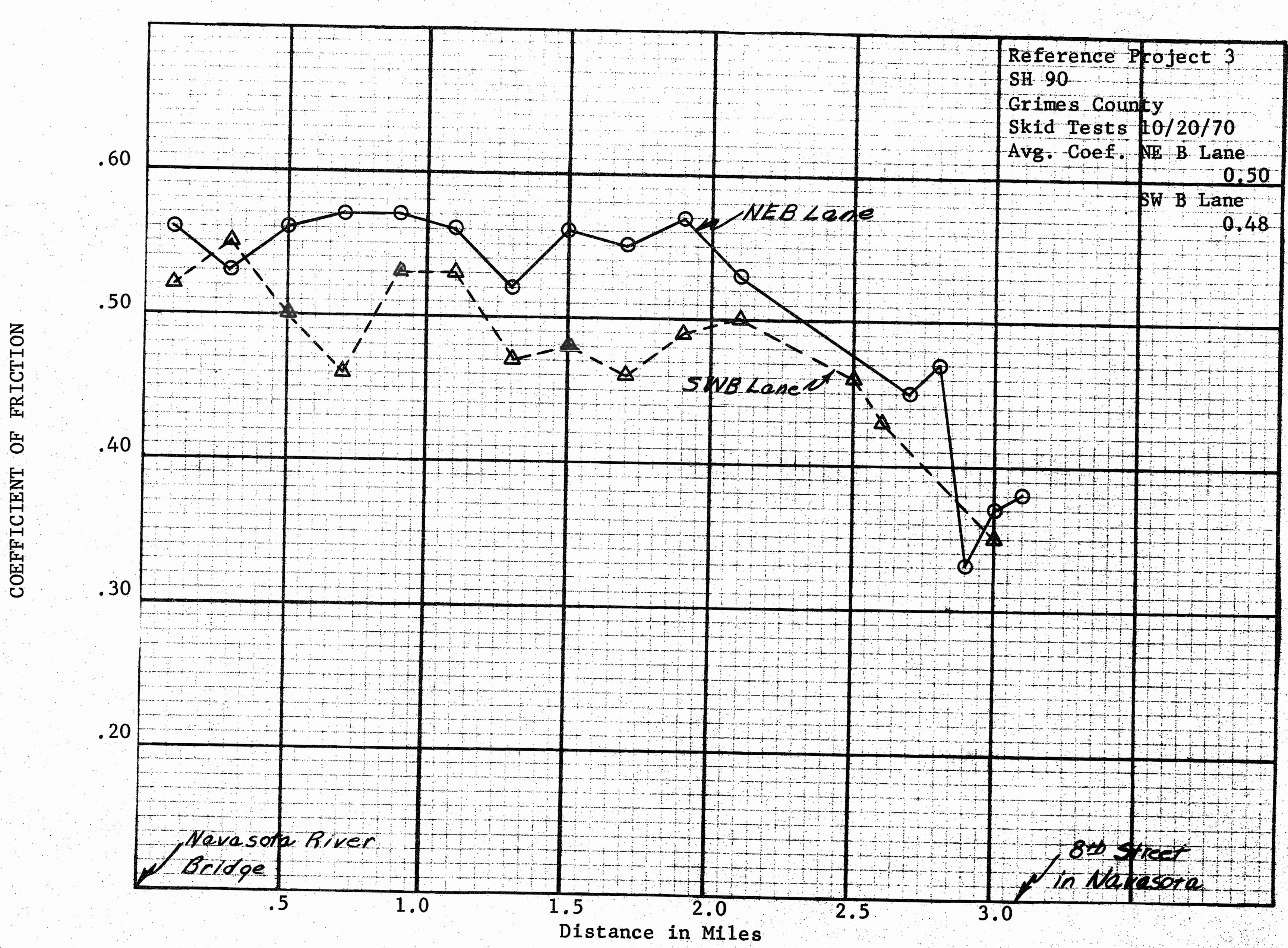
APPENDIX XIV.

APPENDIX XIV.



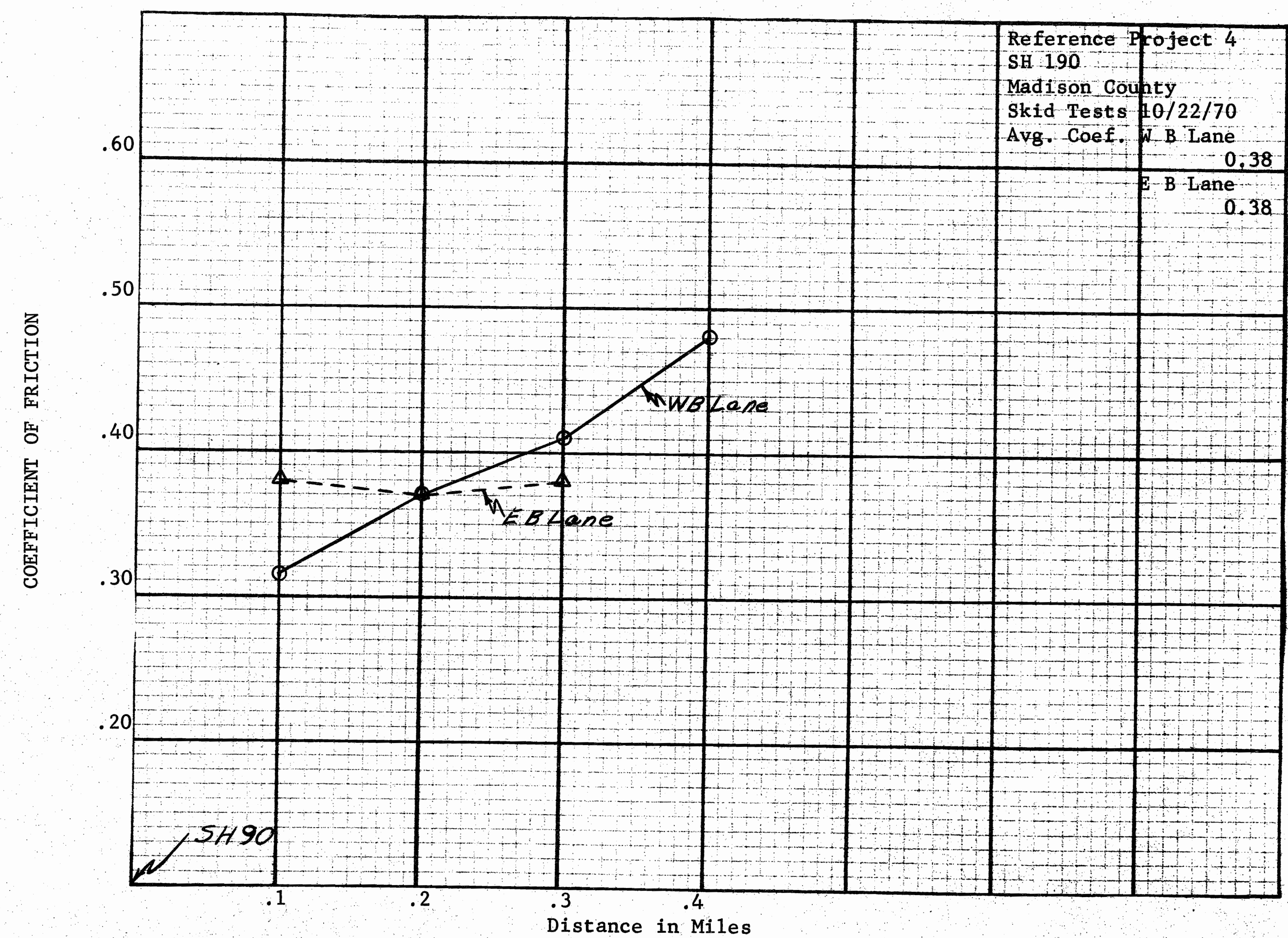
SUMMARY OF SKID TEST RESULTS (1969 PROJECT)

APPENDIX XIV.



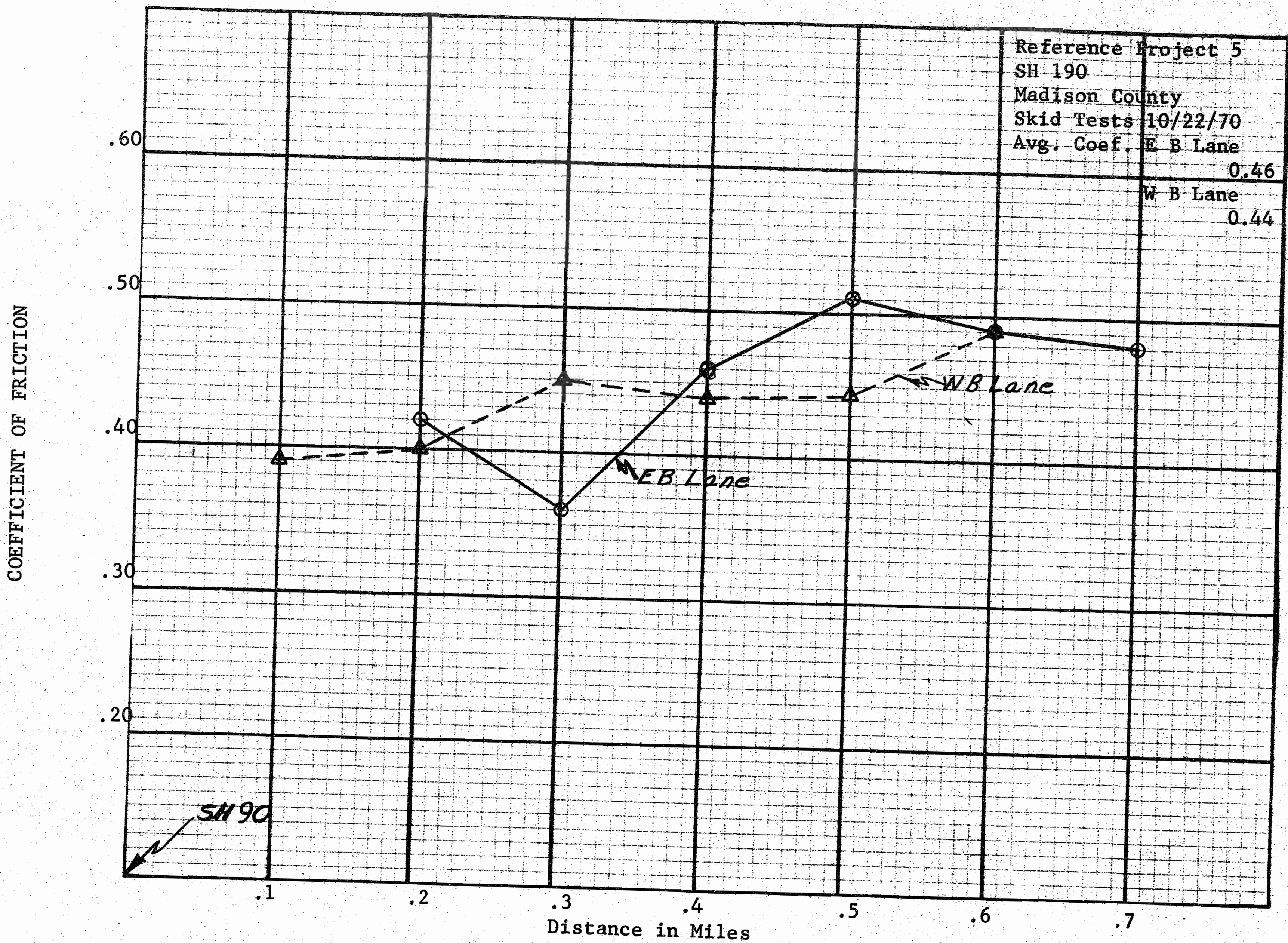
SUMMARY OF SKID TEST RESULTS (1969 PROJECT)

APPENDIX XIV.



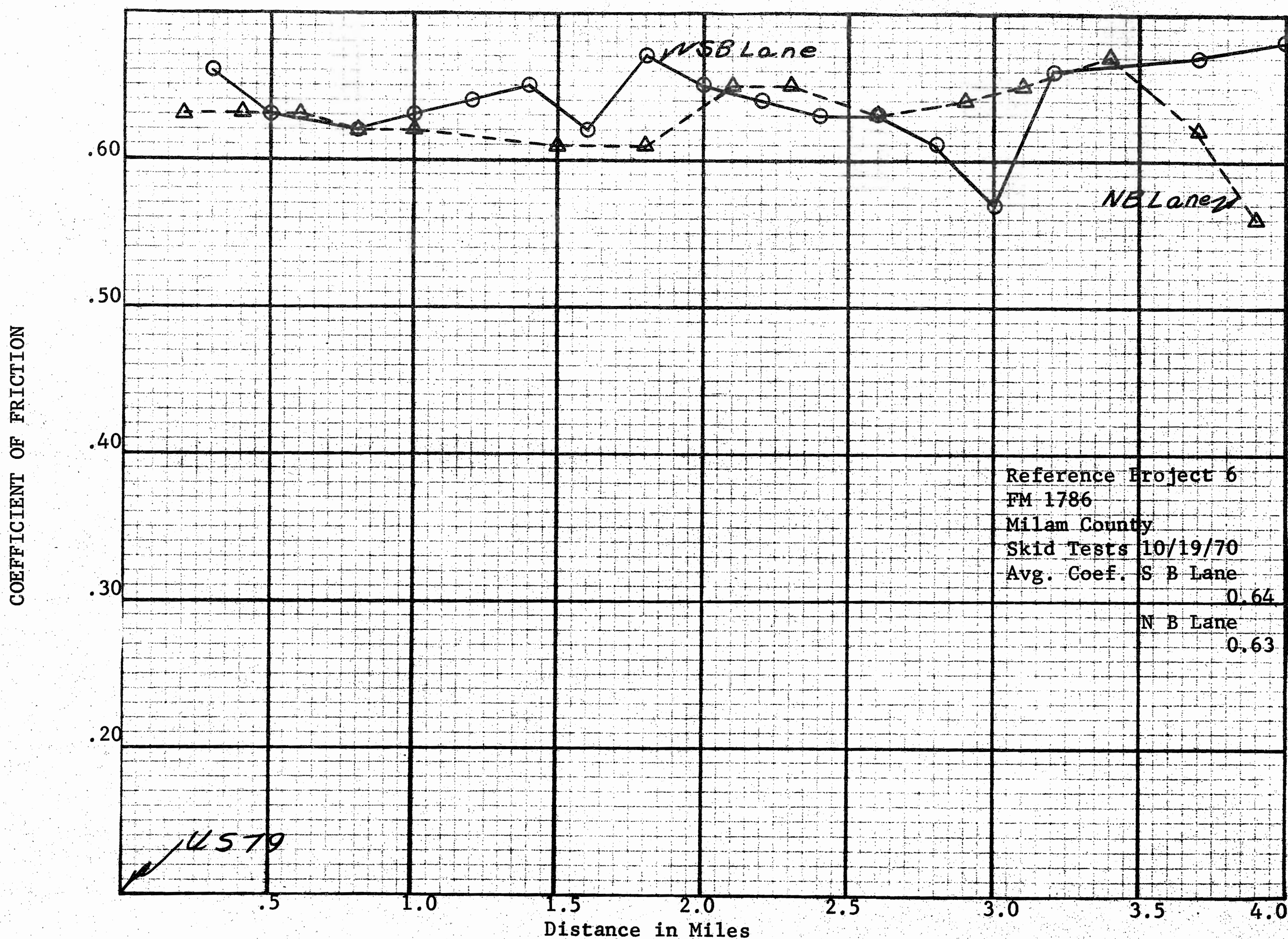
SUMMARY OF SKID TEST RESULTS (1969 PROJECT)

APPENDIX XIV.



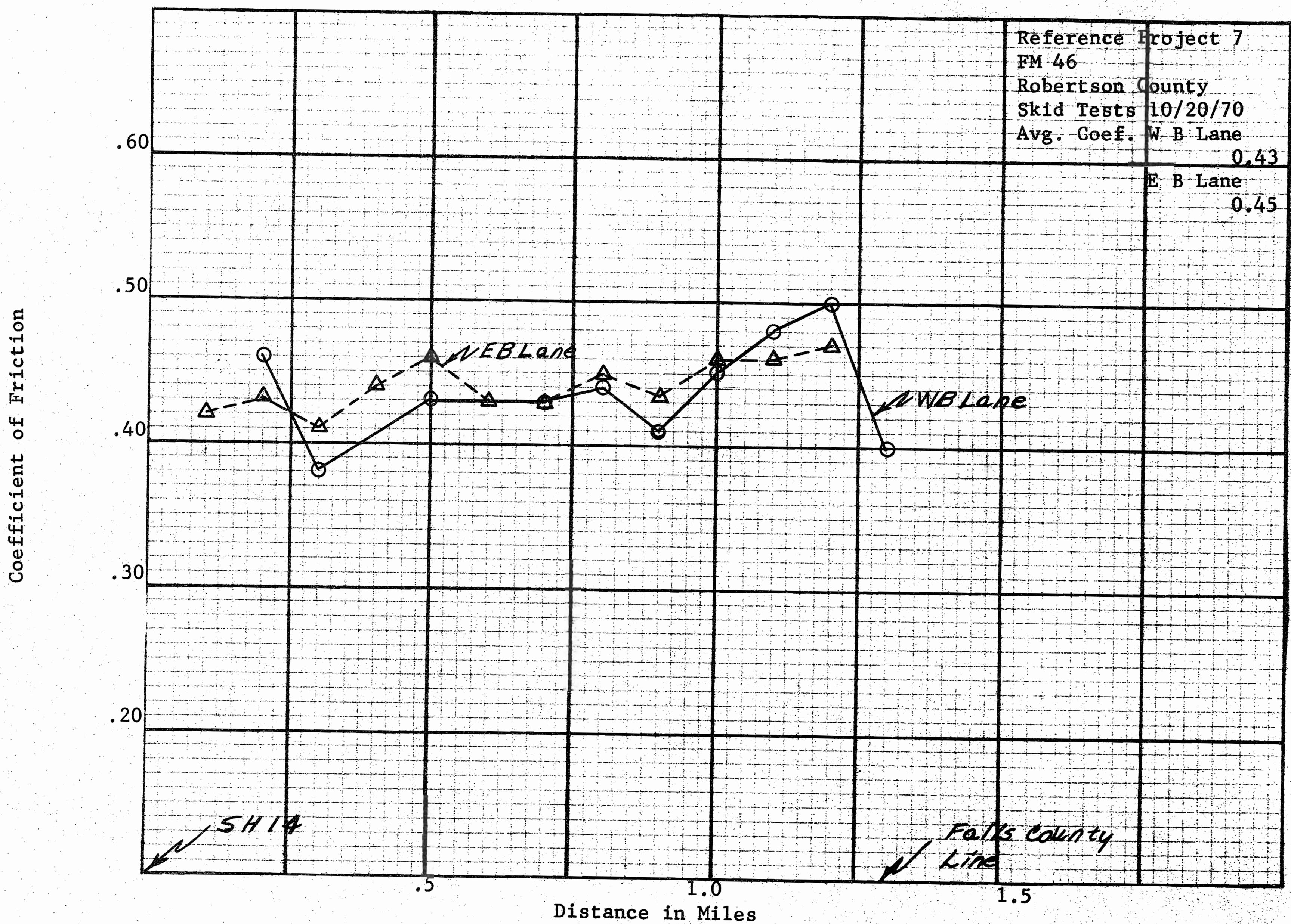
SUMMARY OF SKID TEST RESULTS (1969 PROJECT)

APPENDIX XIV.



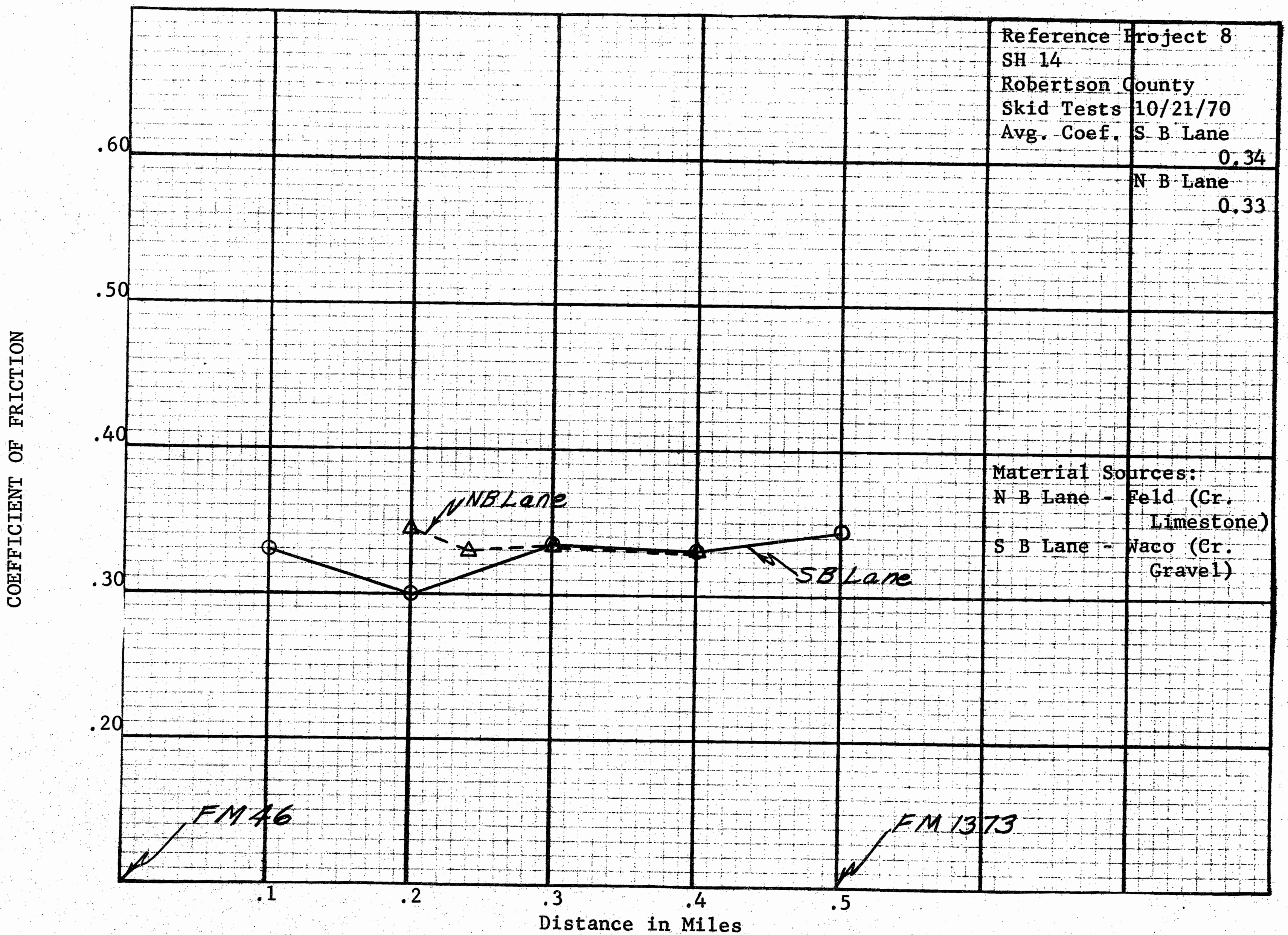
SUMMARY OF SKID TEST RESULTS (1969 PROJECT)

APPENDIX XIV.



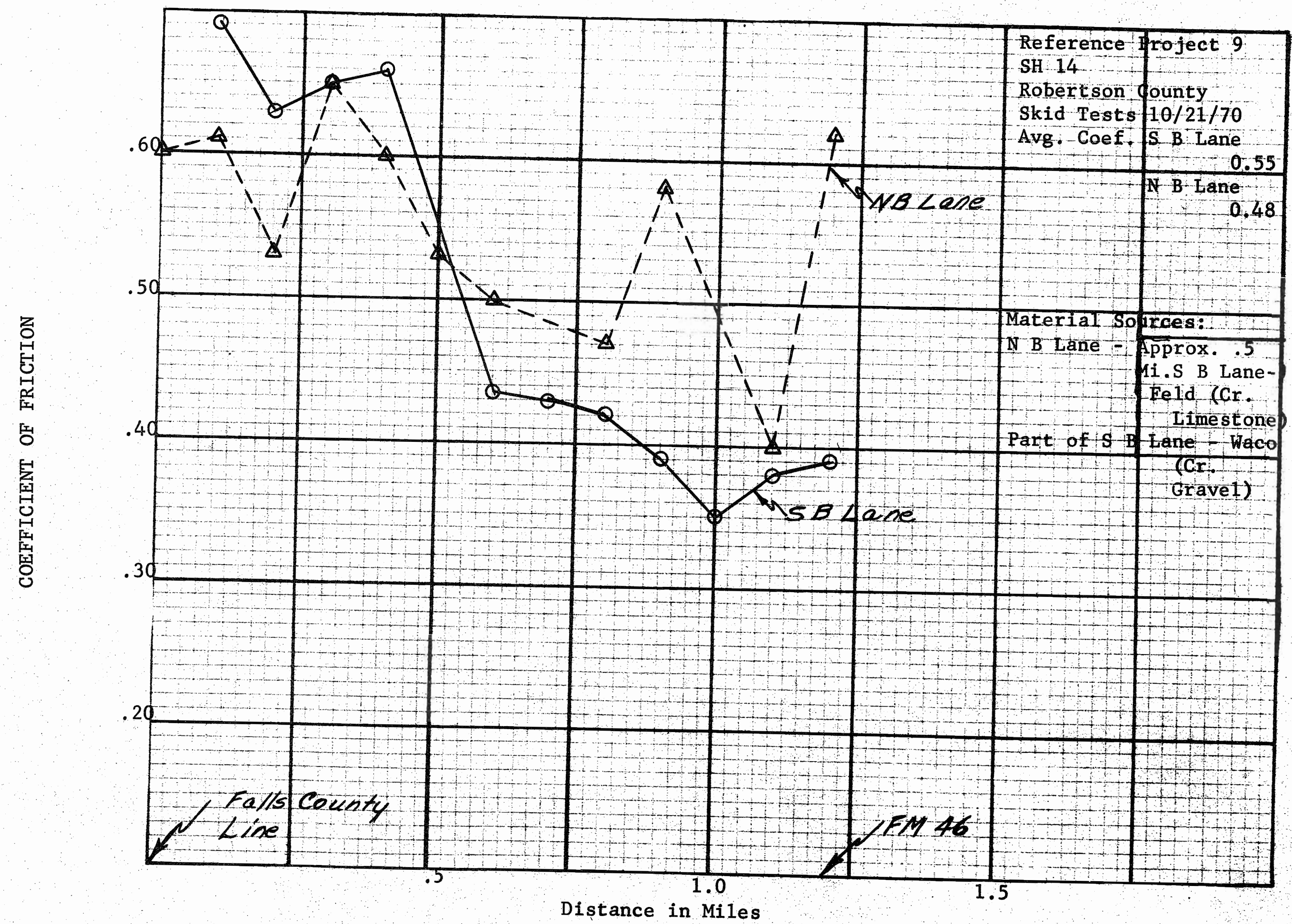
SUMMARY OF SKID TEST RESULTS (1969 PROJECT)

APPENDIX XIV.



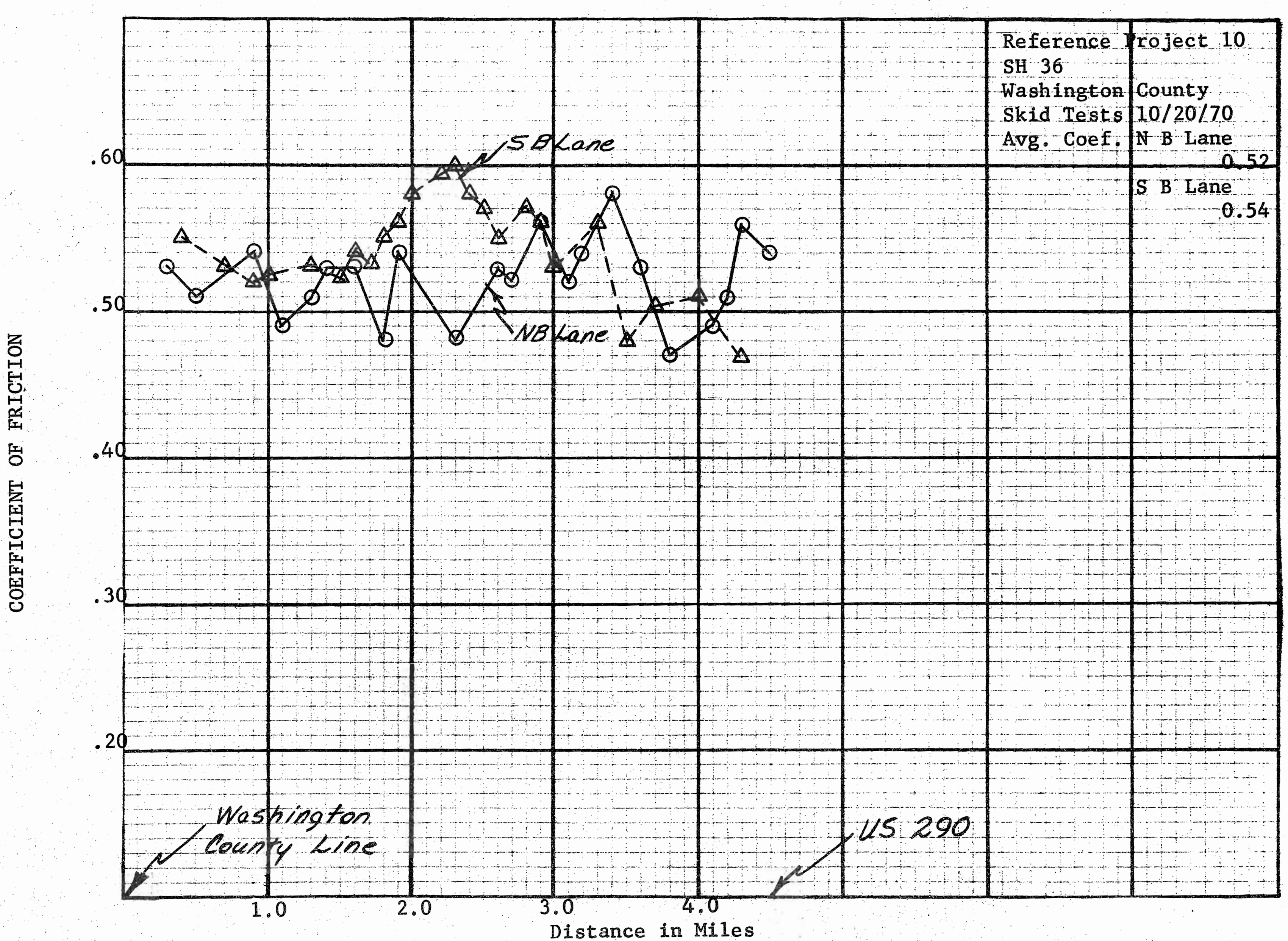
SUMMARY OF SKID TESTS RESULTS (1969 PROJECT)

APPENDIX XIV.



SUMMARY OF SKID TEST RESULTS (1969 PROJECT)

APPENDIX XIV.



SUMMARY OF SKID TEST RESULTS (1969 PROJECT)

APPENDIX XV

Skid Resistance Results - 1970 Project

APPENDIX XV

SKID TEST RESULTS - 1970 PROJECT

Project No.	Lane	Date of Test	Range of Coef. Min.	Range of Coef. Max.	Average Coef.	Standard Deviation
1	NW Bound	4/28/71	.57	.67	.62	.03
SH 6 Robertson	SE Bound	4/28/71	.55	.66	.60	.03
	NW Bound	7/13/71	.51	.68	.61	.04
	SE Bound	7/13/71	.50	.71	.61	.06
2	NW Bound	4/28/71	.63	.67	.65	.01
SH 6 Brazos	SE Bound	4/28/71	.58	.64	.61	.02
	NW Bound	7/13/71	.60	.64	.65	.01
	SE Bound	7/13/71	.61	.65	.65	.02
3	S Bound	7/14/71	.57	.68	.63	
SH 36 Washington	N Bound	7/14/71	.59	.67	.63	
4A	S Bound	7/14/71	.61	.68	.65	
	N Bound	7/14/71	.59	.70	.63	
4B	E Bound	7/14/71	.65	.72	.68	.02
	W Bound	7/14/71	.62	.69	.65	.02
	E Bound	7/14/71	.55	.67	.62	.03
	W Bound	7/14/71	.55	.64	.59	.03
4C	E Bound	7/14/71	.55	.68	.63	.03
	W Bound	7/14/71	.62	.68	.65	.02
	E Bound	7/14/71	.53	.62	.58	.02
	W Bound	7/14/71	.56	.63	.58	.02
5	N Bound	4/28/71	.53	.66	.60	.04
US 77 Milam	S Bound	9/28/71	.60	.67	.64	.02
	N Bound	7/12/71	*.40	.67	.61	.05
	S Bound	7/12/71	.54	.69	.62	.03

*This reading represents only one test and data is subject to question. All other coefficients in this series of tests are .58 or higher.

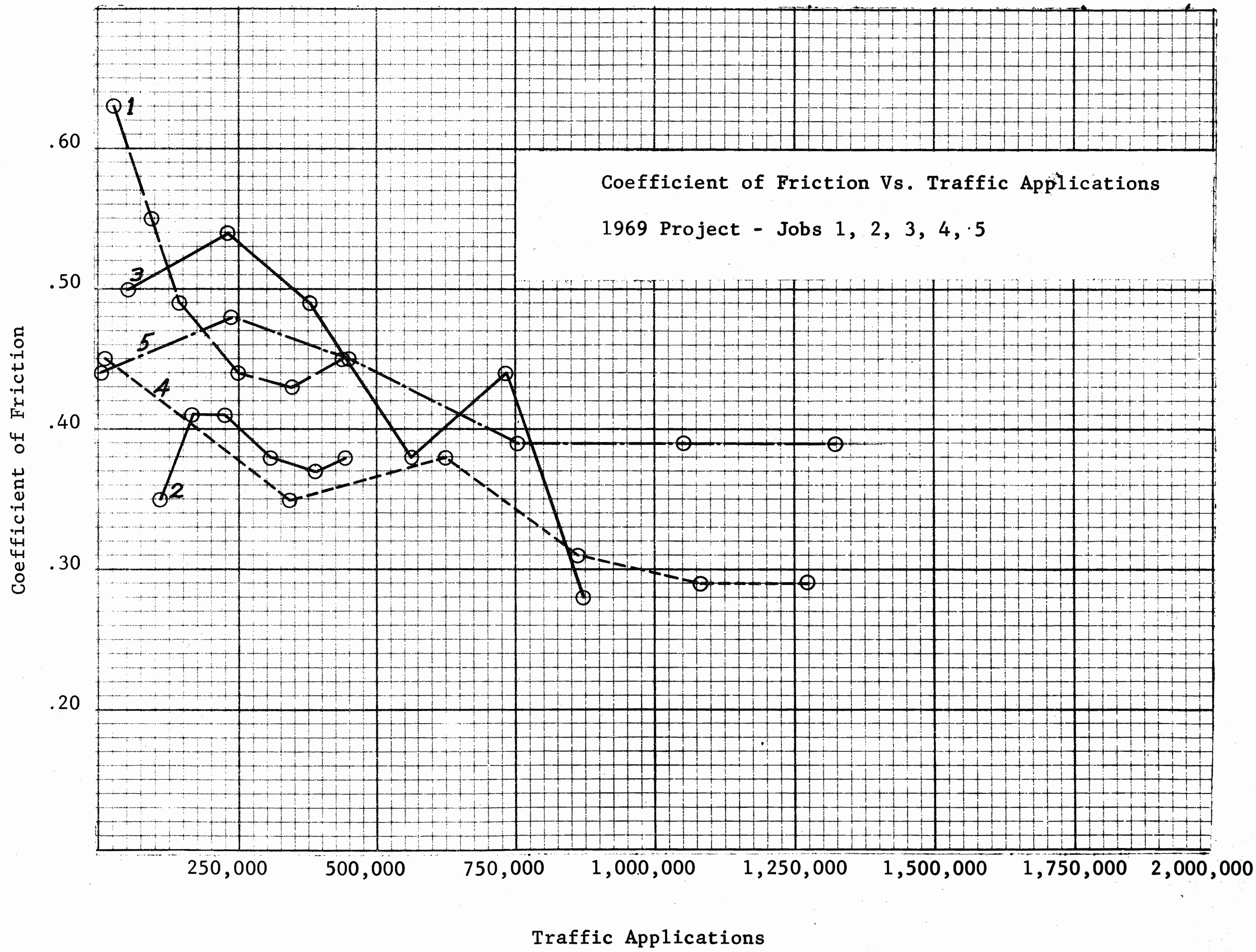
NOTE: For testing Project 4 was divided into 3 sections:

4A - From Loop 283 N. of Brenham to US 290 W. of Brenham
4B - From US 290 W. of Brenham to SH 36 S. of Brenham
4C - From SH 36 S. of Brenham to FM 577

APPENDIX XVI.

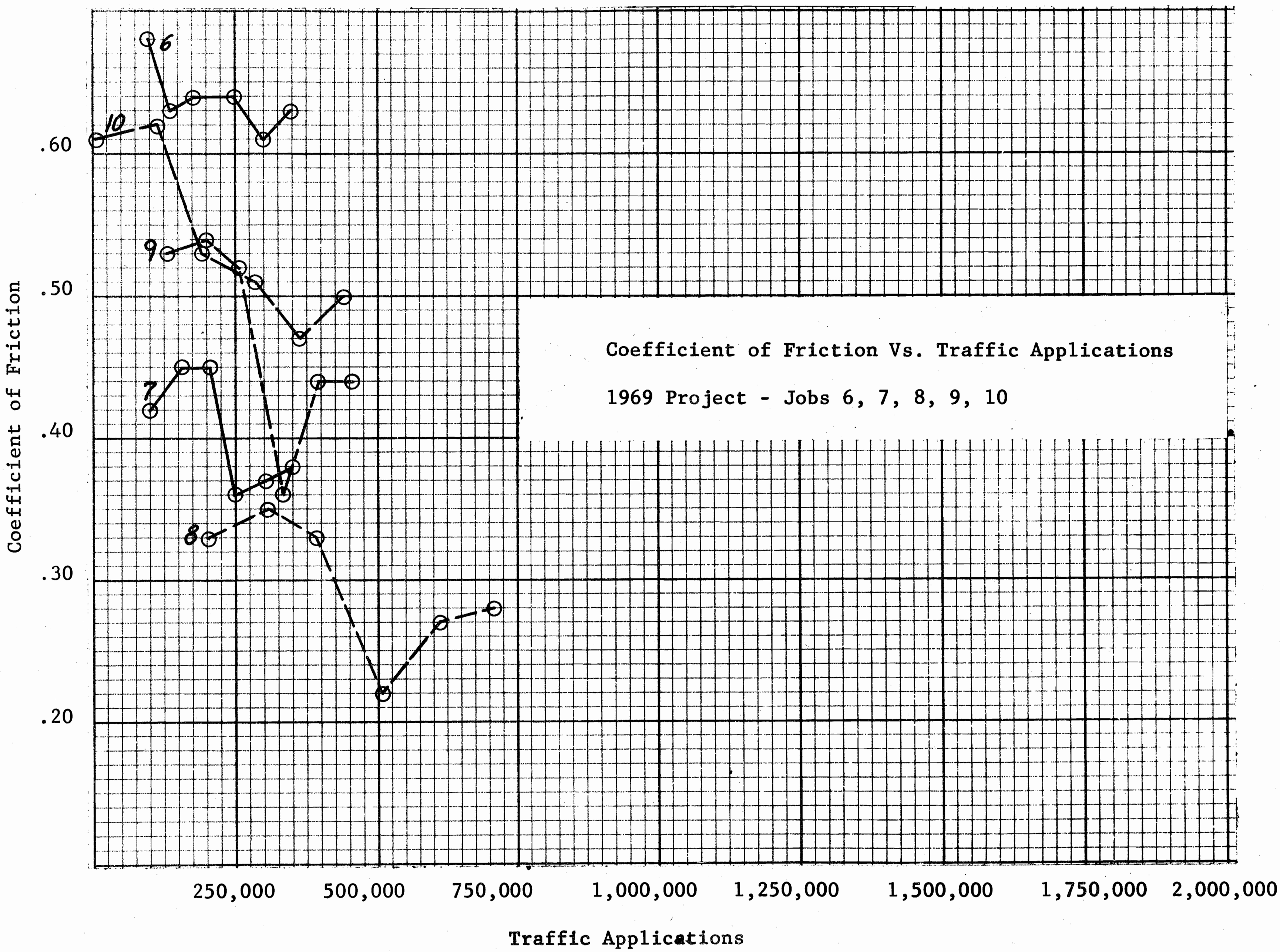
Curves - Coefficient of Friction Versus
Traffic Applications

1969 Project



APPENDIX XVI.

APPENDIX XVI.



APPENDIX XVII.

Curves - Coefficient of Friction Versus
Traffic Applications

1970 Project

APPENDIX XVII.