DETAILED TEST PROCEDURES FOR DESIGN AND FIELD CONTROL OF ASPHALT PAVING MIXTURES

By
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This paper delineates the test procedures which have resulted from the comprehensive investigation outlined in the preceding papers of this symposium. The apparatus used in the laboratory is described and the method of selecting design asphalt contents from the test data is discussed. Since this test method is also adaptable for use in the construction control of plant mixtures and for determining the properties of in-place pavements, by means of core samples, a description of these features is included. A list of the equipment required to conduct the tests subsequently outlined is shown on Table 1. Detailed working drawings of the compaction and testing equipment are shown on Figures 1-5 inclusive.

The completed assembly of Marshall stability testing equipment mounted in the CBR frame is shown on Figure 5. This testing equipment consists of the CBR testing frame in which is mounted a proving ring with gage dial, screw-jacking mechanism, the flow meter and Marshall stability breaking head, and a penetration piston used as an extension by which to transfer load applied by jack to the proving ring.

LABORATORY TEST FOR DESIGN OF ASPHALT PAVING MIXTURES

Penetration of asphaltic mixture - When using the method to design a bituminous pavement mix, it is first desirable to make a sieve analysis and to determine the specific gravity of the aggregates and filler proposed for use. Specific gravity of the asphalt cement likewise should be determined for use in computations as discussed later. The proper proportions of various types of aggregates and filler to produce a reasonable gradation may then be determined. Depending on the quantity of the material to be produced and local costs of various aggregates, it may be desirable to investigate a number of aggregate blends.

To insure accurate control of blends in the preparation of test mixtures, the aggregate should be separated into fractions, and where adequate heating facilities are available the following size separations are suggested: 3/4 in., ½ in., 3/8 in., Nos. 4, 10, 40, 80, 200. Aggregate larger than 1 in. should not be used in the standard equipment with this test method.

All separated fractions of aggregate and filler should be heated separately to temperatures between 350 F. and 375 F. Asphalt cement should be heated to temperatures between 250 F. and 280 F., but should not be held at this temperature for more than one hour. Figure 6 shows aggregate heating facilities at the Waterways Experiment Station. After all materials have reached the desired temperature, the bowl or pan in which the mixture is to be prepared is placed on a solution balance and tared. The aggregate and filler are then scooped from the heating pans and weighed in proportions calculated to give approximately 3000 gms of the desired blend. When removing the aggregates from the heating pans, a representative sample of the material may be obtained by scooping to the bottom of the pan; otherwise segregation may occur. The aggregate and filler are then thoroughly mixed by a trowel or large spatula. Aggregate temperatures should then be be-

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TABLE 1

EQUIPMENT REQUIREMENTS FOR LABORATORY TESTS

Item	No Req'd	Remarks
Compaction mold cylinder	6	See Figure 1
Compaction mold base plate	4	See Figure 1
Compaction mold collar	2	See Figure 1
Compaction hammer	2	See Figure 2
Marshall breaking head	1	See Figure 3
Flow meter	1	See Figure 3
Testing machine	1	See Figures 4 and 5
Sample extractor	2	See Figure 1
Ovens or hot plates for heating aggregate, asphalt cement and molding equipment		Approximately 12-sq-ft heating surface area (approximately 1 5-ft by 8-ft) is desirable
Pans for heating aggregate	12	Approximately 12-in x 18-in x 4-in
Can with pitcher-type handle for heating asphalt cement	2	1-gallon capacity
Mixing bowls or pans for mixing aggregate and asphalt cement	2	Approximately 10-quart capacity To fit mechanical mixer if available
Mechanical bakery or restaurant-type mixer	1	Approximately 10-quart capacity
Scoop for handling hot aggregate	1	2-quart size
Square pointed masons trowels	2	2-in x 4-in blade, wood handle
Spatulas	2	1-in x 6-in blade, wood handle
Thermometers for determining mixture temperatures	6	Dial-type with metal stem or armored glass thermometer, minimum sensitivity 5-degree F, range 50-degree F to 400-degree F
Compaction pedistal, support for compaction mold while tamping	1	6-in x 6-in wood post capped with 12-in x 12-in x 2-in wood, and 12-in x 12-in x 1-in steel plate, supported on concrete base or floor slab
Hot water bath with perforated false bottom for heating test specimens, thermostatically controlled for 140-degree F ± 1-degree	1	Approximately 18-in x 30-in x 9-in deep
Thermometers for hot water bath	2	Mercury thermometers, 0 2-degree F divisions, 134-degree F to 148-degree F range
Solution balance for weighing aggregate and asphalt	1	20-kg capacity, sensitive to 1 gm
Balance for weighing compacted specimens	1	2-kg capacity, sensitive to 0 5-gm
Saddle and wire basket for weighing specimens under water	1	
Water bucket for weighing specimens under water	1	Approximately 10-quart capacity
Welders gloves, or similar, for handling hot equipment	3 pr	

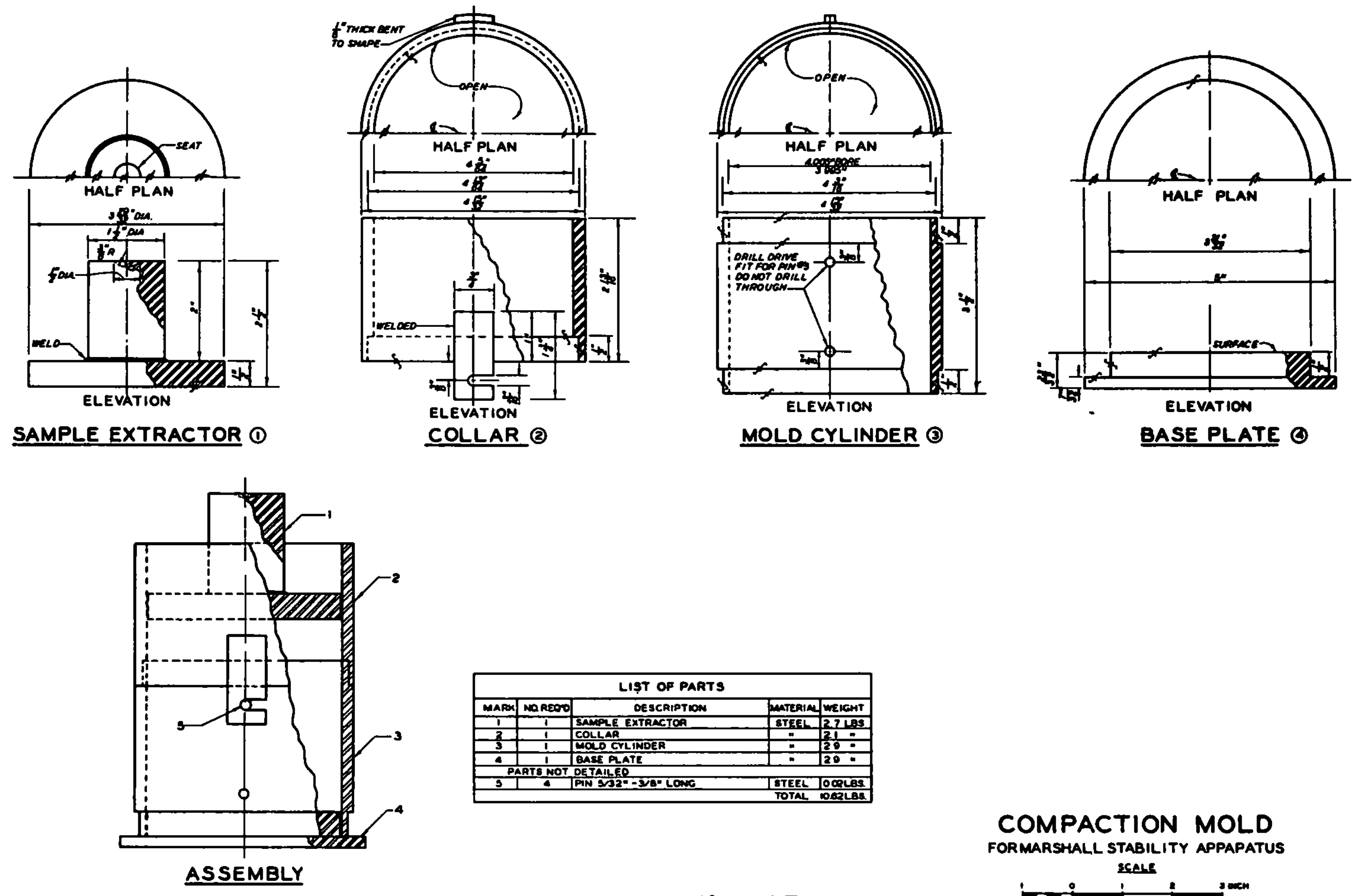
tween 340 F. and 360 F. Upon attaining the desired mixing temperature, a crater is formed in the mixing bowl or pan. The bowl (or pan) and aggregates are rebalanced on the solution balance and the hot asphalt cement is introduced in the required amount.

The amounts of asphalt cement used in the preparation of test specimens necessarily must be estimated, since one of the primary objectives of the test method is to determine the optimum asphalt content. An estimate of the optimum asphalt content based on judgement and past experience with similar mixtures is adequate for a starting point. Trial mixtures are prepared at the estimated optimum asphalt content and generally at asphalt contents 1 and 2 percent below and above the estimated optimum asphalt content. Experience has indicated that eight test specimens are required at each asphalt content to assure adequately accurate test data.

Mixing is accomplished immediately after the introduction of the asphalt cement and should be completed as rapidly as possible. Mixing may be done either by hand or in a mechanical mixer. A 10- to 14-quart bread dough mixer is recommended. Thorough mixing should be accomplished within two minutes. The temperature of the mixture should not be below 225 F. upon completion of mixing. If below this temperature, the mixture should be discarded and the process repeated. The mixture should not be reheated after mixing.

Preparation of test specimens - Production of test specimens is initiated immediately after mixing is completed. The compaction hammers and compaction molds should be heated to between 200 and 300 F., cleaned and ready for use. All of the mixture is first transferred from the mixing bowl to a large pan, divided equally, and each half placed in a compaction mold. A piece of filter paper or paper toweling, cut to size and placed in the bottom of the mold before the mixture is introduced, facilitates removal of the base plate after compaction. After the mixture is transferred to the molds, compaction proceeds immediately.

The temperature of the mixture immediately prior to compaction should not be less than 225 F. After the mix has been



LIST OF PARTS

MARK	NO. REQ'D	DESCRIPTION	MATERIAL	WEIGHT
1	1	SAMPLE EXTRACTOR	STEEL	2.7 LBS
2	1	COLLAR	"	2.1 "
3	1	MOLD CYLINDER	"	2.9 "
4	1	BASE PLATE	"	2.9 "
PARTS NOT DETAILED				
5	4	PIN 5/32" - 3/8" LONG	STEEL	0.02 LBS.
			TOTAL	10.62 LBS.

Figure 1. Plan and Profiles of Test Section

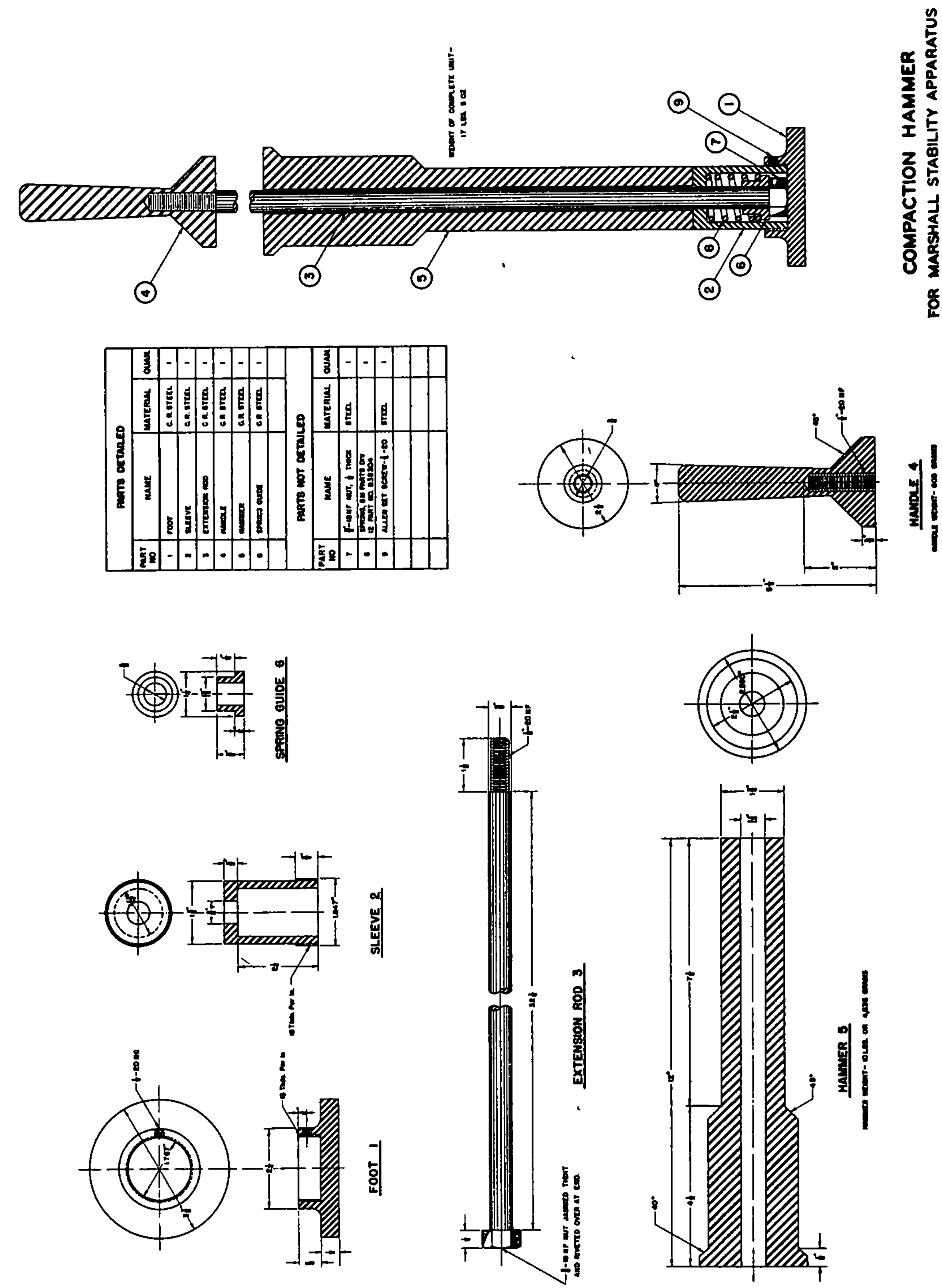

COMPACTION HAMMER
FOR MARSHALL STABILITY APPARATUS
WEIGHT OF COMPLETE UNIT - 17 LBS. 5 OZ
PARTS DETAILED
PART NO | NAME | MATERIAL | QUAN.
1 | FOOT | C.R. STEEL | 1
2 | SLEEVE | C.R. STEEL | 1
3 | EXTENSION ROD | C.R. STEEL | 1
4 | HANDLE | C.R. STEEL | 1
5 | HAMMER | C.R. STEEL | 1
6 | SPRING GUIDE | C.R. STEEL | 1
PARTS NOT DETAILED
PART NO | NAME | MATERIAL | QUAN.
7 | NUT | STEEL | 1
8 | SPRING, 12 PART NO. 839304 | | 1
9 | ALLEN SET SCREW | STEEL | 1
FOOT 1
SLEEVE 2
EXTENSION ROD 3
HANDLE 4
HAMMER 5
SPRING GUIDE 6

Figure 2.

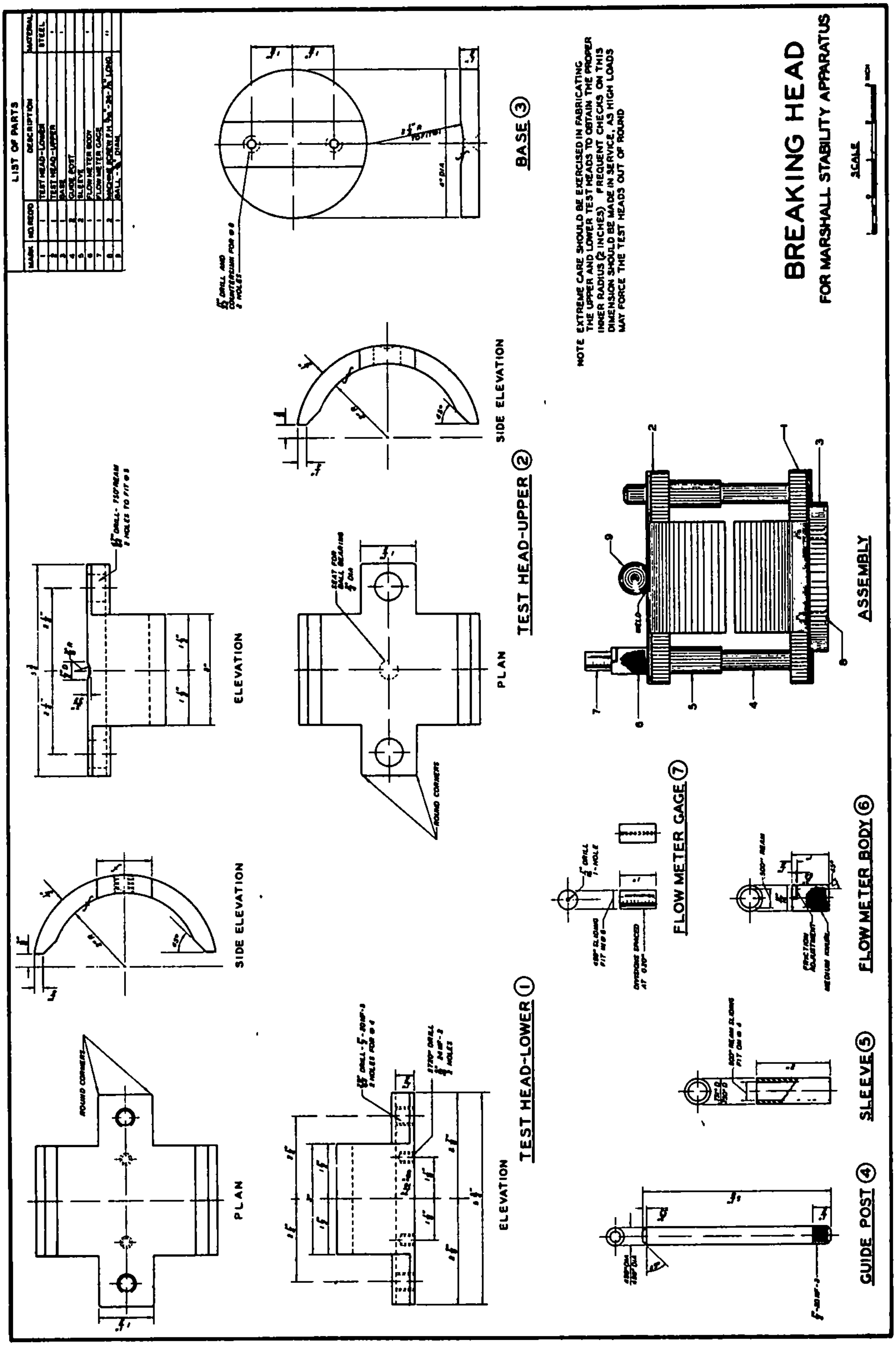
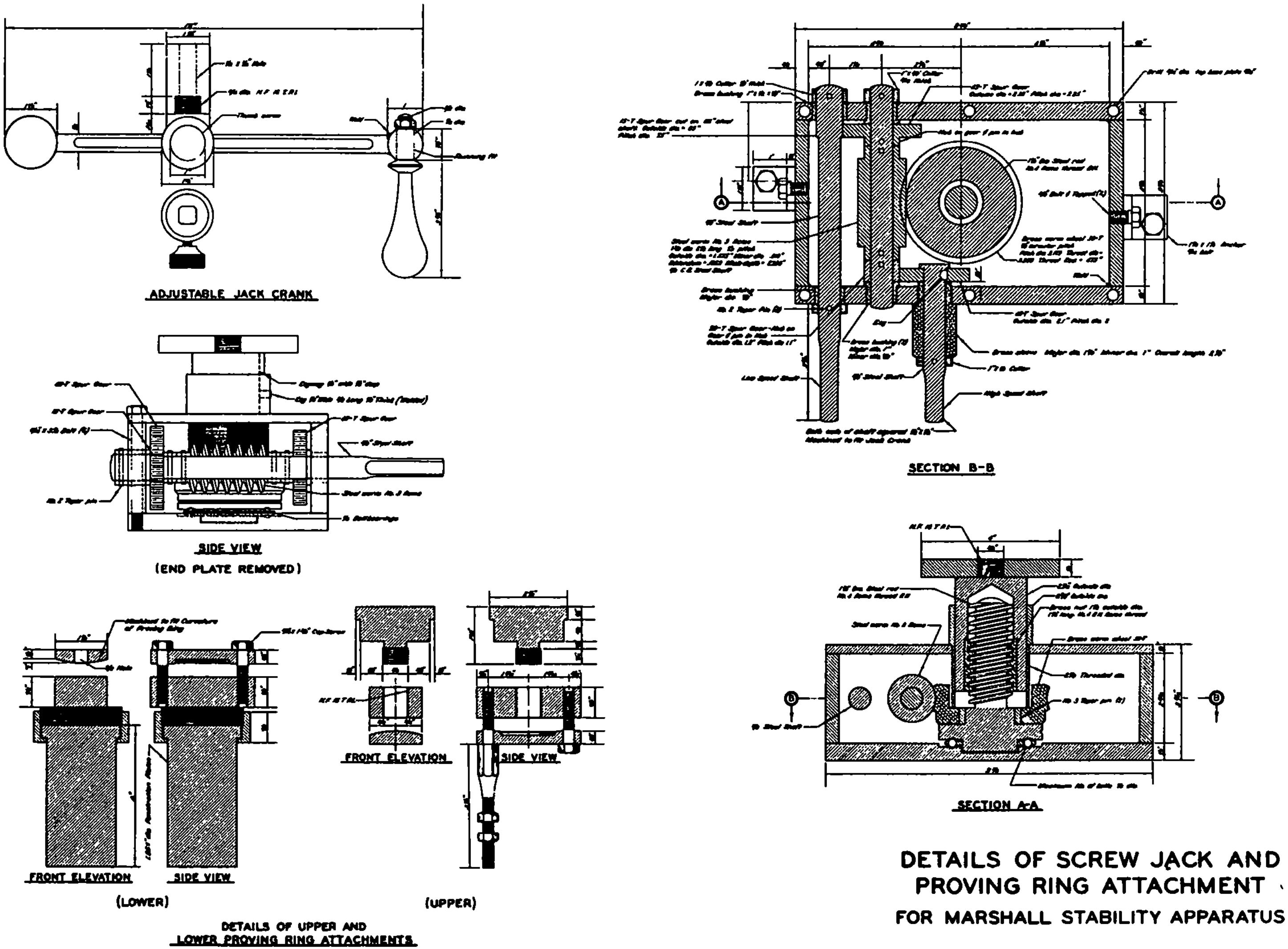

BREAKING HEAD
FOR MARSHALL STABILITY APPARATUS
LIST OF PARTS
TEST HEAD-LOWER ①
TEST HEAD-UPPER ②
BASE ③
GUIDE POST ④
SLEEVE ⑤
FLOW METER BODY ⑥
FLOW METER GAGE ⑦
ASSEMBLY
PLAN
ELEVATION
SIDE ELEVATION
ROUND CORNERS
SCALE
NOTE EXTREME CARE SHOULD BE EXERCISED IN FABRICATING THE UPPER AND LOWER TEST HEADS TO OBTAIN THE PROPER INNER RADIUS (2 INCHES). FREQUENT CHECKS ON THIS DIMENSION SHOULD BE MADE IN SERVICE, AS HIGH LOADS MAY FORCE THE TEST HEADS OUT OF ROUND

Figure 3



DETAILS OF SCREW JACK AND PROVING RING ATTACHMENT FOR MARSHALL STABILITY APPARATUS

Figure 4

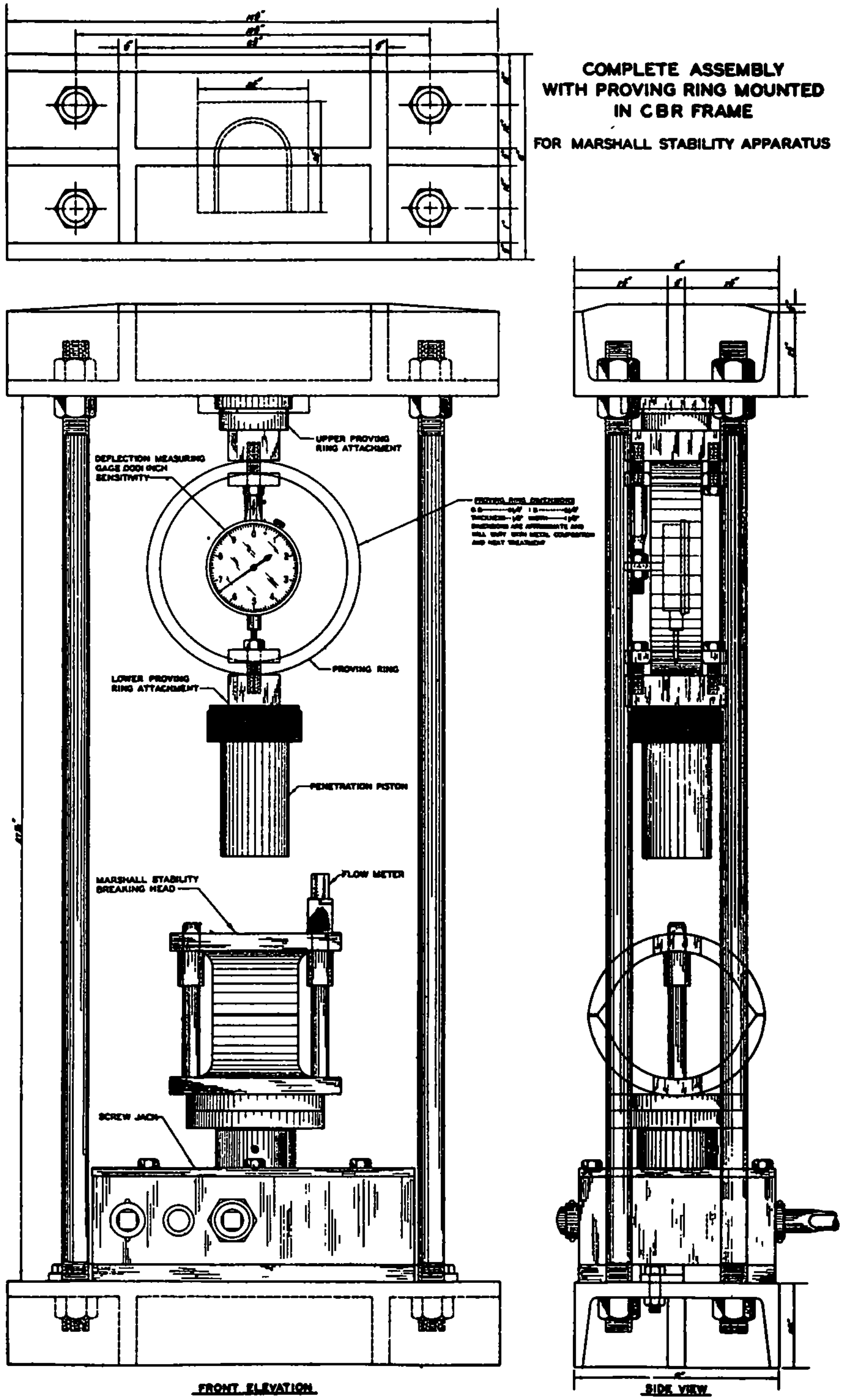

COMPLETE ASSEMBLY
WITH PROVING RING MOUNTED
IN CBR FRAME
FOR MARSHALL STABILITY APPARATUS
UPPER PROVING RING ATTACHMENT
DEFLECTION MEASURING GAGE .0001 INCH SENSITIVITY
PROVING RING
LOWER PROVING RING ATTACHMENT
PENETRATION PISTON
MARSHALL STABILITY BREAKING HEAD
FLOW METER
SCREW JACK
FRONT ELEVATION
SIDE VIEW

Figure 5

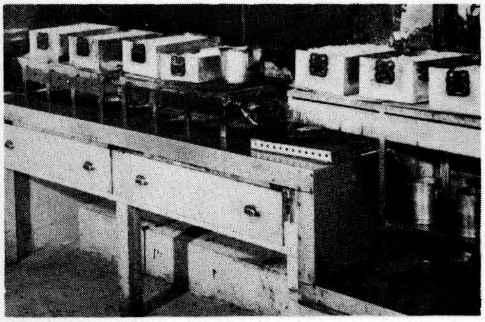


Figure 6. Aggregate and Asphalt Heating Facilities

placed in the mold, the collar is removed and the surface of the material smoothed with a trowel to a slightly rounded shape. The collar is then replaced and the surface of the mix leveled using hand pressure on a heated sample extractor (Figure 7). An extra sample extractor equipped with a wooden handle extension is handy for this purpose. The mold assembly is placed on a heavy substantial compaction base, the heated compaction hammer is placed on the specimen and 50 blows of the hammer are applied. After this the base plate and collar are removed and the mold reversed and reassembled so that the base plate is adjacent to the original top of the specimen. Fifty blows of the compaction hammer are then applied to this face of the specimen.

The base plate and collar are removed and the mold with the specimen inside is immersed in cool water for approximately two minutes, after which the collar is replaced on the mold and the sample extractor is placed on the opposite end of the specimen. The assembly is then placed with the mold collar down in the compression machine, and pressure is applied to the sample extractor, forcing the specimen into the mold collar. The specimen may then be removed from the mold and suitably identified. It should be carefully handled and placed on a smooth and level surface until ready for testing. The height of the specimen should be 2½ in. ± 1/8 in.

Testing specimens - Specimens may be tested at any time after preparation. Weights are determined for each specimen by weighing in air and suspended under water (to obtain the volume). The water should not contain an excess of suspended or dissolved materials and its temperature should be approximately 77 F. The volume of specimens having an open texture is determined by measuring their height and diameter as accurately as possible or by coating with paraffin.

The specimen is immersed in a water bath at 140 F. ± 1 deg. for a period of at least 20 min. After this period it is ready to be tested for stability and flow in the Marshall apparatus; however, testing should not be begun until all apparatus is in readiness, as follows:

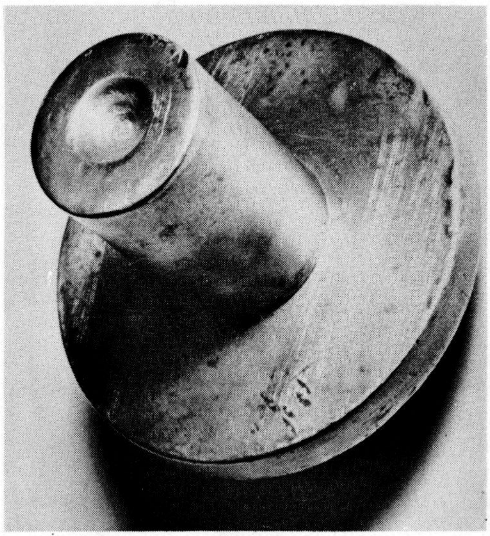


Figure 7. Sample Extractor

a. The inside surfaces of the upper and lower test heads and the guide rods of the breaking head should be thoroughly cleaned, the guide rods well lubricated, and the upper test head should slide freely over the guide rods to the lower test head.
b. Clearance between the jack and the lower proving ring support should be just sufficient to permit introduction of the test mold.

After the necessary preparations have been completed, the specimen is removed from the hot water bath and fitted to testing position on its side in the lower part of the breaking head; the complete assembly is then placed in testing position in the compression machine. The flow meter is placed on one of the guide rods and pressed down against the upper test head, and the initial reading of the flow meter is made and recorded. Pressure is then applied to the specimen in such a manner that the jack head rises at a rate of 2 in. per min. Failure of the specimen occurs and is recorded when the load-measuring dial reaches its maximum reading and begins to return toward zero. The total number of pounds required to produce failure of the specimen is recorded as its stability value. In order to prevent excessive cooling of the specimen with a resulting increase in stability value, the entire test procedure from the time the specimen is removed from the water bath should be performed as quickly as possible; normally, the test should be performed in about 30 sec. Figure 8 shows details of a specimen ready for test in the field apparatus. A close-up view of the specimen, test head and flow meter is shown on Figure 3 of a preceding paper entitled "Selection of Test Equipment."

The flow value is obtained during the test for stability. When the load is being applied to the specimen, the body of the flow meter should be held firmly against the top of the upper test head so that the guide rod pushes the flow meter gage upwards as the sample deforms. When the maximum stability reading is obtained on the load measuring dial, the flow meter is instantly removed from its position on the guide rod. The difference between the initial and final readings expressed in hundredths of an inch is recorded as the flow value.

The stability test may be performed in a universal testing machine with stress-strain recorder as shown on Figure 9. The stability is recorded as the maximum value on the load-deformation curve. The flow value read from the curve is selected at the point beyond the peak where the load first begins to decrease. It has been established that this flow value agrees closely with the flow meter reading, as there is a slight time lag in removing the flow meter from the breaking head in the hand method of performing the test.

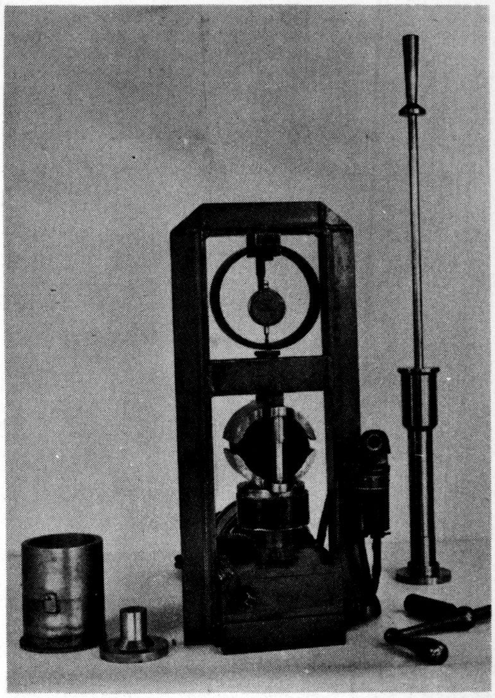


Figure 8. Marshall Stability Apparatus for Field or Laboratory Use

INTERPRETATION OF TEST RESULTS

Test properties curves - Data obtained as outlined above furnish the basis for determining, either directly or by computation, the following properties of each test specimen:

a. Flow
b. Stability
c. Unit weight, total mix
d. Unit weight, aggregate only
e. Percent voids, aggregate only
f. Percent voids, total mix
g. Percent voids filled with asphalt cement

Data averages from the eight specimens at each asphalt content are then prepared

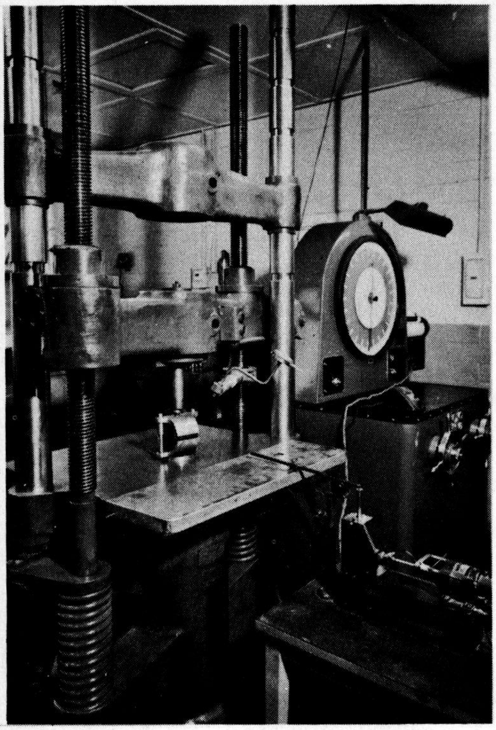


Figure 9. Universal Testing Machine Used for Marshall Test

for each of the above test properties. Individual test values which are at considerable variance with the average may be discarded. The average test properties outlined above are then plotted versus asphalt content on separate diagrams and smooth curves are drawn through the plotted points. For the determination of optimum asphalt, the unit weight, aggregate only, and percent voids, aggregate only, are not used as criteria. These data are frequently computed for general information only. The other five test properties are used in the determination of optimum asphalt, and typical data plots of these five properties are shown on Figure 10. In order to eliminate erratic test values, it has been found convenient to plot the test points for the unit weight of the total mix and to draw the best smooth curve through these points. The remaining density and void relationships are then computed from values read from this curve. In this manner, smooth curves are obtained for the computed test properties and all void and weight relationships are in mutual agreement.

Selection of optimum asphalt content - The test procedure and computations described previously have been directed toward furnishing information on a given bituminous mixture such that the proper asphalt content may be selected for satisfactory pavement design. The asphalt content desired, termed the "optimum asphalt," is determined by assigning criteria to certain of the test properties, selecting the asphalt content that satisfies each individual case, and averaging the asphalt contents obtained. The average value is the optimum asphalt content. The criteria for satisfactory pavements have been established by the investigations described in the preceding papers and are found on page 87.

The criteria shown above for asphaltic concrete are considered to be entirely valid while criteria shown for sand asphalt are considered to be tentative and subject to possible revision. This is due to the quantity and type of data obtained to date on these two types of asphaltic mixtures. The test section, described in a previous paper, and other field data, have given an adequate background for the selection of asphaltic concrete design criteria while data on the sand asphalt pavements have been limited.

An example of the selection of optimum asphalt content is shown for the test results plotted on Figure 10. Using the criteria for asphaltic concrete presented in the preceding paragraph the following asphalt contents have been selected for the various test properties:

Test Property	Selected Asphalt Content-Percent
Stability	5.3
Unit Weight Total Mix	5.5
Voids Total Mix	5.8
Voids Filled With Asphalt	6.3
Average	5.7

Design Criteria

Test Property	Limits	Value To Be Used For Selection of Optimum Asphalt Content
Asphaltic Concrete		
Flow	Less than 20	-
Stability	More than 500	Maximum
Unit Weight, Total Mix	-	Maximum
Percent Voids, Total Mix	3 to 5	4
Percent Voids Filled with Asphalt	75 to 85	80
Sand Asphalt		
Flow	Less than 20	-
Stability	More than 500	Maximum
Unit Weight, Total Mix	-	Maximum
Percent Voids, Total Mix	5 to 7	6
Percent Voids Filled with Asphalt	65 to 75	70

The individual test properties at the average asphalt content of 5.7 percent are then reexamined to determine how closely they agree with the criteria. At this asphalt content the flow value is 14, stability is 700 lb., voids total mix is 4.1 percent, and voids filled with asphalt 76 percent. All values are in reasonable agreement with the criteria. The variables that are present during construction are recognized. The value of 5.7 percent does not imply absolute accuracy but may vary within a range of values for the criteria. For example, inspection of the test properties curves on Figure 10 shows that at asphalt contents between 5.5 and 6 percent the individual values are in substantial agreement with the criteria, and any value between these limits may be acceptable for construction. However, the asphalt content selected on the basis of test properties should be used for design purposes.

In some cases the selection of an optimum asphalt content from the test properties curves is more difficult than was shown in the example cited. Certain mixes, for instance, may approach but not reach 4 percent voids total mix or 80 percent voids filled with asphalt. If the gradation of the mix and the other test properties are otherwise acceptable, a tolerance of 1 percent in the voids total mix and 5 percent in the voids filled with asphalt may be allowed. The optimum asphalt content as determined from stability and unit weight criteria is examined with respect to the voids total mix and voids filled with asphalt; if these values at optimum asphalt are within the tolerances allowed the mix is considered satisfactory. If the values are not within the tolerances, consideration should be given to adjusting the optimum asphalt to come within the voids tolerances, provided this asphalt content is reasonable with respect to maximum stability and unit weight and the flow does not exceed 20. If the selected optimum asphalt content does not provide test properties that are in reasonable agreement with the criteria, a redesign of the blend is indicated.

LABORATORY TESTS FOR FIELD CONTROL OF ASPHALT PAVING MIXTURES

The foregoing paragraphs have described the method by which the proper asphalt content for the design of a bituminous pavement is obtained in the laboratory. Fully as important as the initial design procedure is the control of plant operations and the placement of the mixture in the field to insure that the pavement; as constructed, satisfies the design requirements. The following paragraphs outline a suggested procedure for the control of bituminous mixtures at the plant and in the field. It is recommended that ade-

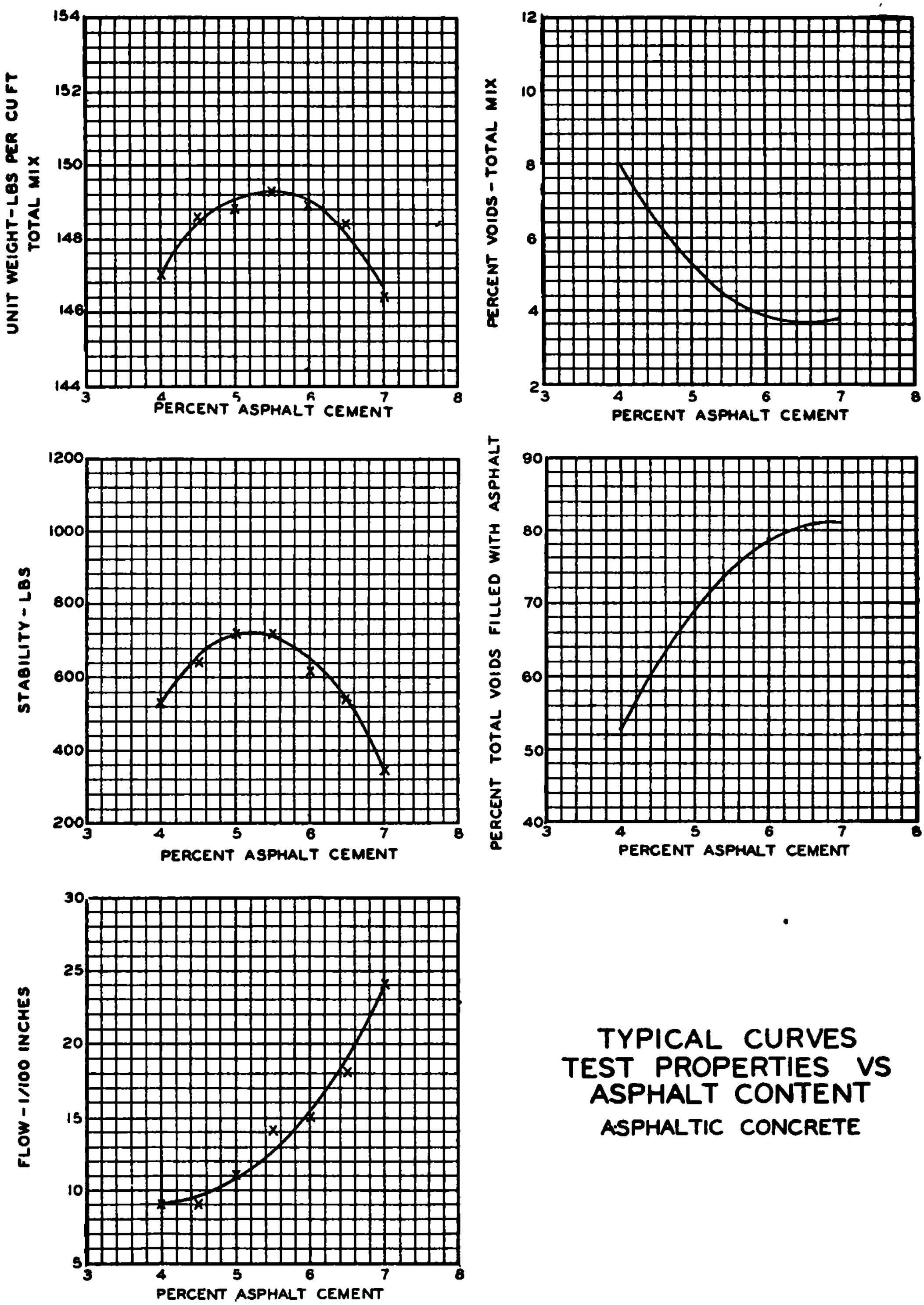

UNIT WEIGHT-LBS PER CU FT TOTAL MIX
PERCENT ASPHALT CEMENT
PERCENT VOIDS - TOTAL MIX
PERCENT ASPHALT CEMENT
STABILITY - LBS
PERCENT ASPHALT CEMENT
PERCENT TOTAL VOIDS FILLED WITH ASPHALT
PERCENT ASPHALT CEMENT
FLOW - 1/100 INCHES
PERCENT ASPHALT CEMENT
TYPICAL CURVES
TEST PROPERTIES VS
ASPHALT CONTENT
ASPHALTIC CONCRETE

Figure 10

quate laboratory facilities be provided at the plant in order that proper control may be exercised. The test procedure is not intended to supplant the routine gradation and extraction tests that are normally run in connection with plant control.

Control of plant mixtures - It is probable that initial laboratory tests to determine the proper proportions of materials and the optimum asphalt content will be conducted on aggregate obtained from stockpiles or from proposed source locations. Such materials, when they are processed through the plant, often are subject to changes in gradation primarily due to degradation of aggregate, difficulties in securing representative aggregate samples, nonuniformities in the supply of material or loss of fines in the driers. Such changes may require a different proportioning of the aggregate in the plant to meet specification requirements, and possibly a modification of the asphalt content may be required to meet the pavement design criteria. The first step in plant control, therefore, is to obtain representative samples of the processed aggregate (preferably samples from the bins after the aggregate has been processed through the plant) and to adjust the proportions of material as may be desired. The test procedure for selection of optimum asphalt content should then be repeated to determine what changes, if any, are necessary in the optimum asphalt content. The separation of aggregate into numerous fractions for laboratory blending is too tedious and possibly unnecessarily accurate for plant control. For this purpose it is satisfactory to separate the coarse and fine aggregates on the No. 10 sieve and further separate the coarse aggregate on the ½-in. sieve. The normal screen sizes used on the plant may also prove satisfactory for separation of aggregates. This method will give more variations in blend proportions due to variations in gradation of the material, but it is believed sufficiently accurate for plant control purposes.

After the plant is in operation, frequent checks should be made to insure that the bituminous mixture as produced meets the design requirements. Representative specimens of the plant-mixed material sufficiently large to make 8 test specimens (about 50 lb.) should be obtained and specimens compacted as previously outlined. Samples should be compacted before the mixture has cooled below 225 F., and the mix should not be reheated. The completed specimens are then tested and test properties are determined. The number of representative samples prepared and tested in this manner will vary with the size of the job. It is suggested that continuous tests be made in the first few days of operation in order to determine the variation in test results due to the normal variations in the stockpiled aggregate and in plant operations. Routine checks may be made at less frequent intervals when plant operations are stabilized.

A comparison of test results on the plant mixed materials with those obtained in the design tests will indicate whether any significant changes in aggregate gradation or asphalt content have taken place which will affect the pavement design. An increase in the flow value to above 20, a decrease in stability of 50 to 100 lb., variations in voids total mix greater than 1 percent and voids filled with asphalt greater than 5 percent indicate the need for revisions in the proportions of aggregate, the asphalt content, or both. The values cited are tolerances which are considered reasonable; specific tolerances may be established for a given job. Since speed is essential in the proper control of plant mixtures, considerable time may be saved by computing only the flow, stability, and unit weight total mix of the test specimens. For a given mixture, variations in the unit weight total mix reflect variations in the voids relationships. For instance, a variation of 1.5 to 2 lb. per cu. ft. in the unit weight total mix is accompanied by about the 1 percent change in voids total mix and the 5 percent change in voids filled with asphalt mentioned above. The allowable tolerance in unit weight for a given voids tolerance may be computed and used for rapid control of the plant mixture.

Control of field construction - Field control of placement of bituminous pavements is based on attaining a desired density in rolling operations. Results of previous studies, discussed in a preceding paper, indicate that a laboratory compactive effort of 15 blows on each side of the test specimen will produce densities approximately equivalent to those obtained with carefully controlled rolling in the field. It is further shown that the density obtained by 15-blow compaction approximately equals 98 percent of the density obtained with 50-blow compaction. Therefore, a factor amounting to 98 percent of the density determined from test specimens compacted by the 50-blow procedure previously described should be computed.

OBTAINING AND TESTING PAVEMENT SAMPLES

Pavement density control - To control the desired density to be obtained in the field, test specimens are cored or otherwise cut from the pavements during construction. The desired construction density being known, density measurements on these specimens indicate whether additional rolling is required. Specified construction densities may be easily obtained or even exceeded in some mixtures, whereas in others careful control in the rolling procedures must be exercised.

Field coring of pavements - Coring field test specimens may be accomplished with truck-mounted rotary core drilling equipment, such as that shown on Figure 11, provided with a means of supplying water to the area being cored to flush out the cuttings. A steel core barrel tipped with carboloy chips (Figure 12) has been found to be very satisfactory for most coring operations in asphaltic pavements. During hot weather it has been found necessary to chill the pavement with ice prior to coring. Field cores should be 4 in. ± 1/16 in. diameter. Where density measurements only are desired or where core cutting facilities are available in the laboratory but not in the field, square or rectangular segments of pavement may be cut by a mattock, or other means.

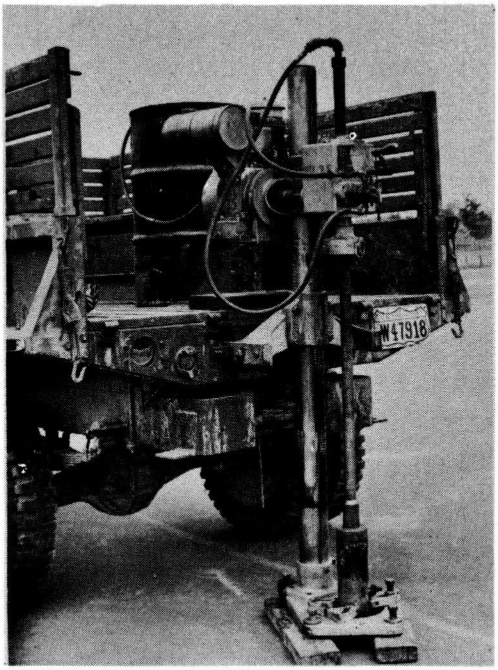


Figure 11. Core Drill Rig

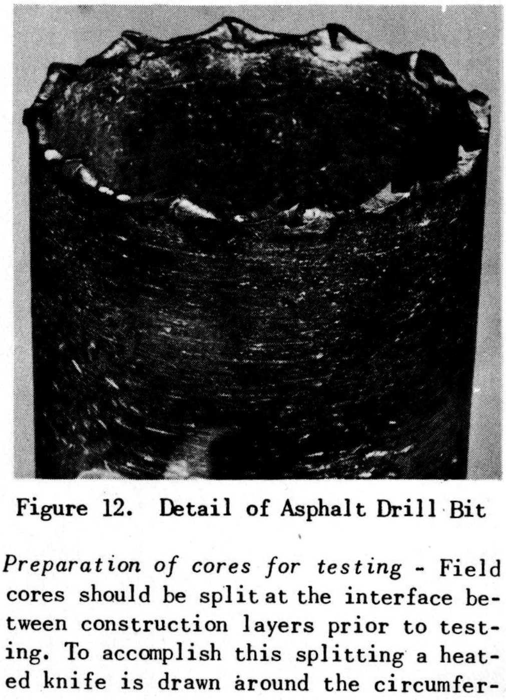


Figure 12. Detail of Asphalt Drill Bit

Preparation of cores for testing - Field cores should be split at the interface between construction layers prior to testing. To accomplish this splitting a heated knife is drawn around the circumfer-

TABLE 2

STABILITY CORRELATION RATIO

Volume of Specimen in Cubic Centimeters	Approximate Thickness of Specimen in Inches	Correlation Ratio
200 - 213	1	5.56
214 - 225	1-1/16	5.00
226 - 237	1-1/8	4.55
238 - 250	1-3/16	4.17
251 - 264	1-1/4	3.85
265 - 276	1-5/16	3.57
277 - 289	1-3/8	3.33
290 - 301	1-7/16	3.03
302 - 316	1-1/2	2.78
317 - 328	1-9/16	2.50
329 - 340	1-5/8	2.27
341 - 353	1-11/16	2.08
354 - 367	1-3/4	1.92
368 - 379	1-13/16	1.79
380 - 392	1-7/8	1.67
393 - 405	1-15/16	1.56
406 - 420	2	1.47
421 - 431	2-1/16	1.39
432 - 443	2-1/8	1.32
444 - 456	2-3/16	1.25
457 - 470	2-1/4	1.19
471 - 482	2-5/16	1.14
483 - 495	2-3/8	1.09
496 - 508	2-7/16	1.04
509 - 522	2-1/2	1.00
523 - 535	2-9/16	0.96
536 - 546	2-5/8	0.93
547 - 559	2-11/16	0.89
560 - 573	2-3/4	0.86
574 - 585	2-13/16	0.83
586 - 598	2-7/8	0.81
599 - 610	2-15/16	0.78
611 - 625	3	0.76

NOTES:
1. The measured stability of a specimen multiplied by the ratio for the thickness of the specimen equals the corrected stability for a 2-½-inch specimen.
2. Volume-thickness relationship is based on a specimen diameter of 4 inches.

ance of the core at the interface of the layers making a groove approximately 1/16 in. deep. The core is then placed in an ice bath and allowed to chill thoroughly, after which it is removed from the bath and placed on its side on a level surface. A heavy butcher knife or a machete is placed in the groove previously made and the back of the blade hit sharply with a hammer. It may be necessary to rotate the core and strike it at several points in the groove in order to break it apart.

Testing field cores - The cores are weighed, heated in the water bath, and tested in the Marshall apparatus as previously described. Since field cores are generally of some thickness other than the standard 2½-in. thickness to which laboratory compacted specimens are prepared, a correction must be applied to the stability value in order that all test results may be compared on a standard basis. Investigations made by the Waterways Experiment Station indicate there is a direct relationship between thickness and stability of specimens. Table 2 shows stability correction factors for specimens ranging in thickness from 1 to 3 in. Also presented are approximate volumes of 4-in. diameter specimens for the various thicknesses, as it is sometimes more convenient to use the volume determined by weighing the core in air and under water rather than to make an actual measurement of thickness. A correction factor for flow is not necessary.

COMPLETED CONSTRUCTION DATA

Upon completion of pavement structures, representative cored specimens of the pavement should be obtained and their test properties determined. Coring and testing periodically are also desirable to check the validity of the tentatively adopted criteria. It should be remembered that the criteria previously established were for airfield pavements supporting very heavy wheel loads. The frequency and nature of the traffic and the magnitude of the superimposed wheel loads on highways are different than for airfield pavements, and it may be that some modifications of these criteria for highway use are warranted. The maintenance of data and observation files on pavement behavior under highway traffic is the only sound basis on which to make such modifications. The pavement behavior study should include all locally potential sources of material to assure the establishment of satisfactory design criteria.

EVALUATION OF EXISTING PAVEMENTS

Coring and testing procedures previously outlined are also applicable to existing pavements. Much additional data of considerable value may be obtained for the verification of modification of proposed criteria by systematically evaluating the existing pavements. Locations in an existing road system may be chosen in which pavements are definitely failing, in which pavements are giving only slight indications of unsatisfactoriness, and in which pavements are definitely adequate. When such data are used to verify or modify the tentative criteria, the adequacy of the base and subgrade should definitely be established. Pavement criteria data should be used only where satisfactoriness or unsatisfactoriness is due to the properties of the pavement itself. Deficiencies of the base may, in some cases, be compensated for by the additional pavement thickness. This compensation, however, is discussed in another paper in this Symposium.