MILITARY STANDARD

TEST METHODS FOR BITUMINOUS PAVING MATERIALS

TO ALL HOLDERS OF MIL-STD-620A.

1. THE FOLLOWING PAGE OF MIL-STD-620A HAS BEEN REVISED AND SUPERSEDES THE PAGE BELOW:

NEW PAGE	DATE	SUPERSEDED PAGE	DATE
iv	_____ 1967	iv	13 January 1965
v	_____ 1967	NEW	
vi	_____ 1967	NEW	

2. TEST METHOD 102 HAS BEEN ADDED. INSERT IT BETWEEN PAGES 24 AND 25.

3. CHANGE THE DATES ON ALL OF THE INTERNAL PAGES FROM 13 JANUARY 1965 TO 13 JANUARY 1966.

4. RETAIN THIS NOTICE AND INSERT BEFORE THE TABLE OF CONTENTS.

5. Holders of MIL-STD-620A will verify that page changes and additions indicated above have been entered. This notice will be retained as a check sheet. This issuance, together with appended pages, is a separate publication. Each notice is to be retained by stocking points until the Military Standard is completely revised or cancelled.

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Method 102

GYRATORY TESTING MACHINE METHOD OF DESIGN OF HOT-MIX BITUMINOUS PAVEMENT

1. SCOPE

1.1 This test method is intended for use in design of all dense-graded, hot bituminous paving mixes in which not more than 10 percent of the aggregate is larger than 1 inch (2.54 cm) in diameter.

2. APPARATUS

2.1 Mechanical sieve shaker, hand or power-driven, having a capacity of not less than six full-height, 8-inch (20.3 cm) diameter sieves. The shaker may be of the large, processing type, of the standard mechanical laboratory type, or a rocker-type hand shaker.

2.2 Sieves, 8 inches (20.3 cm) in diameter, of the following sizes: 1-inch (2.54 cm), 3/4-inch (1.90 cm), 1/2-inch (1.27 cm), and 3/8-inch (0.95 cm) and numbers 4, 8, 16, 30, 50, 100, and 200. Sieves of suitable size and height are selected from these for the material to be tested. These sieves shall have square openings and shall conform to ASTM E11. Large, rectangular screens and shaking facilities are desirable for more expeditious processing of aggregates when a large volume of sample preparation is to be accomplished, as in central laboratories.

2.3 Ovens or hotplates for heating aggregates and bituminous materials to the following temperatures:

	Mixing temperature, °F. & °C.	
Type Bitumen	Aggregate	Bitumen
Asphalt cement	300±5° F., 149±2° C.	270±5° F., 132±2° C.
Tar, RT-10, -11, or -12	225±5° F., 107±2° C.	200±5° F., 93±2° C.
Rubberized tar	250±5° F., 121±2° C.	225±5° F., 107±2° C.

When hotplates are employed, a metal shield shall be interposed between the hotplates and the mixing pans or specimen molds. A shield can be made by crimping the edges of a sheet of metal so that there will be an air space beneath its surface.

2.4 Mixing equipment. A commercial bread-dough mixer of 10-quart capacity has been found satisfactory for mixing the aggregate and bituminous material. Two 10-quart mixing bowls and two wire stirrers are desirable.

2.5 Gyratory testing machine as shown in figure 102-1.

2.6 Compaction molds and carrying trays as shown in figure 102-2, a and b. A minimum of two molds, two carrying trays, and two jack heads is required.

2.7 Steel tamp of the following dimensions: 1-1/2-inch (3.8-cm-) -diameter shaft, 7-1/2 inches (19.05 cm) long, with 3-7/8-inch (9.84-cm-) -diameter foot, 1/2 inch (1.27 cm) thick. The weight of the tamp is approximately 5-1/4 pounds. Steel tamp is shown in figure 102-2c to the right of the spatula.

2.8 Marshall stability machine consisting of a loading frame incorporating a loading jack and proving ring assembly (see figure 100-1). The Marshall stability test can also be run in any other type of loading machine that can produce a loading rate of 2 inches per minute.

2.9 Marshall stability breaking head (figure 100-1).

2.10 Flowmeter which will register the deformation of the test specimen (figure 100-1).

2.11 Sink with running cold water in which the compacted specimens can be cooled prior to extrusion from the mold.

2.12 Sample extractor. A means of applying load to the sample to eject it from the mold, such as a hydraulic jack and frame or a lever-arm type of arrangement for manually applying load to the extractor.

2.13 Hot water baths.

(a) For heating test specimens, one hot-water bath with mechanical water agitator and thermostatic controls capable of maintaining the following water temperatures:

Type bitumen	Marshall stability test temperature, °F. & °C.
Asphalt cement	140±1° F., 60± 1° C.
Tar	100±1° F., 38± 1° C.
Rubberized tar	120±1° F., 49± 1° C.

The water-bath tank shall be at least 18 by 20 inches (46 by 51 cm) in size, have a perforated false bottom, and shall be sufficiently deep for immersion of the test specimens.

(b) For heating molds and jack heads, one hot-water bath with mechanical agitator and thermostatic controls capable of maintaining a temperature of 160° F. (71° C.) plus or minus 5° F. (2° C.).

2.14 Appurtenant equipment:

(a) 4 metal pans, 12 by 18 by 4 inches (31 by 45 by 10 cm), for drying aggregates.
(b) 3 pouring cans with handle for heating bituminous cement, 1/2-gallon size.
(c) 10 metal pans with capacity for approximately 2000 g of aggregate.
(d) 1 scoop, approximately 2-quart size, for handling hot aggregates.
(e) 2 spatulas, 1- by 6-inch (2.5- by 15.2-cm) blade.
(f) 6 thermometers for determining temperatures of the aggregates and bituminous mixtures. Armored glass thermometers or dial type with metal stem, having a range of 50° F. (10° C.) to 400° F. (204° C.) with sensitivity of 5° F. (2° C.) are acceptable.
(g) 2 thermometers, glass, mercury, for hot-water bath with range appropriate for type of bituminous material sensitive to 1° F. (1° C.).
(h) 2 trowels, rectangular blade, approximately 2 by 4 inches (5.1 by 10.2 cm).
(i) 1 balance, 10-kg capacity, sensitive to 1 g, for weighing bituminous material and aggregate mixtures.
(j) 1 balance, 2-kg capacity, sensitive to 0.1 g, for weighing compacted specimens.
(k) 1 wire basket and water bucket suitable for weighing compacted specimens in water.
(l) 6 pairs of gloves, leather palm or welders, for handling hot equipment.
(m) 1 clipboard for data sheets.
(n) 1 pair of gloves, rubber, gauntlet type, for lifting specimens from hot-water bath.
(o) 1 scoop, flat bottom, of adequate size for use in placing bituminous mixture in molds prior to compaction.
(p) 1 trowel, 6-inch (15.2-cm) garden type, for use in preparation of mixes.

3. SELECTION OF GYRATORY COMPACTION EFFORT

3.1 The gyratory testing machine is capable of preparing pavement test specimens over a wide range of compaction efforts by varying the compaction pressure, the gyratory angle, and the number of revolutions. For design of pavements within the conventional range of densities, machine settings can be selected that will result in pavement densities equivalent to those obtained by impact compaction, i.e. by standard Marshall hammer (see Method 100).

In the impact compaction method, 50 blows on each end of specimen shall be used in designing mixes for roads, streets, and facilities for aircraft with low-pressure (up to 100 psi) tires, and 75 blows for airfield facilities for heavier planes (tire pressures from 100 to 200 psi). The following tentative machine settings to obtain equivalent compaction are suggested: 1/

Impact compaction	Gyratory compaction
50 blows per end	100 psi, 1 degree, 30 revolutions
75 blows per end	200 psi, 1 degree, 30 revolutions

The gyratory testing machine can also be used in the design of airfield pavements for more severe types of traffic, i.e. where tire pressures will exceed 200 psi and coverages will be concentrated in certain areas of the pavement. The following tentative machine setting to simulate traffic of heavy bomber or cargo aircraft is suggested: 1/

Traffic coverages	Gyratory compaction
5,000	240 psi, 1 degree, 60 revolutions

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4. DETERMINATION OF DESIGN BITUMINOUS MATERIAL CONTENT

4.1 The design bituminous material content shall be determined in several steps. First the design bituminous material content for the aggregate being tested shall be estimated, then the correct proportions of each size aggregate shall be blended to produce the required aggregate gradation, after which the test specimens shall be prepared and tested. The design bituminous material content shall be selected on the basis of the test results. Details of these steps are as follows.

4.1.1 Selection of test bituminous material contents. To start the laboratory tests, estimate a design bituminous material content for the aggregate to be tested. Then prepare specimens at the estimated design bituminous material content, and at a minimum of four other bituminous material contents - two above, and two below the estimated design content. One percent incremental changes in bituminous material content may be used for preliminary work; but 0.5 percent incremental changes usually are used when the approximate design bituminous material content is known and for final designs.

1/ The correlations are based on limited laboratory and field tests and may be revised as more data become available. Users of the gyratory testing machine should attempt to establish their own correlations and adopt compaction criteria appropriate for the traffic conditions anticipated for the pavement being designed.

4.1.2 Preparation of aggregate blend. After it has been determined that the proposed aggregate will meet the specification requirements for quality and gradation, dry to constant weight at 230° F. (110° C.) a sufficient quantity of aggregate of the correct stockpile or plant-bin proportions to make the required number of test specimens (at least two per bituminous material content). Then separate this entire quantity of dry aggregate into several size ranges by sieving. Preparation of test specimens by recombining separated size fractions prevents nonuniformity of test specimens resulting from aggregate segregation during handling and heating. For example, the following size separations are suggested for a paving mix having a 3/4-inch maximum size aggregate: 3/4-inch (1.90 cm) to 3/8-inch (0.95 cm), 3/8-inch (0.95 cm) to No. 8, No. 8 to No. 50, finer than No. 50, and mineral filler. Separations may vary, depending on the grading of the aggregate and on the aggregate heating and screening facilities available. Recombine the aggregates by taking a sufficient quantity of each size to produce the required proportions, as indicated in the first three columns of figure 102.6. After recombining, run a sieve analysis to insure that the specified gradation has been obtained.

4.1.3 Preparation of test specimens. Prepare the laboratory test specimens to a standard diameter of 4 inches (10.16 cm) and height of 2-1/2 inches (6.35 cm) plus or minus 1/8 inch (0.32 cm). Experience has indicated that a batch containing approximately 1600 g of dry aggregate blend is adequate for one specimen. The percentage of bituminous material is based on the total weight of all ingredients in the mixture; a mix having 4 percent bituminous material thus has 96 percent aggregate and filler. The percentage and weight of each aggregate fraction and of the mineral filler are maintained essentially constant for every batch. The total weight of aggregate plus bituminous material at any particular content is determined as follows:

$$\frac{\text{Aggregate weight}}{\text{Percent aggregate}} \times 100 = \text{aggregate} + \text{bituminous material weight}$$

If 1600 g of aggregate is taken to be 96 percent of the batch, the total batch would weigh 1667 g, which indicates the need for the addition of 67 g of bituminous material. These computations are made separately for each bituminous material content selected for testing. Figure 102.6 is a form for use in these calculations. Prepare the dry aggregate for each batch, and heat to the required temperature as indicated in the tabulation below.

Type bitumen	Mixing temp, °F. & °C.		Compaction temp, °F. & °C.
	Aggregate	Bitumen	
Asphalt cement	300±5° F., 149±2° C.	270±5° F., 132±2° C.	250±5° F., 121±2° C.
Tar, RT-10, -11, or -12	225±5° F., 107±2° C.	200±5° F., 93±2° C.	180±5° F., 82±2° C.
Rubberized tar	250±5° F., 121±2° C.	225±5° F., 107±2° C.	200±5° F., 121±2° C.

Then, charge the mixing bowl with the desired weight of heated aggregate and form a crater in the dry aggregate blend after hand-mixing with a trowel. Next, weigh the required amount of bituminous material, heated to the correct temperature as indicated in the tabulation, into the hot aggregate blend. Mix the aggregate and bituminous material as thoroughly and rapidly as possible; mechanical mixing is recommended.

4.1.4 TEST PROCEDURE. The procedures for setting vertical pressure and gyration angle of the gyratory compactor are given in 7. Steps to be followed in filling and placing the mold in the gyratory compactor, making the test, and removing the specimen from the machine are described below.

4.1.4.1 Preheat the test molds and jack heads in a water bath to 160° F., (71° C.) plus or minus 5° F., (2° C.). Assemble the lower jack head and the mold on the carrying tray as shown in figures 102-2a and b. Put a paper disk over the jack head. Fill the mold with sufficient material to produce a compacted sample 2-1/2 inches (6.35 cm) plus or minus 1/8 inch (0.32 cm) in height. (A few trials will indicate the quantity of mix required to produce a sample of the required dimensions.) Figure 102-2c shows equipment and set-up for filling the mold. Insert the spatula along the inside of the mold. Pass the spatula twice around the inside of the mold in an up-and-down sawing motion to seat the mix against the mold and remove cavities. Level off the material with a trowel; then tamp lightly with the steel tamp to consolidate the mix in the mold. Place another paper disk on top of the mixture.

4.1.4.2 Carry the filled mold on a tray and insert into the mold chuck of the gyratory testing machine shown in figure 102-2d. Raise lower jack head against the specimen, using full vertical pressure selected for test. Pressure against the sample creates sufficient wall friction to hold the mold in position and permits removal of the carrying tray. Place the chuck clamp in position over the mold and tighten as shown in figure 102-2e. Start recorder and then start the gyratory machine.

4.1.4.3 After completion of compaction, stop the gyratory machine; then stop recorder. Loosen chuck lugs and remove the chuck clamp. Place the carrying tray in position, lower the jack ram, and remove the mold containing the sample. Let the sample cool and remove it from the mold by means of a hydraulic jack or similar apparatus. Handle the sample carefully, and place on a smooth, level surface until needed for further testing.

4.1.5 Selection of design bituminous material content. The gyratory motion charts made by the recorder are called gyrographs. The point where spreading begins on the gyrographs establishes the maximum permissible bituminous material content. Typical gyrographs are shown in figure 102-3 together with density versus bitumen content data. In this example, the unit weight of aggregate only has reached a maximum at 4.0 percent bituminous material content, and the gyrographs exhibit little if any spreading. At 4.5 percent bituminous material content, unit weight of aggregate only has decreased, and the gyrograph definitely shows spreading. These results indicate a loss in density and strength and that the "optimum" has been exceeded;

therefore, a leaner bituminous material content must be selected. Hence, the design bituminous material content in this example is considered to be 4.0 percent.

5. DETERMINATION OF OTHER PROPERTIES OF TEST SPECIMENS

5.1 After selection of design bituminous material content, test the samples with this bituminous material content for density, stability, and flow as described in method 100, under test procedure.

6. REPORT

6.1 Report test results on a form similar to that illustrated in figure 102-4.

7. PROCEDURE FOR SETTING VERTICAL PRESSURE AND GYRATION ANGLE (DEGREES KNEADING) FOR GYRATORY TESTING MACHINE

7.1 Setting vertical pressure.

7.1.1 The formula for the vertical sample pressure, ignoring friction and weight of components, is:

$$P = \frac{p\,A_R}{A_S}$$

where

P = vertical pressure on sample, psi.

p = gage pressure, psi.

A_R = area of hydraulic cylinder ram, sq in. (sq cm).

A_S = area of sample, sq in. (sq cm).

This formula is used only for making approximate calculations. For exact measurements, the machine must be calibrated for vertical pressure by use of a proving ring inserted between the two jack heads. The calibration shall cover a range from 0 to 4000 pounds (1800 kg) total load; therefore, a proving ring of somewhat greater capacity than 4000 pounds (1800 kg) is required.

Note: The vertical pressure for operation of the gyratory mechanism shall not exceed 250 psi by more than 10 psi.

The correct vertical pressure as indicated by the pressure gage is set with the pressure control valve as shown in figure 102-5a.

7.1.2 Setting gyration angle. The gyration angle is set as follows:

(a) Set the top roller at its lowest position by means of the detachable hand crank. (Note: To avoid breaking the rollers, they shall always be set so that the solid side of the rim is on the inside traveling position.)
(b) Set the lower roller to any position approximating the desired angle (figure 102-5a).
(c) Load a sample of material in the machine and operate the machine for several revolutions under the vertical pressure to be used in testing.
(d) Stop roller carriage but maintain vertical pressure.
(e) By hand operation, as shown in figure 102-5c, position roller carriage so that the top roller is in front and the line on the carriage coincides with the line on the front of the machine.
(f) Operate recorder to obtain a mark on the recorder paper as indicated by the upper mark in figure 102-5e.
(g) By hand operation as shown in figure 102-5d, position the roller carriage so that the bottom roller is in front and the line on the carriage coincides with the line on the front of the machine.
(h) Operate recorder to obtain a mark on the recorder paper as indicated by the lower mark in figure 102-5e.
(i) Count the number of small divisions of the recorder paper between the two horizontal lines made as described above. Eight small divisions of the recorder paper[1/] equal one degree gyration angle. If the correct number of divisions is not obtained, then adjust the vertical position of the bottom roller and repeat the steps outlined above.

16.

1/ Chart No. BL 923, Brush Electronics Company.

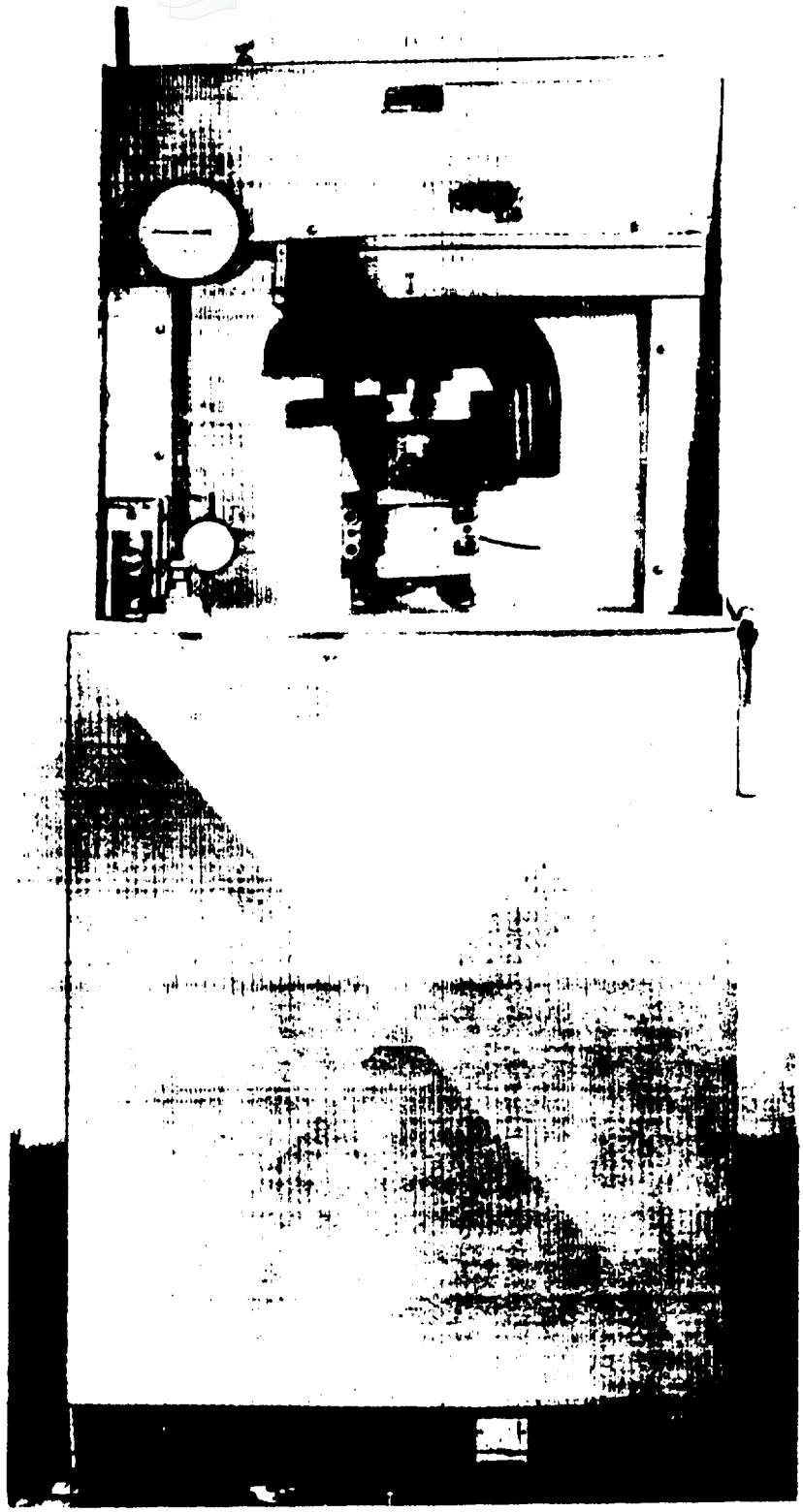
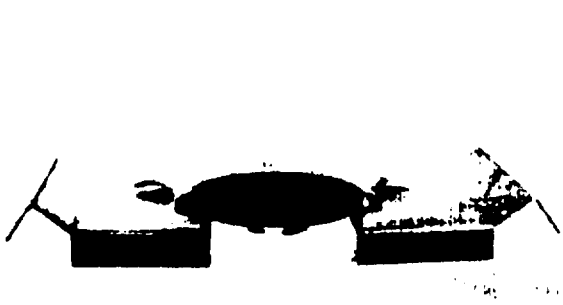
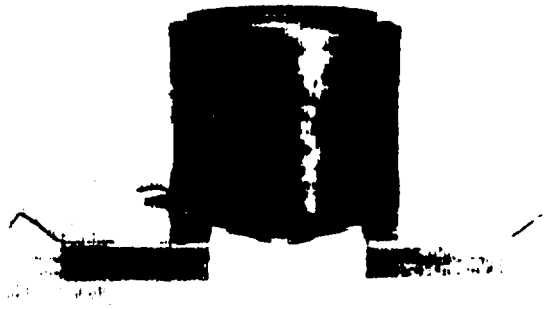


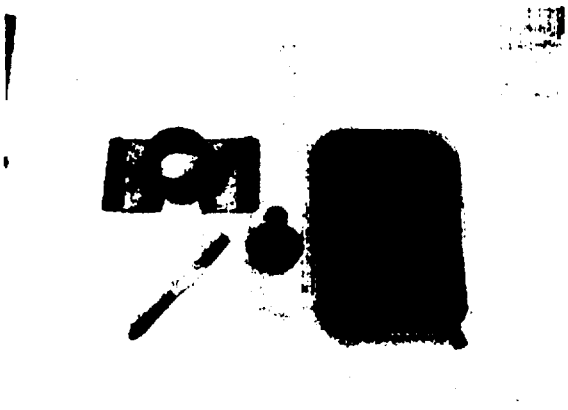
FIGURE 102-1. Gyratory testing machine for bituminous paving mixtures.



a. LOWER JACK HEAD ON CARRYING TRAY



b. LOWER JACK HEAD AND MOLD ASSEMBLED ON CARRYING TRAY

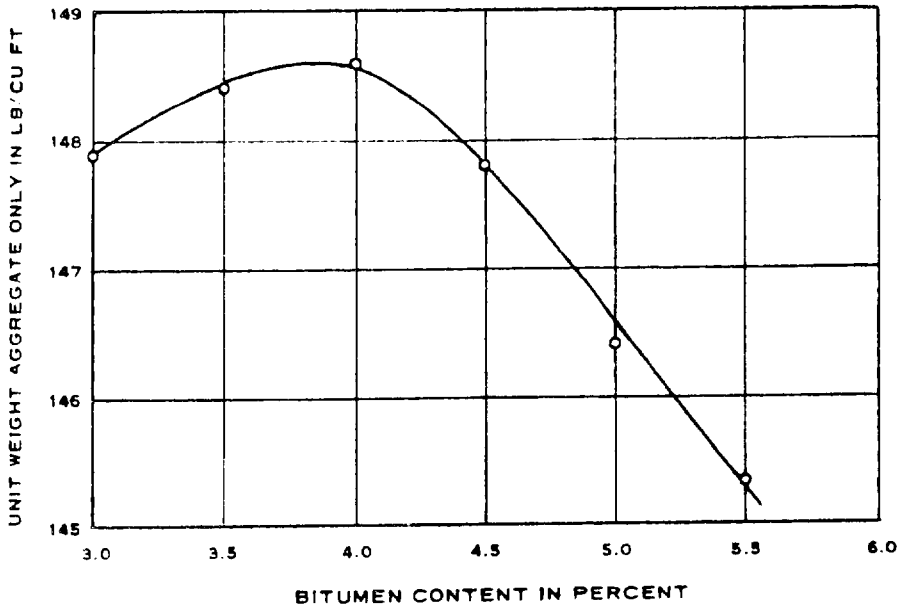


c. EQUIPMENT AND SETUP FOR FILLING MOLD

d. PLACING MOLD IN MOLD CHUCK

e. TIGHTENING CHUCK LUGS

FIGURE 102-2. Steps in loading gyratory testing machine.



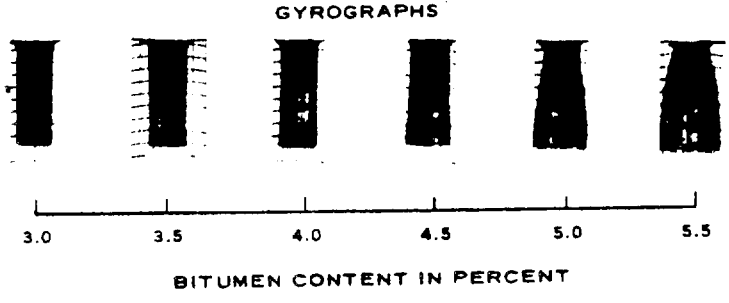


FIGURE 102-3. Mixture design as determined with gyratory testing machine.

BITUMINOUS MIX ANALYSIS

Project _____ Job No. _____ Date _____

Source _____ Sampled by _____ Date Rec'd _____

Description of Materials _____

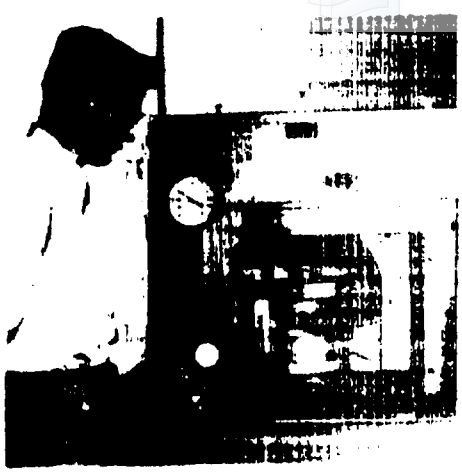
Laboratory No.						
Field No.						
Other Identification						
Pavement Criterion ( ) psi Tire Pressure		Job Mix Formula (Approved)				
Size of Sieve	Specified Limits					
1 1/2 inch						
1 inch						
3/4 inch						
1/2 inch						
3/8 inch						
No. 4						
No. 10						
No. 20						
No. 40						
No. 80						
No. 200						
Percent Bitumen						
Grade Bitumen						
Stability (Marshall) Lb						
Flow 0.01 Inches						
Percent Voids Total Mix						
Percent Voids Filled						
Density – Lb/Cu Ft						
Theo. Density – Lb/Cu Ft						
Stripping, %						
Swell, %						
Agg. – Sp Gr						
Agg. – % Water Absorption						

Remarks:

Tested by: _____
Checked by: _____

WES FORM NO. 1008
SEPT 1958

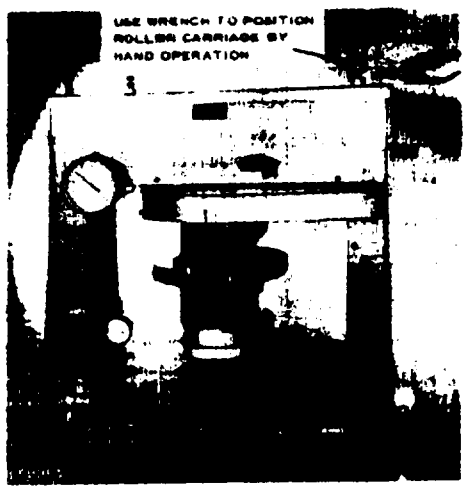
FIGURE 102-4. Form for recording results of tests.



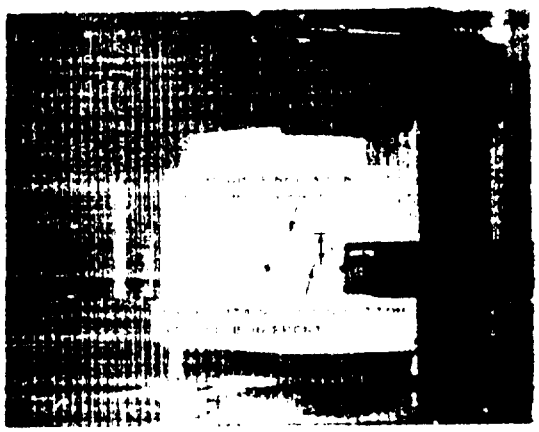
a. SETTING VERTICAL PRESSURE TO THE PRESSURE CONTROL VALVE

b. ADJUSTING BOTTOM ROLLER

c. TOP ROLLER IN FRONT POSITION



d. BOTTOM ROLLER IN FRONT POSITION



...ADJUSTING GYRATION ANGLE

FIGURE 102-5 ... vertical pressure and gyration angle.

BITUMINOUS MIXTURE WEIGHTS

JOB NO.:	W/R NO.: —	DATE: 5 June 1959
PROJECT: Typical Mix		
DESCRIPTION OF BLEND USED: Processed Samples		
TYPE OF BITUMEN: 85-100 Pen Asphalt Cement		
AGG TEMP: 300 F	BITUMEN TEMP: 270F	COMP TEMP: 250F

BLEND NO. A

AGG SIZE	PER CENT	WEIGHTS
3/4 - 3/8	19	304
3/8 - 10	35	560
-10	43	688
LSD	3	48
TOTAL	100	1600

	PER CENT	WEIGHTS*
	No. A-3.5	
Aggregate	96.5	1600
Bitumen	3.5	—
Agg & Bitumen	100	1658
	No. A-4.0	
Aggregate	96.0	1600
Bitumen	4.0	—
Agg & Bitumen	100	1667
	No. A-4.5	
Aggregate	95.5	1600
Bitumen	4.5	—
Agg & Bitumen	100	1675
	No. A-5.0	
Aggregate	95.0	1600
Bitumen	5.0	—
Agg & Bitumen	100	1684
	No. A-5.5	
Aggregate	94.5	1600
Bitumen	5.5	—
Agg & Bitumen	100	1693

* $\frac{\text{AGGREGATE WT}}{\text{PER CENT AGG}} 100 = \text{AGG + BITUMEN WT}$

COMPUTED BY: DPB	CHECKED BY: MES	AGG BLEND PREPARED BY: ES	MIX PREPARED BY: PSM COMPACTED BY: SJ-AC

FIGURE 102-6. Form for recording weights of bituminous mixtures.