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16. ABSTRACT

In testing bituminous mixes there are a number of factors involved and when assigning tests and analyzing test results these factors must be considered in order that the tests assigned will produce data which will provide for sound and practical recommendations.

In assigning tests, consideration must be given to what particular tests will be required to provide the necessary data to check specification requirements, make recommendations if preliminary work or to provide applicable data in the case of pavement failure.

The selection of grade or type of bitumen must be governed by the type of construction proposed, grading of the aggregates, climatic conditions and method of mixing on the job. Possible reworking of the mix at some future date should be considered, especially where maintenance work is involved.

In evaluating test results, stabilometer and cohesiometer values are of foremost importance in surface courses and a low value in one may be somewhat compensated for by a high value in the other. To make the optimum asphalt content recommendation visual inspection should always be a part of the test result analyses. In special cases where the asphalt content obtained from the C.K.E. test is not consistent with test results due to some unusual characteristic of the aggregate such as high absorptive properties or excessive fines it is necessary to select the considered optimum by means of stabilometer values and visual inspection.

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STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPARTMENT

DETAILED PROCEDURE

FOR

TESTING

BITUMINOUS MIXTURES

51-12

September 1, 1951

51-12

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPARTMENT

DETAILED PROCEDURE FOR TESTING BITUMINOUS MIXTURES

The following detailed instructions cover the preparation and testing of bituminous mixes and are in conformance with standard methods in use at Headquarters Laboratory at Sacramento.

Conscientious effort on the part of the operator, close adherence to methods and tolerances and proper adjustment of testing equipment are all of vital importance if uniform and reliable test results are to be obtained.

In preparing this detailed test procedure it was recognized that the District Laboratories would not be equipped with certain pieces of equipment necessary to perform some of the tests described. However, it was considered advisable to make the instructions complete in the event that all of the equipment may become available to the District Laboratories at some future time.

An index is provided for ready reference.

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III. Appendix I

Attachments

(b) Sample adjusted by wasting retained #4 and passing 200 material

(c) Example of screening to 1" maximum and correcting the grading accordingly

(d) Example of combining 5 samples to conform to a specified grading

(e) Example showing a mix becoming critical to increasing asphalt content due to increase density.

GENERAL DISCUSSION AND EVALUATION OF TEST RESULTS

In testing bituminous mixes there are a number of factors involved and when assigning tests and analyzing test results these factors must be considered in order that the tests assigned will produce data which will provide for sound and practical recommendations.

In assigning tests, consideration must be given to what particular tests will be required to provide the necessary data to check specification requirements, make recommendations if preliminary work or to provide applicable data in the case of pavement failure.

The selection of grade or type of bitumen must be governed by the type of construction proposed, grading of the aggregates, climatic conditions and method of mixing on the job. Possible reworking of the mix at some future date should be considered, especially where maintenance work is involved.

In evaluating test results, stabilometer and cohesiometer values are of foremost importance in surface courses and a low value in one may be somewhat compensated for by a high value in the other. To make the optimum asphalt content recommendation visual inspection should always be a part of the test result analyses. In special cases where the asphalt content obtained from the C.K.E. test is not consistent with test results due to some unusual characteristic of the aggregate such as high absorptive properties or excessive fines it is necessary to select the considered optimum by means of stabilometer values and visual inspection.

Low stabilometer values may be caused by excessive asphalt, and or excessive moisture, high sand content, excessive fines and densities which approach the theoretical maximum density. A typical example of the effect density has on stabilometer values is shown on the attached work card No. 104. As the calculated relative densities indicate, stabilometer values are satisfactory with air voids in excess of 4.5%. With the voids reduced to 2.2% the stabilometer value drops sharply. Extreme care should be exercised in order not to exceed the critical asphalt content in this type of mix.

It is the practice of Headquarters Laboratory that all specimens are visually inspected before the final bitumen content for the mix is recommended.

Procedure

I. Preparation and Testing of Aggregates for use in Bituminous Mixtures.

A. Computation for design of mix.

The design of bituminous mixes simply consists of blending or adjusting graded aggregates to conform to a specification. Designing to a smooth grading curve approximating the middle of a specified range is desirable but not always essential, general practice is to produce the best possible grading within the specification limits with the material on hand.

a. Samples requiring scalping only.

The maximum size to be used in the tests is that portion passing the 1" and retained on the 3/4" sieve. A sample to be tested without adjusting other than removal of oversize should be screened to pass the 1" sieve if containing the larger sizes and the grading corrected accordingly. All gradings should be wash gradings.

The following example shows a grading before and after screening to 1" maximum.

	As Received	Screened and Corrected
1-1/2"	Sieve = 100% pass.	
1-1/4"	Sieve = 95% pass.	
1"	Sieve = 90% pass.	90 = 100% pass.
3/4"	Sieve = 80% pass.	$\frac{100}{90} \times 80 = 89\%$ pass.
3/8"	Sieve = 70% pass.	$\frac{100}{90} \times 70 = 78\%$ pass.
#4	Sieve = 60% pass.	$\frac{100}{90} \times 60 = 67\%$ pass.

The remainder of the grading is computed in the same manner.

b. Samples requiring grading adjustment to comply with specification requirements.

Samples of aggregates which are to conform to a specific grading requirement and fail to do so on certain sieve sizes, can in many instances be adjusted to conform to the grading requirement by wasting certain portions of the sample. Any adjustment of grading should be such that it can be duplicated under actual field conditions. Computations and examples for these adjustments will be found in Appendix I, pages 1 to 6 inclusive.

c. Combining samples.

The procedure for blending 2 or more aggregates of different sizes in combination to produce a final grading conforming to certain requirements is simply to try various percentages of each in combination until a satisfactory grading is produced. As grading limits are based on materials of 2.65 specific gravity, correction should be made to compensate for any variations in specific gravity of ± 0.20. The correction may be calculated by using the attached paper titled, "Formula for Grading Aggregates to Absolute Volume when Individual Size Fractions Vary in Specific Gravity of Combination," dated October 20, 1941.

B. Weighing procedure for Test Specimens.

a. The amount used in the C.K.E. Test (Centrifuge Kerosene Equivalent) shall be exactly 100 grams of coarse aggregate (3/8" - No. 4) for determining Kc and 100 grams of fine aggregate (passing No. 4) for determining Kf. These amounts are to be taken from a quartered sample and approximately 5 grams in excess of the 100 grams needed should be taken to compensate for the loss of moisture in drying. The samples should be thoroughly dried before making the final 100 gram weight to an accuracy of ± 0.1 grams.* In the event the sample is a combination of two or more samples, use computation on page 7 Appendix I for securing a representative sample.

b. The cumulative weights derived from various gradings for 1000 and 1200 gram test specimens which will be the weights most commonly used are shown as an example on the back of the attached work cards. In cases when adjustment of the grading is necessary, cumulative weights are obtained on the adjusted grading. These weights are derived by multiplying the cumulative percent as used by 10 or 12 for the 1000 gram sample and 1200 gram sample respectively.

*Torsion balances will give the desired accuracy.

Pass.	Ret.	1000 G Sample	1200 G Sample
1"	3/4"	(100 - 89) x 10 = 110	110 x 12 = 132
3/4"	3/8"	(100 - 78) x 10 = 220	220 x 12 = 264
3/8"	#4	(100 - 67) x 10 = 330	330 x 12 = 396
#4	-	(100 - 0) x 10 = 1000	1000 x 12 = 1200

c. In weighing out material for the test specimens, the sizes generally used are the 1" - 3/4", 3/4" - 3/8", 3/8" - #4 and #4 to dust. In the event a 1/2" specification is used, the 1/2" to 3/8" size should be included. All material should be free from moisture and the passing #4 material should be thoroughly mixed, quartered and placed in deep milk pans approximately 10" wide 2" deep. The minus #4 material should not be added from the sample sack as segregation may occur while in a sacked condition. The dry weight (before the addition of oil) of the aggregate for the swell specimens should always be 1000 grams and normally 1200 grams dry weight should be sufficient for the stabilometer specimen. If the average specific gravity of the aggregate is 2.80 or higher, 1300 grams dry weight will be required for the stabilometer specimens. From the computed cumulative weights on reverse side of work card prepare the necessary specimens, normally 2 swell and 3 stabilometer tests are sufficient. Weights should be made to the closest 1 gram.

d. The film stripping test sample consists of 60 grams representative of the 3/8" to #8 portion. In the event the oversize of a sample has been removed, crushed and recombined with the natural material 3 separate stripping tests shall be prepared; one on the natural material, one on the crushed, and one on the natural and crushed material in combination as used.

C. Adding Bitumen and Mixing.

a. Determination of "K" Value

Refer to publication: "The Centrifuge Kerosene Equivalent as used in Establishing the Oil Content for Dense Graded Bituminous Mixtures," dated October, 1946.

b. On normal material 3 stabilometer specimens will be sufficient for evaluating a sample. General practice is to prepare stabilometer specimens varying the amount of bitumen 0.6% below and above the theoretical optimum bitumen ratio

(the value obtained from the C.K.E.). This increment should be satisfactory for the majority of samples although on asphalt concrete and extremely critical mixes the increment is lowered to 0.3% and the number of test specimens is increased to five. On highly absorptive non-critical mixes a 1.0% increment is generally satisfactory. In unusual cases, such as highly absorptive aggregates or extremely fine materials it is sometimes necessary to select the proper amount of asphalt by visual inspection and stabilometer values.

c. The swell test specimens are normally prepared in duplicate on the theoretical optimum bitumen content (obtained by C.K.E. Test). In special cases, referred to above, the swell test specimens should be prepared with the asphalt content selected as the considered optimum.

d. The aggregate for the film stripping test should be treated in a manner compatible with the construction procedure in which it is to be employed. The sample should be oven dried at 230°F if it is intended for hot mix construction. The aggregate shall be washed free from dust if washing is to be employed in actual construction. Otherwise, the bitumen shall be applied to the sample as received after air drying at room temperature. Sufficient asphalt to thoroughly coat the aggregate (generally from 4% to 8%) is applied and mixed with the aggregate using a small spatula or palette knife. This mixing is usually performed on a small hot plate using precaution to not overheat the materials. When emulsified asphalt is used as the bitumen the procedure is somewhat different. The aggregate to be coated with bitumen should be thoroughly dampened before applying the emulsified asphalt. After adding the emulsified asphalt (10 grams is generally sufficient) the mixture is thoroughly stirred, allowed to stand for 2 or 3 minutes, restirred and the excess emulsion drained off.

Any film stripping sample that shows draining or thinness of film after the 15 hour curing period should be heated slightly and restirred before placing in the testing jar.

e. Open graded mixes.

For determining the bitumen content of open graded mixes the following formula will give a good approximation of the proper asphalt content. $(K_c \times 1.5) + 2.5 =$ Bit. ratio.

As the stabilometer test is not performed on open graded mixes a sample is prepared and after undergoing the normal curing period is inspected visually as a check on the asphalt content obtained by the above formula. Unless the aggregate are quite unusual, the proper asphalt content can usually be determined by the one sample

The swell test on open graded mixes is performed only on the portion passing the #4 sieve. The bitumen ratio is determined by the C.K.E. method and the material will then be treated the same as dense graded mixes for the swell test.

D. Aggregate mixing temperatures and curing of samples.

a. Aggregates which are to be mixed with paving grade asphalts require preheating in order to facilitate mixing.

Following are suggested aggregate temperatures for mixing with appropriate grade of asphalt.

60-70 Pen. Asphalt - 325°F
85-100 Pen. Asphalt - 300°F
100-150 Pen. Asphalt - 275°F
150-300 Pen. Asphalt - 250°F
SC-6 Pen. Asphalt - 250°F

Aggregates to be mixed with liquid asphalts do not, as a rule, require preheating.

After adding the asphalt to the aggregate, the mixture is transferred to a suitable pan for mixing and placed on a hot plate to maintain the mixing temperature. It is then hand mixed vigorously with a small pointed trowel until all particles are coated. Do not overheat the material while mixing. Aggregates that do not require preheating are mixed in the same manner using the lowest possible temperature for mixing.

b. When mixing is completed, the mix is transferred to a suitable flat pan (11" x 7" x 1") for curing, film stripping samples are cured in the small pans they are mixed in. The curing period for all bituminous mixes consists of subjecting the mixture to a 15 hour period of 140 ±5°F air temperature in an oven preferably equipped with air circulation.

E. Compacting

a. Swell Test Specimen (4" dia. height variable).

The swell test specimen should always be compacted first. The molds to be used for the swell test are prepared for the test by placing a paraffin impregnated strip of ordinary wrapping paper 3/4" wide around the inside of the mold 1/2" to 3/4" from the bottom, to prevent the water from escaping between the sample and the mold during the immersion period. The paper strip is dipped in hot paraffin and applied to the inside of the mold while hot. Any portion of the paper which fails to adhere to the mold should be painted with hot paraffin and brush.

Compaction temperatures for the swell specimens will be 140°F or 230°F. Mixes using grades of liquid asphalt 1 to 5 inclusive shall be compacted at 140°F and all heavier grades at 230°F.

1000± 1 gram of mix is weighed into a specially constructed feeder trough (4" wide, 18" long) for introducing the mix into the mold. (Molds not preheated.) The material shall be thoroughly mixed and dispersed on the trough to insure a uniform sample when transferred to the mold. One half of the sample is then placed in the mold which is in position in the mold holder and has a paper disc covering the plate on the mold holder. A paddle made to fit the shape of the trough is used to push the material into the mold. The material is then rodded 20 times in the center of the mass and 20 times around the edge with a bullet nosed steel rod 3/8" diameter 16" long. The remainder of the sample is then transferred to the mold and the rodding procedure repeated. These operations should be performed as rapidly as possible to prevent cooling of the sample.

By using the above rodding procedure, comparable test results are obtained by either performing the operation before placing the assembly under the compactor or after the unit is assembled in compaction position. Operators at Headquarters Laboratory have found that a great deal of time is saved by preparing the next specimen while one is being compacted. Assuming that the sample has been placed in the mold prior to placing the unit on the compactor, the procedure for compacting is as follows.

The mold and assembly is placed in position on the mechanical compactor and is ready for compacting. The compactor foot should be kept hot enough at all times to prevent the mix from adhering to it by regulating the foot heater by means of the variable transformer. The sample should be given approximately 20 blows at 250 psi. before applying the full load of 500 psi. The number of blows with the 250 psi. load will vary with the type of material, the purpose being to form the mix in a semi-compacted condition so it will not be unduly disturbed by the 500 psi. load. 150 blows (or 300 seconds of compacting) at 500 psi. completes the compaction in the mechanical compactor. The mold and specimen are then removed from the compactor and the specimen is pushed to the opposite end of the mold; (this is done in order to present the face of the specimen which has not been in contact with the compactor foot to the water contact in the swell test). To complete the compaction the specimen is given 1000 psi. leveling off load in the testing press with the bottom of the sample in contact with the lower platen of the press. It is usually desirable to place a piece of cardboard or heavy paper between the specimen and the metal plate of the press to protect the plate from being scratched. The height of the specimen is measured and recorded

for use in determining the amount of material necessary to provide a 2.5" height for the stabilometer specimen. Material which will not compact under full tamper foot load is subjected to 40,000 lbs. static load under the press. This 40,000 lb. static load is applied to the mix with the head speed of the machine at .05" per minute employing a double plunger assembly, (free fitting 4" plungers on the top and bottom of the mix). The load is released immediately upon attaining the 40,000 lb. load. The specimen height is measured and recorded.

b. Stabilometer specimen

Compaction procedure for the stabilometer specimens is essentially the same as for the swell test with a few variations. Compaction temperatures for stabilometer specimens are, mixes using liquid asphalt grades 1 to 5 inclusive, 140°F. Mixes using liquid asphalt grade SC-6 and all grades of paving asphalt, 230°F. On road mixes and bituminous surface treatment samples where it is desired to test the mix with whatever moisture which may happen to be contained in the mix, the compaction is performed at room temperature. The compaction at room temperature should be made at such a time when the stabilometer test can be performed immediately following compaction to prevent loss of moisture due to evaporation. As the stabilometer specimen should be 2.50"±0.10" high after compaction the amount of mix necessary to obtain this height is determined from the height which was recorded for the 1000 grams of material used for the swell specimen. Using the following computation the "X" value should give the desired height. If 1000 grams of mix compacted gives a height of 2.2, 1135 grams of mix will give a 2.5" height. (See attached graph).

Example: 1000 : 2.2" = X : 2.5"

X = 1135

No special preparation of the mold is necessary except that on cohesionless mixes such as sands, mixed with liquid asphalt, a paper "basket" or liner should be placed inside of the mold to support the specimen upon removal from mold. A basket should also be used with mixes having an excess of asphalt in order to prevent contamination of the rubber diaphragm. When a basket is used, extreme care should be exercised when rodding the mix to prevent damage to, or the pushing of the basket out of position. Molds to be used for mixes to be compacted at 230°F should be preheated to approximately 150°F to prevent rapid loss of temperature during the compaction procedure. The leveling off load of 1000 psi. is applied by the double plunger method where a free fitting plunger is used on the bottom of the sample as well as at the top. After the leveling off load is applied, the height of the sample is measured and recorded.

F. Testing Procedure

a. Swell Test

The compacted specimen is allowed to stand for approximately one hour at room temperature to permit rebound from compaction and is then placed in a pan capable of holding 500 cubic centimeters of water plus the mold and specimen. The swell test disc with an adjustable stem is then placed on the surface of the specimen and set to zero on a suitable measuring device capable of measuring the swell to .001". An Ames Dial mounted on a tripod is satisfactory for this purpose. 500 cc of water is then poured into the mold on top of the specimen and allowed to remain for a 24 hour period, after which time the vertical swell or expansion is recorded in thousandths of an inch and the amount of water in cubic centimeters that passes through the sample is recorded as an index to the permeability. The amount of water passing through the specimen can be measured by a calibrated measuring stick, or scale graduated to read in 25 cc intervals.

b. Stabilometer Test

All specimens of bituminous paving mixtures are tested at a temperature of 140°F except in instances where it is desired to test with moisture present in the mix, in such cases the test must be performed at not more than room temperature. Specimens compacted at 230°F should remain in a 140°F oven after compaction at least one and one-half hours prior to testing in order to bring them to 140°F for stabilometer test. Those specimens compacted at 140°F should be kept in a 140°F oven at least one hour before testing. The test procedure shall be as outlined in the article entitled, "Details of the California Procedure for Operation, Installing Rubber Cell and Adjusting the Hveem Stabilometer".

c. Specific Gravity

1. Weight in air, weight in water method.

This method is used to obtain the bulk specific gravity on specimens non-uniform in size and shape, such as a slab cut from an existing pavement or a compacted briquette having excessively rough side surfaces. The procedure is to obtain the normal weight of the specimen and the weight while immersed in water.

Weight in air (grams) - weight in H_2O (grams) = Volume

$$\frac{\text{Weight in Air}}{\text{Volume}} = \text{Specific Gravity}$$

2. Measured Volume and Weight Method.

This method is used on laboratory test specimens having a uniform 4" diameter. The procedure is to obtain the weight and height of the specimen and use the following computation:

$$\frac{\text{Weight in air(grams)} \times .004856}{\text{Height (inches)}} = \text{Specific Gravity}$$

3. Weight per cubic foot.

Specific Gravity x 62.4 = weight per cu.ft.

d. Cohesiometer Test

The cohesiometer testing apparatus shall be calibrated to allow 1800± 20 grams of shot per minute to flow into the receiving bucket at the end of the 30" lever arm. The test is performed on the same specimen that was used in the stabilometer and specific gravity tests. After these tests are completed the specimen should be placed in an oven a sufficient length of time (normally 2 hours) to bring temperature of specimen to 140°F. The standard temperature for cohesiometer testing is 140± 5°F. The test is performed by clamping the test specimen firmly in the testing machine being certain that it is well centered with the top plates parallel with the surface of the specimen. The flow of shot is released into the container fastened to the end of the beam and continued until the specimen breaks, which is indicated by a sudden drop of the beam. In the event that the specimen is flexible rather than brittle, the flow of shot is stopped when the end of the 30" beam has lowered 1/2" from the horizontal. The shot in the container is then weighed to the nearest gram and the cohesiometer value calculated from the following equation:

$$C = \frac{L}{.80H + .178\,H^2}$$

L = Weight in grams of shot
H = Height of specimen
C = Cohesiometer Value (grams per inch width corrected to 3 inch height).

Cohesiometer values are also easily obtained by multiplying the weight of shot necessary to break the specimen by factors established for each 4" diameter specimen height. These factors and an example are as follows:

Height	Factor	Height	Factor
2.20"	.382	2.50"	.322
2.25"	.371	2.55"	.313
2.30"	.360	2.60"	.305
2.35"	.349	2.65"	.297
2.40"	.340	2.70"	.290
2.45"	.331	2.75"	.283

Example:

Wf = C

600 x .322 = 193

W = Weight of shot in grams necessary to break a 2.5" high 4" dia. specimen
f = factor for 2.5" high 4" dia. specimen
C = Cohesiometer Value

e. Film Stripping Test

Fifty grams of the sample are placed in a suitable 8 ounce screw top glass jar with approximately 175 milliliters of pure water and agitated vigorously for 15 minutes at 77°F. At the end of this period the sample is examined for evidence of stripping. By visual inspection, if the sample shows less than 25% stripping it is considered to be satisfactory. Results are reported as No Stripping, Slight Stripping (less than 25%) and Bad Stripping (more than 25%).

In unusual cases, where special information is desired, the test may be continued through the additional cycles of agitation and temperatures as described in Section 6 of the 1949 Standard Specifications.

II. Testing of Bituminous Mix Control Samples

A. Preparation of samples

a. Plant mixed samples (uncompacted)

The loose sample should consist of approximately 7000 grams of mix. If the grade of asphalt used in the mix was SC-6 or heavier, the sample should be heated to approximately 200°F for workability. The entire sample is then screened through a 1" sieve to remove the oversize (which is not used in the stabilometer test). This oversize shall be weighed and a proportion shall be returned to that portion of the sample which is to be extracted and graded. The screened material is then thoroughly mixed and quartered into the amounts needed for the various tests. The approximate amounts needed for each test are as follows: Stabilometer 1200 to 1300 grams, swell test 1000+ grams, extraction and grading 750 to 1000 grams. Samples for test specimens are cured 15 hours at 140°F prior to testing. The sample for extraction and grading should be thoroughly free of moisture before extracting except if the type of extractor obtains the moisture determination along with the asphalt extraction. The drying time and temperature is 140°F for 15 hours. The excess material should be saved for a reasonable length of time in case check tests are necessary.

b. Plant Mixed Samples (compacted)

In the case of compacted street samples the compacted sample is cut to a suitable size (1000 - 1500 grams) for obtaining the specific gravity. The specimen should contain no cracks. The portion of the sample to be extracted should not consist of portions that have edges cut with a chisel or other sharp instrument as this may result in an erroneous result in the sieve analyses.

c. Plant Mixed Samples (open graded)

In the case of an open graded mix the sample should consist of approximately 2000 grams of material. This sample should be thoroughly mixed and quartered to 800 or 900 grams for extraction and grading. 60 grams of the mix is also taken for the film stripping test.

d. Road Mixed Surfacing and Bituminous Surface Treatment Samples

The sample for testing should consist of approximately 7000 grams of mix which has been kept in a sealed container (a 1 gallon friction top can or tin concrete cylinder container will be suitable) since the time of sampling. The same screening and quartering procedure is used as in the plant mixed samples. Samples sizes are the same as previously mentioned. A moisture determination sample weighing exactly 500 grams is also taken. The material for use in the stabilometer and moisture tests should be weighed into, and kept in a sealed container until time of testing. A suitable sealed container for these samples is a 1 quart friction top can.

B. Compacting

a. Swell test specimen.

Same as Part I, Section E, a

b. Stabilometer test specimen.

Same as Part I, Section E, b

C. Testing Procedure

a. Swell test

Same as Part I, Section F, a

b. Stabilometer test

Same as Part I, Section F, b except that road mixed and bituminous surface treated samples are tested at room temperature with moisture, if any present. In the event a low

stabilometer value is obtained and measurable moisture is present, the stabilometer test is performed at 140°F on another portion of the sample from which the moisture has been removed. This additional test at 140°F will indicate if the moisture present in the mix is the cause of the low stabilometer value.

c. Cohesiometer test.

Same as Part I, F, d.

d. Moisture Determination.

See Page 188 of 1950 Construction Manual

e. Extraction.

See attachment.

f. Film Stripping

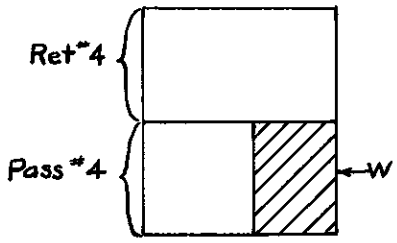
Same as Part I, F, e.

APPENDIX I

Adjustment of Gradings by Wasting a Portion of the Sample

A. Grading Adjustments

(a) To waste a portion of passing #4:



Consider a unit amount of material
Let W = amount to be wasted
Let P_1 = original proportion of -4
Let P_2 = final proportion of -4

$$P_2 = \frac{P_1 - W}{1 - W} \text{ from which } W = \frac{P_1 - P_2}{1 - P_2}$$

Example:

Given Size	% Passing Original
3/4	100
3/8	90
#4	70
#8	55

To meet specifications it is necessary to reduce the -4 to 60% then $W = \frac{.70 - .60}{1 - .6} = \frac{.1}{.4} = .25$ or 25% of total sample

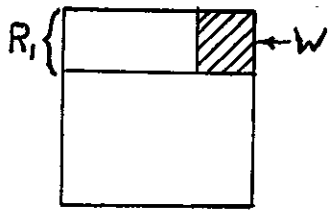
The new grading will be

Passing #8 = $\frac{60}{70} \times (55) = 47$

Retained 3/8 = $\frac{100-60}{100-70} \times (100-90) = \frac{40}{30} \times (10) = 13$

Passing 3/8 = 100 - 13 = 85%

(b) To waste a portion of retained #4:



Consider a unit amount of the material
Let W = proportion wasted
R_1 = proportion retained #4 originally
R_2 = proportion retained #4 finally
P_1 = proportion passing #4 originally
P_2 = proportion passing #4 finally

$$R_2 = \frac{R_1 - W}{1 - W} \quad \text{from which} \quad W = \frac{R_1 - R_2}{1 - R_2} = \frac{P_2 - P_1}{P_2}$$

Example: Given the following grading

Size	% Passing
3/4	100
3/8	90
#4	70
#8	40

It is necessary to waste enough retained #4 to increase the passing #4 to 80%

Substituting into the above equation, R_1 = 100-70 = 30 R_2 = 20

$$W = \frac{.30 - .20}{1 - .20} = \frac{.1}{.8} = .125 \text{ or } \underline{12.5\%} \text{ of total}$$

$$\text{or } W = \frac{80 - 70}{80} = \frac{10}{80} = 12.5\%$$

The new grading will be:

Passing #8 = $\frac{80}{70}$ x (40) = 46%

Retained 3/8" = $\frac{20}{30}$ x (10) = 6.7

Passing 3/8" = 100 - 6.7 = 93%

(c) To Waste a Portion of the Passing #200 Sieve

Procedure:

The portion of material wasted is subtracted from the percent passing each sieve size. This gives a grading less than 100%, which is corrected proportionately to equal 100%.

Example:

From a sample it is desired to remove 15% of the material passing the #200 sieve.

Sieve Size	Specified Limits	Original Grading	Excess % Passing #200		Grading less than 100%	Corrected to 100%*
1"	100					
3/4"	95-100	100	- 15	=	85	100
3/8"	67-85	80	- 15	=	65	76
#4	50-65	64	- 15	=	49	58
#8	37-50	49	- 15	=	34	40
#16		42	- 15	=	27	32
#30	18-28	35	- 15	=	20	24
#50		29	- 15	=	14	16
#100		23	- 15	=	8	9
#200	3-8	19	- 15	=	4	5
#270		18	- 15	=	3	4

*85 : 100 = 65 : X X = 76

also 85 : 100 = 49 : X etc. X = 58

(d) To Waste all Material Passing #4

Procedure:

Subtract the percent passing the #4 sieve from each sieve size retained, then readjust to equal 100%.

Sieve Size						
3/4	100	-	53	=	47	= 100
1/2	82	-	53	=	29	= 62
3/8	73	-	53	=	20	= 43
4	53	-	53	=	0	
8	37					
16	24					
30	15					

47 : 100 : : 29 : X X = 62

47 : 100 : : 20 : X X = 43 etc.

(e) Wasting Material from Uncrushed Portion.

When an adjustment is necessary to produce a specified grading from a sample that has had the oversize crushed, the wasted material shall be taken from the uncrushed portion of the aggregate. This will change the portions of crushed and uncrushed and a correction is necessary.

Example.

From a sample originally having 50% uncrushed and 50% crushed it was necessary to waste a portion of the total sample equivalent to 25% in order to conform to the grading requirement. This 25% is to be removed from the uncrushed portion and it is desired to obtain the proportions of crushed and uncrushed after this material has been wasted.

Let W = % of total to be wasted

X = original uncrushed portion

X_1 = final uncrushed portion

Y = Original crushed portion

Y_1 = final crushed portion

$X+Y = 1$ also $X_1+Y_1 = 1$

$\frac{1 - W}{1} = \frac{X - W}{X_1}$ Then $X_1 = \frac{X - W}{1 - W}$

Also $\frac{1 - W}{1} = \frac{Y}{Y_1}$ Then $Y_1 = \frac{Y}{1 - W}$

Substituting into the above equation

$$X_1 = \frac{.50 - .25}{1 - .25} = \frac{.25}{.75} = 33\%$$

Also $Y_1 = \frac{.50}{1 - .25} = \frac{.50}{.75} = 67\%$

The final grading will contain 33% uncrushed and 67% crushed material.

B. Combining Materials

(a) To recombine a sample in which the oversize has been crushed.

Procedure: The gradings are considered individually i.e. uncrushed and crushed. Each grading is then proportioned as to its relative percentage of the original sample and recombined.

Example: A sample was separated on the 3/4" sieve. The oversize (or 46%) was crushed to pass the 3/4" sieve, then recombined with the original portion.

Sieve Size	Original Sample	Oversize Crushed	Proportioning	Combined Sample Original and Crushed
1"	59			
3/4"	54	100	100 x .46 = 46	54 + 46 = 100
3/8"	45	56	56 x .46 = 26	45 + 26 = 71
#4	39	35	35 x .46 = 16	39 + 16 = 55
#8	37	20	20 x .46 = 9	37 + 9 = 46
#16	34	15	15 x .46 = 7	34 + 7 = 41
#30	20	11	11 x .46 = 5	20 + 5 = 25
#50	16	9	9 x .46 = 4	16 + 4 = 20
#100	10	8	8 x .46 = 4	10 + 4 = 14
#200	4	4	4 x .46 = 2	4 + 2 = 6
#270	3	3	3 x .46 = 1	3 + 1 = 4

(b) Proportioning material for C.K.E.

For passing #4 or fine aggregate divide the percentage passing the #4 for each sample used by the total for all the samples and multiply by 100.

If a, b and c are the percentages passing the #4 in the combination for individual samples A, B and C respectively the amount to give a 100 gram sample will be

$$X_A = \frac{a}{a + b + c} \times 100$$

$$X_B = \frac{b}{a + b + c} \times 100$$

$$X_C = \frac{c}{a + b + c} \times 100$$

If it is desired to take extra material as for instance 5 grams to allow for loss of weight in drying, then

$$X_A = \frac{a}{a + b + c} \times 105 \quad \text{etc.}$$

For the coarse K value determine the % of 3/8" x #4 material for each sample and combine as above.

October 20, 1941

State of California
Department of Public Works
Division of Highways
Materials and Research Department

Formula for Grading Aggregates to Absolute Volume When Individual Size Fractions Vary in Specific Gravity Including Determination of Specific Gravity of Combination

- - -

The grading analysis of a mineral aggregate is usually expressed as the percentage by weight passing each sieve size. Although this method is convenient and is entirely satisfactory for most materials, it may be misleading if there is much variation in the specific gravity of different size groups. In order to correctly show the particle size distribution of the aggregate the grading analysis should be expressed as the percentage by absolute volume passing each sieve.

If, for example, it is desired to have 55% passing the No. 4 sieve, and the aggregate consists of a uniform crushed ledge rock, the grading analysis both by weight and by volume will be the same. If, on the other hand, the coarse aggregate consists of a light weight rock with a specific gravity of say 1.80 and the portion passing the No. 4 is a crushed granite with a specific gravity of 2.80, a grading of 55% by weight passing the No. 4 sieve would actually be 43.9% by volume. A harsher and much less workable mix than that desired would be the result. This is, of course, an exaggerated or at least an unusual case, but the same principles apply in some degree to every aggregate grading.

If it is necessary in designing an asphaltic concrete or plant mix to blend two or more materials with specific gravities differing by twenty points or more a correction should be applied to the batch weights. To make this correction the mix should first be designed in the usual manner without regard to the specific gravities of the aggregates. This will give the desired or volume grading. To obtain the per cent by weight of each material multiply the per cent by volume by its specific gravity and divide by one hundred times the average specific gravity of the total aggregate. Typical examples and formulas for the calculation are attached.

$$\frac{W}{G} = V \qquad \text{A}$$

$$VG = W \qquad \text{B}$$

$$Ga = \frac{Pv_1 G_1 + Pv_2 G_2 + \ldots + Pv_n G_n}{100} \qquad \text{C}$$

$$Pw = \frac{Pv_1\ G_1}{100\ Ga} \qquad Pw_2 = \frac{Pv_2\ G_2}{100\ Ga} \qquad D$$

$$Ga = \frac{100}{\frac{Pw_1}{G_1} + \frac{Pw_2}{G_2} + \ldots + \frac{Pw_n}{G_n}} \qquad E$$

W = Mass of Aggregate
G = Specific Gravity of Aggregate
V = Mass of a volume of water equal to the volume of aggregate
Pv = Per cent of sample by volume
Pw = Per cent of sample by weight
Ga = Combined or average specific gravity of Aggregate

Example of Correcting Grading Where Specific Gravity Varies in All Sizes from Fine to Coarse

Sieve Size	Desired Grading or Theoretical Grading by Abs. Vol. % Passing	Pv % Each Size By Abs. Vol.	G Sp. Gr. Each Size	PvG	Pw Equation D	Grading by Wt. Percent Passing	$\frac{Pw}{G}$ Equation E
Wash 200	10	10	2.65	26.5	15.4	15.4	5.8
100	15	5	2.55	12.7	7.4	22.8	2.9
80	16	1	2.45	2.4	1.4	24.2	.6
50	20	4	2.25	9.0	5.2	29.4	2.3
40	23	3	2.11	6.3	3.7	33.1	1.8
30	27	4	2.06	8.2	4.8	37.9	2.3
20	31	4	1.89	7.6	4.4	42.3	2.3
10	42	11	1.76	19.3	11.2	53.5	6.4
3	60	18	1.49	26.5	15.4	68.9	10.5
1/2	75	15	1.46	21.9	12.7	81.6	8.7
3/4	88	13	1.41	18.3	10.6	92.2	7.5
1	100	12	1.14	13.7	8.0	100	7.0
		100		172.4*	100		58.1

Pw_1 = By equation (D) $\frac{26.5}{172.4} = 15.4$

Sp.Gr.= By equation (E) $\frac{100}{58.1} = 1.72$

*It will be noted that the sum of this column equals one hundred times the combined specific gravity. This should not be confused with the standard method of calculating the combined specific gravity which is based on the grading by weight, Equation (E).

May 9, 1951

State of California
Department of Public Works
Division of Highways
Materials and Research Department

INSTRUCTIONS FOR OPERATING CALIFORNIA TYPE EXTRACTION APPARATUS

Note: This extractor utilizes cold solvent, and is essentially a pressure filter operating with compressed air in the approximate range of from 35 to 75 lbs. pressure.

1. The sample of bituminous mixture for extraction is first heated sufficiently to permit breaking up and pulverizing. It is then carefully reduced to an aliquot part of appropriate size using hand quartering or mechanical methods. Before extraction the sample is placed in a drying oven maintained at 140°F. and allowed to dry overnight to remove moisture.

2. Prepare Thimble. (The thimble is a thin steel cylinder 4" deep and roughly 5 1/2" in diameter, with a flange at one end.) Glue a heavy filter paper (a 6-in. diameter disk, Braun-Knecht-Heimann Co. No. 11148) to the flange to form a bottom for the thimble. LePage's water soluble liquid glue is satisfactory. Before applying new filter paper to thimble old glue must be removed and the metal cleaned lightly with steel wool or emery cloth. Thimbles should be weighted while glue is drying.

3. After the glue is hardened, determine the tare weight of the thimble to the nearest one-tenth gram.

4. Place in the thimble from 600 to 900 grams of the bituminous mixture which has been previously dried. For fine material all of which will pass a No. 4 sieve, 600 grams is sufficient. For mixtures containing coarse aggregate up to one inch, from 700 to 900 grams should be used.

5. Determine combined weight of thimble and sample to nearest one-tenth gram.

6. Place thimble in extractor shell by inserting upward from the bottom of the shell, and with the filter stone in place in contact with the filter paper, tighten the lower clamp ring using a long-handled spanner wrench. Then place the stirring paddle in place and screw on the lid of the extractor, making sure that the stirring crank socket is fitted to the stirring paddle.

Example of Combining Two Samples With Different Specific Gravities

Specific Gravity of Sample A = 2.78

Specific Gravity of Sample B = 2.30

Sieve Size	Grading by Weight		Calculated desired Grading Assuming Sp.Gr. the Same			Spec.	70% A See Calc. Below	30% B See Calc. Below	Comp.Grad. % Passing By Wt.
	Sample A % Passing	Sample B % Passing	66% A	34% B	Comb. Vol. Grading				
1"		100	66	34	100	100	70	30	100
3/4"		94	66	32	98	95-100	70	28	98
3/8"	100	24	66	8	74	65-85	70	7	77
No. 4	89	3	59	1	60	50-65	62	1	63
No. 8	70	0	46	0	46		49	0	49
No. 16	56	0	37	0	37	30-43	39	0	39
No. 30	41		27	0	27		29	0	29
No. 50	27		18	0	18	16-25	19	0	19
No. 100	17		11	0	11		12	0	12
No. 200	8		5	0	5	3-8	6	0	6
Wash	8		5	0	5		6	0	6

$$100\ Ga = 66 \times 2.78 + 34 \times 2.30 = 261$$

$$\frac{Pv_1\ G_1}{100\ Ga} = \frac{183}{261} = 70 \qquad \frac{Pv_2\ G_2}{100\ Ga} = \frac{78}{261} = 30$$

7. Next introduce a charge of solvent (any solvent may be used such as benzol or trichlorethylene; California experience indicates that ethylene dichloride is the most economical and effective solvent, as well as being relatively safe to handle). Approximately 600 ml. of solvent is poured through the funnel at the top of the extractor. After all the solvent is in, be sure that the solvent shut-off valve is closed.

8. Open compressed air valve to force the solvent through the filter and out of extractor.

DETAILS OF ACTUAL EXTRACTION PROCEDURE

(a) When the first charge of solvent is introduced, close the solvent valve, stir the sample lightly, being careful not to tear the filter paper, and then turn on the air pressure at once.

(b) When the solvent ceases flowing through the discharge tube, the second charge may be introduced, being sure to close the air valve before opening the solvent valve. When the second charge of solvent is in, close the valve and again stir the sample. If first charge came through rapidly, allow second charge to stand from 10 to 20 minutes before turning on air pressure. If first charge came through slowly, the air should be turned on immediately. The reason for these variations is the fact that if a large quantity of asphalt is taken into solution immediately, the viscous liquid tends to clog the filter.

(c) Repeat same procedure with successive charges of solvent until solvent comes through clear. For the average sample, four charges of solvent are sufficient for complete extraction.

9. The solvent is usually all discharged from the extractor when free air can be heard blowing through the filter. If the flow of solvent ceases before all the solvent is discharged, release the air pressure and stir the sample by means of the crank handle on top of the extractor. The thimble containing the sample is removed from the extractor and the sample dried to constant weight at 140°F. without removing from the thimble. Normal procedure is to place in 140°F. oven overnight. The thimble and sample are again weighed and the percentage of bitumen is indicated by the loss in weight during extraction.

Formula $\frac{Wm - We}{We - Wt}$ = Oil Ratio

Where

Wm = Wt. of sample plus thimble before extracting
We = Wt. of sample plus thimble after extracting
Wt = Wt. of thimble

General Note:

Care should be taken in the operation of the apparatus so that solvent is not permitted to overflow the top of the thimble. It should also be realized that there is a small constant error due to the fine mineral matter of colloidal size passing through the filter. This loss in weight is considered negligible in routine extraction procedure.

Wash sieve analysis is determined on the dried extracted aggregate.

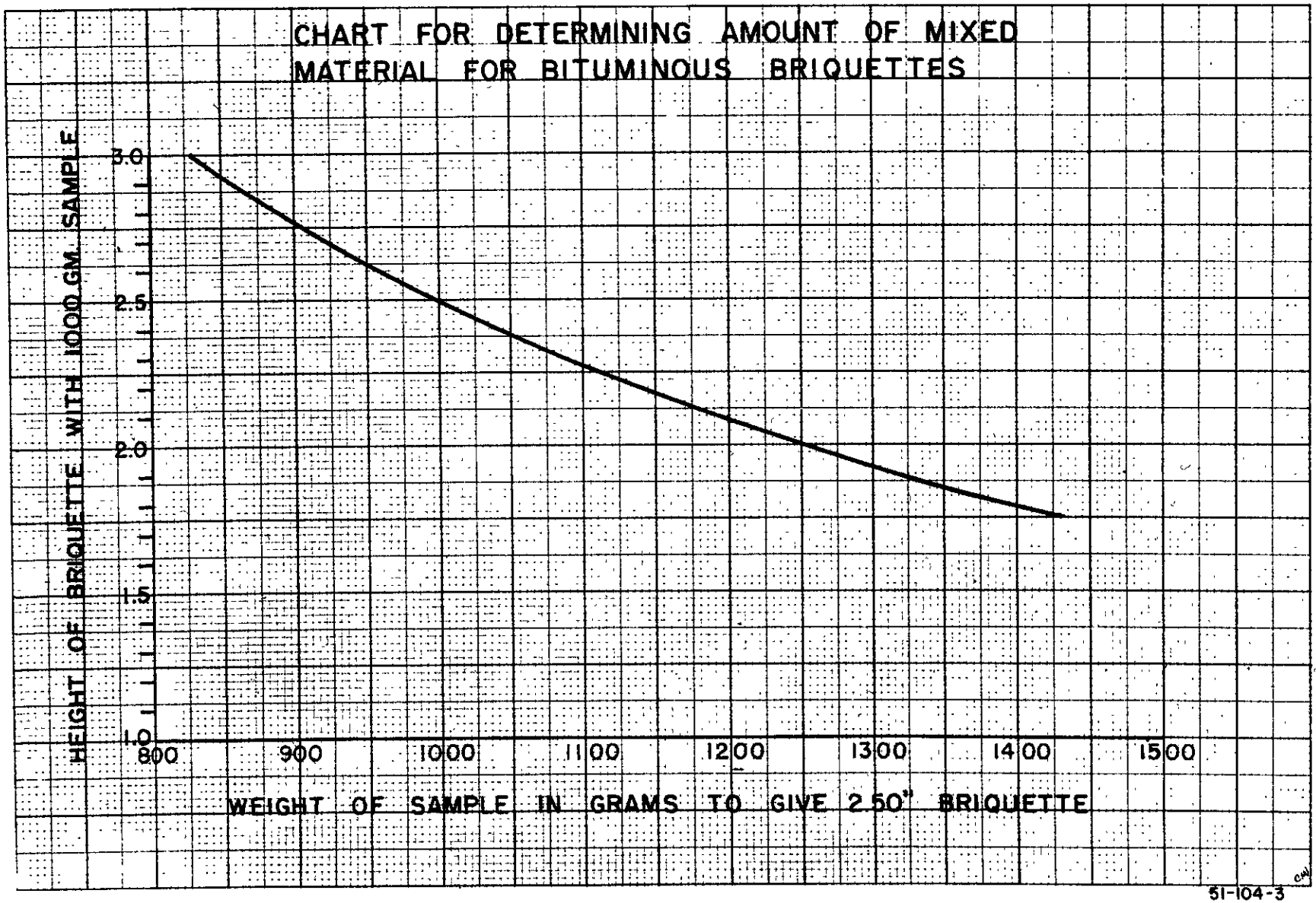
Before determining the wash analysis, approximately 50 cc of an industrial alcohol mixture such as "Shellacol" should be mixed thoroughly with the material to alter surface tension and facilitate washing.

STATE OF CALIFORNIA

MATERIALS & RESEARCH DEPARTMENT

DIVISION OF HIGHWAYS

CHART FOR DETERMINING AMOUNT OF MIXED MATERIAL FOR BITUMINOUS BRIQUETTES



51-104-3

STATE OF CALIFORNIA

DIVISION OF HIGHWAYS

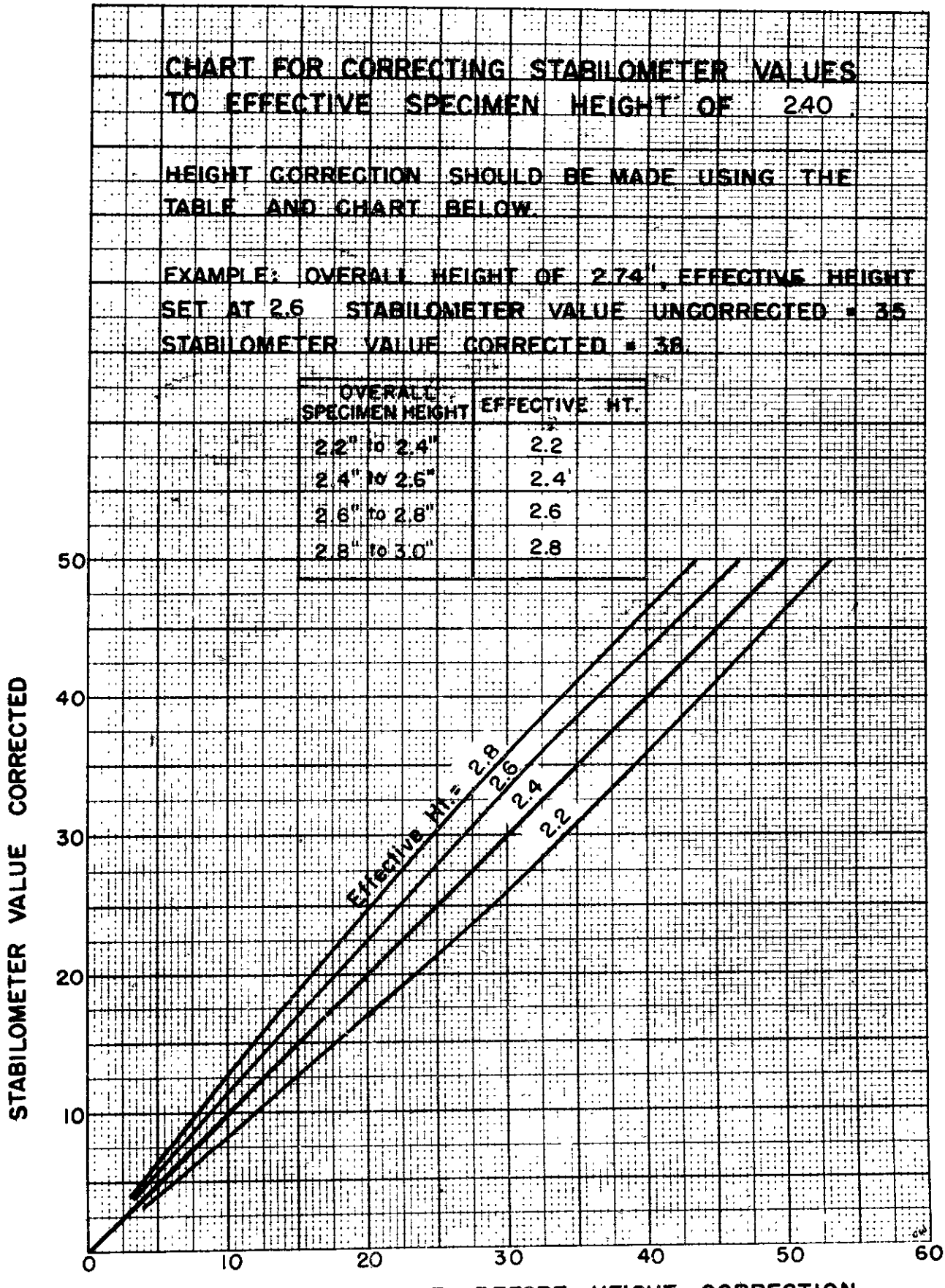
MATERIALS & RESEARCH DEPARTMENT

CHART FOR CORRECTING STABILOMETER VALUES TO EFFECTIVE SPECIMEN HEIGHT OF 2.40"

HEIGHT CORRECTION SHOULD BE MADE USING THE TABLE AND CHART BELOW.

EXAMPLE: OVERALL HEIGHT OF 2.74", EFFECTIVE HEIGHT SET AT 2.6 STABILOMETER VALUE UNCORRECTED = 35 STABILOMETER VALUE CORRECTED = 38.

OVERALL SPECIMEN HEIGHT	EFFECTIVE HT.
2.2" to 2.4"	2.2
2.4" to 2.6"	2.4
2.6" to 2.8"	2.6
2.8" to 3.0"	2.8



Rev 8-28-51

51-103-3

F.(a) –

LABORATORY RECORD OF BITUMINOUS MIXTURES

FORM T-302-51

Test No. 100

Untr. Matl. Test No.

Cement Tr. Test No.

Grade		Stab. 140° F.		Swell	
Extraction		Stab. Cold		Film Strip.	
Surface area		Sp. Gr. Briq.		M V. S.	
Sp. Gr. Comp.		Cohesiometer		Moisture	

Dist. Co. Rte. Sec. Cont. No.

Instructions:

Tests to be Charged

Agg. Dept. Series To

To Extraction

Extraction Completed

Indexed

Date Received

Tests Completed

Approved by

Plotted

Date Reported

Final % As Received	Final % Crushed		Adjusted on #4 Sieve	Combined Crushed and Uncrushed	% Crushed Material
33	67		100	100	50
25	48		73	80	36
17	35		52	64	26
15	27		44	54	20
14	13		34	42	10
12	11		28	34	8
6	8		16	20	6
4	5		10	12	4
3	4		7	9	3
2	3		5	6	2

	As Received	Ret. Crushed	As Used By Vol.	As Used By Wt.	Specif. ☐ Limits Sought ☐
2	90				
1½	85				
1¼					
1	62				100
¾	50	100		100	95-100
½					
⅜	44	72		73	67-85
3					
4	38	52		52	50-65
8	34	40		42	37-50
16	32	20		27	
30	26	16		23	18-28
50	14	12		14	
100	8	8		9	
200	6	6		7	3-8
270	4	4		5	
5 Micron					
1 Micron					
Bitumen					
Weight Sample					
F. Sp. Gr.					
C. Sp. Gr.					

Wt. in Air

Wt. in Water

Volume

Field Comp. Sp. Gr.

Stand. Lab. Sp. Gr.

Relative Compaction

Surface Area Factors	Surface Area
	2.0
2	
4	
8	
14	
30	
60	
80	
100	

Surface Area Sq. Ft./Lb.

Note: All surface area factors must be used in calculations

Specimen	A	B	C	D	E	F	Specif.
Temperature							
Moisture							
Bit. Grade							
Bit. Ratio							
Sp. Gr. Briq.							
STABILOMETER							
COHESIOMETER							
Rt VALUE							
SUSCEPTIBILITY TO WATER							
Swell (24 hrs.)							
Permeability							
SUSCEPTIBILITY TO MOISTURE VAPOR							
No. Cycles							
Moist. Absorb.							
Stabilometer							
Cohesion							

Passing No. 200 by Dry Sieving—

Passing No. 200 by Washing— =

Film Stripping (on coarse aggregate)— Stripping Min. ° F.

Centrifuge Kerosene Equivalent Values: F= C=

Kc= Kf= Km=

Theoretical Bitumen Ratio for Grade 2 Bitumen= %

Theoretical Bitumen Ratio for Grade Bitumen= %

Theoretical Oil Index Curve No.

Optimum Bitumen Content, Considering All Test Data: %

Recommended K—value to

Equiv. Gal. Bit. Per Sq. Yd. for 1" Comp. Surf. = 5.62 × × ( ) =

Crushed Particles = %

Grading as Used Was Obtained by Combining Samples as Follows.

% By Wt.	% By Vol.	Test No.	Field No.	Description

REMARKS: Example showing sample having over size crushed, being adjusted by wasting passing #4 material from the uncrushed portion only. (See App. I, Pg. 5)

The grading as used is the result of wasting a portion of the passing #4 sieve equivalent to 25% of the total sample.

See back of card for cumulative weights used in making test specimen.

FORM T-302-51

b.

LABORATORY RECORD OF BITUMINOUS MIXTURES

Test No. 101 C

Untr. Matl. Test No.

Cement Tr. Test No.

Dist. Co. Rte. Sec. Cont. No.

Instructions:

Tests to be Charged

Agg. Dept. Series To

To Extraction

Extraction Completed

Indexed

Date Received

Tests Completed

Approved by

Plotted

Date Reported

Grade		Stab. 140° F.		Swell	
Extraction		Stab. Cold		Film Strip.	
Surface area		Sp. Gr. Briq.		M. V. S.	
Sp. Gr. Comp.		Cohesiometer		Moisture	

Corrected to 100%	- 2% of passing 200	Adjusted on #4 Sieve	Screened to pass ¾" sieve		As Received	Ret. Crushed
				1½		
				1¼		
100	98	100	100	1	100	
				¾	97	
				½		
70	69	71	60	⅜	58	
				3		
50	49	51	32	4	31	
39	38	40	25	8	24	
29	28	30	19	16	18	
19	19	21	13	30	13	
14	14	16	10	50	10	
9	9	11	7	100	7	
8	8	10	6	200	6	
6	6	8	5	270	5	
				5 Micron		
				1 Micron		
				Bit umen		
				Weight Sample		
				F. Sp. Gr.		
				C. Sp. Gr.		

As Used By Vol.	As Used By Wt.	Specif. Limits Sought	Surface Area Factors	Surface Area
			Note: All surface area factors must be used in calculations	
		100		
	100	95-100		
	70	67-85		
				2.0
	50	50-65	2	
	39	37-50	4	
	29		8	
	19	18-28	14	
	14		30	
	9		60	
	8		80	
	6		100	

		Surface Area Sq. Ft./Lb.
Wt. in Air		
Wt. in Water		
Volume		
Field Comp. Sp. Gr.		
Stand. Lab. Sp. Gr.		
Relative Compaction		

Specimen	A	B	C	D	E	F	Specif.
Temperature							
Moisture							
Bit. Grade							
Bit. Ratio							
Sp. Gr. Briq.							
STABILOMETER							
COHESIOMETER							
Rt VALUE							
SUSCEPTIBILITY TO WATER							
Swell (24 hrs.)							
Permeability							
SUSCEPTIBILITY TO MOISTURE VAPOR							
No. Cycles							
Moist. Absorb.							
Stabilometer							
Cohesion							

Passing No. 200 by Dry Sieving— =

Passing No. 200 by Washing—

Film Stripping (on coarse aggregate)— Stripping Min. ° F.

Centrifuge Kerosene Equivalent Values: F= C=

Kc= Kf= Km=

Theoretical Bitumen Ratio for Grade 2 Bitumen= %

Theoretical Bitumen Ratio for Grade Bitumen= %

Theoretical Oil Index Curve No.

Optimum Bitumen Content, Considering All Test Data: %

Recommended K—value to

Equiv. Gal. Bit. Per Sq. Yd. for 1" Comp. Surf. = 5.62 × × / ( ) =

Crushed Particles = %

Grading as Used Was Obtained by Combining Samples as Follows:

% By Wt.	% By Vol.	Test No.	Field No.	Description

REMARKS: Example showing sample being adjusted by wasting retained #4 and passing 200 material.

The grading as used is the result of wasting a portion of the retained #4 equivalent to 37% of the total sample. (See App. I Pg. 2). From this product a portion of the passing 200 equivalent to 2% of the total sample was screened out and wasted. (See App. I. Pg. 3).

See back of card for cumulative weights used in making test specimen.

C.

LABORATORY RECORD OF BITUMINOUS MIXTURES

FORM T-302-51

Test No. 102 (L)

Untr. Matl. Test No.

Cement Tr. Test No.

Grade		Stab. 140° F.		Swell	
Extraction		Stab. Cold		Film Strip.	
Surface area		Sp. Gr. Briq.		M. V. S.	
Sp. Gr. Comp.		Cohesiometer		Moisture	

Dist. Co. Rte. Sec. Cont. No.

Instructions:

Tests to be Charged

Agg. Dept. Series To

To Extraction

Extraction Completed

Indexed

Date Received

Tests Completed

Approved by

Plotted

Date Reported

	As Received	Ret. Crushed	As Used By Vol.	As Used By Wt.	Specif. Limits Sought	Surface Area Factors	Surface Area
1½	100					Note: All surface area factors must be used in calculations	
1¼	95						
1	90			100			
¾	80			99			
½							
⅜	70			78			
3							2.0
4	60			67		2	
8	47			52		4	
16	40			44		8	
30	29			32		14	
50	18			20		30	
100	12			13		60	
200	6			7		80	
270	4			4		100	
5 Micron			Wt. in Air			Surface Area Sq. Ft./Lb.	
1 Micron			Wt. in Water				
Bitumen			Volume				
Weight Sample			Field Comp. Sp. Gr.				
F. Sp. Gr.			Stand. Lab. Sp. Gr.				
C. Sp. Gr.			Relative Compaction				

Specimen	A	B	C	D	E	F	Specif.
Temperature							
Moisture							
Bit. Grade							
Bit. Ratio							
Sp. Gr. Briq.							
STABILOMETER							
COHESIOMETER							
Rt VALUE							
SUSCEPTIBILITY TO WATER							
Swell (24 hrs.)							
Permeability							
SUSCEPTIBILITY TO MOISTURE VAPOR							
No. Cycles							
Moist. Absorb.							
Stabilometer							
Cohesion							

Passing No. 200 by Dry Sieving— =

Passing No. 200 by Washing—

Film Stripping (on coarse aggregate)— Stripping Min. ° F.

Centrifuge Kerosene Equivalent Values: F= C=

Kc= Kf= Km=

Theoretical Bitumen Ratio for Grade 2 Bitumen= %

Theoretical Bitumen Ratio for Grade Bitumen= %

Theoretical Oil Index Curve No.

Optimum Bitumen Content, Considering All Test Data: %

Recommended K—value to

Equiv. Gal. Bit. Per Sq. Yd. for 1" Comp. Surf. = 5.62 × × / ( ) =

Crushed Particles = %

Grading as Used Was Obtained by Combining Samples as Follows:

% By Wt.	% By Vol.	Test No.	Field No.	Description

REMARKS:

Example of screening to 1" Maximum and correcting the grading accordingly.

See back of card cumulative weights used in making test specimen.

d.

LABORATORY RECORD OF BITUMINOUS MIXTURES

FORM T-302-51

Test No. 103

Untr. Matl. Test No.

Cement Tr. Test No.

Dist. Co. Rte. Sec. Cont. No.

Instructions:

Tests to be Charged

Agg. Dept. Series To

To Extraction

Extraction Completed

Indexed

Date Received

Tests Completed

Approved by

Plotted

Date Reported

Grade		Stab. 140° F.		Swell	
Extraction		Stab. Cold		Film Strip.	
Surface area		Sp. Gr. Briq.		M. V. S.	
Sp. Gr. Comp.		Cohesiometer		Moisture	

						As Received	Ret. Crushed	As Used By Vol.	As Used By Wt.	Specif. ☐ Limits Sought ☐	Surface Area Factors	Surface Area
					1½						Note: All surface area factors must be used in calculations	
					1¼							
4539	4540	4541	4542	4543	1					100		
47.0	15.0	15.0	20.0	3.0	¾				100	90-100		
25.8	15.0	15.0	20.0	3.0	½				79	70-85		
6.1	14.2	14.5	20.0	3.0	⅜				58			
					3							2.0
2.3	5.8	12.6	19.8	3.0	4				4	40-52	2	
1.9	2.3	10.8	17.6	3.0	8				36	30-40	4	
	1.0	8.5	13.0	3.0	16				26		8	
	.7	5.1	9.4	3.0	30				18	18-28	14	
	.6	2.0	6.4	3.0	50				12		30	
	.5	.9	4.0	2.9	100				8	8-16	60	
	.3	.4	2.4	2.1	200				5	4-8	80	
	.3	.4	2.2	1.9	270				5		100	
					5 Micron			Wt. in Air			Surface Area Sq. Ft./Lb.	
					1 Micron			Wt. in Water				
					Bitumen			Volume				
					Weight Sample			Field Comp. Sp. Gr.				
					F. Sp. Gr.			Stand. Lab. Sp. Gr.				
					C. Sp. Gr.			Relative Compaction				

Specimen	A	B	C	D	E	F	Specif.
Temperature							
Moisture							
Bit. Grade							
Bit. Ratio							
Sp. Gr. Briq.							
STABILOMETER							
COHESIOMETER							
RI VALUE							
SUSCEPTIBILITY TO WATER							
Swell (24 hrs.)							
Permeability							
SUSCEPTIBILITY TO MOISTURE VAPOR							
No. Cycles							
Moist. Absorb.							
Stabilometer							
Cohesion							

Passing No. 200 by Dry Sieving—
Passing No. 200 by Washing— =

Film Stripping (on coarse aggregate)— Stripping Min. ° F.

Centrifuge Kerosene Equivalent Values: F= C=
Ke= Kf= Km=

Theoretical Bitumen Ratio for Grade 2 Bitumen= %
Theoretical Bitumen Ratio for Grade Bitumen= %
Theoretical Oil Index Curve No.

Optimum Bitumen Content, Considering All Test Data: %

Recommended K—value to

Equiv. Gal. Bit. Per Sq. Yd. for 1" Comp. Surf. = 5.62 × × / ( ) =

Crushed Particles = %

Grading As Used Was Obtained by Combining Samples as Follows:

% By Wt.	% By Vol.	Test No.	Field No.	Description
47.0		50-4539		#3 Cr. Gravel
15.0		50-4540		#4 Cr. Gravel
15.0		50-4541		Sand
20.0		50-4542		Rock Dust-
3.0		50-4543		Min. Filler

REMARKS:

Example of combining 5 samples to conform to a specified grading.

See back of card for cumulative weights used in making test specimen.

FORM T-302-51

LABORATORY RECORD OF BITUMINOUS MIXTURES

e.

Test No. 104

Untr. Matl. Test No.

Cement Tr. Test No.

Dist. Co. Rte. Sec. Cont. No.

Instructions:

Tests to be Charged

Agg. Dept. Series To

To Extraction

Extraction Completed

Indexed

Date Received

Tests Completed

Approved by

Plotted

Date Reported

Grade	Stab. 140° F.	Swell	
Extraction	Stab. Cold	Film Strip.	
Surface area	Sp. Gr. Briq.	M. V. S.	
Sp. Gr. Comp.	Cohesiometer	Moisture	

Corrected to 100%	Less 2% -200 material	Screened to pass ¾" sieve		As Received	Ret. Crushed	As Used By Vol.	As Used By Wt.	Specif. Limits Sought
			1½					
			1¼					
			1	100				100
100	98	100	¾	97		100	100	95-100
			½					
73	72	74	⅜	72		72	73	67-85
			3					
53	52	54	4	52		51	53	50-65
46	45	47	8	46		44	46	37-50
36	35	37	16	36		35	36	
28	27	29	30	28		27	28	18-28
18	18	20	50	19		17	18	
12	12	14	100	14		12	12	
8	8	10	200	10		8	8	3-8
7	7	9	270	9		7	7	
			⅕ Micron					
			1 Micron					
			Bitumen					
			Weight Sample					
			F. Sp. Gr.	2.59				
			C. Sp. Gr.	2.36				

Surface Area Factors	Surface Area
Note: All surface area factors must be used in calculations	
	2.0
2	1.0
4	1.8
8	2.8
14	3.8
30	6.1
60	7.2
80	6.4
100	7.0
Surface Area Sq. Ft./Lb.	371

Wt. in Air	
Wt. in Water	
Volume	
Field Comp. Sp. Gr.	
Stand. Lab. Sp. Gr.	
Relative Compaction	

Specimen	A	B	C	D	E	F	Specif.
Temperature							
Moisture							
Bit. Grade		85-100 Penetration Asphalt					
Bit. Ratio	6.9	7.5	8.1		7.5		
Sp. Gr. Briq.	2.11	2.15	2.18				
STABILOMETER							
	47	36	12				35
COHESIOMETER							
	314	438	516				
Rt VALUE							
	100	100	88				
SUSCEPTIBILITY TO WATER							
Swell (24 hrs.)		.006			.008		.030
Permeability		75			50		
SUSCEPTIBILITY TO MOISTURE VAPOR							
No. Cycles							
Moist. Absorb.							
Stabilometer							
Cohesion							

Passing No. 200 by Dry Sieving— =

Passing No. 200 by Washing—

Film Stripping (on coarse aggregate)— Stripping Min. ° F.

Centrifuge Kerosene Equivalent Values: F= 6.4 C= 5.9

Kc= 2.25 Kf= 1.45 Km= 1.65

Theoretical Bitumen Ratio for Grade 2 Bitumen= %

Theoretical Bitumen Ratio for Grade Bitumen= %

Theoretical Oil Index Curve No.

Optimum Bitumen Content, Considering All Test Data: 6.5 to 7.0 %

Recommended K—value to

Equiv. Gal. Bit. Per Sq. Yd. for 1" Comp. Surf. = 5.62 × ( ) × =

Crushed Particles = %

Grading As Used Was Obtained by Combining Samples as Follows:

% By Wt.	% By Vol.	Test No.	Field No.	Description

REMARKS: Example showing a mix becoming critical to increasing asphalt content due to increased density.

~~7.5% Bit.~~ $= \frac{51}{2.59} + \frac{49}{2.36} + \frac{7.5}{1.03} = \frac{107.5}{47.8} = 2.25$ $\frac{2.15}{2.25} = 95.5$ Rel. Dens.

~~8.1% Bit.~~ $= \frac{51}{2.59} + \frac{49}{2.36} + \frac{8.1}{1.03} = \frac{108.1}{48.4} = 2.23$ $\frac{2.18}{2.23} = 97.8$ Rel. Dens.

See back of card for cumulative weights used in making test specimen.

Test No._____ Type Bitumen_____ Bit. No._____ Temp. Bit._____ ° F. Temp. Aggregate_____ ° F.

WEIGHT SAMPLE	1000 GRAMS	1200 GRAMS
Test No.		
1"		
1"-¾		
¾-½		
½-⅜	270	324
⅜-4	470	564
4-Dust	1000	1200
Gms. Oil for 1000 gm. S.		
" " " " "		
" " " " "		

Calculated by _____ Date _____

Prepared by _____ Date _____

INSTRUCTIONS

REMARKS FROM STABILOMETER SHEETS

Spec.	
A	
B	
C	
D	
E	
F	

Cohesion _____

Remarks:

Tested by _____

Remarks:

Test No. _____ Type Bitumen _____ Bit. No. _____ Temp. Bit. _____ ° F. Temp. Aggregate _____ ° F.

WEIGHT SAMPLE	1000 GRAMS						1200 GRAMS						INSTRUCTIONS
Test No.	4539	4540	4541	4542	4543		4539	4540	4541	4542	4543		
1"													
1"-¾													
¾-½	212						255						
½-⅜	409	478	625				491	574	750				
⅜-4	447	562	644	772			536	675	773	927			
4-Dust	470	620	770	970	1000		564	744	924	1165	1200		
Gms. Oil for 1000 gm. S.							Calculated by			Date			
" " " " "							Prepared by			Date			
" " " " "													

REMARKS FROM STABILOMETER SHEETS	
Spec.	
A	
B	
C	
D	
E	
F	
Cohesion	
Remarks:	
Tested by	

Remarks:

Test No. _____ Type Bitumen _____ Bit. No. _____ Temp. Bit. _____ ° F. Temp. Aggregate _____ ° F.

WEIGHT SAMPLE	1000 GRAMS						1200 GRAMS					
Test No.												
1"												
1"-¾	110						132					
¾-½												
¾ ½-⅜	220						264					
⅜-4	330						396					
4-Dust	1000						1200					
Gms. Oil for 1000 gm. S.							Calculated by			Date		
" " " " "							Prepared by			Date		
" " " " "												

INSTRUCTIONS

REMARKS FROM STABILOMETER SHEETS	
Spec.	
A	
B	
C	
D	
E	
F	

Cohesion

Remarks:

Tested by

Remarks:

Test No._____ Type Bitumen_____ Bit. No._____ Temp. Bit._____° F. Temp. Aggregate_____° F.

WEIGHT SAMPLE	1000 GRAMS						1200 GRAMS					
Test No.												
1"												
1"-¾												
¾-½												
½-⅜	300						360					
⅜-4	500						600					
4-Dust	1000						1200					
Gms. Oil for 1000 gm. S.							Calculated by			Date		
" " " " "							Prepared by			Date		
" " " " "												

INSTRUCTIONS

REMARKS FROM STABILOMETER SHEETS	
SPEC.	
A	
B	
C	
D	
E	
F	
COHESION	
REMARKS:	
Tested by	

REMARKS:

Test No._____ Type Bitumen_____ Bit. No._____ Temp. Bit._____° F. Temp. Aggregate_____° F.

WEIGHT SAMPLE	1000 GRAMS						1200 GRAMS						INSTRUCTIONS
Test No.	Un-Crushed	Crushed					Un-Crushed	Crushed					
1"													
1"-¾													
¾-½													
½-⅜	80	520					96	624					
⅜-4	160	650					192	780					
4-Dust	330	1000					396	1200					
Gms. Oil for 1000 gm. S.							Calculated by		Date				
" " " " "							Prepared by		Date				
" " " " "													

REMARKS FROM STABILOMETER SHEETS	
Spec.	
A	
B	
C	
D	
E	
F	
Cohesion	
Remarks:	
Tested by	

Remarks: