WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

SOUNDNESS OF AGGREGATES USING SODIUM SULFATE

1.0 PURPOSE

1.1 To establish a procedure testing aggregates for soundness following guidelines set forth by AASHTO T-104.

2.0 SCOPE

2.1 This procedure is designed to determine resistance to disintegration by saturated solution of sodium sulfate in both coarse and fine aggregates.

3.0 APPLICABLE DOCUMENTS

3.1 AASHTO T-104

4.0 APPARATUS

4.1 Mechanical Sieving Device - The mechanical sieving device shall be capable of providing a means of a lateral motion of the sieve, accompanied by a jarring action so as to keep the sample moving continuously over the surface of the sieve.

5.0 SPECIAL SOLUTION REQUIRED

5.1 Prepare the sodium sulfate solution for immersion of test samples in accordance with AASHTO T-104, Section 4.1 and 4.1.1 (Notes 2 and 3).

NOTE: After the new sulfate solution has been maintained at the designated temperature for at least 48 hours and prior to use, it is recommended that crushed limestone be introduced into the new sulfate solution for an additional 48 hour period. This is to prevent any harmful chemical reaction which may occur between the carbonates and the freshly prepared sulfate solution.

6.0 SAMPLES

6.1 Fine Aggregate

6.1.1 Before starting a test, all equipment especially sieves, shall be inspected, adjusted and cleaned as necessary.

6.1.2 A representative portion shall be split from the field sample by means of a sample splitter or quartering. The test portion shall be of such size that it will yield not less than 120 gms of each of the following sieve fractions which are present in amounts of 5 percent or more in accordance with the mid-band grading of standard aggregate sizes for fine aggregates.

Passing Sieve	Retained Sieve
9.5 mm	4.75 mm
4.75 mm	2.36 mm
2.36 mm	1.18 mm
1.18 mm	600 um
600 um	300 um

6.2 Coarse Aggregate

6.2.1 Before starting a test, all equipment, especially sieves, shall be inspected, adjusted and cleaned as necessary.

6.2.2 A representative portion shall be split from a field sample by means of a sample splitter or quartering.

6.3 The test portion shall consist of material from which the sizes finer than the 4.75 mm sieve have been removed.

6.3.1 The sample shall be of such a size that it will yield the following amounts of the different sizes that are available in amounts of 5 percent or more:

Sieve Test Portions	Weight (gms)
63 mm to 3.75 mm	5000 $\pm$ 300
Consisting of:	
63 mm to 50 mm material	3000 $\pm$ 300
50 mm to 3.75 mm material	2000 $\pm$ 200

Sieve Test Portions	Weight (gms)
37.5 mm to 19 mm	1500 ± 50
Consisting of:	
3.75 mm to 25 mm material	1000 ± 50
25 mm to 19 mm material	500 ± 30
19 mm to 9.5 mm	1000 ± 10
Consisting of:	
19 mm to 12.5 mm material	670 ± 10
12.5 mm to 9.5 mm material	330 ± 5
9.5 mm to 4.75 mm	300 ± 5

6.3.2 When setting up test portions in accordance with Section 6.3.1, such as combining 25 mm and 19 mm material, should there be insufficient material of one of these sizes or should there be no material at all of one of these sizes; then the other size, such as the 19 mm material, shall be used to make up the difference or whole amount of the test portion.

6.3.3. When test portion sizes are not available in sufficient quantities to make up the desired test portion, then those sizes shall not be tested.

6.4 For purposes of evaluating the entire sample, test portion sizes that are not tested will be calculated in accordance with Section 11.7.1.

6.5 When an aggregate sample contains both fine and coarse material, the fine and coarse fractions shall be tested separately. Each fraction shall be prepared and tested in accordance with the procedures for fine aggregate and coarse aggregate, respectively (6.1 and 6.2).

6.5.1 Calculate and report test results by combining the final results of both the coarse and fine aggregate test fractions. Calculations are based on mid-band gradings of standard aggregate sizes as found in Table 1.

7.0 PREPARATION OF TEST SAMPLES

7.1 The fine aggregate shall be washed over a 300 um sieve. Washing shall be continued until the wash water becomes clear, the material retained on the 300 um sieve shall be dried to a constant weight at 230 ± 9 °F (110 ± 5 °C).

7.1.2 The washed portion shall be separated into different sizes by sieving as follows: Make a rough grading of the sample by means of a set of nested sieves as specified in 6.1.2 by mechanically sieving for 5 minutes. From the fractions obtained in this manner, select samples from each sieve of sufficient size to yield not less than 100 grams. (Generally, a 120 gram sample will be sufficient.) Renest the sieves with intermediate retainer pans to prevent intermingling and mechanically shake for 10 minutes, then check for thoroughness of sieving as defined in AASHTO T-27, Paragraph 7.4. If necessary, continue sieving until the requirements of Paragraph 7.4 are met.

7.1.3 Weigh out test portions of 100 ± 0.5 grams from each of the separated sieve fractions. Record initial weights to nearest 0.1 gram.

7.1.4 Fine aggregate sticking in the meshes of the sieves shall not be used in preparing the test portion. Carefully clean the sieves after each use by removing and discarding any particles sticking in the meshes of the sieves.

7.1.5 Place the individual test portions into separate containers for testing. Containers for all fractions finer than the 4.75 mm sieve shall be the standard 76 mm diameter testing sieves, with two sieves nested to completely enclose the sample. Screen sizes to be used with each fraction are as follows:

Test Portion Sieve Size	Container Sieve Size
19 mm - 4.75	See note in Paragraph 10.1.2.1
4.75 mm - 2.36 mm	2 mm
2.36 mm - 1.18 mm	850 μm
1.18 mm - 600 μm	425 μm
600 μm - 300 μm	250 μm

7.2 Coarse Aggregate

7.2.1 The coarse aggregate sample shall be mechanically sieved for 10 minutes or hand sieved to refusal until none of the particles being sieved are passed in one minutes time, so as to yield sufficient quantities of the different sizes within the tolerances of Paragraph 6.3.1.

NOTE: Finger manipulation of the particles may be used to determine refusal.

7.2.2 Thoroughly wash the individual fractions over a 4.75 mm screen and dry to constant weight at a temperature of 230 ± °9 OF (110 ± 50 °C).

7.2.3 Weigh out the amounts required for test portions as specified in Paragraph 6.3.1. Record the initial weights to the nearest gram.

7.2.4 Place the test portions into separate containers for testing.

NOTE: Containers for the 9.5 mm to 4.75 mm fraction shall be constructed of 3.2 mm galvanized hardware cloth with dimensions approximately 76 mm x 76 mm x 51 mm deep. Containers for 19 mm to 9.5 mm fractions shall be constructed of 6.4 mm galvanized hardware cloth with dimensions approximately 114 mm x 140 mm x 38 mm deep. Containers for the plus 19 mm fractions shall be constructed of 6.4 mm galvanized hardware cloth with dimensions approximately 114 mm x 165 mm x 76 mm deep.

7.3 Ledge rock submitted for testing before final commercial preparation shall be crushed. Testing shall be performed in accordance to Section 7.2.

7.4 Stone for riprap, special rock fill, rock gutter, etc. shall be tested in accordance with their intended use. Representative test portions shall be selected from the sample and tested as follows: The sample shall be thoroughly washed and dried to a constant weight at a temperature of 230 ± 9 °F (110 ± °C). Allow the sample to cool to room temperature. Weigh out a test portion of 12,000 grams ± 1000. Record the initial weights to the nearest gram. Place the test portion into suitable containers for testing.

8.0 PROCEDURE

8.1 The samples shall be immersed in the prepared solution of sodium sulfate for not less than 16 hours nor more than 18 hours in such a manner that the solution covers them to a depth of at least 12.7 mm.

NOTE: Suitably weighted wire grids placed over the sample containers will prevent lightweight aggregates from floating out of the container.

8.2 The solution should be covered to reduce evaporation and prevent the accidental addition of extraneous materials into the test portions.

8.3 The samples shall remain immersed in the solution at a temperature of 70 ± 2 °F (21 ± 1 °C) for the immersion period.

8.4 Remove the test portions from the solution and allow to drain for 15 ± 5 minutes, and then place in the drying oven. The temperature of the oven shall have been brought previously to 230 ± 9 °F (110 ± 5 °C). Dry samples at the specific temperature until constant weight has been achieved.

NOTE: Time required to establish a condition of constant weight can be attained as follows: With the oven containing the maximum sample load expected, check the weight losses of test samples by removing and weighing them, without cooling, at intervals of 2 to 4 hours, make enough checks to establish required drying time for the least favorable oven location (See AASHTO T-104) and sample condition. A condition of constant weight will be considered to have been achieved when weight loss is less

than 0.1 percent of sample weight in 4 hours of drying. When such a determination has been made, samples may be considered to have attained a constant weight when they have been dried at the specified temperature for an equal or longer period of time than that which has previously been found to be adequate for producing the desired constant weight condition under equal or heavier loading conditions of the oven.

8.5 After removal of the test portions from the solution, the specific gravity and temperature of the solution shall be determined and recorded. Any necessary adjustments to the specific gravity and temperature can be made upon removal of the test portions from the solution.

8.6 After drying, allow samples to cool to room temperature, when they shall again be immersed in the prepared solution as described in 8.1.

NOTE: If the test must be continued over a weekend, leave the samples in an oven-dried condition (constant weight) at room temperature and resume the cycles on the next work day.

8.7 Repeat the steps outlined in Paragraphs 8.1 through 8.6 until five immersions and drying cycles have been completed.

NOTE: It is recommended that a record be kept of the number of cycles that each test portion undergoes to prevent over or under cycling.

9.0 QUANTITATIVE EXAMINATION

9.1 After the final drying cycle, cool the test portions to room temperature. Wash the test portions free of the sodium sulfate solution by soaking the test portions in a circulatory bath of water at 110 $\pm$ 10 °F (43 $\pm$ 6 °C) for one hour or more as determined by the reaction of the rinse water with barium chloride ($BaCL_2$). If reaction occurs, as evidenced by a milky, white precipitate, continue washing and rinsing. Washing may be considered complete when no reaction occurs. In the washing operation, the samples shall not be subjected to impact or abrasion that may tend to break up particles.

NOTE: The washing procedure may be accomplished more effectively if the test portions were placed in the bottom of a tank where hot water may be introduced near the bottom and allowed to overflow.

9.1.1 After the sodium sulfate solution has been removed, each fraction of the sample shall be dried to a constant weight at 230 ± 9 °F (110 ± 5 °C). When the test portions have dried, allow them to cool to room temperature.

9.1.2 Mechanically sieve the fine aggregate fraction for 10 minutes over the same sieves with intermediate retainer pans as specified in Paragraph 6.1.2. Weigh the residue retained after sieving, including all material cleaned from the meshes of the screen to the nearest 0.1 gram and record.

9.1.3 Hand sieve the coarse aggregate fraction over the sieve shown below for the appropriate size of particle:

Size of Aggregate	Sieve Used to Determine Loss
63 to 27.5 mm	31.5 mm
37.5 mm to 19.0 mm	16 mm
19 mm to 9.5 mm	8.0 mm
9.5 mm to 4.75 mm	4.0 mm

9.1.4 Hand sieving shall be conducted with agitation sufficient only to assure that all ~undersize material passes the designated sieve. No extra manipulation shall be employed to break up particles or cause them to pass the sieves. Weigh the residue retained after sieving, including all material cleaned from the meshes of the screen to the nearest gram and record.

9.1.5 Ledge rock examination shall be conducted in the same manner as for any coarse aggregate using the appropriately designated sieve shown above for the appropriate sized particles. Weigh to the nearest gram and record.

9.1.6 Stone for riprap, special rock fill, rock gutters, etc., requires no hand sieving. Weigh sample to the nearest gram and record.

NOTE: The difference between each of these amounts and the initial weight of the fraction of the sample tested is the loss in the test and is to be expressed as a percentage of the initial weight.

10.0 MID-BAND GRADATION REQUIREMENTS

10.1 Fine Aggregate

10.1.1 The gradation used to calculate the weighted percentage loss shall normally be a mid-band grading of standard sized fine aggregate as follows:

Sieve Size	Mid-Band Grading for Fine Aggregate (Percent Retained)
9.5 mm - 4.75 mm	2 (NOTE)
4.75 mm - 2.36 mm	20
2.36 mm - 1.18 mm	16
1.18 mm - 600 mm	23
600 mm - 300 mm	20

10.1.2 Mortar Sand

10.1.2.1 The gradation used to calculate the weighted percentage loss for mortar sand shall normally be a mid-band grading of a standard mortar sand as follows:

Sieve Size	Mid-Band Grading for Mortar Sand (Percent Retained)
4.75 mm - 2.36 mm	5 (NOTE)
2.36 mm - 1.18 mm	31
1.18 mm - 600 mm	21
600 mm - 300 mm	17

NOTE: If the fraction retained on the 4.75 mm (or a 2.36 mm for mortar sand) is not available in the amount of 5 percent or more, it shall not be tested. However, in calculating the weighted percentage loss, the 4.75 mm (or 2.36 mm for mortar sand) is assumed to have the same loss as the fraction retained on the next smaller sieve.

10.2 Coarse Aggregate

10.2.1 The gradation used to calculate the weighted percentage loss shall be the mid-band grading of the standard size of aggregates being tested. Table I lists the mid-band grading of the standard sizes commonly used.

10.3 The gradation used to calculate the weighted percentage loss for aggregate consisting of a combination of coarse and fine fractions shall be the mid-band grading of the sizes of aggregate being tested. Table I lists ~gradings for Concrete Aggregates, Base Course Aggregates, Classes 1, 2, 7, 8, and 9.

10.4 The percentage loss for stone and riprap, rock gutter, special rock fill, etc., shall be the total percentage loss of the test portion. No weighting will be necessary.

10.5 The gradation used to calculate the weighted percentage loss when the standard size is unknown shall be governed by the largest size particle present in the test portion, as listed in Table II.

11.0 CALCULATIONS

11.1 The report shall include the following data:

NOTE: Refer to Form HS-9

11.2 Mid-band grading (A) of standard sized aggregates as listed in Tables I and II.

11.3 The weight of each sieve fraction before testing is expressed as an initial weight B).

11.4 The weight of each sieve fraction of each sample retained after sieving is expressed as a final weight (C).

11.5 The weight loss (D) of each fraction of each sample is the difference between the initial sieve fraction weight (B) and the final sieve fraction weight (C).

$$D = (B - C)$$

11.6 The percentage of loss (E) is calculated for each sieve fraction, as a quotient of the weight loss (D) and the initial weight (B) of each sieve fraction.

$$E = D/B \times 100$$

11.7 The weighted percentage loss (F) is calculated for each sieve fraction, as a product of the percentage of loss (E) and the mid-band grading (A) of the sample as received for examination.

$$F = E \times A/100$$

11.7.1 For the purpose of calculating the weighted percentage loss, consider any sizes in 6.1.2 and 6.3.1 that contain less than 5 percent of the sample to have the same loss as the average of the next smaller and the next larger size; or if one of these sizes is absent to have the same loss as the next larger or next smaller size whichever is present.

11.7.2 The weighted percentage loss shall be calculated to the nearest 0.1 percent.

11.7.3 Sizes finer than the sieve (0.300 μm) shall be assumed to have 0 percent loss.

11.8 The total weighted percentage loss is calculated as the sum of each weighted percentage loss (F) of each sieve fraction.

11.9 For aggregates containing appreciable amounts of both fine and coarse material calculate their weighted percentage losses collectively for both the minus 4.75 mm and plus 4.75 mm fractions based on their mid-band gradings, considering both the fine and coarse fractions combined as 100 percent. Report the results jointly giving the percentage of the minus 4.75 mm and plus 4.75 mm material as one sample.

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