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DIVISION OF ENGINEERING SERVICES
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METHOD OF TEST FOR THE SOUNDNESS OF AGGREGATES BY USE OF SODIUM SULFATE

CAUTION: Prior to handling test materials, performing equipment setups, and/or conducting this method, testers are required to read "**SAFETY AND HEALTH**" in Section J of this method. It is the responsibility of the user of this method to consult and use departmental safety and health practices and determine the applicability of regulatory limitations before any testing is performed.

A. SCOPE

The procedure to be followed when testing aggregates to determine their resistance to disintegration by saturated solutions of sodium sulfate is described in this method. This method is a modification of AASHTO Designation: T 104.

B. APPARATUS

1. Sieves: Standard sieves conforming to AASHTO Designation: M 92 are required. The sieves sizes shall consist of the following: 2½ in., 2 in., 1½ in., 1 in., ¾ in., ½ in., ⅜ in., ¼ in., No. 4, No. 8, No. 16, No. 30, No. 50, No. 100, and No. 200.

2. Sieve shaker: A mechanical sieve shaker must conform to the requirements for thoroughness of sieving as defined in California Test 202.

3. Sample containers: Wire screen baskets are required for immersing the aggregate samples in the solution. The wire screen and frames shall be made of corrosion-resistant metal such as brass, bronze, or stainless steel. The openings in the screen shall be smaller than the openings of the sieve that will be used to determine the percent loss at the end of the test. Sample baskets shall have a bail suitable for suspending them from brackets while in the solution and in the oven.

4. Balance: A 25-kg balance, or larger, is required. It shall be sensitive to 0.1 % of the sample mass.

5. Drying oven: A vented, forced-draft oven capable of maintaining a temperature of 230 ± 9°F is required. The interior of the oven shall be equipped with racks designed to suspend the sample baskets above the shelves allowing free circulation of air around and under the baskets.

6. Immersion tank: A suitable solution container is required for immersing samples. The container shall be of such height that the solution covers the samples in the sample containers to a depth of at least ½ in., and of such capacity that it will hold a volume of solution equal to at least five times the total volume of the samples immersed at any one time. Protection against the accidental addition of extraneous substances shall be provided. An enclosed cabinet housing the immersion tank or individual covers over the sample baskets are both satisfactory methods of protection.

C. MATERIALS

1. Saturated sodium sulfate solution: The sodium sulfate solution shall be prepared by dissolving a C.P., U.S.P., or equal grade of the salt in water at a temperature of 77 to 86°F. Sufficient salt of either the anhydrous (Na_2SO_4) or the crystalline ($Na_2SO_4 \cdot 10H_2O$) form, shall be added to ensure not only saturation, but also the presence of excess crystals when the solution is ready for use in the tests. The mixture shall be thoroughly stirred during the addition of the salt and the solution shall be stirred at frequent intervals until used. The solution shall be cooled to a temperature of 70 ± 2°F and maintained at the temperature for at least 48 hours before use. The solution shall again be thoroughly stirred immediately before use and, when used, shall have a specific gravity of not less than 1.151 and not greater than 1.174.

   For the solution, 215 g of anhydrous salt or 700 g of the decahydrate per liter of water are sufficient for saturation at 72°F. However, since these salts are not completely stable and since it is desirable that an excess of crystals be present, the use of not less than 225 g of the anhydrous salt or 750 g of the decahydrate salt for each liter of water is recommended.

2. Barium chloride, approximately 10 % solution, is required.

D. CONTROL

The temperature of the solution during testing shall be maintained at 70 ± 2°F.

E. PREPARATION OF SAMPLE

1. Fine aggregate

   a. Split or quarter a representative portion of material of sufficient size to yield not less than 100 g of each of the following sizes after washing:

Passing Sieve Size	Retained Sieve Size
No. 4	No. 8
No. 8	No. 16
No. 16	No. 30
No. 30	No. 30
No. 50	No. 100

   b. Wash the sample to remove all coatings. Washing may be done by any means, which will accomplish thorough cleaning without degrading the material. Inundating the sample in a pan of water and stirring by hand is an accepted method. Washing shall be continued until the water passing through or being poured off the sample is clear. All wash water shall be passed through a No. 100 sieve and all material retained on the sieve shall be returned to the sample.

   c. Dry to constant mass at 230 ± 9°F.

   d. Divide the sample into representative portions for sieving.

   e. Sieve the individual portions to refusal on the sieves listed above until the required 100 g fractions are obtained. Do not use the aggregate sticking in the meshes of the sieves.

   f. Weigh out 100 g test portions from each aggregate size and place in separate sample containers.

2. Coarse aggregate

   a. Separate the aggregate on the sieve sizes listed in B-1 and determine the amount of each size fraction.

b. Split or quarter a test portion meeting the mass requirements shown below for each size fraction, which makes up 5 percent or more of the submitted sample.

WEIGHT OF TEST PORTIONS
SCHEDULE A

Aggregate Size		Weight* (g)
Passing Sieve Size	Retained Sieve Size	
2 ½ in.	2 in.	24,000
2 in.	1 ½ in.	16,000
1 ½ in.	1 in.	12,000
1 in.	¾ in.	2,000
¾ in.	½ in.	1,500
½ in.	⅜ in.	1,000
⅜ in.	No. 4	600

SCHEDULE B

Aggregate Size		Weight* (g)
Passing Sieve Size	Retained Sieve Size	
2 ½ in.	2 in.	3,000
2 in.	1 ½ in.	2,000
1 ½ in.	1 in.	1,500
1 in.	¾ in.	1,000
¾ in.	½ in.	750
½ in.	⅜ in.	500
⅜ in.	No. 4	300

* The mass of the test portion may be reduced according to Schedule B when the soundness loss on the previous sample from the same source is less than 5 %. Any material tested according to mass Schedule B shall be retested using the mass specified in Schedule A when the determined loss is 5 % or more. All sources for which previous test data is not available shall be tested according to Schedule A.

c. Wash the individual test portions to remove all coatings.

d. Dry to constant weight at 230° ± 9°F.

e. Resieve each test portion to refusal on the respective retaining sieve.

f. Weigh and record each test portion and place in separate sample containers.

F. TEST PROCEDURE

1. Immerse the test samples in the sodium sulfate solution for 17 ± 1 h. Suspend the sample containers from racks over the tank in such a manner that the solution covers the samples to a minimum depth of ½ in.

2. Remove the samples from the solution and allow to drain for about 15 min.

3. Dry to constant mass at 230° ± 9°F and cool to room temperature.

   a. Suspend the sample containers from the racks in the oven.

   b. The oven shall not be used for any other purpose while it is being used to dry soundness test samples.

4. Repeat the immersion, drying, and cooling for a total of five complete cycles.

5. After completion of the fifth cycle, immerse the test samples in a continuous flow of fresh, water at 110 ± 10°F until all of the sodium sulfate has been removed

   a. The presence of sodium sulfate in the wash water can be detected by the reaction of the wash water with barium chloride ($BaCl_2$). Cloudiness indicates the presence of sodium sulfate.

6. Dry to constant mass at 230° ± 9°F and cool to room temperature.

7. Sieve each test sample to refusal over a sieve having square openings one-half the size of the sieve on which the aggregate was originally retained. Weigh the particles retained on this sieve and record the mass.

G. CALCULATION OF SOUNDNESS LOSS

1. Individual Test Portions.

   a. Compute the "Percentage Loss" for each test portion using the equation:

Percentage loss = [(Wo - Wf)/ Wo] x 100Where:

Wo = Original mass of the test sample, to the nearest 1 g

Wf = The mass of aggregate retained on the half size sieve after the sample has been tested to the nearest 1 g

b. Size fractions which amount to less than 5 % of the total sample shall be considered to have the same loss as the average of the next smaller and next larger sizes. If one of these sizes is absent, use the loss of the portion, which is present.

2. Weighted Average Loss of Coarse Aggregate.

a. Determine the total sample percentage that each size fraction represents.

b. Multiply the percent for each size by the percentage loss determined for that size.

c. To determine the weighted average percentage loss of the sample, divide the sum of the products for the percent of each size and its respective percent loss by the sum of the percents for each size.

d. Example:

Size Fractions in Sample	A % of Each Size in As Rec'd Grading	B % Loss of Each	C Products of A & B
1 in. x ¾ in.	4*	7.5	30.0
¾ in. x ½ in.	32	7.5	240.0
½ in. x ⅜ in.	24	6.4	153.6
⅜ in. x No. 4	35	8.0	280.0
Total	95		703.6

Weighted Average Percent Loss: 703.6/95 = 7.4

* Not tested size represents less than 5 % of total sample.

3. Batch Soundness Loss of Coarse Aggregate.

a. The "batch soundness loss" is the combined loss of each primary size of coarse aggregate being used in the mix.

b. The "batch soundness loss" may be used only when the loss for one primary size exceeds the maximum allowable loss by not more than 2 %.

c. Calculate the batch soundness loss using the weighted average basis shown below regardless of the actual proportions to be used.

2½ in. Maximum	
2½ in. x 1½ in.	34%
1½ in. x ¾ in.	33%
1 in.x No. 4	33%

1½ in. Maximum	
1½ in. x ¾ in.	67%
1 in.x No. 4	33%

d. Example:

Primary Aggregate Size	Percent Loss	Weighted Percentage	
1½ in. x ¾ in.	11.8	67	=7.9
1 in. x No. 4	6.1	33	=2.0
Batch Soundness Loss			9.9

4. Weighted Average Loss of Fine Aggregate.

a. Use the following standard size distribution regardless of the actual sample grading:

Size Fraction	Total Sample (%)
No. 4 x No. 8	22
No. 8 x No. 16	19
No. 16 x No. 30	24
No. 30 x No. 50	20
No. 50 x No 100	15

b. Multiply the loss determined for each size by the percent of the total sample shown in "a" above and divide the product by 100 to

determine the loss of each fraction as a percentage of the total sample.

c. Example:

Size Fraction	Percent of Total Sample	Percent Loss of Each Size	Percent Loss on Total Sample Basis
No. 4 x No. 8	22	4.7	1.0
No. 8 x No. 16	19	4.2	0.8
No. 16 x No. 30	24	3.6	0.9
No. 30 x No. 50	20	4.0	0.8
No. 50 x No. 100	15	8.1	1.2
Weighted Average Percent Loss			4.7

H. PRECAUTIONS

1. Be sure that the aggregate is both clean and dry prior to subjecting it to the first cycle of the test because the solution must have free access to any cracks or crevices in the aggregate particles.

2. The aggregate must be completely dried during the drying phases of the test procedure.

3. Do not place aggregate in the solution until it has cooled to room temperature. Some aggregates may split and disintegrate when subjected to sudden temperature changes, and warm aggregate can cause objectionable increases in the temperature of the sodium sulfate solution.

4. Be sure to use sample baskets with openings smaller than the openings of the sieve that will be used at end of test for the determination of the percent loss.

5. Check both the specific gravity and the temperature of the solution daily, as test reproducibility will be seriously affected if the specific gravity and/or the temperature are allowed to vary from the specified requirements.

I. REPORTING THE RESULTS

Report the weighted average percentage loss for the coarse and fine aggregate and the Batch Soundness Loss when necessary. When reporting the Batch Soundness Loss includes the Test Number and Soundness Loss of each primary size of coarse aggregate used in the computation.

J. SAFETY AND HEALTH

Aggregates may contain bacteria and/or organisms, which can be harmful to one's health. The wearing of dust masks and protective gloves when handling materials is advised.

Heat-resistant gloves are required for removing samples from the ovens.

The dust from sodium sulfate or barium chloride, in the crystalline or powder form, may cause irritation of the eyes, nose, throat and bronchial tubes. Repeated or prolonged contact with skin may also cause irritation. Eye or skin contact by these salt solutions may also cause irritation.

Use of dust masks, protective eyewear and protective gloves are recommended when mixing solutions. Protective eyewear and gloves are advised when handling solutions.

First aid for any eye contact involves flushing the eyes, including under the eyelids, with running water for 15 min and seeking medical attention. For skin contact, flush affected area with water, wash with soap and water, and seek medical attention if irritation exists.

Barium chloride is a poison. If ingested, induce vomiting, if person is conscious. If available, give one tablespoon of epsom salt (MgSO4) in a glass of water and seek medical attention.

Prior to handling, testing or disposing of any materials, testers are required to read Caltrans Laboratory Safety Manual - Part A, Section 5.0, Hazards and Employee Part B, Sections: 5.0, Safe Laboratory Practices; 6.0, Chemical Procurement Distribution and Storage; and 10.0, Personal Protective

Apparel and Equipment; and Part C, Section 1.0; Safe Laboratory Practices. Users of this method do so at their own risk.

REFERENCES:
AASHTO Designations: M 92 & T 104

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(California Test 214 contains 6 Pages)