

	NEW YORK STATE DEPARTMENT OF TRANSPORTATION MATERIALS BUREAU ALBANY, NY 12232	Method No.: 703-07P,G Issue Date: February 1, 1993 Subject Code: 7.42-5
<h2>TEST METHOD</h2>		
SUBJECT: STANDARD TEST METHOD FOR SOUNDNESS OF COARSE AGGREGATES BY USE OF MAGNESIUM SULFATE		
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1. SCOPE

1.1 This method covers the procedure to be followed in testing coarse aggregates to determine their resistance to disintegration by a saturated solution of magnesium sulfate. It furnishes information helpful in judging the soundness of aggregates subject to weathering action, particularly when adequate information is not available from service records of the material exposed to weathering conditions. The format and wording of this method is similar to AASHTO T 104.

2. REFERENCE DOCUMENTS

2.1 AASHTO Standard:

M 92 Wire cloth sieves for testing purposes

2.2 ASTM Standards:

E 11 Wire cloth sieves for testing purposes

E 100 Specification for ASTM Hydrometers

C 295 Standard Recommended Practice for PETROGRAPHIC EXAMINATION OF AGGREGATES FOR CONCRETE

3. APPARATUS

3.1 Sieves - With square openings of the following sizes conforming to AASHTO M 92 or ASTM E 11, for sieving the samples in accordance with sections 5, 6 and 8:

4.75mm (No. 4)	12.5mm (1/2 in.)
6.3mm (1/4 in.)	19.0mm (3/4 in.)
9.5mm (3/8 in.)	25.0mm (1 in.)

3.2 Containers - Baskets for immersing samples of aggregate in solution, in accordance with the procedure described in this method, shall be made entirely of stainless steel with wire mesh sides and bottoms, permitting free access of the solution to the sample, and drainage of solution from the sample without loss of aggregate. The baskets shall be a minimum of 15.24cm (6 in.) in diameter and 15.24cm (6 in.) high, for No. 2 sized aggregate, and a minimum of 10.16cm (4 in.) in diameter and 15.24cm (6 in.) high, for No. 1 sized aggregate.

3.3 Temperature Regulation - Suitable means for regulating the temperature of the samples during immersion in the magnesium sulfate solution shall be provided. A circulation tank with a filter and a cover to reduce evaporation and prevent the accidental addition of extraneous substances is preferred.

3.4 Balance - The balance shall conform to AASHTO M 231, Class G5.

3.5 Drying Oven - The oven shall have circulating fans and shall be capable of being heated continuously at $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$). The rate of evaporation, at this range of temperature shall average at least 25 g/h for 4 h, during which period the doors of the oven shall be kept closed. This rate shall be determined by the loss of water from 1-liter Griffin low-form beakers, each initially containing 500 g of water at a temperature of $21 \pm 2^{\circ}\text{C}$ ($70 \pm 3^{\circ}\text{F}$), placed at each corner and the center of each shelf of the oven. The evaporation requirement is to apply to all test locations when the oven is empty except for the beakers of water.

3.6 Specific Gravity Measurement - A hydrometer conforming to the requirements ASTM E 100, or a suitable combination of graduated glassware and balance, capable of measuring the solution specific gravity within ± 0.001 shall be used.

4. Magnesium Sulfate Solution

4.1 Prepare the solution of magnesium sulphate for immersion of test samples in accordance with Section 4.1.1. The volume of the solution shall at least be five times the solid volume of all samples immersed at any one time.

4.1-1 Magnesium Sulphate Solution - Prepare a saturated solution of magnesium sulfate by dissolving a USP or equal grade of the salt in water at a temperature of 25 to 30°C (77 to 86°F). Add sufficient salt (Note 1), of either the anhydrous (MgSO_4) or the crystalline ($\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$) (Epsom salt) form to ensure saturation and the presence of excess crystals when the solution is ready for use in the tests. Thoroughly stir the mixture during the addition of the salt and stir the solution at frequent intervals until used. To reduce evaporation and prevent contamination, keep the solution covered at all times when access is not needed. Allow the solution to cool to $23.3 \pm 0.6^{\circ}\text{C}$ ($74.0 \pm 1.0^{\circ}\text{F}$). Again, stir and allow the solution to remain at the designated temperature for at least 48 hours before use. Prior to each use, break up the salt cake in the container, if any, stir the solution thoroughly, and determine the specific gravity of the solution. When used, the solution shall have a specific gravity of 1.300 ± 0.002 and a temperature of $23.3 \pm 0.6^{\circ}\text{C}$ ($74.0 \pm 1.0^{\circ}\text{F}$). Discolored solution shall be discarded or filtered for use if, when checked, the chemical purity and specific gravity meet the requirements.

Note 1 - For the solution, 350 g of anhydrous salt or 1230 g of the heptahdrate per liter of water are sufficient for saturation at 23.3°C (74.0°F). However, since these salts are not completely stable, with the hydrous salt being the more stable of the two, and since it is desirable that an excess of crystals be present, it is recommended that the heptahydrate salt be used and in an amount of not less than 1400 g per liter of water.

5. SAMPLES

5.1 Coarse Aggregate - The sizes of coarse aggregate for the test shall be restricted to the NYSDOT No. 1 and No. 2 sizes, (see Note 2). A representative sample from the source shall be tested using square opening sieves and the sample weights listed below:

<u>NYSDOT Size</u>	<u>Passing Sieve</u>	<u>Retained Sieve</u>	<u>Weight (grams)</u>
No.2	25.0mm (1 in.)	12.5mm (1/2 in.)	2500 ± 50
Consisting of:	25.0mm (1 in.)	19.0mm (3/4 in.)	1500 ± 50
	19.0mm (3/4 in.)	12.5mm (1/2 in.)	1000 ± 30
No. 1	12.5mm (1/2 in.)	6.3mm (1/4 in.)	1000 ± 25

Note 2 - Research completed by the Materials Bureau, NYSDOT indicates that, the surface area of the sample tested, influences the final losses of the magnesium sulfate soundness test. A sandstone lithology may double it's loss each time the particle diameter is reduced by one-half. To eliminate this variable, the NYSDOT Acceptance for the magnesium sulfate soundness test (10 cycles) is based on the No. 2 size fraction. At this time, the No. 1 size fraction is tested for information only.

6. PREPARATION OF TEST SAMPLE

6.1 Thoroughly wash and dry the sample to constant weight at $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$) and separate into the different sizes shown in Section 5.1 by sieving to refusal. In preparing the sample, do not use any of the material sticking in the meshes of the sieves. The proper weight of each size fraction shall be obtained by splitting or quartering. Combine the plus 19.0mm (3/4 in.) and the plus 12.5mm (1/2 in.) sizes to meet the tolerances of the N.Y.S. No. 2 sizes shown in Section 5.1. Place the No. 1 and the No. 2 sizes in separate baskets. Prior to testing, a petrographic examination shall be made of the No. 2 size test sample. ASTM C 295 "Standard Recommended Practice for PETROGRAPHIC EXAMINATION OF AGGREGATE FOR CONCRETE" shall be followed.

7. PROCEDURE

7.1 Storage of samples - Immerse the samples in the prepared solution of magnesium sulfate for not less than 16 h nor more than 18 h in such a manner that the solution covers them to a depth of least 12.5mm (1/2 inch) (Note 3). Maintain the samples immersed in the solution at a temperature of $23.3 \pm 0.6^{\circ}\text{C}$ ($74.0 \pm 1^{\circ}\text{F}$).

Note 3 - Cover the tank to reduce evaporation and prevent the accidental addition of extraneous substances. For lightweight aggregates it is necessary to cover each basket with a tight fitting plastic cover containing perforations.

7.2 Drying samples after immersion - After the immersion period, remove the aggregate sample from solution, permit it to drain for 15 ± 5 minutes and place in the drying oven. The temperature of the oven shall have been brought previously to $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$). Dry the samples at the specified temperature until constant weight has been achieved. Establish the time required to attain constant weight 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 and sample condition (Note 4). Constant weight will be considered to have been achieved when weight loss is less than 0.1 percent in 4 hours of drying. After constant weight has been achieved, allow the samples to cool to 20-25°C (68-77°F) when they shall again be immersed in the prepared solution as described in Section 7.1. Experience has shown that sample temperatures significantly different than 23.3°C (74°F) may change the temperature of the solution temporarily, thereby causing a change in salt saturation, even though the solution returns to 23.3°C (74°F) for most of the soaking period. Cooling of the sample may be aided by use of an air conditioner or fan.

Note 4 - Drying time required to reach constant weight may vary considerably for several reasons. Efficiency of drying will be reduced as cycles accumulate because of the salt adhering to the particles and, in some cases, of increased surface area due to breakdown. The different size fractions of aggregate will have differing drying rates. The smaller sizes will tend to dry more slowly because of their larger surface area and restricted interparticle voids, but this tendency may be altered by the effects of the container size and shape.

7.3 Number of Cycles - Repeat the process of alternate immersion and drying until 10 cycles have been completed. If the test must be interrupted, leave the samples in an oven dried condition (constant weight) at room temperature until testing can be resumed.

8. QUANTATIVE EXAMINATION

8.1 Make the quantitative examination as follows:

8.1.1 After the completion of the final cycle and after the sample has cooled, wash the sample free from the magnesium sulfate. Wash by circulating water at $43 \pm 6^\circ\text{C}$ ($110 \pm 10^\circ\text{F}$) through the samples in their containers by introducing hot water near the bottom and allowing the water to pass through the samples and overflow. The thoroughness of washing shall be checked by obtaining a sample of rinse water after it has passed through the samples and checked with a 10% solution of barium chloride. Further washing is required if sample becomes cloudy upon addition of the barium chloride solution. In areas where the water gives a reaction with barium chloride other analytical means shall be used to assure thoroughness of washing. In the washing operation, the samples shall not be subjected to impact or abrasion that may tend to break up particles.

8.1.2 After the magnesium sulfate has been removed, dry each fraction of the sample to constant weight at $110 \pm 5^\circ\text{C}$ ($230 \pm 9^\circ\text{F}$). Sieve the coarse aggregate over the sieve shown below for the appropriate size of particle. Sieving shall be done by hand, 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 to cause them to pass the sieves. Weigh the material retained on each sieve and record each amount. 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 for use in Table 1.

<u>Size of Aggregate</u>	<u>Sieve Used to Determine Loss</u>
25.0mm (1 in). to 12.5mm (1/2 in.)	9.5mm (3/8 in.)
12.5mm (1/2 in.) to 6.3mm (1/4 in.)	4.75mm (No. 4)

9. QUALITATIVE EXAMINATION

9.1 After testing, examine the No. 2 size fraction. Using the lithologies found in the premag petrographic examination, (6.1) determine the weight and percent of each lithology which has been retained on the 9.5mm (3/8 in.) sieve.

9.1.1 Examine the particles passing the (9.5mm) (3/8 in.) sieve and note the type of distress exhibited by each lithology, (See Note 5).

Note 5 - Many types of action may be expected. In general, they may be classified as disintegration, splitting, crumbling, cracking, flaking, etc. While only the No. 2 size fraction is required to be examined, it is recommended that an examination of the No. 1 size be made. The information obtained from the petrographic examination shall be used to aid in the interpretation of test results.

10. REPORT

10.1 The report shall include the following data:

10.1.1 Weight of the No. 2 and No. 1 size fractions before test.

10.1.2 Weight of the No. 2 and No 1. size fractions retained on the designated sieve used in Section 8.1.2 to determine loss for these size fractions after test. The loss shall be expressed as a percentage of the original weight of each fraction.

TABLE 1

SUGGESTED FORM FOR RECORDING TEST DATA (With illustrative Test Values)

NYSDOT Aggregate Size No.	2	1
Original Weight of Sample (Grams)	2500	1000
Weight After 10 Cycles	2200	760
Weight Loss in Grams	300	240
Loss in Percent	12.0	24.0