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METHODS OF TEST FOR AGGREGATES FOR CONCRETE

PART V SOUNDNESS

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Indian Standard

METHODS OF TEST FOR AGGREGATES FOR CONCRETE

PART V SOUNDNESS

0. FOREWORD

0.1 This Indian Standard (Part V) was adopted by the Indian Standards Institution on 13 September 1963, after the draft finalized by the Cement and Concrete Sectional Committee had been approved by the Building Division Council.

0.2 One of the major contributing factors to the quality of concrete is the quality of aggregates used therein. The test methods given in this standard are intended to assist in assessing the quality of aggregates. In a given situation, for a particular aggregate, it may not be necessary to assess all the qualities, and therefore it is necessary to determine beforehand the purpose for which a concrete is being used and the qualities of the aggregate which require to be assessed. Accordingly, the relevant test methods may be chosen from amongst the various tests covered in this standard. For the convenience of the users, the test methods are grouped into the following eight parts of Indian Standard Methods of Test for Aggregates for Concrete (IS : 2386 - 1963):

Part I	Particle Size and Shape
Part II	Estimation of Deleterious Materials and Organic Impurities
Part III	Specific Gravity, Density, Voids, Absorption and Bulking
Part IV	Mechanical Properties
Part V	Soundness
Part VI	Measuring Mortar Making Properties of Fine Aggregate
Part VII	Alkali Aggregate Reactivity
Part VIII	Petrographic Examination

0.3 The Sectional Committee responsible for the preparation of this standard has taken into consideration the views of concrete specialists, testing authorities, consumers and technologists and has related the standard to the practices followed in this country. Further, the need for international co-ordination among standards prevailing in different countries

of the world has also been recognized. These considerations led the Sectional Committee to derive assistance from C88 - 61T Tentative Method of Test for Soundness of Aggregates by Use of Sodium Sulphate or Magnesium Sulphate issued by American Society for Testing and Materials.

0.4 Wherever a reference to any Indian Standard appears in this method, it shall be taken as a reference to its latest version.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2 - 1960 Rules for Rounding Off Numerical Values (*Revised*). The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

0.6 This standard is intended chiefly to cover the technical provisions relating to testing of aggregates for concrete, and it does not include all the necessary provisions of a contract.

1. SCOPE

1.1 This standard (Part V) covers the method of test to determine the resistance to disintegration of aggregates by saturated solutions of sodium sulphate or magnesium sulphate.

NOTE — This test 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 actual weathering conditions. Attention is called to the fact that test results by the use of the two salts differ considerably, and care shall be exercised in fixing proper limits in any specification which may include requirements for these tests.

2. APPARATUS

2.1 Sieves — Sieves of the following sizes, having square openings, complying with the requirements specified in IS : 460 - 1962 Specification for Test Sieves (*Revised*) shall be used:

Fine Series	*Coarse Series*
150 microns	8·0 mm
	10 mm
300 microns	12·5 mm
600 microns	16 mm
	20 mm
1·18 mm	25 mm
2·36 mm	31·5 mm
	40 mm
4·00 mm	50 mm
	63 mm
4·75 mm	80 mm

2.2 Containers — Containers for immersing the samples of aggregate in the solution, in accordance with the procedure described in this method, shall be perforated in such a manner as to permit free access of the solution to the sample and drainage of the solution from the sample without loss of aggregate. Arrangements shall also be available to ensure that the volume of the solution in which samples are immersed shall be at least five times the volume of the sample immersed at any one time.

NOTE — Baskets made of suitable wire mesh or sieves with suitable openings are satisfactory containers for the samples.

2.3 Temperature Regulation — Suitable means for regulating the temperature of the samples during immersion in the sodium sulphate or magnesium sulphate solution shall be provided.

2.4 Balances — For weighing fine aggregate, a balance having a capacity of not less than 500 g, sensitive to at least 0·1 g, shall be used; for weighing coarse aggregate, a balance having a capacity of not less than 5 000 g, sensitive to at least one gram, shall be used.

2.5 Drying Oven — The drying oven shall be capable of being maintained between 105° and 110°C and the rate of evaporation, at this range of temperature, shall average at least 25 g/h for four hours during which period the doors of the oven shall be kept closed.

NOTE — This rate shall be determined by the loss of water from 1-litre low-form beakers each initially containing 500 g of water at a temperature of 27° ± 2°C placed at each corner and centre of each shelf of the oven. The evaporation requirement is to apply when the oven is empty except for the beakers of water.

3. REAGENTS

3.1 Sodium Sulphate Solution — Saturated solution of sodium sulphate shall be prepared by dissolving sodium sulphate, technical grade, conforming to IS: 255 - 1950 Specification for Sodium Sulphate, Anhydrous, Technical, or an equivalent grade of the salt of either the anhydrous (Na_2SO_4) or the crystalline ($Na_2SO_4.10H_2O$)* form in water at a temperature of 25° to 30°C. Sufficient salt (*see* Note) 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 27° ± 2°C and maintained at that temperature for at least 48 hours before use. The solution shall be thoroughly stirred immediately before

*Experience with the test method indicates that a grade of sodium sulphate designated by the trade as dried powder, which may be considered as approximately anhydrous, is the most practical for use. That grade is more economically available than the anhydrous form. The decahydrate sodium sulphate presents difficulties in compounding the required solution on account of its cooling effect on the solution.

use and salt cakes, if any, shall be broken and the specific gravity shall be determined. When used, the solution shall have a specific gravity of not less than 1·151 and not greater than 1·174. Discoloured solution shall be discarded, or filtered and checked for specific gravity.

NOTE — For making up the solution, 350 g of anhydrous salt or 1 150 g of the decahydrate salt per litre of water are sufficient for saturation at 28°C. 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 420 g of the anhydrous salt or 1 300 g of the decahydrate salt per litre of water is recommended.

3.2 Magnesium Sulphate Solution — The saturated solution of magnesium sulphate shall be made by dissolving magnesium sulphate, technical grade, conforming to IS : 257 - 1950 Specification for Magnesium Sulphate (Epsom Salt), Technical, or an equivalent grade of the salt of either the anhydrous ($MgSO_4$) or the crystalline ($MgSO_4.7H_2O$) (epsom salt) form in water at a temperature of 25° to 30°C. Sufficient quantity of salt (*see* Note) shall be added to ensure saturation and 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 27° $\pm$ 1°C and maintained at that temperature for at least 48 hours before use. The solution shall be thoroughly stirred immediately before use and salt cakes, if any, shall be broken up and the specific gravity shall be determined. When used, the solution shall have a specific gravity of not less than 1·295 and not more than 1·308. Discoloured solution shall be discarded, or filtered and checked for specific gravity.

NOTE – For making up the solution, 400 g of anhydrous salt or 1 400 g of the heptahydrate per litre of water are sufficient for saturation at 28°C. 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 hoptahydrate salt be used and in an amount of not less than 1 600 g per litre of water.

4. SAMPLES

4.1 Fine Aggregate — Fine aggregate for the test shall be passed through a 10-mm IS Sieve. The sample shall be of such a size that it will yield not less than 100 g of each of the following sizes, which shall be available in amounts of 5 percent or more, expressed in terms of the following sieves:

Passing IS Sieve	*Retained on IS Sieve*
600-micron	300-micron
1·18-mm	600-micron
2·36-mm	1·18-mm
4·75-mm	2·36-mm
10-mm	4·75-mm

4.2 Coarse Aggregate — Coarse aggregate for the test shall consist of material from which sizes finer than 4·75-mm IS Sieve have been removed; such sizes shall be tested in accordance with the procedure for fine aggregate. The sample shall be of such a size that it will yield not less than the following amounts of the different sizes, which shall be available in amounts of 5 percent or more:

Size (*Square-Hole Sieves*)	*Yield*
10 mm to 4·75 mm	300 g
20 mm to 10 mm	1 000 g
consisting of:	
12·5 mm to 10 mm	33 percent
20 mm to 12·5 mm	67 percent
40 mm to 20 mm	1 500 g
consisting of:	
25 mm to 20 mm	33 percent
40 mm to 25 mm	67 percent
63 mm to 40 mm	3 000 g
consisting of:	
50 mm to 40 mm	50 percent
63 mm to 50 mm	50 percent
80 mm and larger sizes by 20 mm spread in sieve size, each fraction	3 000 g

4.3 All-in-Aggregate — All-in-aggregate shall be separated in two major fractions, finer than 4·75 mm and coarser than 4·75 mm. The former shall be dealt with as fine aggregate and the latter as coarse aggregate.

NOTE — It shall be noted that testing closely sized aggregates, such as these constitutes a more severe test than testing a graded aggregate, and this fact should be taken into account while specifying limits in specifications.

4.4 Should the samples contain less than 5 percent of any of the sizes specified in **4.1** or **4.2**, that size shall not be tested, but, for the purpose of calculating the test result, it shall be considered to have the same loss in sodium sulphate or magnesium sulphate treatment as the average of the next smaller and the next larger size, or if one of these sizes is absent, it shall be considered to have the same loss as the next larger or next smaller size, whichever is present. When the 20 mm to 10 mm, 40 mm to 20 mm or 63 mm to 40 mm test samples specified in **4.2** cannot be prepared due to the absence of one or two sizes of aggregate shown for each, the size available shall be used to prepare the sample tested.

5. PREPARATION OF TEST SAMPLE

5.1 Fine Aggregate — The sample of fine aggregate shall be thoroughly washed on a 300-micron IS Sieve, dried to constant weight at 105° to 110°C,

and separated into different sizes by sieving as follows:

Make a rough separation of the graded sample by means of a nest of the sieves specified in **4.1**. From the fractions obtained in this manner, select samples of sufficient size to yield 100 g after sieving to refusal. (In general, a 110 g sample will be sufficient.) Fine aggregate sticking in the meshes of the sieves shall not be used in preparing the samples. Samples of 100 g shall be weighed out of each of the separated fractions after final sieving and placed in separate containers for the test.

5.2 Coarse Aggregate — The sample of coarse aggregate shall be thoroughly washed and dried to constant weight at 105°C to 110°C and shall be separated into different sizes shown in **4.2** by sieving to refusal. The proper weight of sample for each fraction shall be weighed out and placed in separate containers for the test. In the case of fractions coarser than the 20-mm IS Sieve, the number of particles shall also be counted.

6. PROCEDURE

6.1 Storage of Samples in Solution — The samples shall be immersed in the prepared solution of sodium sulphate or magnesium sulphate 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 15 mm (*see* Note). The containers shall be covered to reduce evaporation and prevent the accidental addition of extraneous substances. The samples immersed in the solution shall be maintained at a temperature of 27° ± 1°C for the immersion period.

NOTE — Suitably weighted wire grids placed over the sample in the containers will permit this coverage to be achieved with very light aggregates.

6.2 Drying Samples After Immersion — After the immersion period, the aggregate sample shall be removed from the solution, permitted to drain for 15 ± 5 minutes, and placed in the drying oven. The temperature of the oven shall have been brought previously to 105° to 110°C. The samples shall be dried to constant weight at this specified temperature. During the drying period, the samples shall be removed from the oven, cooled to room temperature and weighed at intervals of not less than 4 hours nor more than 18 hours. Constant weight may be considered to have been achieved when two successive weights for any one sample differ by less than 0·1 g in the case of fine aggregate samples, or by less than 1·0 g in the case of coarse aggregate samples. After constant weight has been achieved the samples shall be allowed to cool to room temperature, then they shall again be immersed in the prepared solution as described in **6.1**.

6.3 Number of Cycles — The process of alternate immersion and drying shall be repeated until the specified number of cycles as agreed to between the purchaser and the vendor is obtained.

7. QUANTITATIVE EXAMINATION

7.1 The quantitative examination (*see* Note) shall be made as follows:

a) After the completion of the final cycle and after the sample has cooled, the sample shall be washed free from the sodium sulphate or magnesium sulphate as determined by the reaction of the wash-water with barium chloride ($BaCl_2$).

b) After the sodium sulphate or magnesium sulphate solution has been removed, each fraction of the sample shall be dried to constant weight at 105° to 110°C, and weighed. Fine aggregates shall be sieved over the same sieve on which it was retained before the test, and coarse aggregate over the sieve shown below for the appropriate size of particle:

Size of Aggregate	*Sieve Used to Determine Loss*
63 mm to 40 mm	31·5 mm
40 mm to 20 mm	16 mm
20 mm to 10 mm	8·0 mm
10 mm to 4·75 mm	4·00 mm

NOTE — In addition to the procedure described in (a) and (b), it is suggested that additional information of value will be obtained by examining each fraction visually in order to determine whether there is any evidence of excessive splitting of the grains. It is also suggested that additional information of value will be obtained if, after treating each separate fraction of the sample as described in (b), all sizes, including detritus, are combined and a sieve analysis made using sieves of the following sizes:

150, 300 and 600 micron, 1·18, 2·36, 4·75, 10, 20, 40, and 80 mm.

The results of the sieve analysis shall be recorded as cumulative percentages retained on each sieve.

8. QUALITATIVE EXAMINATION

8.1 Fractions of samples coarser than 20 mm shall be examined qualitatively after each immersion and quantitatively at the completion of the test.

8.2 The qualitative examination and record shall consist of two parts, (a) observing the effect of the action (*see* Note) by the sodium sulphate or magnesium sulphate solution and the nature of the action, and (b) counting the number of particles affected.

NOTE — Many types of actions may be expected. In general, they may be classified as disintegration, splitting, crumbling, cracking, flaking, etc.

While only particles larger than 20 mm in size are required to be examined qualitatively, it is recommended that examination of the smaller sizes be also made in order to determine whether there is any evidence of excessive splitting.

9. REPORTING OF RESULTS

9.1 The report shall include the following data:

a) Weight of each fraction of each sample before test.

b) Material from each fraction of the sample finer than the sieve on which the fraction was retained before test, expressed as a percentage by weight of the fraction.

c) Weighted average calculated from the percentage of loss for each fraction, based on the grading of the sample as received for examination or, preferably, on the average grading of the material from that portion of the supply of which the sample is representative. In these calculations sizes finer than the 300-micron IS Sieve shall be assumed to have zero percent loss.

d) In the case of particles coarser than 20 mm before test, (1) the number of particles in each fraction before test, and (2) the number of particles affected, classified as to number disintegrating, splitting, crumbling, cracking, flaking, etc.

e) Character of solution (sodium sulphate or magnesium sulphate).

9.2 A recommended form for recording of test data is given in Table I. Test values given are for illustration and these may be appropriate for either salt depending on the quality of the aggregate.

TABLE I SUGGESTED FORM FOR RECORDING SOUNDNESS TEST DATA
(With Illustrative Test Values)

Sieve Size		Grading of Original Sample Percent	Weight of Test Fractions Before Test	Percentage Passing Finer Sieve After Test (Actual Percent Loss)	Weighted Average (Corrected Percent Loss)
Passing	Retained on				
(1)	(2)	(3)	(4)	(5)	(6)
Soundness Test for Fine Aggregate					
150 micron	—	5·0	—	—	—
300 ,,	150 micron	11·4	—	—	—
600 ,,	300 ,,	26·0	100	4·2	1·09
1·18 mm	600 ,,	25·2	100	4·8	1·21
2·36 ,,	1·18 mm	17·0	100	8·0	1·36
4·75 ,,	2·36 ,,	10·8	100	11·2	1·21
10 mm	4·75 ,,	4·6	—	11·2*	0·52
Total	—	100·0	400	—	5·39
Soundness Test for Coarse Aggregate					
63 mm	40 mm	20·0	3 000†	4·8	0·96
40 ,,	20 ,,	45·0	1 500†	8·0	3·60
20 ,,	10 ,,	23·0	1 000†	9·6	2·20
10 ,,	4·75 ,,	12·0	300†	11·2	1·34
Total	—	100·0	5 800	—	8·10

*The percentage loss (11·2 percent) of the next smaller size is used as the percentage loss for this size, since this size contains less than 5 percent of the original sample as received (*see* **4.4**).

†Minimum amounts; larger samples may be used.