Indian Standard

METHODS OF TEST FOR AGGREGATES FOR CONCRETE

PART I PARTICLE SIZE AND SHAPE

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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Indian Standard

METHODS OF TEST FOR AGGREGATES FOR CONCRETE

PART I PARTICLE SIZE AND SHAPE

0. FOREWORD

0.1 This Indian Standard (Part I) was adopted by the Indian Standards Institution on 22 August 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 the 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 the published standards and publications of the following organizations:

British Standards Institution

American Society for Testing and Materials

0.4 Wherever a reference to any Indian Standard appears in these methods, 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 cover all the necessary provisions of a contract.

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1. SCOPE

1.1 This standard (Part I) covers the following tests for aggregates for concrete:

a) Sieve analysis,
b) Determination of materials finer than 75-micron,
c) Determination of flakiness index,
d) Determination of elongation index, and
e) Determination of angularity number.

2. SIEVE ANALYSIS

2.1 Object — This method covers the procedure for the determination of particle size distribution of fine, coarse and all-in-aggregates by sieving or screening.

2.2 Apparatus

2.2.1 *Sieves* — Sieves of the sizes given in Table I, conforming to IS : 460-1962 Specification for Test Sieves (*Revised*) shall be used.

TABLE I IS SIEVES FOR SIEVE ANALYSIS OF AGGREGATES FOR CONCRETE

(*Clause* 2.2.1)

Type	Sieve Designations
Square hole, perforated plate	80-mm, 63-mm, 50-mm, 40-mm, 31·5-mm, 25-mm, 20-mm, 16-mm, 12·5-mm, 10-mm, 6·3-mm, 4·75-mm
Fine mesh, wire cloth	3·35-mm, 2·36-mm, 1·18-mm, 600-micron, 300-micron, 150-micron, 75-micron

2.2.2 *Balance* — The balance or scale shall be such that it is readable and accurate to 0·1 percent of the weight of the test sample.

2.3 Sample — The weight of sample available shall be not less than the weight given in Table II. The sample for sieving (*see* Table II) shall be prepared from the larger sample either by quartering or by means of a sample divider.

TABLE II MINIMUM WEIGHTS FOR SAMPLING

Maximum Size Present in Substantial Proportions	Minimum Weight of Sample Despatched for Testing
mm	kg
63	100
50	100
40	50
25	50
20	25
16	25
12·5	12
10·0	6
6·3	3

2.4 Test Procedure for Coarse and Fine Aggregate

2.4.1 The sample shall be brought to an air-dry condition before weighing and sieving. This may be achieved either by drying at room temperature or by heating at a temperature of 100° to 110°C. The air-dry sample shall be weighed and sieved successively on the appropriate sieves starting with the largest. Care shall be taken to ensure that the sieves are clean before use.

2.4.2 Each sieve shall be shaken separately over a clean tray until not more than a trace passes, but in any case for a period of not less than two minutes. The shaking shall be done with a varied motion, backwards and forwards, left to right, circular clockwise and anti-clockwise, and with frequent jarring, so that the material is kept moving over the sieve surface in frequently changing directions. Material shall not be forced through the sieve by hand pressure, but on sieves coarser than 20 mm, placing of particles is permitted. Lumps of fine material, if present, may be broken by gentle pressure with fingers against the side of the sieve. Light brushing with a soft brush on the under side of the sieve may be used to clear the sieve openings.

2.4.3 Light brushing with a fine camel hair brush may be used on the 150-micron and 75-micron IS Sieves to prevent aggregation of powder and blinding of apertures. Stiff or worn out brushes shall not be used for this purpose and pressure shall not be applied to the surface of the sieve to force particles through the mesh.

2.4.3.1 On completion of sieving, the material retained on each sieve, together with any material cleaned from the mesh, shall be weighed.

2.4.4 In order to prevent binding of the sieve apertures by overloading, the amount of aggregate placed on each sieve shall be such that the weight of the aggregate retained on the sieve at completion of the operation is not greater than the value given for that sieve in Table III. Sample weights given in Table IV will thus normally require several operations on each sieve.

NOTE 1 — For many routine purposes mechanical sieving is advantageous, but if this method is used, care should be taken to ensure that the sieving is complete.

NOTE 2 — The following alternative procedure is permissible where it is required to determine only the cumulative percentage figures:

The weighed sample shall be passed through the largest of the appropriate sieves as described above. The fraction which passes the sieve shall be weighed, and then passed through the next smaller sieve; the fraction which passes shall be weighed, and so on.

The cumulative weight passing each sieve shall be calculated as a percentage of the total sample weight.

NOTE 3 — If sieving is carried out with a nest of sieves on a machine, not less than 10 minutes sieving will be required for each test.

2.5 Test Procedure for All-in-Aggregates, or Mixed Coarse and Fine Aggregates — The weight of sample available shall not be less than the

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weight given in Table II. The sample for sieving (*see* Table IV) shall be prepared from the larger sample either by quartering or by means of a sample divider. It shall be brought to air-dry condition before weighing and sieving. This may be achieved either by drying at room temperature or by heating at a temperature of 100° to 110°C.

TABLE III MAXIMUM WEIGHT TO BE RETAINED AT THE COMPLETION OF SIEVING

(*Clause* 2.4.4)

COARSE AGGREGATE			FINE AGGREGATE	
IS Sieve	Maximum Weight for		IS Sieve	Maximum Weight for 20-cm dia Sieve
	45-cm dia sieve	30-cm dia sieve		
	kg	kg		g
50-mm	10	4·5	2·36-mm	200
40-mm	8	3·5	1·18-mm	100
31·5-mm or 25-mm	6	2·5		
20-mm	4	2·0	600-micron	75
16-mm or 12·5-mm	3	1·5	300-micron	50
10-mm	2	1·0		
6·3-mm	1·5	0·75	150-micron	40
4·75-mm	1·0	0·50	75-micron	25
3·35-mm	—	0·30		

TABLE IV MINIMUM WEIGHT OF SAMPLE FOR SIEVE ANALYSIS

(*Clauses* 2.4.4, 2.5 *and* 2.5.2)

MAXIMUM SIZE PRESENT IN SUBSTANTIAL PROPORTIONS	MINIMUM WEIGHT OF SAMPLE TO BE TAKEN FOR SIEVING
mm	kg
63	50
50	35
40 or 31·5	15
25	5
20 or 16	2
12·5	1
10	0·5
6·3	0·2
4·75	0·2
2·36	0·1

2.5.1 In some cases the sieve analysis of all-in-aggregate can be carried out in accordance with the procedure given in **2.4**. Frequently, however, this will result in heavy overloading of the finer sieves. In such cases it will be necessary to make a preliminary separation of the all-in-aggregate into two fractions, coarse and fine, using for this purpose a convenient sieve for example, a 3·35-mm or 4·75-mm IS Sieve.

2.5.2 If the amount of either the coarse or fine aggregate obtained as above is substantially less than that required for testing in accordance with Table IV, another sample shall be taken which is sufficiently large to produce an adequate sample of both the coarse and the fine aggregate. If the amount of either the coarse or the fine aggregate thus obtained is substantially greater than that required for testing, it shall be reduced by quartering or by means of a sample divider.

2.6 Reporting of Results — The results shall be calculated and reported as:

  a) the cumulative percentage by weight of the total sample passing each of the sieves, to the nearest whole number (*see* Note under **2.6.1**); or

  b) the percentage by weight of the total sample passing one sieve and retained on the next smaller sieve, to the nearest 0·1 percent.

2.6.1 *Graphical Method of Recording Results* — The results of sieve analysis may be recorded graphically on the chart for recording sieve analysis shown in Fig. 1.

  NOTE — It is recommended that cumulative percentage figures should be used for comparison with specification requirements, or for reporting results graphically.

3. DETERMINATION OF MATERIALS FINER THAN 75-MICRON

3.1 Object — This method of test deals with the procedure for determining the total quantity of material finer than 75-micron IS Sieve in aggregates by washing.

  NOTE — Clay particles that are dispersed by wash water as well as water soluble materials will be removed from the aggregate during the test.

3.2 Apparatus — The apparatus shall consist of the following:

  a) *Balance* — The balance or scale shall be of sufficient capacity and sensitivity (*see* **3.3.1** and **3.4.1**) and shall have an accuracy of 0·1 percent of the weight of the test sample.

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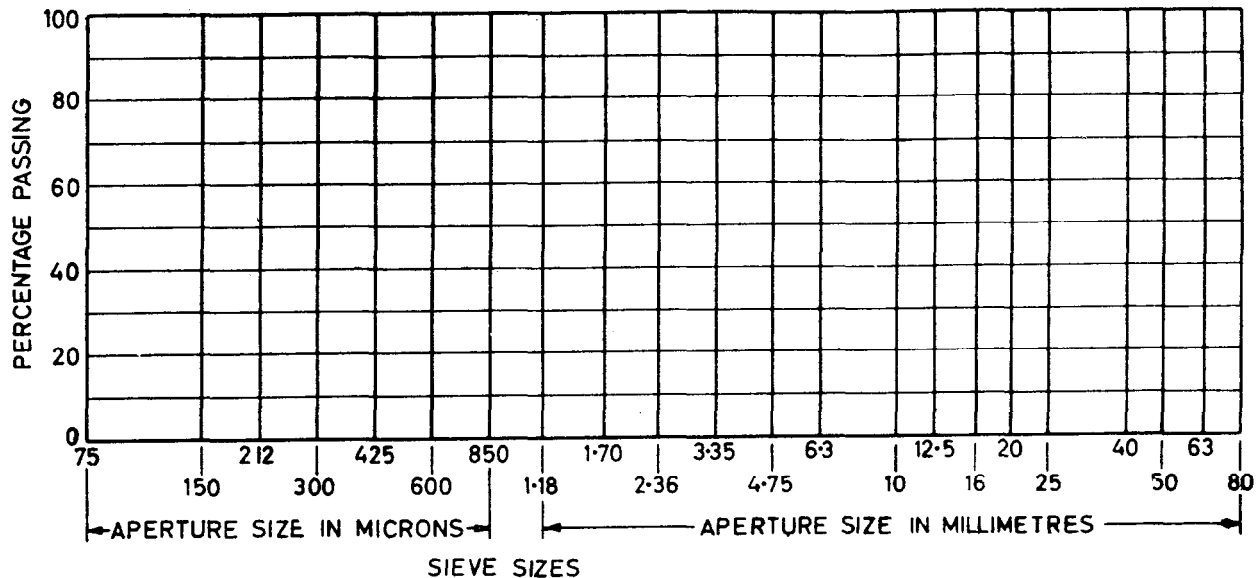
NOTE — The vertical scale of this chart is an arithmetic scale and the horizontal scale is logarithmic.

FIG. 1   CHART FOR RECORDING SIEVE ANALYSIS RESULTS

b) *Sieve* — A nest of two sieves, the lower being 75-micron IS Sieve and the upper approximately 1·18-mm IS Sieve [*see* IS : 460-1962 Specification for Test Sieves (*Revised*)].

c) *Container* — A pan or vessel of a size sufficient to contain the sample covered with water and to permit of vigorous agitation without inadvertent loss of any part of the sample or water.

d) *Oven* — An oven of sufficient size capable of maintaining an uniform temperature of $110° \pm 5°C$.

3.3 Sample — The test sample shall be selected from material which has been thoroughly mixed and which contains sufficient moisture to prevent segregation. A representative sample, sufficient to yield not less than the appropriate weight of dried material, as shown below, shall be selected:

Maximum Nominal Size of Aggregate	*Approximate Minimum Weight of Sample*
mm	g
4·75	500
10·0	2 000
20	2 500
40 or over	5 000

3.4 Procedure

3.4.1 The test sample shall be dried to constant weight at a temperature of $110° \pm 5°C$ and weighed to the nearest 0·1 percent.

3.4.2 The test sample after being dried and weighed shall be placed in the container and sufficient water added to cover it. The contents of the container shall be agitated vigorously.

3.4.3 The agitation shall be sufficiently vigorous to result in the complete separation from the coarse particles of all particles finer than 75-micron and bring the fine material into suspension.

Care shall be taken to avoid, as much as possible, the decantation of the coarse particles of the sample. The operation shall be repeated until the wash water is clear.

3.4.4 The wash water containing the suspended and dissolved solids shall be immediately poured over the nested sieves arranged with the coarser sieve on the top.

3.4.5 All material retained on the nested sieves shall be returned to the washed sample. The washed aggregate shall be dried to constant weight at a temperature not exceeding 110°C and weighed to the nearest 0·1 percent.

3.5 Calculation — The amount of material passing the 75-micron IS Sieve shall be calculated as follows:

$$A = \frac{B-C}{B} \times 100$$

where

A = percentage of material finer than 75-micron,

B = original dry weight, and

C = dry weight after washing.

4. DETERMINATION OF FLAKINESS INDEX

4.1 Object — This method of test lays down the procedure for determining the flakiness index of coarse aggregate.

> NOTE — The flakiness index of an aggregate is the percentage by weight of particles in it whose least dimension (thickness) is less than three-fifths of their mean dimension. The test is not applicable to sizes smaller than 6·3 mm.

**4.2 Apparatus** — The apparatus shall consist of the following:

a) *Balance* — The balance shall be of sufficient capacity and sensitivity (*see* **4.4.3**) and shall have an accuracy of 0·1 percent of the weight of the test sample.

b) *Metal Gauge* — The metal gauge shall be of the pattern shown in Fig. 2.

c) *Sieves* — IS Sieves of sizes shown in Table V.

4.3 Sample — A quantity of aggregate shall be taken sufficient to provide the minimum number of 200 pieces of any fraction to be tested.

4.4 Procedure

4.4.1 *Sieving* — The sample shall be sieved in accordance with the method described in **3** with the sieves specified in Table V.

4.4.2 *Separation of Flaky Material* — Each fraction shall be gauged in turn for thickness on a metal gauge of the pattern shown in Fig. 2 or in bulk on sieves having elongated slots. The width of the slot used in
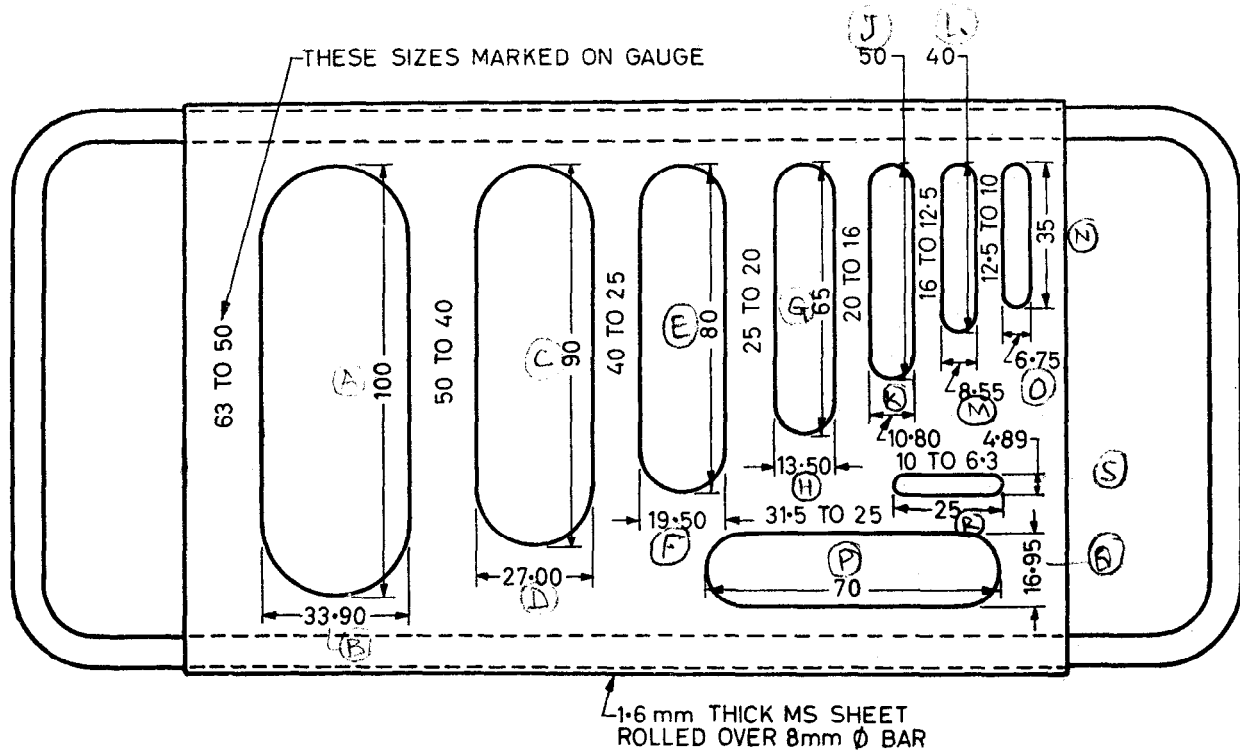
All dimensions in millimetres.

FIG. 2 THICKNESS GAUGE

the gauge or sieve shall be of the dimensions specified in col 3 of Table V for the appropriate size of material.

TABLE V   DIMENSIONS OF THICKNESS AND LENGTH GAUGES

(Clauses 4.2, 4.4.1, 4.4.2, 5.2 and 5.4.1)

SIZE OF AGGREGATE		THICKNESS GAUGE*	LENGTH GAUGE†
Passing Through IS Sieve	Retained On IS Sieve		
(1)	(2)	(3)	(4)
		mm	mm
63-mm	50-mm	33·90	—
50-mm	40-mm	27·00	81·0
40-mm	25-mm	19·50	58·5
31·5-mm	25-mm	16·95	—
25-mm	20-mm	13·50	40·5
20-mm	16-mm	10·80	32·4
16-mm	12·5-mm	8·55	25·6
12·5-mm	10-mm	6·75	20·2
10-mm	6·3-mm	4·89	14·7

*This dimension is equal to 0·6 times the mean sieve size.

†This dimension is equal to 1·8 times the mean sieve size.

4.4.3 *Weighing of Flaky Material* — The total amount passing the gauge shall be weighed to an accuracy of at least 0·1 percent of the weight of the test sample.

4.5 Reporting of Results — The flakiness index is the total weight of the material passing the various thickness gauges or sieves, expressed as a percentage of the total weight of the sample gauged.

5. DETERMINATION OF ELONGATION INDEX

5.1 Object — This method of test lays down the procedure for determining the elongation index of coarse aggregate.

NOTE — The elongation index of an aggregate is the percentage by weight of particles whose greatest dimension (length) is greater than one and four-fifths times their mean dimension. Normally, the properties of interest to the engineer are sufficiently covered by the flakiness or angularity tests. The elongation test is not applicable to sizes smaller than 6·3 mm.

5.2 Apparatus — The apparatus shall consist of the following:

a) *Balance* — The balance shall be of sufficient capacity and sensitivity (*see* **5.4.3**) and shall have an accuracy of 0·1 percent of the weight of the test sample.

b) *Metal Gauge* — The metal gauge shall be of the pattern shown in Fig. 3.

c) *Sieves* — IS Sieves of the sizes shown in Table V.

5.3 Sample — A quantity of aggregate shall be taken, sufficient to provide a minimum number of 200 pieces of any fraction to be tested.

5.4 Procedure

5.4.1 *Sieving* — The sample shall be sieved in accordance with the method described in **3** with the sieves specified in Table V.

5.4.2 *Separation of Elongated Material* — Each fraction shall be gauged individually for length on a metal length gauge of the pattern shown in Fig. 3. The gauge length used shall be that specified in col 4 of Table V for the appropriate size of material.

5.4.3 *Weighing of Elongated Material* — The total amount retained by the length gauge shall be weighed to an accuracy of at least 0·1 percent of the weight of the test sample.

5.5 Report of Results — The elongation index is the total weight of the material retained on the various length gauges, expressed as a percentage of the total weight of the sample gauged.

## 6. DETERMINATION OF ANGULARITY NUMBER

6.1 Object — This method of test lays down the procedure for determining the angularity number of coarse aggregate.

NOTE 1 — Angularity or absence of rounding of the particles of an aggregate is a property which is of importance because it affects the ease of handling of a mixture of aggregate and binder, for example the workability of concrete, or the stability of mixtures that rely on the interlocking of the particles. It is emphasized that this is a laboratory method intended for comparing the properties of different aggregates for mix design purposes.

NOTE 2 — Since considerably more effort is used than in the test for bulk density and voids [*see* IS : 2386 (Part III)-1963], the results of the two tests are different. Also weaker aggregates may be crushed during compaction, and the angularity number test does not apply to any aggregate which breaks down during the test.
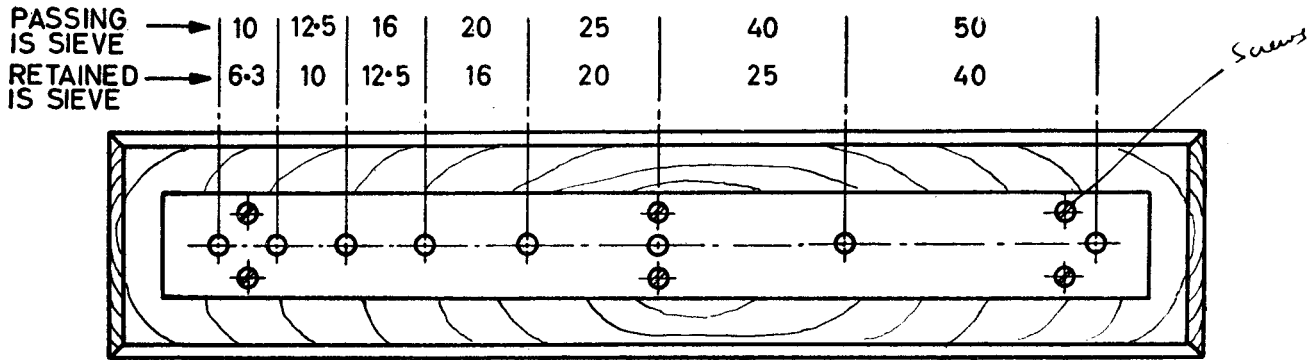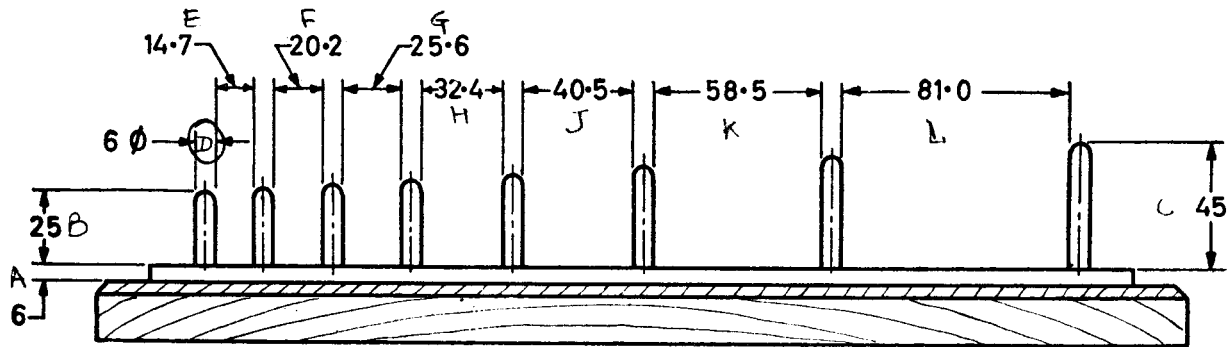
All dimensions in millimetres.

Fig. 3 Length Gauge

6.2 Apparatus — The apparatus shall consist of the following:

a) *Metal Cylinder* — A metal cylinder closed at one end and of about 3 litres capacity, the diameter and height of which shall be approximately equal, for example 15 cm and 15 cm. The cylinder shall be made from metal of thickness not less than 3 mm and shall be of sufficient rigidity to retain its shape under rough usage.

b) *Tamping Rod* — A straight metal tamping rod of circular cross-section of 16 mm diameter and 60 cm long, rounded at one end.

c) *Balance* — Balance or scale of capacity 10 kg readable to one gram.

d) *Scoop* — A metal scoop approximately $20 \times 12 \times 5$ cm, that is, about 1-litre heaped capacity.

6.3 Calibration of the Cylinder — The cylinder shall be calibrated by determining to the nearest gram the weight of water at 27°C required to fill it, so that no meniscus is present above the rim of the container.

6.4 Preparation of the Test Sample — The amount of aggregate available shall be sufficient to provide, after separation on the appropriate pair of sieves, at least 10 kg of the predominant size, as determined by the sieve analysis on the 20-mm, 16-mm, 12·5-mm, 10-mm, 6·3-mm and 4·75-mm IS Sieves.

6.4.1 The test sample shall consist of aggregate retained between the appropriate pair of IS Sieves (square mesh) from the following sets:

20-mm and 16-mm

16-mm and 12·5-mm

12·5-mm and 10-mm

10-mm and 6·3-mm

6·3-mm and 4·75-mm

NOTE — In testing aggregates larger than 20 mm, the volume of the cylinder shall be greater than 3 litres, but for aggregate smaller than 4·75 mm a smaller cylinder may be used. The procedure shall be the same as with 3 litre cylinder, except that the amount of compactive effect (weight of tamping rod × height of fall × number of blows) shall be proportioned to the volume of the cylinder.

6.4.2 The aggregate to be tested shall be dried for at least 24 hours in shallow trays in a well ventilated oven at a temperature of 100° to 110°C, cooled in an air-tight container and tested.

6.5 Test Procedure — The scoop shall be filled and heaped to over-flowing with the aggregate, which shall be placed in the cylinder by allowing it to slide gently off the scoop from the least height possible.

6.5.1 The aggregate in the cylinder shall be subjected to 100 blows of the tamping rod at a rate of about 2 blows per second. Each blow shall be applied by holding the rod vertical with its rounded end 5 cm above the surface of the aggregate and releasing it so that it falls freely. No force shall be applied to the rod. The 100 blows shall be evenly distributed over the surface of the aggregate.

6.5.2 The process of filling and tamping shall be repeated exactly as described above with a second and third layer of aggregates; the third layer shall contain just sufficient aggregate to fill the cylinder level with the top edge before tamping.

6.5.3 After the third layer has been tamped, the cylinder shall be filled to overflowing, and the aggregate struck off level with the top using the tamping rod as a straight edge.

6.5.4 Individual pieces shall then be added and 'rolled-in' to the surface by rolling the tamping rod across the upper edge of the cylinder, and this finishing process shall be continued as long as the aggregate does not lift the rod off the edge of the cylinder on either side. The aggregate shall not be pushed in or otherwise forced down, and no downward pressure shall be applied to the tamping rod, which shall roll in contact with the metal on both sides of the cylinder.

6.5.5 The aggregate in the cylinder shall then be weighed to the nearest 5 grams.

6.5.6 Three separate determinations shall be made, and the mean weight of aggregate in the cylinder calculated. If the result of any one determination differs from the mean by more than 25 grams, three additional determinations shall immediately be made on the same material and the mean of all the six determinations calculated.

6.6 Calculation — The angularity number shall be calculated from the formula:

$$\text{Angularity number} = 67 - \frac{100\ W}{C\ G_A}$$

where

W = mean weight in g of the aggregate in the cylinder,
C = weight of water in g required to fill the cylinder, and
G_A = specific gravity of aggregate.

6.7 Reporting of Results — The angularity number shall be expressed to the nearest whole number.

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117/418 B, Sarvodaya Nagar, KANPUR 208005	21 68 76
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Patliputra Industrial Estate, PATNA 800013	26 23 05
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AMENDMENT NO. 1   JANUARY 1983

TO

IS:2386(Part I)-1963 METHODS OF TEST FOR
AGGREGATES FOR CONTRETE

PART I   PARTICLE SIZE AND SHAPE

Alteration

[*Page 11, clause 4.2*(b)] - Substitute the
following for the existing matter:

'b) *Metal Gauge* - The metal gauge shall be of
the pattern shown in Fig. 2 with elongated
slots of dimensions indicated in Fig. 2.
The tolerance on dimensions shall be + 0.20 mm
for dimensions equal to or more than 50 mm and
+ 0.10 mm for dimensions less than 50 mm.'

(BDC 2)

AMENDMENT NO. 2   OCTOBER 1991
TO
IS 2386 (Part 1) : 1963 METHODS OF TEST FOR AGGREGATES FOR CONCRETE
PART 1 PARTICLE SIZE AND SHAPE

(*Page* 12, *Fig.* 2) — Substitute '40 to 31.5' *for* '40 to 25'.

(*Page* 13, *Table* V, *col* 2, *third entry*) — Substitute '31.5-mm' *for* '25-mm'.

(*Page* 13, *clause* 4.4.3) — Substitute the following for the existing clause :

'**4.4.3** The number of pieces passing the appropriate gauge in each size fraction shall be counted separately. The total mass of each size fraction of the sample also shall be determined.'

(*Page* 13, *clause* 4.5) — Substitute the following for the existing clause:

"**4.5 Calculation and Reporting of Results**

4.5.1 The number of pieces passing the appropriate gauge in each fraction shall be calculated as a percentage of the total number of pieces in each sieve fraction (x) . The mass of total number of pieces in each sieve fraction shall then be calculated as a percentage of the total mass of the whole sample (y). The weighted percentage of the mass of pieces passing the appropriate gauge in each sieve fraction shall then be calculated by multiplying 'x' by 'y'.

4.5.2 The flakiness index shall be expressed as the sum of weighted percentages of the material passing the appropriate gauge in each sieve fraction. If required, the flakiness index for each sieve fraction may be reported as weighted percentage of the material passing the appropriate gauge."

(CED 2)

AMENDMENT NO. 3 SEPTEMBER 1997
TO
IS 2386 (PART 1) : 1963 METHODS OF TEST FOR AGGREGATES FOR CONCRETE

PART 1 PARTICLE SIZE AND SHAPE
(To be read with Amendment No. 2)

(*Page* 12, *Fig.* 2) — Substitute '21.50' *for* '19.50'.

(*Page* 13, *Table* V, *line* 3, *col* 3) — Substitute '21.50' *for* '19.50'.

(*Page* 13, *Table* V, *line* 3, *col* 4) — Substitute '64.4' *for* '58.5'.

(*Page* 13, *clause* 4.5) — Substitute the following for the existing clause:

'4.5 Calculation and Reporting of Result

4.5.1 The mass of pieces passing the appropriate gauge in each sieve fraction shall be calculated as a percentage of mass of the total number of pieces in each fraction (x) . The mass of total number of pieces in each sieve shall then be calculated as a percentage of the total mass of the whole sample that is the sample which is retained on 6.3 mm sieve (y). The weighted percentage of the mass of the pieces passing the appropriate gauge in each sieve fraction shall then be calculated by multiplying 'x' by 'y'.

(CED 53)