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METHODS FOR

TESTING OF MINERAL AGGREGATES FOR CEMENT CONCRETE MIXES

PART 3 — MECHANICAL PROPERTIES

SRI LANKA STANDARDS INSTITUTION

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SLS 728:Part 3:1986

Gr. 12

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SRI LANKA STANDARD

METHODS FOR TESTING OF MINERAL AGGREGATES FOR CEMENT CONCRETE MIXES

PART 3 : MECHANICAL PROPERTIES

FOREWORD

This Sri Lanka Standard was authorised for adoption and publication by the Council of the Sri Lanka Standards Institution on 1986-05-16, after the draft, finalised by the Drafting Committee on Mineral Aggregates for Cement Concrete Mixes, has been approved by the Civil Engineering Divisional Committee.

This standard is one of a series of Sri Lanka Standards on Methods for Testing of Mineral Aggregates for Cement Concrete Mixes.

The other standards in this series are:

Part 1 Size, shape and classification

Part 2 Physical properties

Part 4 Chemical properties

The Drafting Committee has taken into consideration the views of Civil Engineers of various organizations in Sri Lanka and has related the standard to the practices followed in this country.

All values in this standard have been given in metric units. However, in Part 2 of this standard provision has been made for the use of non-metric apparatus, in certain cases as a temporary measure.

In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with CS 102.

Steps are being taken to incorporate estimates of repeatability and reproducibility of test results and these will be issued as an addendum in due course.

The assistance derived from the British Standards Institution and the Indian Standards Institution in preparation of this standard is gratefully acknowledged.

1 SCOPE

This part of the standard covers methods for the determination of the aggregate impact value, aggregate crushing value, ten per cent fines value and aggregate abrasion value.

The tests are intended for use in obtaining assurance that material complies with specified requirements, for research, production control or assessment of variation and are done on certain size fractions.

2 REFERENCES

CS 122 Vicker's hardness test

CS 124 Test sieves

SLS .... Methods for sampling of mineral aggregates for cement concrete mixes (Under preparation)

SLS 728 Methods for testing of mineral aggregates for cement concrete mixes
Part 1 Size, shape and classification (Under preparation)
Part 2 Physical properties

3 REPORTING

3.1 General

The report shall affirm that the tests were done in accordance with this standard. Any departure from the specified test procedure shall be described with reasons for the departure and, if possible, estimates of its effect on the test results. The report shall also include details of any special processing of the sample, other than that required by the test methods, carried out in the laboratory. For example, crushing to provide larger quantities of smaller sizes or the separation of constituents from an as-dug gravel.

3.2 Certificate of sampling

The report shall affirm that a certificate of sampling was received with the sample and shall declare all the information given on the certificate. If a certificate was not received this shall be stated in the report.

4 SIGNIFICANCE OF THE RESULTS

The distribution of the results of any test on any material stems from a number of contributing factors. In assessing the significance of the results the repeatability and reproducibility of the test should be recognized.

5 GENERAL

All the tests in this part of the standard are carried out on certain size fractions which normally have to be sieved out from the laboratory sample.

Where such a fraction constitutes less than 15 per cent of the total sample the results may not be representative. The aggregate impact test, aggregate crushing test and the 10 per cent fines test are likely to be affected to a greater extent than the aggregate abrasion test where flaky particles are separated in preparing the test sample. Under such circumstances the following recommendations should provide a more representative test sample:

a) where general assurance about a given source of aggregate is required a further sample of a different grade and containing more than 15 per cent of the required size should be obtained and tested;

b) where a particular consignment is to be tested for impact value, crushing value or 10 per cent fines value, a non-standard size should be tested.

In the event of neither of these options proving possible it may be necessary to test the original fraction. The report shall state the fact when a further sample was obtained, when a non-standard size was tested or when the test was made on a fraction containing less than 15 per cent of the laboratory sample.

6 DETERMINATION OF AGGREGATE IMPACT VALUE

6.1 General

The aggregate impact value gives a relative measure of the resistance of an aggregate to sudden shock or impact, which in some aggregates differs from its resistance to a slowly applied compressive load. With aggregate of aggregate impact value higher than 30 the result may be anomalous. Also, aggregate sizes larger than 14 mm are not appropriate to the aggregate impact test.

The standard aggregate impact test shall be made on aggregate passing a 14.0 mm test sieve and retained on a 10.0 mm test sieve. If required or if the standard size is not available, smaller sizes may be tested but owing to the non-homogeneity of aggregates the results are not likely to be the same as those obtained from the standard size. In general, the smaller sizes of aggregate will give a lower impact value but the relationship between the values obtained with different sizes may vary from one aggregate to another.

6.2 Sampling

The sample for this test shall be taken in accordance with SLS.... *

6.3 Apparatus

The following apparatus is required.

6.3.1 *An impact testing machine* of the general form shown in Fig. 1 and complying with the following:

a) *Total mass* not more than 60 kg nor less than 45 kg.

The machine shall have a circular metal base weighing between 22 kg and 30 kg, with a plane lower surface of not less than 300 mm diameter, and shall be supported on a level and plane concrete or stone block or floor at least 450 mm thick. The machine shall be prevented from rocking either by fixing it to the block or floor or by supporting it on a level and plane metal plate cast into the surface of the block or floor.

* *Under preparation.*

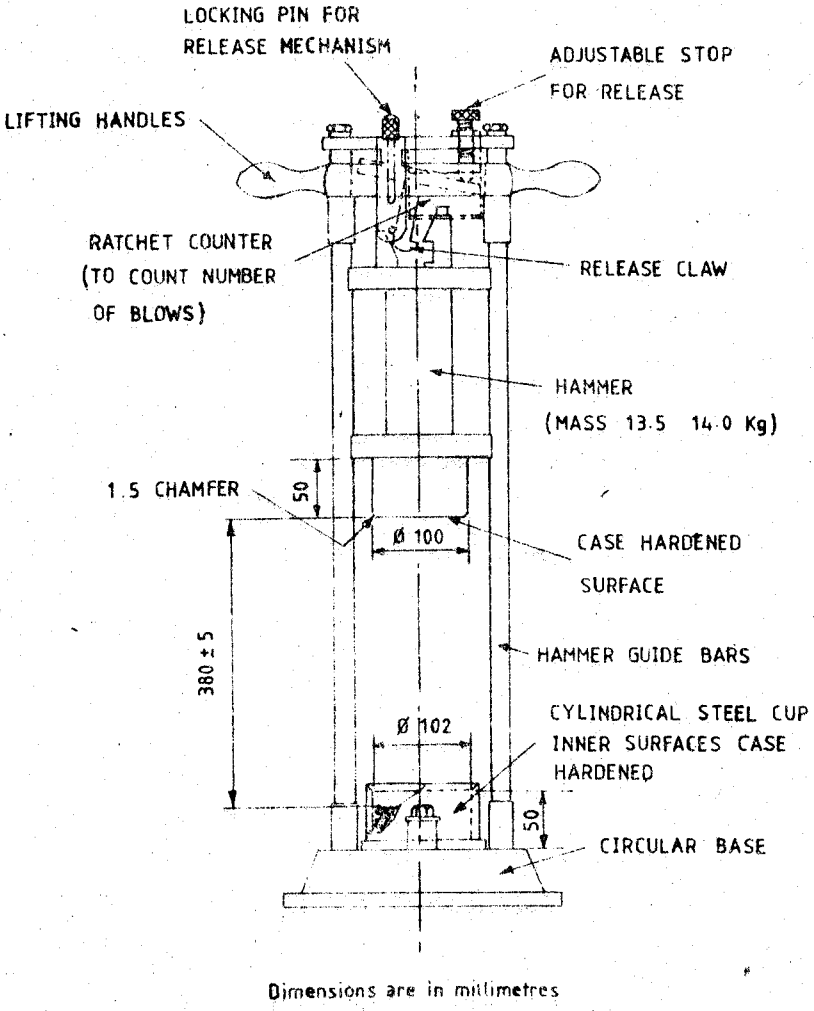

FIGURE 1 - Aggregate impact test machine

b) *A cylindrical steel cup* having an internal diameter of 102 mm and an internal depth of 50 mm. The walls shall be not less than 6 mm thick and the inner surfaces shall be case hardened. The cup shall be rigidly fastened at the centre of the base and be easily removed for emptying.

c) *A metal hammer* weighing 13.5 kg to 14.0 kg the lower end of which shall be cylindrical in shape, 100.0 mm diameter and 50 mm long, with a 1.5 mm chamfer at the lower edge, and case hardened. The hammer shall slide freely between vertical guides so arranged that the lower (cylindrical) part of the hammer is above and concentric with the cup.

d) *Means for raising the hammer* and allowing it to fall freely between the vertical guides from a height of 380 ± 5 mm on to the test sample in the cup, and means for adjusting the height of fall within 5 mm.

e) *Means for supporting the hammer* whilst fastening or removing the cup.

NOTE - Some means for automatically recording the number of blows is desirable.

6.3.2 *Test sieves* of aperture sizes 14.0 mm, 10.0 mm and 2.36 mm conforming to **CS 124** (coarse tolerance) for a standard test. For tests on aggregate sizes samller than the standard, the appropriate aperture sizes of sieves shown in Table 1 shall be used.

6.3.3 *A cylindrical metal measure* of sufficient rigidity to retain its form under rough usage and with an internal diameter of 75 ± 1 mm and an internal depth of 50 ± 1 mm.

6.3.4 *A straight metal tamping rod* of circular cross section, 10 mm diameter, 230 mm long, rounded at one end.

6.3.5 *A balance* of capacity not less than 500 g, and accurate to 0.1 g.

6.4 Preparation of the test sample

The material for the standard test shall consist of aggregate passing a 14.00 mm test sieve and retained on a 10.0 mm test sieve and shall be thoroughly separated on these sieves before testing. For smaller sizes the aggregate shall be prepared in a similar manner using the appropriate sieves given in Table 1. The quantity of aggregate sieved out shall be sufficient for two tests.

The aggregate shall be tested in a surface-dry condition.

The measure shall be filled about one third full with the aggregate by means of a scoop, the aggregate being discharged from a height not exceeding 50 mm above the top of the container. The aggregate shall then be tamped with 25 blows of the rounded end of the tamping rod, each blow being given by allowing the tamping rod to fall freely from a height of about 50 mm above the surface of the aggregate and the blows being evenly distributed over the surface. A further similar quantity of aggregate shall be added in the same manner and a further tamping of 25 blows given. The measure shall finally be filled to overflowing, tamped 25 times and the surplus aggregate removed by rolling the tamping rod across, and in contact with, the top of the container, any aggregate which impedes its progress being removed by hand and aggregate ~~being~~

added to fill any obvious depressions. The net mass of aggregate in the measure shall be recorded (mass m_o) and the same mass used for the second test.

6.5 Test procedure

Rest the impact machine, without wedging or packing, upon the level plate, block or floor, so that it is rigid and the hammer guide columns are vertical.

Fix the cup firmly in position on the base of the machine and place the whole of the test sample in it and compact by a single tamping of 25 strokes of the tamping rod as above.

Adjust the height of the hammer so that its lower face is 380 ± 5 mm above the upper surface of the aggregate in the cup and then allow it to fall freely onto the aggregate. Subject the test sample to a total of 15 such blows, each being delivered at an interval of not less than 1 s. No adjustment for hammer height is required after the first blow. Then remove the crushed aggregate by holding the cup over a clean tray and hammering on the outside with a suitable rubber mallet until the sample particles are sufficiently disturbed to enable the mass of the sample to fall freely on to the tray. Transfer fine particles adhering to the inside of the cup and the underside of the hammer to the tray by means of a stiff bristle brush. Sieve the whole of the sample in the tray, for the standard test, on the 2.36 mm test sieve until no further significant amount passes in 1 min. When testing sizes smaller than the standard separate the fines on the appropriate sieve given in the column 4 of Table 1.

Weigh the fractions passing and retained on the sieve to an accuracy of 0.1 g (mass m_1 and mass m_2 respectively), and if the total mass $m_1 + m_2$ is less than the initial mass (mass m_o) by more than 1 g, discard the result and make a fresh test.

Repeat the whole procedure starting from the beginning of 6.5 using a second sample of the same mass as the first sample.

6.6 Calculations

The ratio of the mass of fines formed to the total sample mass in each test shall be expressed as a percentage, the result being recorded to the first decimal place.

$$\text{Percentage fines} = \frac{m_1}{m_o} \times 100$$

where,

m_o is the mass in g of surface-dry sample;

m_1 is the mass in g of fraction passing the sieve for separating the fines.

6.7 Reporting of results

The mean of the two results shall be reported to the nearest whole number as the aggregate impact value.

If a non-standard size of aggregate is tested, the size shall be reported.

TABLE 1 - Particulars of test sieves (see 6, 7 and 8)

Sample size	Nominal aperture sizes of test sieves complying with the requirements of CS 124 (coarse tolerance)			
	For sample preparation		For separating fines	
	passing	retained		
(1)	(2)	(3)	(4)	
	mm	mm	mm	µm
Non-standard	28.0	20.0	5.00	-
	20.0	14.0	3.35	-
Standard	14.0	10.0	2.36	-
Non-standard	10.0	6.30	1.70	-
	6.30	5.00	1.18	-
	5.00	3.35	-	850
	3.35	2.36	-	600

NOTE - Aggregate sizes larger than 14.0 mm are not appropriate to the aggregate impact test.

7 DETERMINATION OF AGGREGATE CRUSHING VALUE

7.1 Standard size of aggregate

7.1.1 *General*

The aggregate crushing value gives a relative measure of the resistance of an aggregate to crushing under a gradually applied compressive load. With aggregate of an aggregate crushing value higher than 30 the result may be anomalous, and in such cases the 10 per cent fines value (see **8**) should be determined instead. The standard aggregate crushing test shall be made as described in **7.1.3** to **7.1.7** on aggregate passing a 14.0 mm test sieve and retained on a 10.0 mm test sieve. If required, or if the standard size of aggregate is not available, the test shall be made according to **7.2**.

7.1.2 *Sampling*

The sample for this test shall be taken in accordance with **SLS ....***

7.1.3 *Apparatus*

The following apparatus is required for the standard test.

7.1.3.1 *An open ended steel cylinder,* of nominal 150 mm internal diameter with plunger and baseplate, of the general form and dimensions shown in Fig. 2.

* *Under preparation.*

The surface in contact with the aggregate shall be machined and case hardened, or otherwise treated, so as to have a hardness value of not less than 650 HV, in accordance with CS 122 and shall be maintained in a smooth condition.

7.1.3.2 *A straight metal tamping rod* of circular cross section, 16 mm diameter and 450 mm to 600 mm long. One end shall be rounded.

7.1.3.3 *A balance* of at least 3 kg capacity and accurate to 1 g.

7.1.3.4 *Test sieves* of sizes 14.0 mm, 10.0 mm and 2.36 mm conforming to CS 124 (coarse tolerance).

7.1.3.5 *A compression testing machine* capable of applying a force of 400 kN and which can be operated to give a uniform rate of loading so that this force is reached in 10 min. The machine shall comply with the requirements given in Table 2 for a grade A or a grade B machine. The machine may be used with or without a spherical seating.

7.1.3.6 *A cylindrical metal measure* for measuring the sample of sufficient rigidity to retain its form under rough usage and having an internal diameter of 115 mm and an internal depth of 180 mm.

7.1.4 *Preparation of test sample*

The material for the standard test shall consist of aggregate passing the 14.0 mm test sieve and retained on the 10.0 mm test sieve and shall be thoroughly separated on these sieves before testing. The quantity of aggregate sieved out should be sufficient for two tests.

The aggregate shall be tested in a surface-dry condition.

The quantity of aggregate for one test shall be such that the depth of the material in the cylinder shall be 100 mm after tamping as described in 7.1.5.

Fill the cylindrical measure in three layers of approximately equal depth, each layer being tamped 25 times from a height of approximately 50 mm above the surface of the aggregate with the rounded end of the tamping rod and finally level off, using the tamping rod as a straight edge. The mass of material comprising the test sample shall be determined (mass m_o).

7.1.5 *Test procedure*

Put the cylinder of the test apparatus in position on the base plate and add the test sample in thirds, each third being subjected to 25 strokes from the rounded end of tamping rod distributed evenly over the surface of the layer and dropping from a height approximately 50 mm above the surface of the aggregate. Carefully level the surface of the aggregate and insert the plunger so that it rests horizontally on this surface, taking care to ensure that the plunger does not jam in the cylinder. Place the apparatus, with the test sample and plunger in position, between the platens of the testing machine and load it at as uniform a rate as possible so that the required force is reached in 10 min. The required force shall be 400 kN.

Release the load and remove the crushed material by holding the cylinder over a clean tray and hammering on the outside with a suitable rubber mallet until the sample particles are sufficiently disturbed to enable the mass of

TABLE 2 - Requirements of testing machine

Grade	Accuracy of verification devices		Certified range			
	Load applied by weights or proving levers correct to within	Grading of elastic proving device	One-fifth load to full load of machine scale, and all loads of a machine applying fixed loads		Below one-fifth of machine scale range	
			Requirements for repeatability	Requirements for accuracy	Requirements for repeatability	Requirements for accuracy
(1)	(2)	(3)	(4)	(5)	(6)	(7)
A	per cent ± 0.2	1	per cent 1.0	per cent ± 1.0	per cent 0.2	per cent ± 0.2
B	± 0.3	2	2.0	± 2.0	0.4	± 0.4

NOTE - The requirement for accuracy is a percentage of the true load within the range one-fifth load to full load of the machine scale but is a constant load error for loads below one-fifth of the scale.

Thus at one-fifth scale on a 500 kN Grade A machine scale, the maximum percentage error of applied load permitted is ± 1 per cent, and the load error is ± 0.1 kN. The permitted load error from zero to one-fifth of the scale (100 kN) accordingly remains constant at ±0.1 kN.

the sample to fall freely on to the tray. Transfer fine particles adhering to the inside of the cylinder, to the baseplate and the underside of the plunger to the tray by means of a stiff bristle brush. Sieve the whole of the sample on the tray on the 2.36 mm test sieve until no further significant amount passes in 1 min. Weigh the fraction passing the sieve (mass m_1).

Take care in all of these operations to avoid loss of the fines.

Repeat the whole procedure, starting from the beginning of **7.1.5** using a second sample of the same mass as the first sample.

7.1.6 *Calculations*

The ratio of the mass of fines formed to the total mass of the sample in each test shall be expressed as a percentage, the result being recorded to the first decimal place:

$$\text{Percentage fines} = \frac{m_1}{m_o} \times 100$$

where,

m_o is the mass, in g, of surface-dry sample;

m_1 is the mass, in g, of the fraction passing the 2.36 mm test sieve.

7.1.7 *Reporting of results*

The mean of the two results shall be reported to the nearest whole number as the aggregate crushing value.

7.2 Non-standard sizes of aggregate

7.2.1 *General*

If required, or if the standard size is not available, tests may be made on aggregates of other sizes larger than the standard up to a size which passes a 28.0 mm test sieve, using the standard apparatus. Alternatively, tests may be made on aggregates smaller than the standard down to a size which is retained on a 2.36 mm test sieve, using either the standard apparatus or that described in **7.2.2** which is referred to as the smaller apparatus.

Owing to the non-homogeneity of aggregates the results of tests on non-standard sizes are not likely to be the same as those obtained from standard tests. In general, the smaller sizes of aggregate will give a lower aggregate crushing value and the larger sizes a higher value, but the relationship between the values obtained will vary from one aggregate to another. However, the results obtained with the smaller apparatus have been found to be slightly higher than those with the standard apparatus and the errors for the smaller sizes of aggregate tested in the smaller apparatus are therefore compensatory.

7.2.2 *Apparatus*

The following apparatus is required.

7.2.2.1 *An open ended steel cylinder,* with plunger and baseplate, generally as described in Clause **7.1.3.1,** with a nominal internal diameter of 75 mm. The general form and dimensions of the cylinder and of the plunger are shown in Fig. 2.

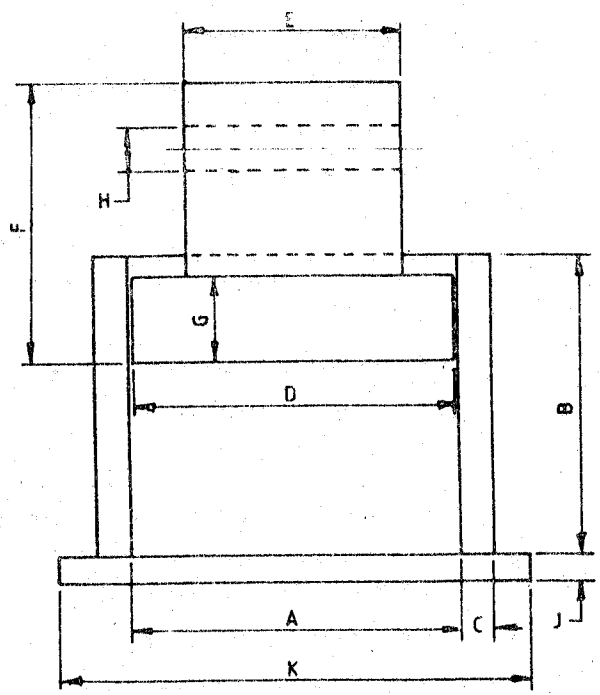

FIGURE 2 - Outline form and principal dimensions of cylinder and plunger apparatus for aggregate crushing test

	KEY TO DIMENSIONS		
Letter	**Dimensions for**	**150 mm Cylinder**	**75 mm Cylinder**
	Cylinder	mm	mm
A	Internal diameter	152.0 ± 0.5	77.0 ± 0.5
B	Height	130 to 140	70 to 80
C	Wall thickness	ϕ16	ϕ8
	Plunger		
D	Diameter of piston	150 ± 0.5	75.0 ± 0.5
E	Diameter of stem	100 to 150	50 to 75
F	Height	100 to 115	65 to 75
G	Depth of piston	25	20
H	Diameter of hole (nominal)	ϕ20	ϕ10
	Base plate		
J	Thickness (nominal)	6.3	6.3
K	Side length of square	200 to 230	110 to 115

7.2.2.2 *A straight metal tamping rod* of circular cross section 8 mm diameter and 300 mm long. One end shall be rounded.

7.2.2.3 *A balance* of at least 500 g capacity and accurate to 0.2 g.

7.2.2.4 *Test sieves* of appropriate sizes given in Table 1.

7.2.2.5 *A compression testing machine* generally as described in **7.1.3.5** except that it shall be capable of applying a force of 100 kN, and of being operated to give a uniform rate of loading so that this force is reached in 10 min.

7.2.2.6 *A cylindrical metal measure* generally as described in **7.1.3.6** except that it shall have an internal diameter of 57 mm and an internal depth of 90 mm.

7.2.3 *Preparation of test sample*

The material for tests on non-standard sizes shall consist of aggregate passing and retained on corresponding test sieves given in Table 1.

The procedure shall in other respects follow that given in **7.1.4** except that in tests with the smaller apparatus the quantity shall be such that the depth of material in the nominal 75.0 mm internal diameter cylinder shall be 50 mm after tamping with the smaller rod. The appropriate quantity is found by using the smaller measure and tamping rod as given in **7.1.4**.

7.2.4 *Test procedure*

Tests on non-standard sizes shall follow the procedure given in **7.1.5** except that, when using the smaller apparatus, the smaller tamping rod shall be used and the total force shall be 100 kN. Take particular care with the larger sizes of aggregate to ensure that the plunger does not jam in the cylinder. Sieve the material removed from the cylinder on the appropriate sieve given in Column 4 of Table 1.

7.2.5 *Calculations*

Calculations for tests on non-standard sizes shall follow the method given in **7.1.6** substituting in the description of mass m_1 the test sieve of appropriate size.

7.2.6 *Reporting of results*

Results of tests on non-standard sizes shall be reported as in **7.1.7** with, additionally, a report on the size of the aggregate tested and if smaller than the standard size, the nominal size of the cylinder used in the test.

8 DETERMINATION OF THE TEN PER CENT FINES VALUE

8.1 Standard size of aggregate

8.1.1 *General*

The 10 per cent fines value gives a measure of the resistance of an aggregate

to crushing which is applicable to both weak and strong aggregates.

The standard 10 per cent fines test shall be made as described in **8.1.3** to **8.1.7** on aggregate passing a 14.0 mm test sieve and retained on a 10.0 mm test sieve. If required, or if the standard size of aggregate is not available, the test shall be made in accordance with **8.2**.

8.1.2 *Sampling*

The sample for this test shall be taken in accordance with SLS . . .*

8.1.3 *Apparatus*

The following apparatus is required for the standard test.

8.1.3.1 *An open ended steel cylinder* with plunger and baseplate, as described in **7.1.3.1**.

8.1.3.2 *A tamping rod* as described in **7.1.3.2**.

8.1.3.3 *A balance* as described in **7.1.3.3**.

8.1.3.4 *Test sieves* as described in **7.1.3.4**.

8.1.3.5 *A compression testing machine* as described in **7.1.3.5** except that the force which is to be applied may vary from 5 kN to 500 kN.

8.1.3.6 *A cylindrical metal measure* as described in **7.1.3.6**.

8.1.3.7 *A means of measuring* (if required ; see note in **8.1.5**) to the nearest 1 mm the reduction in distance between the platens of the testing machine during the test (e.g. a dial gauge).

8.1.4 *Preparation of test sample*

The preparation of the test sample shall be as described in **7.1.4** except that, in the case of weak materials, particular care shall be taken not to break the particles when filling the measure and the cylinder.

NOTE - Sufficient test sample for three or more tests may be necessary.

8.1.5 *Test procedure*

Put the cylinder of the test apparatus in position on the baseplate and add the test sample in thirds, each third being subjected to 25 strokes from the tamping rod distributed evenly over the surface of the layer and dropping from a height approximately 50 mm above the surface of the aggregate, particular care being taken in the case of weak materials not to break the particles. Carefully level the surface of the aggregate and insert the plunger so that it rests horizontally on this surface, taking care to ensure that the plunger does not jam in the cylinder.

Then place the apparatus, with the test sample and plunger in position, between the platens of the testing machine. Apply force at as uniform a rate

* *Under preparation.*

as possible so as to cause a total penetration of the plunger in 10 min of about:

a) 15 mm for rounded or partially rounded aggregates (e.g. uncrushed gravels);

b) 20 mm for normal crushed aggregates;

c) 24 mm for honeycombed aggregates (e.g. some slags).

These figures may be varied according to the extent of the rounding or honeycombing.

NOTE - When an aggregate impact value (see Clause 4) is available, the force required for the 10 per cent fines test can be estimated by means of the following more conveniently than by the use of the dial gauge.

$$\text{Required force (kN)} = \frac{4\ 000}{\text{aggregate impact value}}$$

This value of force will nearly always give a percentage fines within the required range of 7.5 to 12.5.

Record the maximum force applied to produce the required penetration. Release the force and remove the crushed material by holding the cylinder over a clean tray and hammering on the outside with a suitable rubber mallet until the sample particles are sufficiently disturbed to enable the mass of the sample to fall freely on to the tray. Transfer fine particles adhering to the inside of the cylinder and the underside of the plunger to the tray by means of a stiff bristle brush. Sieve the whole of the sample in the tray on the 2.36 mm test sieve until no further significant amount passes in 1 min.

Weigh the fraction passing the sieve, and express this mass as a percentage of the mass of the test sample. Normally this percentage of fines will fall within the range 7.5 to 12.5, but if it does not, make a further test loading to a maximum value adjusted as seems appropriate to bring the percentage fines within the range of 7.5 to 12.5. (The formula given in **8.1.6** may be used for calculating the force required.

In all of these operations take care to avoid loss of the fines. Make a repeat test at the maximum force that gives a percentage fines within the range 7.5 to 12.5.

8.1.6 *Calculations*

The mean percentage fines from the two tests at this maximum force shall be used in the following to calculate the force required to produce 10 per cent fines.

$$\text{Force required to produce 10 per cent fines} = \frac{14x}{y + 4}$$

where,

x is the maximum force in kN;

y is the mean percentage fines from two tests at x kN force.

8.1.7 *Reporting of results*

The force required to produce 10 per cent fines shall be reported, to the nearest 10 kN for forces of 100 kN or more, or to the nearest 5 kN for loads of less than 100 kN, as the 10 per cent fines value.

8.2 Non-standard sizes of aggregate

8.2.1 *General*

If required, or if the standard size is not available, tests may be made on aggregates of other sizes which pass a 28.0 mm test sieve and are retained on a 2.36 mm test sieve. Because of the lack of experience of testing sizes other than the standard it has not been possible to give any indication as to how the results obtained on non-standard sizes would compare with those obtained in the standard test as in the case of the aggregate crushing value.

8.2.2 *Apparatus*

The apparatus shall be as described in 8.1.3.1 to 8.1.3.3 and 8.1.3.5 to 8.1.3.7. Test sieves of appropriate sizes shall be as given in Table 1.

8.2.3 *Preparation of test sample*

The material for test on non-standard sizes shall consist of aggregate passing and retained on corresponding test sieves given in Table 1.

The procedure shall in other respects follow that given in 8.1.4.

8.2.4 *Test procedure*

Tests on non-standard sizes shall follow the procedure given in 8.1.5 using the appropriate separating sieve given in Table 1 it should be noted that the penetration of the plunger may not accord with the values given in 8.1.5.

8.2.5 *Calculations*

Calculations for tests on non-standard sizes shall follow the method given in 8.1.6.

8.2.6 *Reporting of results*

Results of tests on non-standard sizes shall be reported as in 8.1.7 with, additionally, a report on the size of the aggregate tested.

9 DETERMINATION OF AGGREGATE ABRASION VALUE

9.1 General

Two methods are described; one by estimating the abrasion on a prepared specimen of aggregate by a circular grinding lap and the other by the use of Los Angeles machine.

The abrasion value recorded for a particular aggregate would depend on the method of test. When the aggregate abrasion value is reported the method of test should be stated.

9.2 Sampling

The samples for this test shall be taken in accordance with **SLS . . .** *

9.3 Method using grinding lap

9.3.1 *Apparatus*

The following apparatus is required.

9.3.1.1 *An abrasion machine* consisting essentially of a machined flat circular cast iron or steel grinding lap not less than 600 mm in diameter, which can be rotated in a horizontal plane at a speed of 28 rev/min to 30 rev/min, fitted with a revolution counter, and which is provided with the following accessories:

a) At least two machined metal moulds for preparing specimens, manufactured with removable ends and with internal dimensions of 92.0 mm x 54.0 mm x 16.0 mm all ± 0.1 mm (see footnote to **9.3.2.2**).

b) At least two machined metal trays or metal backing plates for holding the prepared specimens. Trays made from 5 mm mild steel plate and of internal dimensions 92.0 mm x 54.0 mm x 8.0 mm, all ± 0.1 mm are suitable.

c) At least two machined flat plates made from 5 mm mild steel plate of dimensions 115 mm x 75 mm, all ± 0.1 mm.

d) Means for locating two of the trays (or specimens with backing plates) with their centre points 260 mm from the centre of the lap diametrically opposite to each other and with their long sides lying in the direction of rotation of the lap. The trays shall be free to move in a vertical plane but restrained from moving in the horizontal plane.

e) Two weights, each with a rounded base for pressing the test specimen against the surface of the lap and each having a means for adjusting its mass, including test specimen and tray, to 2 kg ± 10 g (see **9.3.5**).

f) Means for feeding sand continuously on the lap in front of each test specimen at a rate of 700 g/min to 900 g/min, and for removing and recovering the sand after it has passed under the test specimens.

9.3.1.2 Test sieves 14.0 mm, 1.18 mm, 850 µm, 600 µm, 425 µm, 300 µm and 212 µm conforming to **CS 124** (coarse tolerance).

9.3.1.3 *Two fine haired brushes* (about 3 mm) and a stiff brush.

9.3.1.4 *A balance,* of capacity not less than 1 kg, accurate to 0.1 g.

9.3.1.5 *A well ventillated oven* thermostatically controlled at a temperature of 105 ± 5 °C.

9.3.1.6 A 20.0 mm to 14.0 mm *special slotted flake sorting sieve* (see **Part 1** of this standard) having a slot width of 10.2 ± 0.15 mm.

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* *Under preparation.*

9.3.2 *Materials*

9.3.2.1 *An abrasive* consisting of natural rounded siliceous sand, such as Leighton Bazzard (witn the maximum possible amount of quartz particularly in its fine fraction), at least 75 per cent of which shall pass the 600 µm test sieve and be retained on the 425 µm test sieve and all of which shall pass the 850 µm test sieve and be retained on the 300 µm test sieve. The sand shall be dry, shall not have been previously used and shall show a loss of mass not exceeding 0.25 per cent on extraction with hot dilute hydrocloric acid. About 3 kg of sand shall be used for each sample.

9.3.2.2 *Polyester resin and hardner,* such as crystic resin, together with a release agent such as liquid car polish, a cleaning solvent or a mixture of 90 per cent acetone 10 per cent kerosine (by volume), and disposable paper cups.

NOTE - Crystic resin gives about 0.5 mm shinkage on the length and width of the specimen; if a non-shrinking resin is used the appropriate mould dimensions should be decreased by 0.5 mm.

9.3.2.3 *Fine sand* (passing 212 µm test sieve), to prevent the polyester resin from squeezing up between the individual pieces of aggregate.

9.3.3 *Sample for test*

The test sample shall consist of aggregate passing the 14.0 mm test sieve and retained on the 20.0 mm to 14.0 mm flake sorting sieve. It shall be washed to remove surface dust. The aggregate shall be tested in a surface-dry condition.

9.3.4 *Preparation of test specimen*

Two specimens shall be made for each test. As many particles as possible from the test sample, but in any case not less than 24, shall be placed in the mould in a single layer with their flattest surface lying on the bottom of the mould.

The particles may be selected from the test sample as required but care shall be taken to ensure that they are representative of the test sample.

The interstices between the pieces of aggregate shall then be filled to approximately three quarters of their depth with the fine sand which shall then be levelled with one fine haired brush. The exposed internal faces and top edges of the mould shall be lightly coated with release agent with the second fine haired brush. Sufficient resin and hardener shall then be mixed in a disposable cup and used to fill the mould to overflowing.

One side of the flat plate shall then be coated with the release agent and it shall be placed firmly on the mould coated side down and held in position by a weight of not less than 2 kg. When the resin has hardened (usually after 30 min) the plate shall be removed and excess resin trimmed off with a knife or spatula. The specimen shall then be removed from the mould, the loose sand removed with the stiff brush and the specimen then weighed to the nearest 0.1 g (mass m_o).

NOTES

1 Approximately equal proportions of resin and hardener have been found to be suitable when using Crystic resin.

2 The solvent should be used to clean moulds, tools, etc., as required.

9.3.5 *Test procedure*

Fit each specimen into one of the machined metal trays or metal backing plates, taking care to ensure a tight fit. Weigh each specimen in its tray with one of the weights whose mass shall then be adjusted until the total is 2 kg ± 10 g. Place the two specimens in the abrasion machine diametrically opposite to each other with their centre points 260 mm from the centre of the lap and so that the 92 mm x 54 mm face of exposed aggregate particles rests on the lap over the whole face area; then place the appropriate weights centrally on the specimens. Then turn the lap through 500 revolutions at a speed of 28 rev/min to 30 rev/min, the abrasive sand specified above being fed continuously on to it across the full width of the specimen immediately in front of each test specimen at a rate of 700 g/min to 900 g/min per specimen*. To ensure that the sand is fed beneath each specimen lift them clear of the lap for 1 revolution before the start of abrasion and at every hundredth revolution thereafter. Remove the sand with a rubber edged blade, mounted so that the rubber edge rests lightly on the lap for its full width, and collect it.

If it becomes apparent that, because of the nature of the aggregate, it has abraded away to the level of the resin backing discontinue the test. Report the number of revolutions. Conversely, some very hard aggregates may visibly score the machined surface of the grinding lap, in which case the surface shall be remachined.

Immediately screen the sand on the 1.18 mm test sieve and re-use it as many times as is necessary to complete the test and then discard it.

On completion of 500 revolutions remove the test specimens from the machine, remove the trays or backing plates and weigh the specimens to the nearest 0.1 g (mass m_1).

9.3.6 *Calculations*

The aggregate abrasion value of each test specimen shall be calculated as follows:

$$\text{Aggregate abrasion value} = \frac{3(m_o - m_1)}{\rho}$$

where,

m_o is the mass in g, of specimen before abrasion;

m_1 is the mass in g, of specimen after abrasion;

ρ is the relative density of sample (on saturated surface dried basis) as determined in Clause 6 of **SLS 728:Part 2.**

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* *A slot of about 1.3 mm width is suitable.*

9.3.7 *Reporting of results*

The mean of the two results shall be reported to two significant figures as the aggregate abrasion value by the grinding lap method, unless the individual results differ from the mean of the two results by more than 10 per cent of the mean value. In this case the test shall be repeated and the mean of the four tests shall be reported as the aggregate abrasion value.

9.4 Method using the Los Angeles machine

9.4.1 *Apparatus*

The following apparatus is required.

9.4.1.1 *The Los Angeles abrasion testing machine* conforming in all its essential characteristics to the design shown in Fig. 3. The machine shall consist of a hollow steel cylinder, closed at both ends, having an inside diameter of 711 ± 5 mm and an inside length of 508 ± 5 mm. The cylinder shall be mounted on stub shafts attached to the ends of the cylinder but not entering it, and shall be mounted in such a manner that it may be rotated about its axis in a horizontal position. An opening in the cylinder shall be provided for the introduction of the test sample. The opening shall be closed dust-tight with a removable cover bolted in place. The cover shall be so designed as to maintain the cylindrical contour of the interior surface unless the shelf is so located that the charge will not fall on the cover, or come in contact with it during the test. A removable steel shelf, projecting radially 89 ± 2 mm into the cylinder and extending its full length, shall be mounted along one element of the interior surface of the cylinder. The shelf shall be of such thickness and so mounted, by bolts or other approved means, as to be firm and rigid. The position of the shelf shall be such that the distance from the shelf to the opening, measured along the outside circumference of the cylinder in the direction of rotation, shall be not less than 1 270 mm.

NOTE - The use of a shelf of wear-resistant steel, rectangular in cross-section and mounted independently of the cover, is preferred. However, a shelf consisting of a section of rolled angle, properly mounted on the inside of the cover plate, may be used, provided the direction of rotation is such that the charge will be caught on the outside face of the angle.

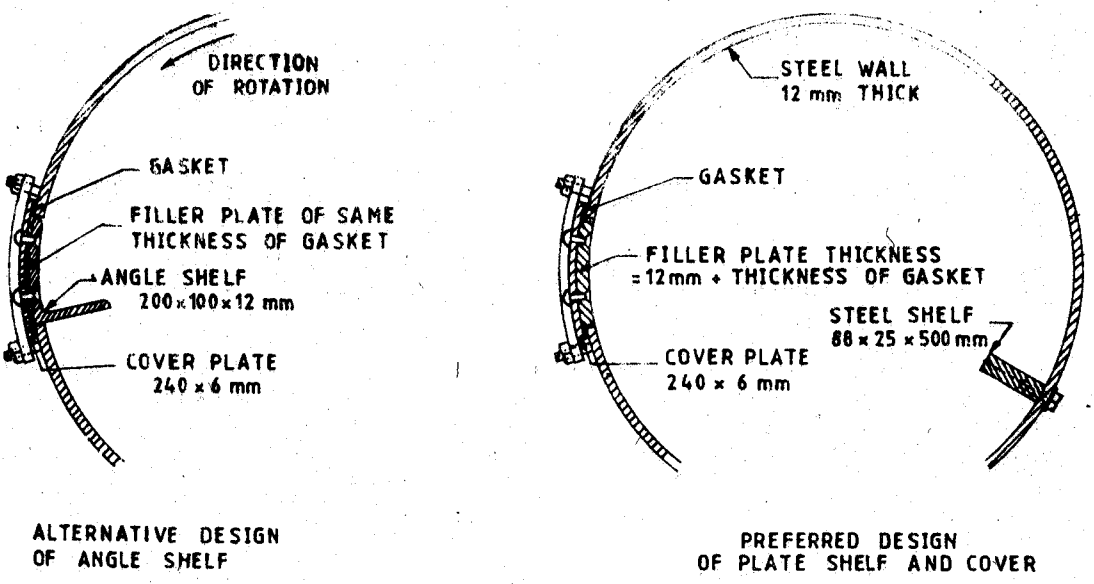
9.4.1.2 *Test sieve* of size 1.70 mm conforming to **CS 124** (coarse tolerance).

9.4.2 *Abrasive charge*

The abrasive charge shall consist of steel spheres approximately 47 mm in diameter and each weighing between 390 g and 445 g.

The abrasive charge, depending upon the grading of the test sample as described in **9.4.3** shall be as follows:

Grading	Number of spheres	Mass of charge g
A	12	5 000 ± 25
B	11	4 584 ± 25
C	8	3 330 ± 20



ALTERNATIVE DESIGN
OF ANGLE SHELF

PREFERRED DESIGN
OF PLATE SHELF AND COVER

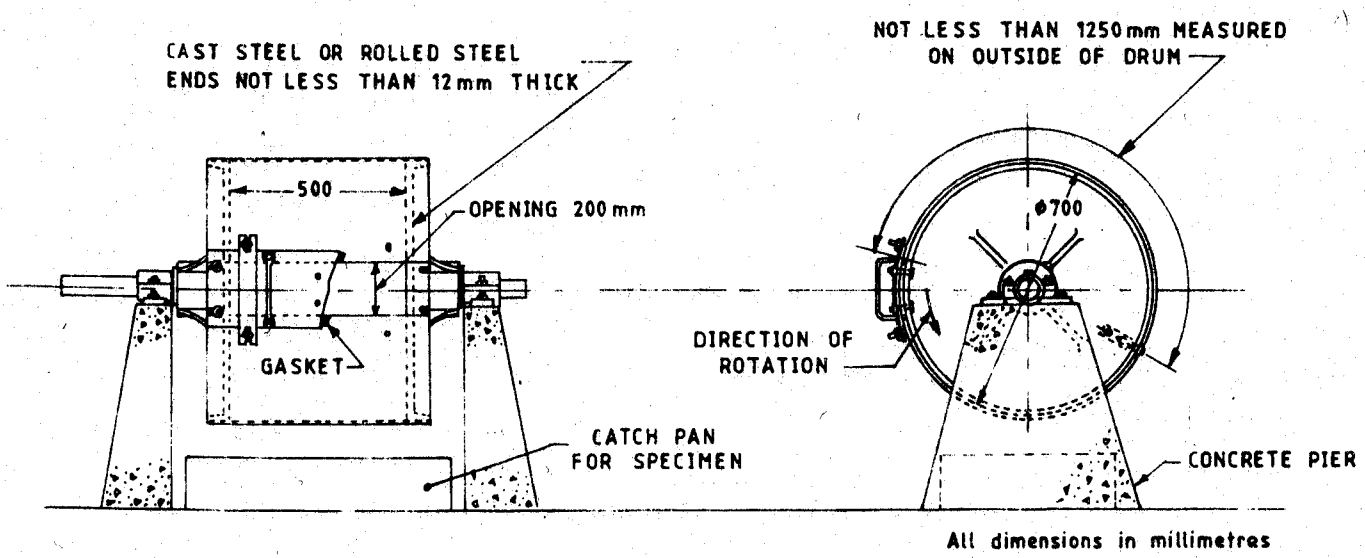


FIGURE 3 - Los Angeles testing machine

Grading	Number of spheres	Mass of charge g
D	6	2 500 ± 15
E	12	5 000 ± 25
F	12	5 000 ± 25
G	12	5 000 ± 25

9.4.3 *Test sample*

The test sample shall consist of clean aggregate which has been dried in an oven at 105 °C to 110 °C to substantially constant weight and shall conform to one of the gradings shown in Table 3. The grading or gradings used shall be those most nearly representing the aggregate furnished for the work.

9.4.4 *Procedure*

The test sample and the abrasive charge shall be placed in the Los Angeles abrasion testing machine and the machine rotated at a speed of 30 to 33 revolutions per minute. For gradings A, B, C and D, the machine shall be rotated for 500 revolutions; for gradings E, F and G, it shall be rotated for 1 000 revolutions. The machine shall be so driven and so counter-balanced as to maintain a substantially uniform peripheral speed. If an angle is used as the shelf, the machine shall be rotated in such a direction that the charge is caught on the outside surface of the angle. At the completion of the test, the material shall be discharged from the machine and a preliminary separation of the sample made on a sieve coarser than the 1.70 mm sieve. The finer portion shall then be sieved on a 1.70 mm sieve in the manner described in **6.1.4** of **SLS 728:Part 1:1986** (Under preparation).

The material coarser than the 1.70 mm sieve shall be washed, dried in an oven at 105 °C to 110 °C to a substantially constant mass, and weighed accurate to the nearest gram.

NOTE - Valuable information concerning the uniformity of the sample under test may be obtained by determining the loss after 100 revolutions. When this determination is made, care should be taken to avoid loss of any part of the sample; the entire sample including the dust of abrasion, shall be returned to the testing machine for the completion of the test.

9.4.5 *Calculations*

The percentage of wear of the test specimen shall be calculated as follows:

$$\text{Percentage of wear} = \frac{(m_o - m_1)\ 100}{m_o}$$

where,

m_o is the mass, in g, of test specimen before abrasion;

m_1 is the mass, in g, of test specimen after abrasion.

NOTE - The percentage of wear determined for gradings A, B, C and D has no known consistant relationship to the percentage of wear for the same material when determined for gradings E, F and G.

TABLE 3 – Grading of test samples for aggregate abrasion value using Los Angeles machine

Aggregate size fraction		Mass of test sample						
Test Sieve aperture	Nominal size	Grade						
Passing mm	Retained mm	A g	B g	C g	D g	E g	F g	G g
75.0	63.0					2 500 ± 50		
63.0	50.0					2 500 ± 50		
50.0	37.5					5 000 ± 50	5 000 ± 50	
37.5	28.5	1 250 ± 25					5 000 ± 25	5 000 ± 25
28.5	20.0	1 250 ± 25						5 000 ± 25
20.0	14.0	1 250 ± 10	2 500 ± 10					
14.0	10.0	1 250 ± 10	2 500 ± 10					
10.0	6.30			2 500 ± 10				
6.30	5.00			2 500 ± 10				
5.00	3.35				2 500 ± 10			
3.35	2.36				2 500 ± 10			

9.4.6 *Reporting of results*

The percentage of wear by the Los Angeles abrasion method shall be reported to two significant figures.

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