

METHOD OF TEST FOR DETERMINATION OF PERCENT FLAT AND ELONGATED PARTICLES IN COARSE AGGREGATE

1. SCOPE

1.1 This method covers the determination of the percentage of flat and elongated particles in processed coarse aggregate, retained on the 4.75 mm sieve by measurement of individual particles.

2. RELEVANT DOCUMENTS

- 2.1 ASTM D4791 Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
- 2.2 CSA-A 23.2-13A Flat and Elongated Particles in Coarse Aggregate

3. DEFINITION

3.1 FLAT AND ELONGATED pieces shall be those particles whose greatest dimension in the longitudinal axis, compared to the least dimension in a plane perpendicular to the longitudinal axis, exceeds a ratio of 4:1.

4. APPARATUS

- 4.1 BALANCE: A balance having a capacity of 5000 g and readable to 1.0 g or less.
- 4.2 CALIPERS: Proportional (figure-of-eight) calipers in which the ratio of the opening at one end to the other is 4:1.

Note: The proportional calipers must be checked periodically to ensure that the 4:1 ratio is maintained throughout the range of opening.

5. PREPARATION OF TEST SAMPLE

- 5.1 Prepare the coarse aggregate according to LS-600.
- 5.2 Dry the sample sufficiently to obtain a clean separation of particles on the 4.75 mm sieve.
- 5.3 Separate the sample by sieving according to LS-602 into one or more of the individual fractions indicated in Table 1.
- 5.4 Prepare the test sample from each coarse aggregate fraction representing at least 5% or more of the submitted sample according to the minimum masses shown in Table 1.

Note: The test sample only needs to be prepared from those coarse aggregate fractions representing at least 5% or more of the submitted sample. Maintain each fraction of the test sample in separate sizes.

5.5 When the test sample contains a mixture of natural aggregate, recovered crushed concrete, recovered asphaltic material, glass and/or ceramic material, the size of test sample shall be

increased so that the amount of natural aggregate and recovered crushed concrete in the test sample meets the requirements of Table 1.

Table 1 - Sample Preparation

Coarse Aggregate Fraction		Mass (minimum), g
Passing	Retained	
37.5 mm	26.5 mm	3000
26.5 mm	19.0 mm	2000
19.0 mm	13.2 mm	1250
13.2 mm	9.5 mm	500
9.5 mm	6.7 mm	200
6.7 mm	4.75 mm	75

5.6 Weigh and record the mass of material of each fraction to the nearest 1 g.

6. TEST PROCEDURE

6.1 Spread each test fraction on a clean, flat surface large enough to permit individual particles to be easily inspected.

6.2 For each fraction, separate the particles of each test fraction by means of calipers into: (i) flat and elongated, and; (ii) cubical particles. Set the caliper on the maximum particle length, and then check whether the least particle dimension will completely pass through the opening at the small end of the caliper.

6.3 Weigh and record the mass of each flat and elongated and cubical portion of the fraction to the nearest 1 g. Table 2 is a laboratory worksheet for recording test data and calculations.

7. CALCULATION

7.1 Calculate the per cent of flat and elongated particles in each test fraction (to one decimal place) as follows:

$$\% \text{ Flat \& Elongated} = \frac{A}{A+B} \times 100$$

Where: A = mass of flat and elongated particles

B = mass of cubical particles

7.2 Compute the percent of each fraction specified in Table 1 using the gradation test (LS-602) results of the coarse aggregate portion, i.e., based on the total mass of material retained on 4.75 mm sieve.

7.3 Calculate the per cent of flat and elongated particles weighted average value for each fraction as follows: Multiply the percentage of each fraction calculated in Section 7.2 and the per cent flat and elongated particles for that fraction.

7.4 Calculate the per cent of flat and elongated particles of the test sample as the sum of the weighted average value for each fraction divided by 100.

7.5 For the purpose of calculating the weighted average, consider any fraction (not tested) containing less than 5% of the test sample to have a value equal to the average of the next smaller and the next larger fractions. If one of these sizes is missing, assign the same value as the next larger or smaller fraction, whichever is present.

8. REPORTING OF RESULTS

8.1 Report the per cent flat and elongated of each fraction of the test sample to the nearest whole per cent.

8.2 Report the weighted average per cent flat and elongated of the test sample to the nearest whole per cent.

9. GENERAL NOTES

9.1 Material used in this test may be reused if insufficient material is available for all the required tests.

10. PRECISION

10.1 The estimates of precision for coarse aggregate passing 19.0 mm and retained on 4.75 mm are based on the results from the proficiency sample testing program conducted by MTO. The data are based on the analyses of the test results from 155 to 221 laboratories that tested eleven pairs of coarse aggregate proficiency test samples covering twelve year period from 2000 to 2011.

10.2 The single-operator standard deviation has been found to be 0.8^A . Therefore, results of two properly conducted tests on samples of the same aggregate by the same operator using the same equipment are not expected to differ by more than 2.2^A of their average. The multi-laboratory standard deviation has been found to be 2.3^A . Therefore, the results of two properly conducted tests by two different laboratories on samples of the same aggregate are not expected to differ by more than 6.4^A of their average.

10.3 ^A These numbers represent, respectively, the (1s) and (d2s) limits as described in ASTM C670. Precision estimates are based on aggregates having a nominal maximum size of 19.0 mm with percent flat and elongated values ranging from 2% to 9.5%.

Table 2. Percent Flat and Elongated Particles Worksheet (all masses in grams)

Sample No.: _____

Date: _____

Test Sample Fraction	Mass of Test Specimen (g)	Percent of Each Fraction ¹	Flat & Elongated Particles Mass (A)	Cubical Particles Mass (B)	% Flat and Elongated Particles (%FE)	
					Per fraction $\frac{A}{A+B} \times 100$	Weighted per fraction ²
37.5 – 26.5 mm						
26.5 – 19.0 mm						
19.0 – 13.2 mm						
13.2 – 9.5 mm						
9.5 – 6.7 mm						
6.7 – 4.75 mm						
Notes: 1. As determined by LS-602 in Section 7.2 2. = %FE (per fraction) x % of each fraction					% FE particles, Weighted Average $(\Sigma \text{Weighted per fraction}) \div 100$	

Remarks: _____

Operator: _____