

METHOD OF TEST FOR RELATIVE DENSITY AND ABSORPTION OF COARSE AGGREGATE

1. SCOPE

This method covers the determination of relative density (oven-dry and saturated-surface-dry) and apparent relative density at 23°C and absorption of coarse aggregate.

2. RELEVANT DOCUMENTS

AASHTO T 85 Specific Gravity and Absorption of Coarse Aggregate
ASTM C127 Standard Test Method for Density, Relative Density (Specific Gravity), and
Absorption of Coarse Aggregate

3. DEFINITION

Coarse aggregate: For the purpose of this test, coarse aggregate is all aggregate material retained on the 4.75 mm sieve. This includes material retained on the 4.75 mm sieve contained in fine aggregates.

4. PROCEDURE

Procedures of ASTM C127 (concrete aggregate) and AASHTO T 85 (asphalt aggregate) shall be followed, except as noted below, for the determination of relative density at 23°C and absorption of coarse aggregate. When the material passing the 4.75 mm sieve in coarse aggregate exceeds 5%, this material shall be blended with the fine aggregate in LS-605, clause 6.2.1.

5. EXCEPTIONS

5.1 Individual coarse aggregates for hot mix asphalt mixture design process.

5.1.1 Obtain a representative sub-sample of approximately 3000 g of oven-dried coarse aggregate by use of a sample splitter or by quartering.

5.1.2 Remove all material finer than 4.75 mm by dry sieving. Remove all dust or other coatings by thorough washing. In the case of RAP, use a wetting agent.

5.1.3 Saturate the samples in water by immersion for 15-19 hours.

5.2 Blended coarse aggregates for hot mix asphalt mixture design process (Note 1).

5.2.1 Prepare two 3-kg sub-samples and perform the test on each.

5.2.2 Sample preparation for hot mix asphalt coarse aggregates shall be modified as follows: When more than one coarse aggregate will be used, the coarse aggregates shall be blended in the volume or mass proportion in which they will be used. When the densities of individual aggregates are within 0.02 of each other, the per cent by mass can be assumed to be the same as per cent by volume.

5.2.3 When there is more than 5% by mass coarse aggregate in the blended fine aggregate, the coarse fraction of the blended fine aggregate shall be included in the coarse aggregate test sample in the correct proportion. When RAP is used, the materials shall be blended by mass proportion.

Note 1: Testing of blended coarse aggregate is carried out only when specified by the owner. If the densities of the individual coarse aggregates used in the mix are significantly different, follow the example provided in Appendix A to prepare the test sample.

5.3 Coarse aggregates extracted from RAP for both Marshall and Superpave mix design.

5.3.1 Obtain a sample of RAP following LS-312. Remove the asphalt from the RAP by solvent extraction with a suitable solvent. Soak the extracted aggregates for a minimum of 16 hours in alcohol (Note 2). Keep the container covered to reduce evaporation. Drain off the alcohol.

Note 2: A variety of alcohols have been used, with methyl hydrate (methanol) being the most common. The use of alcohol following asphalt extraction gives a lower BRD and higher absorption compared to the use of a wetting agent alone.

5.3.2 Soak the extracted aggregate in water treated with a suitable wetting agent such as a solution of Calgon (Note 3) or detergent.

Note 3: To make a suitable solution dissolve 24 g of sodium hexametaphosphate (Calgon) per litre of tap water.

5.3.3 Drain off the water. Oven-dry the material and separate on a 4.75 mm sieve into coarse and fine aggregate fractions. Do not sieve so thoroughly as to significantly change the shape of the aggregate particles. Determine the density of fine aggregate following LS-605, and density and absorption of coarse aggregate following 5.1.

5.4 Combinations of virgin coarse aggregate and RAP for Marshall mix design process.

5.4.1 Determine the density of the coarse aggregate extracted from the RAP using duplicate samples. Calculate the density of the coarse aggregate in the asphalt mixture by using a calculation based on the density of the virgin coarse aggregate determined following 5.1 or 5.2 and the density of the RAP coarse aggregate. The calculation shall be based on the mass proportions of virgin coarse aggregate to the mass proportion of coarse aggregate contributed to the mixture by the RAP after subtracting the amount of asphalt contributed by the RAP.

5.4.2 Combinations of virgin coarse aggregate and RAP for Superpave mix design process.

5.4.3 Mix the coarse aggregate, following extraction, with virgin coarse aggregate in the mass proportions in which the materials will be used in the mixture design. Determine the density and absorption on duplicate samples of the combination following 4.1.

5.5 If duplicate tests of relative density differ by more than 0.020, the material shall be retested.

5.6 If duplicate tests of absorption differ by more than 0.20%, the material shall be retested.

5.7 Coarse aggregate which have been previously treated with a hydrated lime anti-stripping agent.

5.7.1 Obtain and test samples prior to the addition of hydrated lime when both the coarse and the fine aggregate have been treated (Note 4). If only the coarse aggregate has been treated, samples may be obtained after treatment but must be thoroughly washed prior to testing.

Note 4: Hydrated lime cannot be completely removed by washing even with wetting agents. The presence of lime gives fine aggregates lower BRD and higher absorption values. For this reason, testing should be conducted prior to the addition of lime. Coarse aggregate density and absorption values are not significantly affected by the presence of hydrated lime and, in this case, may be obtained after addition of lime, but it is preferable to obtain samples prior to addition of lime if at all possible.

6. USE OF LABORATORY CONTROL AGGREGATE

6.1 Every ten samples, but at least every week in which a sample is tested, a sample of the standard reference aggregate shall also be tested. Material shall be taken from a stock supply of Stoney Lake Brothers Quarry stone maintained by the Soils and Aggregates Section, Ministry of Transportation, 1201 Wilson Avenue, Downsview, Ontario M3M 1J8, Fax (416) 235-4101. Only the material retained 4.75 mm and coarser shall be tested. It is permissible to re-use the reference material provided it does not degrade due to multiple wetting and drying cycles.

6.2 Control Chart Use: The relative density and absorption of the last twenty samples of reference material shall be plotted on a control chart in order to monitor the performance of the laboratory.

6.3 The mean absorption of the Drain Brothers Stoney Lake Quarry standard reference aggregate is 0.39% (MERO-036, 2010). Individual test data should not normally be greater than 0.49% or less than 0.29%.

6.3.1 The mean relative density (oven-dry) of the Drain Brothers Stoney Lake Quarry standard reference aggregate is 2.690. Individual test data should not normally be greater than 2.699 or less than 2.681.

7. REPORT

The report shall include the following:

7.1 If duplicate tests of absorption and relative density are made, the mean of the results shall be reported as the final "test result".

7.2 If more than one aggregate is tested, report the density and absorption of each and the weighted average of the combination.

7.3 The percent absorption to the nearest 0.01%, and relative densities to the nearest 0.001 of the reference sample, tested closest to the time at which the aggregate sample was tested.

7.4 The percent absorption and relative density of the last 20 samples of reference material on control charts.

8. PRECISION

8.1 The estimates of precision for coarse aggregate 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 85 to 110 laboratories that tested twelve pairs of coarse aggregate proficiency test samples covering a twelve year period from 2000 to 2011. The criteria for judging the acceptability of test results obtained by this test method on a range of aggregates found in Ontario are as follows:

Test Result	Standard Deviations (1s)		Acceptable Range (d2s)	
	Single-Operator	Multi-Laboratory	Single-Operator	Multi-Laboratory
Relative Density (O.D)	0.004	0.006	0.010	0.017
Absorption ^B	0.04	0.09	0.110	0.252

^A These numbers represent, respectively, Standard Deviations (1s) and Acceptable Range (d2s) limits as described in ASTM C670. ^B Precision estimates are based on coarse aggregates with absorption of less than 2% and may differ for aggregates having absorption values greater than 2%.

APPENDIX A

Development of Equations for Preparation of Test Samples with Different Densities

The equations are derived for an asphalt mix consisting of three types of coarse aggregates, Type A, B, and C, with different densities and the blended fine aggregate portion used will contain $P_f\%$ by mass of material coarser than 4.75 mm. The mass, bulk specific gravity, and volume of coarse aggregate Type A in the blended portion M_a in grams, G_a and $P_a\%$ by volume. The mass, bulk specific gravity, and volume of other two coarse aggregates (Type B and C) in the mix are M_b , G_b , and $P_b\%$, and M_c , G_c , $P_c\%$, respectively.

$$\text{Mass of coarse aggregate from fine aggregate } M_f \text{ in grams} = (M_t) \left(\frac{P_f}{100} \right)$$

$$\text{Mass of blended coarse aggregates (Type A, B, & C) in the test sample} = (M_t - M_f) \text{ grams}$$

$$P_a + P_b + P_c = 100$$

$$M_a = G_a V_a, M_b = G_b V_b \text{ and } M_c = G_c V_c$$

$$(V_a)/(V_b) = (P_a)/(P_b)$$

$$M_a + M_b + M_c = (M_t - M_f)$$

Where: V_a , V_b , V_c are the volume of coarse aggregates Type A, B, and C in the mix.

Manipulation of the above equations yields masses M_a , M_b , and M_c of coarse aggregates in the test sample.

$$M_a = (M_t - M_f) \left[\frac{(P_a G_a)}{(P_a G_a + P_b G_b + P_c G_c)} \right],$$

$$M_b = (M_t - M_f) \left[\frac{(P_b G_b)}{(P_a G_a + P_b G_b + P_c G_c)} \right] \text{ and}$$

$$M_c = (M_t - M_f) \left[\frac{(P_c G_c)}{(P_a G_a + P_b G_b + P_c G_c)} \right]$$

Example: The proposed asphalt mix will use 3 types of coarse aggregates, Types A, B, and C, in the proportion of 50%, 30%, and 20% by volume. The bulk specific gravity of coarse aggregates A, B, and C are 2.600, 2.685, and 2.750. The fine aggregates in the proposed mix will contain 10% by mass of material coarser than 4.75 mm. Prepare 3000 grams of test sample in the proportion of coarse aggregates expected in the proposed asphalt mix.

$$\text{The portion of the coarse aggregate from the fine aggregate} = 3000 \times (10/100)$$

$$= 300.0 \text{ grams}$$

Mass of blended coarse aggregates (A, B, & C) in the test sample = $(3000.0 - 300.0)$

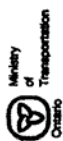
$$= 2700.0 \text{ grams}$$

Mass of Type A in the test sample = $(2700.0)(2.600 \times 50) / (2.600 \times 50 + 2.685 \times 30 + 2.750 \times 20)$
= 1321.8 grams

Mass of Type B in the test sample = $(2700.0)(2.685 \times 30) / (2.600 \times 50 + 2.685 \times 30 + 2.750 \times 20)$
= 819.0 grams

Mass of Type C in the test sample = $(2700.0)(2.750 \times 20) / (2.600 \times 50 + 2.685 \times 30 + 2.750 \times 20)$
= 559.2 grams

The total mass of tests sample = $300.0 + 1321.8 + 819.0 + 559.2 = 3000.0 \text{ grams}$



RELATIVE DENSITY AND ABSORPTION - COARSE AGGREGATE

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DATE _____

OPERATOR

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Figure 1 **Relative Density and Absorption – Coarse Aggregate Data**