FREEZING AND THAWING OF COARSE AGGREGATE

LS-614 R33

1. SCOPE

1.1 This method covers the testing of coarse aggregates to determine their resistance to disintegration by repeated freezing and thawing in a sodium chloride solution. It provides information helpful in judging the soundness of aggregates subject to freezing and thawing action, particularly when adequate information is not available from service records of the material exposed to actual weathering conditions.

3. APPARATUS

3.1 FREEZER: A freezer (chest, stand-up, or walk-in type) capable of maintaining a temperature of -18.0 ± 2.0°C..... _____

There shall be a fan that provides adequate air circulation so that the maximum variation within 25 cm of the top and the bottom of the space does not exceed 2.0°C..... _____

The temperature of the freezer must be continually monitored at different points within the chamber, either by thermometer or thermocouple. If thermometers are used, the bulb should be in a metal sleeve to avoid sudden temperature changes when the door or lid is opened..... _____

3.2 SIEVES: With square openings and of suitable sizes to furnish the information required by the specification covering the material to be tested. The sieves shall conform to ASTM E11..... _____

Half height sieves shall not be used for sieving material coarser than 9.5 mm..... _____

Sieve Sizes

37.5 mm
26.5 mm
19.0 mm
13.2 mm
9.5 mm
4.75 mm

3.3 THERMOMETERS: Mercury or alcohol type with a range of -35°C to +50°C marked in 1° divisions readable to 0.5°C..... _____

All thermometers must be calibrated with an ASTM precision reference thermometer accurate to 0.1°C, at 0°C..... _____

3.4 CONTAINERS: Autoclavable plastic mason jars, with airtight screw-on caps able to withstand a continuous temperature of 110°C..... _____

Jars with a volume of 1 L are used for fractions retained on the 13.2 mm and 9.5 mm sieves and 500 ml jars for the fraction passing 9.5 mm retained 4.75..... _____

Note 1: Containers must not come into contact with metal shelves or freezer walls because more rapid cooling will occur.

3.5 PLASTIC MESH BASKETS: Capable of holding four 500 ml jars or two 1 L and one 500 ml jars, and suitable wooden or plastic spacers placed between them to keep the jars from coming in contact with each other..... _____

The baskets should be stackable with sufficient clearance for the larger jars..... _____

3.6 BALANCE: A balance or scale accurate to within 0.1% of the sample mass, or 1 g, whichever is greater, over the range required for the test..... _____

3.7 MECHANICAL CONVECTION OVEN: Capable of maintaining a temperature of 110 ± 5°C..... _____

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3.8 CONTROL AGGREGATE: A supply of control aggregate shall be obtained from the Soils and Aggregates Section of the Materials Engineering and Research Office at the Ministry of Transportation (soils-aggregates@ontario.ca)..... _____

4. PREPARATION OF SOLUTION

4.1 Prepare sufficient 3% sodium chloride solution for the aggregate to be tested. For example, dissolve 30 g of sodium chloride in 970 g of water. Domestic table salt is acceptable. (Studies have shown that a concentration of 3% caused the most severe freeze-thaw damage.) ..... _____
A graduated beaker or cylinder may be used for the water using 1 g = 1 ml, but check accuracy of volume markings..... _____
Large quantities of sodium chloride solution should be prepared to minimize any error in measurement..... _____
Prior to using the solution, the container should be agitated thoroughly..... _____

5. PREPARATION OF SAMPLE

5.1 Aggregate for the test shall consist of material retained on the 4.75 mm sieve (coarse aggregate) ..... _____
Separate the sample into fractions, shown in Table 1, by sieving (see Note 2) ..... _____
Weigh out quantities, as indicated in Table 1, of the different sizes present in the sample..... _____
If any fraction constitutes less than 5% of the original sample, it shall not be tested..... _____
Note 2: Continuous sieving of aggregates in mechanical sieve shakers will cause continual breakdown. It is good practice to limit mechanical sieving.

Table 1 - Gradings and Masses of Test Samples

Pass	Retained	Mass (g)
37.5 mm	26.5 mm	5000
26.5 mm	19.0 mm	2500
19.0 mm	13.2 mm	1250
13.2 mm	9.5 mm	1000
9.5 mm	4.75 mm	500

The retained material on each sieve is then weighed and the sample placed in the appropriate size jar___
Mark a number on the jar and lid, and refer this number to the laboratory number and sieve size by recording on the laboratory test data cards..... _____
Lids of jars should be marked with an arrow to indicate the direction of rotation between cycles._____
5.2 Every time a freeze-thaw test is conducted, a sample of the standard control aggregate shall also be tested..... _____
The material shall be taken from a stock supply and prepared as described in 5.1..... _____

6. PROCEDURE

6.1 Place aggregate passing 19.0 mm retained 13.2 mm in a 1 L jar. Aggregate passing 13.2 mm and retained 9.5 mm is also placed in a 1 L jar..... _____
Aggregate passing 9.5 mm retained 4.75 mm is placed in a 500 ml jar..... _____

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Aggregate larger than 19 mm shall be placed in 2 or more containers so that all of the required sample is tested..... _____
6.2 Saturation of samples in solution: Jars containing samples should be filled with the prepared 3% sodium chloride solution so as to completely immerse all aggregate..... _____
Seal the jars with lids to prevent evaporation and keep at room temperature for 24 ± 2 h..... _____
6.3 Draining samples after immersion: Rapidly drain off solution by inverting each jar over a screen smaller than 4.75 mm for approximately 5 sec (do not remove aggregate from jars) ..... _____
For convenience, a screen of 1.18 mm mesh can be cut to fit inside a modified Mason jar lid to facilitate draining and washing..... _____
Two or three ml of solution should remain in the jar..... _____
Seal the jars to maintain a 100% relative humidity condition..... _____
Note 3: Make sure the lids are screwed on properly to form an airtight seal. When using a lid with a screen to drain off solution or when washing, ensure that the lid is on tight and/or hold a finger against the side of the lid to prevent loss of sample as lids may not fit all jars satisfactorily.
6.4 Freeze thaw cycles: Subject the samples to 5 cycles of freezing and thawing..... _____
Place the jars on their sides in baskets with spacers between to separate them..... _____
Place the baskets in the freezer at -18.0 ± 2.0°C for 16 ± 2 h (usually overnight), and remove them (usually in the morning) to allow approximately 8 h to thaw out at room temperature..... _____
Rotate the jars one quarter turn each cycle to ensure that all aggregate particles receive adequate exposure to the solution..... _____
Note 4: Damage due to freezing and thawing is more severe if the rate of cooling in the temperature range -2°C to -12°C is relatively slow. It has been found to be good practice to turn the freezer off, with the door closed, at the end of freezing cycle and then turn the freezer on when the thawed samples are put back in the freezer.
Note 5: If for any reason the sequence of freezing and thawing must be interrupted, the aggregates should be kept frozen inside the container until the cycle can be resumed.
6.5 Wash aggregate after thawing at the end of the fifth cycle. Fill the jar with water and invert over the sink using a lid fitted with a screen as in 6.3 above..... _____
Repeat this washing 5 times, without removing the aggregate from the jars..... _____
6.6 Drying samples: Remove the lids from the jars and oven-dry the samples to constant mass at 110°C ± 5°C, usually overnight..... _____

7. QUANTITATIVE EXAMINATION

7.1 After drying the samples, place the aggregate on the same sieve used in the preparation of the sample and shake in the same sieve shaker used for sample preparation for the amount of time established by the procedure given in Appendix I of the LS (± 10 sec) ..... _____
Following removal from the sieve shaker, shake gently all of the aggregates on the sieve for a maximum of 5 sec to ensure that thorough sieving has taken place..... _____
Note 6: Sieves may be inverted before the samples are sieved (i.e. 4.75 mm sieve at the top and 13.2 mm sieve at the bottom of the nest). Any material that passes through the 4.75 mm sieve will naturally fall through the larger sieves below into the pan.
Note 7: Further sieving beyond the established sieving time may lead to additional aggregate loss due to mechanical breakdown.

7.2 Weigh the individual sieve fractions and record the mass to nearest 1 g..... _____

8. CALCULATION

8.1 Calculate the percent loss and weighted average for each fraction as follows: ..... _____

Percent Loss = $\frac{\text{Original Mass - Mass Retained After Test}}{\text{Original Mass}} \times 100$

Calculate the per cent loss to the nearest 0.1%..... _____

8.2 Calculate the weighted average loss as follows: Compute the percent of each fraction specified in Table 1 from the coarse aggregate portion of the as-received material (See Note 8)..... _____
The computation should be based on the total mass of material retained on 4.75 mm sieve..... _____
Multiply the percentage of each fraction computed by the percent loss for that fraction..... _____
The sum of these products divided by 100 is the weighted average percent freeze-thaw loss for the sample..... _____

Table 2 - Example

Fraction		Percent Loss	Percent Retained	Product
Pass	Retained			
26.5 mm	19.0 mm	15.0	4.0	60
19.0 mm	13.2 mm	15.0	16.0	240
13.2 mm	9.5 mm	18.0	30.0	540
9.5 mm	4.75 mm	16.0	50.0	800
				Total = 1640

Weighted Average = $\frac{1640}{100}$ = 16.4%

8.3 For the purpose of calculating the weighted average, consider any sizes (not tested) that contain less than 5% of the coarse aggregate portion of the sample to have the same value as the next larger or smaller size, whichever is present (See Table 2 – Example)..... _____

9. USE OF CONTROL AGGREGATE

9.1 Every time a freeze-thaw test is conducted, a sample of the control aggregate shall also be tested___
The material shall be taken from a stock supply and prepared as described in 5.1..... _____
9.2 For the purpose of calculating the weighted average loss of the control aggregate, use the grading shown in Table 3..... _____

Table 3 - Grading of Control Aggregate

Sieve Fraction	Percent Retained
19 - 13.2 mm	45
13.2 - 9.5 mm	35
9.5 - 4.75 mm	20

9.3 Control Chart Use: The percent loss of the last twenty samples of control material shall be plotted on a control chart in order to monitor the variation in results..... _____
9.4 The mean loss of the control aggregate is provide on the label..... _____
9.5 The control aggregate is used to adjust the sieving time required for the quantitative analysis of samples for a given set of equipment (see Appendix I of the LS) ..... _____

10. REPORTING OF RESULTS

10.1 Report the loss on each sieve to the nearest decimal place. Report the weighted loss to the nearest decimal place..... _____
10.2 Report the weighted loss of the control aggregate to the nearest decimal place..... _____

COMMENTS