Designation: D7428 – 15

Standard Test Method for
Resistance of Fine Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus[1]

This standard is issued under the fixed designation D7428; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers a procedure for testing fine aggregate for resistance to abrasion using the Micro-Deval apparatus.

1.2 The text of this method references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the test method.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C88 Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

C117 Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing

C136 Test Method for Sieve Analysis of Fine and Coarse Aggregates

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

D6928 Test Method for Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

3. Terminology

3.1 *Definitions:*

3.1.1 *constant mass, n*—the condition of a test sample dried at a temperature of 110 ± 5°C such that it will not lose more than 0.1 % moisture after 2 h of drying.

3.1.1.1 *Discussion*—Such a condition of dryness can be verified by determining the mass of the sample before and after successive 2-h drying periods. In lieu of such a determination, samples may be considered to have reached constant mass when they have been dried at a temperature of 110 ± 5°C for an equal or longer period than that previously found adequate for producing the desired constant mass condition under equal or heavier loading conditions of the oven.

4. Summary of Test Method

4.1 The Micro-Deval Test is a measure of abrasion resistance and durability of mineral aggregates resulting from a combination of actions including abrasion and grinding with steel balls in the presence of water. A 500-g sample with standard grading is initially soaked in water for not less than one hour. The sample is then placed in a jar mill with 0.75 L of water and an abrasive charge consisting of 1250 g of 9.5-mm diameter steel balls. The jar, aggregate, water, and charge are revolved at 100 rpm for 15 minutes. The sample is then washed and oven dried. The loss is the amount of material passing the 75 µm sieve expressed as a percent by mass of the original sample.

5. Significance and Use

5.1 The Micro-Deval abrasion test is a test of fine aggregate to determine abrasion loss in the presence of water and an abrasive charge. Many aggregates are more susceptible to abrasion when wet than dry, and the use of water in this test incorporates this reduction in resistance to degradation. The test results are helpful in evaluating the toughness/abrasion resistance of fine aggregate subject to abrasion when adequate information is not available from service records. This test is suitable for measuring the amount of weak, soft material such as shale or shaley carbonate in fine aggregate. Materials that give a low loss in this test are unlikely to exhibit significant degradation during handling, mixing or placing. There is a relationship between drying shrinkage of cement mortar and

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[1] This test method is under the jurisdiction of ASTM Committee D04 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.51 on Aggregate Tests.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

Micro-Deval abrasion loss of fine aggregate, with higher loss materials resulting in higher drying shrinkage. Descriptions of the development of the test and the relationship with other properties have been published.[3,4,5]

5.2 The Micro-Deval abrasion test on fine aggregate is useful for detecting changes in properties of aggregate produced from an aggregate source as part of a quality control or quality assurance process.

5.3 The Micro-Deval abrasion test on fine aggregate, in contrast to the version on coarse aggregate, has a significant correlation with the Magnesium Sulfate soundness loss of fine aggregate. The Micro-Deval test on fine aggregate has better precision than the sulfate soundness test, is quicker, and may be used in place of that test. Advice on specific values for selection of aggregate will be found in the appendix.

6. Apparatus

6.1 *Micro-Deval Abrasion Machine,* a jar rolling mill as specified in Test Method D6928.

6.2 *Containers,* stainless steel Micro-Deval abrasion jars as specified in Test Method D6928.

6.3 *Abrasive Charge*—Magnetic stainless steel balls are required. These shall have a diameter of 9.5 ± 0.5 mm. Each jar requires a charge of 1250 ± 5 g of balls.

NOTE 1—Prior to use, new containers and new steel balls should be conditioned. Conditioning is accomplished by running the equipment with a charge of 500 g of silica sand with 750 ml of water for a period of four hours. From time to time it may be necessary to recondition the containers and steel balls. The need for this will be indicated by significant reduction in loss with the calibration material. It has been found that reconditioning is usually needed when the equipment has been used for testing carbonate coarse aggregate in the coarse aggregate version of the test (Test Method D6928), which may lead to polishing of the inside of the container and ball surfaces. The conditioning process gives the containers and balls a "frosted" surface, which promotes tumbling of the balls and aggregate inside the container, rather than sliding when the containers are rotated. When silica rich fine aggregates are tested, the need for reconditioning may be reduced or eliminated provided the calibration aggregate gives satisfactory results. For this reason, it is good practice to not use containers used for testing coarse aggregate in the fine aggregate version of the test.

6.4 *Sieves,* with square openings, and of the following sizes conforming to Specification E11 specifications: 4.75 mm, 2.36 mm, 1.18 mm, 600 µm, 300 µm, 150 µm, 75 µm.

6.5 *Oven,* capable of maintaining a temperature of 110 ± 5°C.

6.6 *Balance,* or scale accurate to 0.1 g.

7. Supplies

7.1 *Laboratory Reference Aggregate*—A supply of standard "Standard Sutherland Micro-Deval Fine Aggregate."[6] The material shall be prepared as follows:

Passing	Retained	Mass
4.75-mm	2.36-mm	40 g
2.36-mm	1.18-mm	115 g
1.18-mm	600-µm	180 g
600-µm	300-µm	120 g
300-µm	150-µm	38 g
150-µm	75-µm	7 g

7.2 *Calibration Aggregate*—An adequate supply of aggregate, established by the Laboratory to use for calibration of the test method (see 11.1).

8. Test Sample

8.1 The test sample shall be washed over a 75-µm sieve following Test Method C117 and oven-dried at 110 ± 5°C to constant mass, separated into individual size fractions in accordance with Test Method C136, and recombined to meet the grading shown in 8.2.

8.2 Aggregate for the test sample shall consist of material passing the 4.75-mm sieve, retained on the 75-µm sieve with a Fineness Modulus of 2.8 (Note 2). An oven dried sample of 500 ± 5 g shall be prepared as follows:

Passing	Retained	Mass
4.75-mm	2.36-mm	50 g
2.36-mm	1.18-mm	125 g
1.18-mm	600-µm	125 g
600-µm	300-µm	100 g
300-µm	150-µm	75 g
150-µm	75-µm	25 g

NOTE 2—Fine aggregates that have a fine grading give a slightly higher Micro-Deval Abrasion loss than those with a coarser grading from the same source. The effect of grading is small when the mean loss is less than about 20 %. For materials of low loss, which easily meet applicable specification requirements, it may be practical to test material without preparing to the grading given above for routine quality control purposes. When desired, other grading may be used but the use of such grading should be reported.

9. Test Procedure

9.1 Prepare a representative 500 ± 5 g test sample in accordance with Section 8. Weigh the test sample and record the Mass, *A*, to the nearest 0.1 g.

9.2 Immerse the test sample in 0.75 ± 0.05 L of tap water at a temperature 20 ± 5°C for a minimum of 1 h either in the Micro-Deval container or some other suitable container.

9.3 Add 1250 ± 5 g steel balls to the prepared test sample and the water used to immerse the sample. Install the cover and place the Micro-Deval container on the machine. If another suitable container was used to immerse the sample, transfer the entire test sample and the water to the Micro-Deval abrasion jar and add the steel balls.

9.4 Run the machine at 100 ± 5 rpm for 15 min ± 5 s. If a revolution counter is available; run the machine for 1500 ± 10 revolutions.

[3] Rogers, C., "Canadian Experience with the Micro-Deval Test for Aggregates," *Advances in Aggregates and Armourstone Evaluation*, Latham, J. P., ed., Geological Society, London, Engineering Geology Special Publications, 13, 1998, pp. 139-147.

[4] Rogers, C. A., Bailey, M. L., and Price, B., "Micro-Deval Test for Evaluating the Quality of Fine Aggregate for Concrete and Asphalt," Transportation Research Board, Washington, DC, Record 1301, 1991, pp. 68-76.

[5] Rogers, C., Lane, B., and Senior, S., "The Micro-Deval Abrasion Test for Coarse and Fine Aggregate in Asphalt Pavement," *Proceedings of Annual Symposium of International Center for Aggregate Research*, Austin, TX, April, 2003. Also published as Ontario Ministry of Transportation Report, Materials Engineering and Research Office Report MERO 006.

[6] Available from the Soils and Aggregates Section, Materials Engineering Materials Office, Ministry of Transportation, 1201 Wilson Avenue, Downsview, Ontario, Canada M3M1J8.

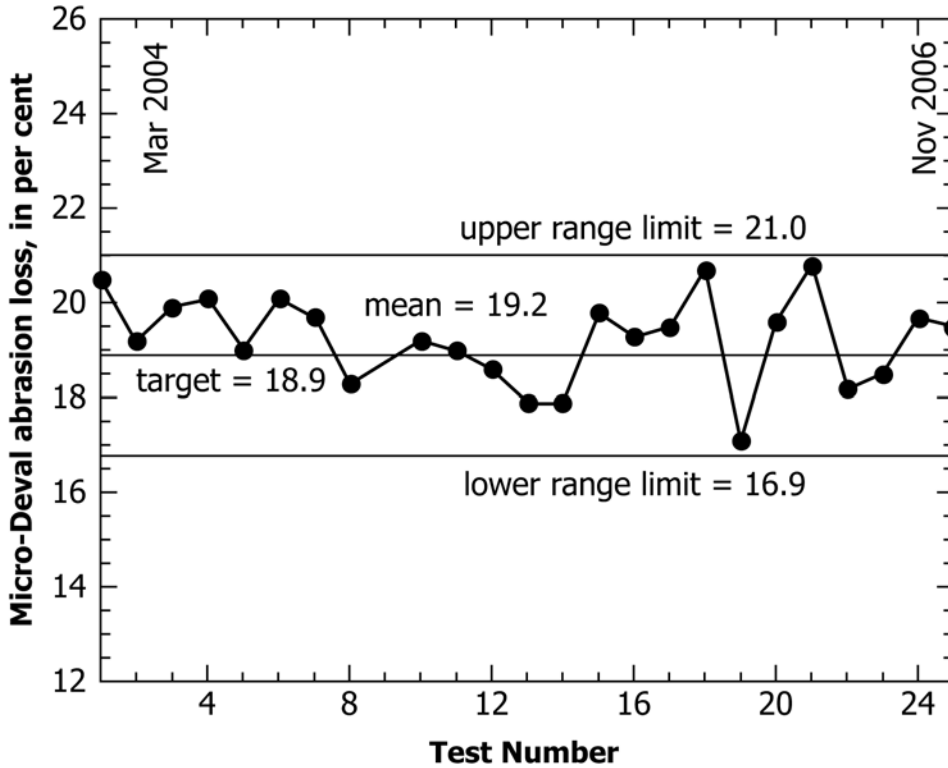

FIG. 1 Micro-Deval Abrasion Trend Chart for Calibration Aggregate Samples

9.5 Carefully pour the sample and steel balls over a sieve into a suitable container (Note 3). Take care to remove the entire sample from the stainless steel jar and that no aggregate is lost. Wash the steel balls retained on the sieve so that no aggregate adheres. The steel balls shall be removed from the sieve after washing. Wash the fine aggregate, recovered in the container placed below the sieve, following Test Method C117 until the washings are clear and all material smaller than 75 µm passes that sieve.

NOTE 3—Sieves with 6.7 or 6.3 mm^2 openings have been found acceptable for this purpose.

9.6 Oven dry the washed sample to constant mass at 110 ± 5°C.

9.7 Weigh the oven dry sample to the nearest 0.1 g. Record the Mass, *B*.

10. Calculation

10.1 Calculate the Micro-Deval abrasion loss, as follows, to the nearest 0.1 %.

$$\text{Percent Loss} = (A - B)/A \times 100 \tag{1}$$

11. Use of the Calibration Aggregate

11.1 *Calibration Aggregate*—The Laboratory will establish an adequate supply of material to use for calibration of the test method. A suitable material with a loss of between 10 and 25 % shall be established. From this material 10 samples shall be taken randomly and tested. At the same time 10 samples of "Standard Sutherland Micro-Deval Fine Aggregate" (see 7.1) shall also be tested. Provided the mean loss and variation of the "Standard Sutherland Micro-Deval Fine Aggregate" are within allowed tolerance given below in 11.1.1, the mean value and range obtained with the supply of the in-house calibration aggregate shall be used thereafter. At any time a new supply of the in-house calibration aggregate is required, the calibration procedure shall be conducted.

11.1.1 The mean loss of the "Standard Sutherland Micro-Deval Fine Aggregate" (see 7.1) in multi-laboratory study of the Micro-Deval test is 16.8 %. For continued acceptance of data, individual test data must fall within the range 15.2 to 18.4 % loss for 95 % of the time.

11.1.2 When test data of the calibration aggregate is outside the limits established in 11.1, an investigation as to the probable cause shall be conducted. The equipment shall be re-calibrated and the testing technique examined to detect non-conformance with the test procedure.

11.2 Every 10 samples, but at least every week in which a sample is tested, a sample of the calibration aggregate shall also be tested. The material shall be taken from a stock supply and prepared according to 8.2. When 20 samples of calibration material have been tested, and the results show satisfactory variation, the frequency of testing may be changed to a minimum of one sample every month.

11.3 *Trend Chart Use*—The percent loss of the last twenty samples of calibration material shall be plotted on a trend chart in order to monitor the variation in results (Fig. 1).

12. Report

12.1 The report shall include the following:

12.1.1 The grading used if different from that specified.

12.1.2 The percent loss of the test sample to one decimal place.

12.1.3 The percent loss of the calibration aggregate, tested closest to the time at which the aggregate was tested, to the nearest 0.1 %.

12.1.4 The percent loss of the last twenty samples of calibration aggregate on a trend chart.

13. Precision and Bias[7]

13.1 *Precision*—For fine aggregate with abrasion losses in the range from 7 to 30 %, the single-operator coefficient of variation has been found to be 3.4 %.[8] 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 9.6 %[8] of their average, 95 % of the time. The multi-laboratory coefficient of variation has been found to be 8.7 %.[8] Therefore, the results of two properly conducted tests by different laboratories on samples of the same aggregate are not expected to differ by more than 24.6 %[8] of their average, 95 % of the time.

13.2 *Bias*—The procedure in this test method for measuring resistance to abrasion has no bias because the resistance to abrasion can only be defined in terms of the test method.

14. Keywords

14.1 abrasion resistance; fine aggregate; micro-Deval; test

[7] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D04-1030.

[8] These numbers represent, respectively, the (1s %) and (d2s %) limits as described in Practice C670.

APPENDIX

(Nonmandatory Information)

X1. INTERPRETATION OF TEST RESULTS

X1.1 In studies of the performance of fine aggregates in this test, the limits in Table X1.1 have been found useful for separating aggregates of satisfactory performance from those of fair or poor performance. The Ontario Ministry of Transportation has used these limits, with a wide variety of aggregates in severe climatic conditions since 1997, or earlier. There have been no failures or reports of reduced service life that can be attributed to deficiency of fine aggregate, which met these limits.

X1.2 In studies of the relationship of Micro-Deval abrasion loss with the Magnesium Sulfate soundness test (Test Method C88) the relationship between the performance of fine aggregate in the two tests is shown in Figs. X1.1 and X1.2.

TABLE X1.1

Application	Maximum Micro-Deval Abrasion Loss (%)
Granular sub-base	35[A,B]
Granular base	30[A,B]
Open graded base course	25[A,B]
Structural Concrete	20[A,B]
Concrete Pavement	20[A,B]
Asphalt concrete base course and secondary road surface course	25[A,B]
Asphalt concrete premium surface course	15 for manufactured sand, 20 for natural sand[A,B]
Asphaltic concrete—all traffic levels	15[C]
Bedding and Joint sands for interlocking concrete pavements in vehicular applications with greater than 1.5 million lifetime equivalent standard axle loads (ESALS) of 11 000 kg	8[D]

[A] Rogers, C., "Canadian Experience with the Micro-Deval Test for Aggregates," *Advances in Aggregates and Armourstone Evaluation*, Latham, J. P., ed., Geological Society, London, Engineering Geology Special Publications, 13, 1998, pp. 139-147.
[B] Rogers, C., Lane, B., and Senior, S., "The Micro-Deval Abrasion Test for Coarse and Fine Aggregate in Asphalt Pavement," *Proceedings of Annual Symposium of International Center for Aggregate Research*, Austin, TX, April, 2003. Also published as Ontario Ministry of Transportation Report, Materials Engineering and Research Office Report MERO 006.
[C] White, T. D., Haddock, J. E., Rismantojo, E., "Aggregate Tests for Hot-Mix Asphalt Mixtures Used in Pavements," Transportation Research Board, Washington, NCHRP Report 557, 2006, p. 38.
[D] Interlocking Concrete Pavement Institute, "Bedding Sand Selection for Interlocking Concrete Pavements in Vehicular Applications," Technical Specification Number 17, Interlocking Concrete Pavement Institute, Washington, DC, 2007, p. 8.

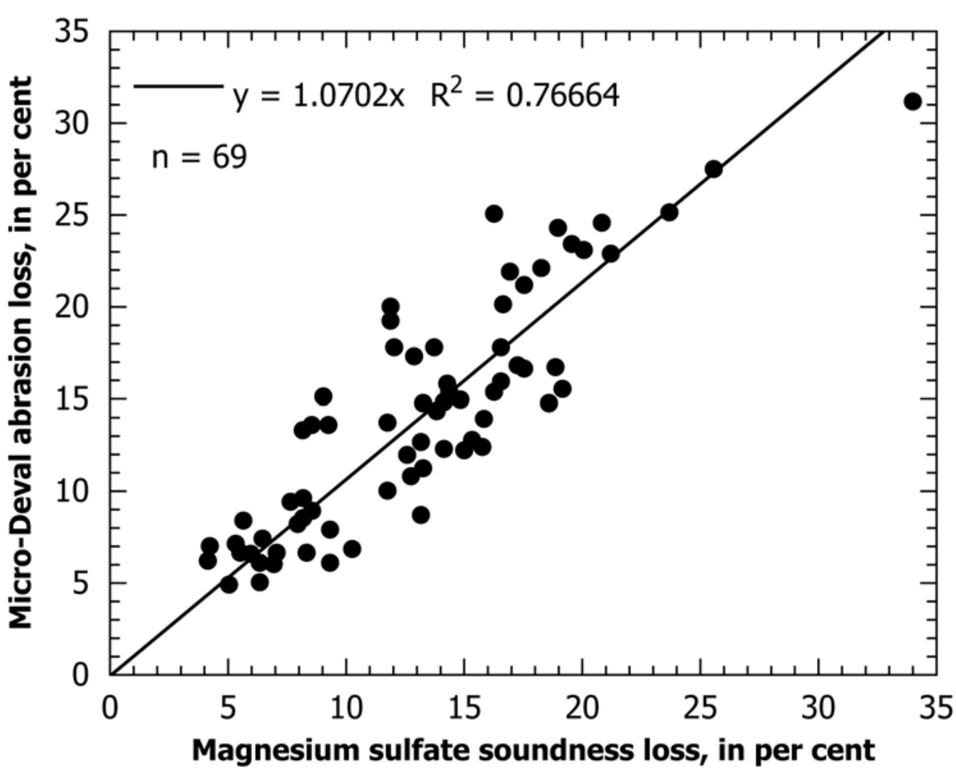

FIG. X1.1 Magnesium Sulfate Soundness Loss versus Micro-Deval Abrasion Loss for Asphalt Sands and Crusher Screenings

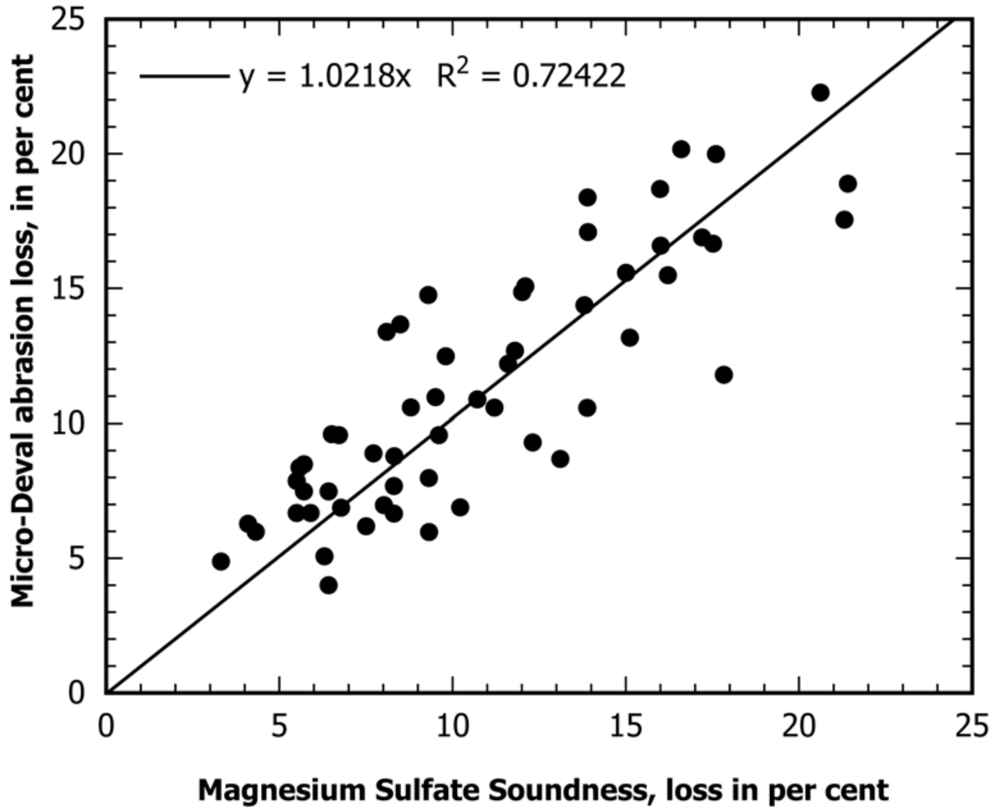

FIG. X1.2 Magnesium Sulfate Soundness Loss versus Micro-Deval Abrasion Loss for Natural Sands Used in Concrete