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Initiated By: Aggregate quality issues have been raised in five CDOT Regions.

Start Date: February 19, 2003

Purpose: This effort would examine the full set of Superpave consensus and source aggregate requirements as described in Asphalt Institute MS-2 and SP-2. After Superpave, follow-up national research has been completed in NCHRP Report 405 and soon to be completed Project No. 04-19(02) and Project No. 9-35. These requirements would be compared to the current CDOT specifications to identify areas for improvement. This would affect Standard Specification 703.04. CDOT requirements for plasticity of aggregate stockpiles with 10% or more material passing the #4 sieve will be examined.

Key Issues: Magnesium sulfate soundness and Micro Deval help identify friable aggregates. Sand equivalent and methylene blue help identify excessive clay content. Aggregate stockpile quality control requirements were evaluated. Methods to determine bulk specific gravity of fine aggregates were studied. Testing belt samples vs. individual stockpile samples will be studied.

Status: The Aggregate Quality Task Force recommends a three pronged strategy to improve the quality of HBP by testing aggregates with the Micro-Deval test.

Implementation Plan:

1. Micro-Deval tests will be required on each aggregate stockpile and the combined aggregate for each asphalt mix design. This will be implemented with a revision to CP-52.
2. Micro-Deval tests will be performed at a frequency of 1/10,000 tons for every HBP mix with a superpave gyratory compaction design with 100 design revolutions. Belt samples of the combined aggregates will be submitted from the project to Staff Materials at the same time as Hamburg Wheel Tracking samples are submitted. This can be implemented with a ceremony at the September MAC where each RME promises to be trustworthy, loyal, helpful, friendly, courteous, kind, obedient, cheerful, thrifty, brave, clean, reverent and require Micro-Deval Tests at a frequency of 1/10,000 tons for every HBP mix with a superpave gyratory compaction design with 100 design revolutions.
3. A project special provision will be implemented as a pilot on one project in each region where there will be a penalty of \$1000 for each combined aggregate sample, 1/10,000 tons during production, that is greater than 20 when tested in accordance with the Micro-Deval tests.

Suitability: Results of the 2004 testing and pilot projects will be analyzed during the Fall of 2004.

Attachments: Colorado Procedure 52 Standard Practice for Contractor Mix Design Approval Procedures
Subsection 703.04 from the purple book
Project special provision 703.04 for 2004 pilot projects, one per region
Standard special provision 703.04
Colorado Procedure L-4211 Resistance of Coarse Aggregate to Degradation By Abrasion in the Micro-Deval Apparatus

Colorado Procedure 52-01

Standard Practice for

Contractor Mix Design Approval Procedures

1. SCOPE

1.1 This method describes the procedures for mix design approval, the time required to perform the required tests, and the cost of the testing.

2. APPROVAL OF MIX DESIGNS

2.1 Mix Designs shall be performed in conformance with CP-L 5115, CP-L 5106, and CP-L 5109 as well as other specified Colorado, AASHTO, and ASTM procedures. Mix designs for S and SX mixes will be done using 4-inch molds. Mix designs for SG mixes will be done using 6-inch molds. A complete mix design will be required for all mixtures placed on the project. One-point mix design verification will not be accepted.

2.2 The Contractor must submit to the Engineer three copies of the mix design on CDOT Form #429, which contains all the information detailed in Section 3.2, and the aggregate samples, a minimum of 4 weeks prior to the anticipated paving start date. Pursuant to Section 12-25-102(10) of the Colorado Revised Statutes all mix designs shall be sealed by a registered Professional Engineer in the State of Colorado. The Engineer must approve the Contractor's proposed mix design before paving may proceed. (In Region 6, the Contractor must submit the mix design to the Region Materials Engineer for approval.) Form # 429 may be obtained through the RME or through the Flexible Pavement Unit of the Central Lab.

2.2.1 To verify the mix design, the aggregates to be used shall be sampled in accordance with CP 30, in the presence of the Engineer, and will be tested by the Concrete/Physical Properties Unit of the CDOT Central Laboratory. The aggregates shall be tested for: Aggregate Specific Gravity and Absorption, (AASHTO T 84 & T 85) and Plastic Index (AASHTO T 90), and if requested by the Region Materials Engineer, Los Angeles Abrasion (AASHTO T 96) or Micro Deval (CP-L 4211 Gradation D).

Note: If the aggregate specific gravity of the contractor's mix design is not within 0.020 of the results from the CDOT Central Laboratory testing, the Contractor and CDOT Central Laboratory shall both recheck calculations, retest, and/or resample as needed until the resulting mix aggregate specific gravities agree to within 0.020. The contractor's aggregate specific gravity values will then be used to calculate the HBP mixture volumetric properties. After the Contractor develops the mix design he may use the aggregate test results from the CDOT Central Laboratory as listed in Section 2.2.1 for mix development.

2.3 If all tests conform to the specifications, a CDOT Form #43 (Job Mix Formula) will be executed.

2.4 All mix design properties must satisfy Table 403-1 from the Project Special Provisions. The CDOT Form #43 will establish construction targets for Asphalt Content and all mix properties at Air Voids up to 1.0% below the mix design optimum.

2.5 The Form # 43 shall be verified according to Section 106, (see Section 105 & 106 (Quality of Hot Bituminous Pavement) in the Project Standard Special Provisions, part 8(d) Mix Verification testing.)

3. Mix Design Requirements

3.1 Labs and personnel providing mix designs shall comply with the requirements listed in CP 10.

3.2 It is recommended that a complete mix design consisting of test results from three trial blends (in accordance with Superpave Mix Design SP-2) be conducted when the materials sources used in the mix design have not been verified on past CDOT projects. A complete mix design must contain all of the following:

(1) For each aggregate stockpile:

- A. Aggregate sources,
- B. Gradation,
- C. Atterberg limits,
- D. Apparent Specific gravity,
Bulk Specific Gravity,
- E. Micro-Deval according to CPL 4211
- F. Recycled asphalt pavement (RAP)
 - (1) Percent asphalt
 - (2) Aggregate Gradation
- (3) Effective Specific Gravity (in lieu of the RAP aggregate specific gravity).

(2) Combined Aggregate Properties:

- A. Percentage of each aggregate used,
- B. Combined Aggregate Gradation (See #8 below), both before and after RAP use,
- C. Sand Equivalent,
- D. Fine Aggregate Bulk Specific Gravity,
Coarse Aggregate Bulk Specific Gravity,
- F. Fine Aggregate Angularity,
- G. Combined Aggregate Bulk Specific Gravity,
- H. Fractured Faces,
- I. Los Angeles Abrasion,
- J. Micro-Deval according to CPL 4211
- K. Effective Specific Gravity.

(3) Source and grade of asphalt cement from a CDOT Certified Binder Supplier. Use the actual specific gravity of the asphalt cement in calculations.

(4) Name and percentage of each additive.

(5) For each asphalt content tested:

- A. Voids in Mineral Aggregate (VMA) @ N_{des} ,
- B. Dust to Asphalt ratio,
- C. Percent Voids Filled with Asphalt (VFA) @ N_{des} ,
- D. Hveem Stability (@ N_{des}),
- E. Maximum Theoretical Specific Gravity,
- F. Bulk specific gravity @ N_{ini} , and N_{des} ,
- G. Air voids, Voids in Total Mix (VTM) @ N_{ini} , and N_{des} .

(6) Graphs of stability and air voids vs. asphalt content and VMA-VFA, Voids Filled with Asphalt, vs. Asphalt content.

(7) Lottman and wet/dry tensile strength at optimum asphalt content.

(8) A 0.45 power plot of the proposed combined aggregate gradation, with maximum density line, restricted zone and control points included.

4. CONTRACTOR CHECKS

4.1 If a contractor wishes to check a test result with CDOT, they should make arrangements with the Flexible Pavement Unit or Physical Properties Unit of the CDOT Staff Materials Laboratory, depending upon the properties (mix or aggregate) that are to be tested. The Unit will work one-on-one with the contractor, as time permits, to improve inter-lab agreement. The testing will not be a part of the mix design process.

5. COST OF MIX AGGREGATE TESTING

5.1 CDOT Staff Materials Laboratory will conduct one complete set of mix aggregate tests at no cost to the Contractor upon receipt of a completed mix design submittal from the Contractor. (See Section 2.2.1) The Contractor must pay \$500 per aggregate for each subsequent set of mix aggregate tests performed by the CDOT Staff Materials Laboratory. The Project Engineer will document the additional tests performed and the appropriate charges will be passed through to the Contractor.

6. TIME REQUIRED FOR AGGREGATE TESTS

6.1 Reference the Laboratory Test Time table located in the Appendix of the Field Materials Manual.

7. RECORD

7.1 CDOT Form # 429 is used. It is available electronically from the Central Lab at 303-757-9724 or from the Region Materials Engineers. See Chapter 400 for an example and instructions on the use of this form.

**TABLE 703-2
Classification for Aggregate Base Course**

Sieve Size	Mass Percent Passing Square Mesh Sieves						
	LL not greater than 35			LL not greater than 30			
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
100 mm (4")		100					
75 mm (3")		95-100					
63 mm (2½")	100						
50 mm (2")	95-100		100				
37.5 mm (1½")			90-100	100			
25.0 mm (1")				95-100	100		100
19.0 mm (¾")				50-90		100	
4.75 mm (# 4)	30-65			30-50	30-70	30-65	
4.75 mm (# 8)						25-55	20-85
4.75 µm (#200)	3-15	3-15	20 max.	3-12	3-15	3-12	5-15

NOTE: Class 3 material shall consist of bank or pit run material.

703.04 Aggregate for Hot Plant Mix Bituminous Pavement. Aggregates for hot plant mix bituminous pavement shall be of uniform quality, composed of clean, hard, durable particles of crushed stone, crushed gravel, natural gravel, or crushed slag. Excess of fine material shall be wasted before crushing. For Gradings S, SX, and SG, a percentage of the aggregate retained on the 4.75 mm (No. 4) sieve shall have at least two mechanically induced fractured faces when tested in accordance with Colorado Procedure 45. This percentage will be specified in Table 403-1, as revised for the project in Section 403. The angularity of the fine aggregate shall be a minimum of 45.0% when determined according to CP L-5113, Method A. Aggregate samples representing each aggregate stockpile shall be non-plastic if the percent of aggregate passing the Number 4 sieve is greater than or equal to 10 percent by weight of the individual aggregate sample. Plasticity will be determined in accordance with AASHTO T 90.

Reclaimed material shall be of uniform quality. The maximum size of the reclaimed asphalt pavement shall be 38 mm (1½ inches) prior to introduction into the mixer. The maximum aggregate size contained in the combination of reclaimed asphalt pavement and new aggregate shall not exceed the maximum specified in Table 703-3. The hot bituminous pavement shall not contain more than 15 percent reclaimed asphalt pavement.

The material shall not contain clay balls, vegetable matter, or other deleterious substances. The aggregate for Gradings S, SX, and SG shall have a percentage of wear of 45 or less when tested in accordance with AASHTO T 96.

TABLE 703-3
Master Range Table for Hot Bituminous Pavement

Sieve Size	Percent by Weight Passing Square Mesh Sieves		
	Grading S	Grading SG	Grading SX
37.5 mm (1½")		100	
25.0 mm (1")	100	90 - 100	
19.0 mm (¾")	90 - 100		100
12.5 mm (½")	*	*	90 - 100
9.5 mm (3/8")	*	*	*
4.75 mm (#4)	*	*	*
2.36 mm (#8)	23 - 49	19 - 45	28 - 58
1.18 mm (#16)			
600 µm (#30)	*	*	*
300 µm (#50)			
150 µm (#100)			
75 µm (#200)	2 - 8	1 - 7	2 - 10

* These additional Form 43 Screens will initially be established for the Contractor's Quality Control Testing using values from the As Used Gradation shown on the Design Mix.

703.05 Aggregate for Cover Coat Material. Aggregates for cover coat material shall be crushed stone, crushed slag, crushed gravel, or natural gravel. Aggregates shall be composed of clean, tough, durable fragments free from an excess of flat, elongated, soft, or disintegrated pieces and free from fragments coated with dirt or other objectionable matter. Slag shall be air-cooled blast-furnace slag reasonably uniform in density.

The aggregate shall conform to the following requirements:

- (1) Percentage of wear, Los Angeles Test (AASHTO T 96), not more than 35.
- (2) When blast-furnace slag is used, mass per cubic meter shall be at least 1120 kilograms (weight per cubic foot shall be at least 70 pounds).
- (3) For Type I, II, or IV cover coat material, 90 percent by weight of the particles retained on the 4.75 mm (No. 4) sieve shall have at least two fractured faces when tested in accordance with Colorado Procedure 45.
- (4) Lightweight aggregate used for cover coat material shall be an aggregate prepared by expanding shale, clay, or slate in a rotary fired kiln. Lightweight aggregate shall have a dry loose unit weight of 560 to 880 kg/m³ (35 to 55 pounds/cubic foot) determined in accordance with AASHTO T 19, Shoveling Procedure. The total mass of the test sample of lightweight aggregate used in AASHTO T 96 (Los Angles Abrasion) shall be 2000 g.

TABLE 703-4
Gradation Specifications for Cover Coat Aggregate

Sieve Size	Percent by Weight Passing Square Mesh Sieves		
	9.5 mm (3/8") Type 1	12.5 mm (1/2") Type II	19.0 mm (3/4")* Type IV
19.0 mm (3/4")			100
12.5 mm (1/2")		100	95-100
9.5 mm (3/8")	100	70-100	60-80
4.75 mm (No. 4)	0-15	0-4	0-10
75 µm (# 200)	0-1.0	0-1.0	0-1.0

*Type IV shall be used only with lightweight aggregates.

REVISION OF SECTION 703
AGGREGATE FOR PLANT MIX PAVEMENTS

Subsection 703.04 add the following:

The aggregate for HBP and SMA shall meet the requirements of Table 703-3C when tested in accordance with CP-L 4211 Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus. The Contractor shall be assessed a penalty of \$1000 for each production sample of the combined aggregate with a value greater than 20 according to CP-L 4211.

**TABLE 703-3C
Aggregate Degradation by Abrasion in the Micro-Deval CP-L 4211**

	Not to exceed
Each Fine Aggregate Stockpile (Mix Design)	35
Each Coarse Aggregate Stockpile (Mix Design)	25
Combined Aggregate (Mix Design)	18
Combined Aggregate (1/10,000 tons, minimum of 5 per project during production)	20

MEMORANDUM

DEPARTMENT OF TRANSPORTATION

Project Development Branch
Standards and Specifications Unit
4201 East Arkansas Avenue, Room 290
Denver, Colorado 80222
(303) 757-9040 FAX:(303)757-9820



DATE: October 14, 2003

TO: All Holders of Standard Special Provisions

FROM: Dean Van De Wege, Project Development Branch

SUBJECT: Revision of Section 703, Aggregate for Plant Mix Pavements

Attached is a new standard special provision, Revision of Section 703, Aggregate for Plant Mix Pavements, 2 pages, dated October 14, 2003. Use this standard special provision on all projects having hot bituminous pavement, beginning with projects advertised on or after November 6, 2003. Earlier use is permissible.

This new standard special provision eliminates conflicts between recycled asphalt pavement and what is currently provided in subsection 703.03 of the *Standard Specifications*. It also incorporates the aggregate requirements for Stone Mastic Asphalt, and limits plasticity tests to materials with 10% or more passing the #8 sieve to provide a more functional way of measuring this value.

Please add this new standard special provision to your file. A new Index of Standard Special Provisions dated October 14, 2003 is attached.

mrs
Attachment
Distribution: Per Distribution List

October 10, 2003

**REVISION OF SECTION 703
AGGREGATE FOR PLANT MIX PAVEMENTS**

NOTICE

This is a standard special provision that revises or modifies CDOT's *Standard Specifications for Road and Bridge Construction*. It has gone through a formal review and approval process and has been issued by CDOT's Project Development Branch with formal instructions regarding its use on CDOT construction projects. It is to be used as written without change. Do not use modified versions of this special provision on CDOT construction projects, and do not use this special provision on CDOT projects in a manner other than that specified in the instructions unless such use is first approved by the Standards and Specifications Unit of the Project Development Branch. The instructions for use on CDOT construction projects appear below.

Other agencies that use the *Standard Specifications for Road and Bridge Construction* to administer construction projects may use this special provision as appropriate and at their own risk.

INSTRUCTIONS FOR USE ON CDOT CONSTRUCTION PROJECTS:

Use this standard special provision on all projects having Hot Bituminous Pavement.

REVISION OF SECTION 703
AGGREGATE FOR PLANT MIX PAVEMENTS

Section 703 of the Standard Specifications is hereby revised for this project as follows:

Delete subsection 703.04 and replace with the following:

Aggregates for hot plant mix bituminous pavement (HBP) shall be of uniform quality, composed of clean, hard, durable particles of crushed stone, crushed gravel, natural gravel, or crushed slag. Excess of fine material shall be wasted before crushing. For Gradings S, SX, and SG, a percentage of the aggregate retained on the 4.75 mm (No. 4) sieve shall have at least two mechanically induced fractured faces when tested in accordance with Colorado Procedure 45. This percentage will be specified in Table 403-1, as revised for the project in Section 403. The angularity of the fine aggregate shall be a minimum of 45.0% when determined according to AASHTO T 304. Aggregate samples representing each aggregate stockpile shall be non-plastic if the percent of aggregate passing the 2.36 mm (No. 8) sieve is greater than or equal to 10 percent by weight of the individual aggregate sample. Plasticity will be determined in accordance with AASHTO T 90. The material shall not contain clay balls, vegetable matter, or other deleterious substances.

The aggregate for Gradings S, SX, and SG shall have a percentage of wear of 45 or less when tested in accordance with AASHTO T 96.

TABLE 703-3A
Master Range Table for Hot Bituminous Pavement

Sieve Size	Percent by Weight Passing Square Mesh Sieves		
	Grading SX	Grading S	Grading SG
37.5 mm (1½")			100
25.0 mm (1")		100	90 - 100
19.0 mm (¾")	100	90 - 100	
12.5 mm (½")	90 - 100	*	*
9.5 mm (⅜")	*	*	*
4.75 mm (#4)	*	*	*
2.36 mm (#8)	28 - 58	23 - 49	19 - 45
1.18 mm (#16)			
600 µm (#30)	*	*	*
300 µm (#50)			
150 µm (#100)			
75 µm (#200)	2 - 10	2 - 8	1 - 7

* These additional Form 43 Specification Screens will initially be established using values from the As Used Gradation shown on the Design Mix.

Aggregates for stone mastic asphalt (SMA) shall be of uniform quality, composed of clean, hard, durable particles of crushed stone, crushed gravel, or crushed slag. A minimum of 90% of the particles retained on the 4.75 mm (No. 4) sieve shall have at least two mechanically induced fractured faces when tested in accordance with Colorado Procedure 45. The particles passing the 4.75 mm (No. 4) sieve shall be the product of crushing rock larger than 12.5 mm (½ inch) and shall be non-plastic when tested in accordance with AASHTO T 90.

Additionally, each source of aggregate for SMA shall meet the following requirements:

- (1) No more than 30% when tested in accordance with AASHTO T 96 Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
- (2) No more than 12% when tested in accordance with AASHTO T 104 Soundness of Aggregate by Use of Sodium Sulfate.

2
 REVISION OF SECTION 703
 AGGREGATE FOR PLANT MIX PAVEMENTS

TABLE 703-3B
Master Range Table for Stone Mastic Asphalt

Sieve Size	Percent by Weight Passing Square Mesh Sieves		
	9.5 mm (3/8") nominal	12.5 mm (1/2") nominal	19.0 mm (3/4") nominal
19.0 mm (3/4")			100
12.5 mm (1/2")	100	100	85 – 95
9.5 mm (3/8")	90 – 100	85 – 95	55 – 75
4.75 mm (#4)	30 – 55	24 – 32	24 – 32
2.36 mm (#8)	20 – 42	16 – 24	16 – 24
1.18 mm (#16)			
600 μm (#30)	12 – 25	10 – 16	10 – 16
300 μm (#50)			
150 μm (#100)			
75 μm (#200)	8 – 12	8 – 12	8 – 12

**Colorado Procedure
L 4211-03**

Method of Test for

**Resistance of Coarse Aggregate to Degradation
By Abrasion in the Micro-Deval Apparatus**

This procedure modifies AASHTO TP58-00, AASHTO TP58-00 may not be used in place of this procedure.

1. Scope

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

2. Referenced Documents

2.1 AASHTO Standards:
M92 Standard Specification for Wire-Cloth Sieves for Testing Purposes.

Colorado Procedures:
CP 31A Sieve Analyses of Fine and Coarse Aggregates

3. Summary of Method

3.1 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 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 2.0 liters of water and an abrasive charge consisting of 5000 grams of 9.5 mm diameter steel balls. The jar, aggregate, water and charge are revolved at 100 rpm for 2 hours. The sample is then washed and oven dried. The loss is the amount of material passing the 1.18 mm sieve expressed as a percent by mass of the original sample.

4. Significance and Use

4.1 The Micro-Deval Test is a test of coarse aggregates to determine abrasion loss in the presence of water and an abrasive charge. Many aggregates are weaker when wet than when dry, and the use of water in this test measures this reduction in resistance to degradation in contrast to some other tests which are conducted on dry aggregate. It furnishes information helpful in judging the toughness/abrasion resistance and durability/soundness of coarse aggregate subject to abrasion and weathering action when adequate information is not available from service records.

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

5. Terminology

5.1 Constant Mass- Test samples dried at a temperature of $110 \pm 5^\circ \text{C}$ to a condition such that it will not lose more than 0.1 percent moisture after 2 hours of drying. Such a condition of dryness can be verified by weighing the sample before and after successive 2-hour 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 $110 \pm 5^\circ \text{C}$ 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.

6. Apparatus

6.1 Micro-Deval Abrasion Machine- A jar rolling mill capable of running at 100 ± 5 rpm.

6.2 Containers- Stainless steel Micro-Deval abrasion jars having a 5-liter capacity with a rubber ring in the rotary locking cover. Internal diameter- 194 ± 2.0 mm, internal height = 170 ± 2.0 mm. The inside and outside surfaces of the jars shall be smooth and have no observable ridges or indentations.

6.3 Abrasion Charge- Magnetic stainless steel balls are required. These shall have a diameter of 9.5 ± 0.5 mm. Each jar requires a charge of 5000 ± 5 g of balls.

6.4 Sieves- Sieves with square openings and of the following sizes conforming to AASTO M92 specifications: 19.0 mm, 16.0 mm, 12.5 mm, 9.5 mm, 9.0 mm, 6.7 mm, 4.75 mm, 1.18 mm.

6.5 Oven- The oven shall be capable of maintaining a temperature of $110 \pm 5^\circ \text{C}$.

6.6 Balance- A balance or scale accurate to 1.0 g.

7. Test Sample for Individual Stockpiles

7.1 The test sample shall be washed and oven-dried at $110 \pm 5^\circ \text{C}$ to constant mass, separated into individual size fractions in accordance with CP 31A, and recombined to meet the grading as shown in Section 7.2 below.

7.2 Gradation A

This gradation is to be used when the nominal maximum aggregate size is 16.0 mm or greater. An oven-dried sample of 1500 ± 5 g shall be prepared as follows:

<u>Passing</u>	<u>Retained</u>	<u>Mass</u>
19.0 mm	16.0 mm	375 g
16.0 mm	12.5 mm	375 g
12.5 mm	9.5 mm	750 g

7.3 Gradation B

This gradation is to be used when the nominal maximum aggregate size is 12.5 mm or greater but less than 16.0 mm. An oven-dried sample of 1500 ± 5 g shall be prepared as follows:

<u>Passing</u>	<u>Retained</u>	<u>Mass</u>
12.5 mm	9.5 mm	750 g
9.5 mm	6.7 mm	375 g
6.7 mm	4.75 mm	375 g

7.4 Gradation C

This gradation is to be used when the nominal maximum aggregate size is less than 12.5 mm. An oven-dried sample of 1500 ± 5 g shall be prepared as follows:

<u>Passing</u>	<u>Retained</u>	<u>Mass</u>
9.5 mm	6.7 mm	750 g
6.7 mm	4.75 mm	750 g

8. Test Sample for Combined Specimens

8.1 This gradation is used when a combined gradation is to be tested. The test sample shall be washed and oven-dried at $110 \pm 5^\circ$ C to constant mass, separated into individual size fractions in accordance with CP 31A, and recombined to meet the grading as shown in Section 8.2 below.

8.2 Gradation D

An oven-dried sample of 1500 ± 5 g shall be prepared as follows:

<u>Passing</u>	<u>Retained</u>	<u>Mass</u>
19.0 mm	16.0 mm	250 g
16.0 mm	12.5 mm	250 g
12.5 mm	9.5 mm	500 g
9.5 mm	6.7 mm	250 g
6.7 mm	4.75 mm	250 g

9. Test Procedure

9.1 Prepare a representative 1500 ± 5 g sample. Record the Mass 'A' to the nearest 1.0 g.

9.2 Saturate the sample in 2.0 ± 0.05 liters of tap water (temperature $20 \pm 5^\circ$ C) for a minimum of 1 hour. This may be done in the Micro-Deval container or some other suitable container.

9.3 Place the sample in the Micro-Deval abrasion container with 5000 ± 5 g of steel balls and the water used in 9.2 to saturate the sample. Place the Micro-Deval container on the machine.

9.4 For the grading shown in 7.2, run the machine at 100 ± 5 rpm for 2 hours \pm 1 minute. For the grading shown in 7.3, run the machine for 105 ± 1 minutes. For the grading shown in 7.4, run the machine for 95 ± 1 minutes. For the grading shown in 8.2, run the machine for 105 ± 1 minutes.

9.5 Carefully pour the sample over two superimposed sieves: 4.75 mm and 1.18 mm. Take care to remove the entire sample from the stainless steel jar. Wash and manipulate the retained material with water using a hand held water hose and the hand until the washings are clear and all material smaller than 1.18 mm passes the sieve. Remove the stainless steel balls using a magnet or other suitable means. Discard material smaller than 1.18 mm.

9.6 Combine the material retained on the 4.75 mm and 1.18 mm sieves, being careful not to lose any material.

9.7 Oven dry the sample to constant mass at $110 \pm 5^\circ$ C.

9.8 Weigh the sample to the nearest 1.0 g. Record the Mass 'B'.

10. Calculations

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

$$\text{Percent Loss} = \frac{A-B}{A} \times 100$$

11. Report

11.1 The report shall include the following:

11.1.1 The nominal maximum aggregate size of the aggregate tested and the gradation (A, B, C, or D) used.

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

12. Control of Abrasion Charge

12.1 Every 10 samples, but at least every week in which a sample is tested, the abrasion charge must be placed on a 9 mm screen to check for loss of size due to wear. Any balls that fall through the screen are out of specification and must be discarded.

13. Precision and Bias

13.1 The multilaboratory precision

has been found to vary over the range of this test. The figures given in Column 2 are the coefficients of variation that have been found to be appropriate for the materials described in Column 1. The figures given in Column 3 are the limits that should not be exceeded by the difference between the results of two properly conducted tests expressed as a percent of their mean.

Aggregate Abrasion Loss (%)	Coefficient of Variation (% of mean) ^A	Acceptable Range of Two Results (% of mean) ^A
5	10.0	28
12	6.4	18
17	5.6	16
21	5.3	15

^AThese numbers represent, respectively, the (1s %) and (d2s %) limits as described in ASTM C670.