MICRO-DEVAL COARSE AGGREGATE TEST EVALUATION

Final Report

SR 547

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COARSE AGGREGATE
TEST EVALUATION

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by

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16. Abstract

Studded tire use in Oregon results in millions of dollars of pavement damage annually. Accurate tests are needed to qualify durable aggregate for pavements to resist studded tire damage. ODOT currently uses the Los Angeles abrasion test as one of the tests to establish aggregate quality. The LA abrasion test may not adequately represent the aggregate durability. The Micro-Deval test was investigated to determine if it provided a better means of establishing aggregate quality for use in pavements.

During the summer of 1999, ODOT purchased a Micro-Deval abrasion tester to evaluate aggregate durability of known and new sources. Test results were compared with measured or inferred performance of known sources. Based on the results of the Micro-Deval testing, it does not appear that the equipment is any more discriminating with respect to aggregate abrasive resistance than the Los Angeles abrasion testing.

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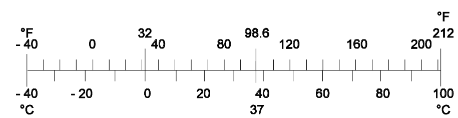
APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	millimeters squared	mm^2
ft^2	square feet	0.093	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometers squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3
NOTE: Volumes greater than 1000 L shall be shown in m^3.				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8 + 32	Fahrenheit	°F



***** SI is the symbol for the International System of Measurement

(4-7-94 jbp)

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DISCLAIMER

MICRO-DEVAL COARSE AGGREGATE TEST EVALUATION

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1.0 INTRODUCTION

Studded tire use in Oregon results in millions of dollars of pavement damage annually. Accurate tests are needed to qualify durable aggregate for pavements to resist studded tire damage. ODOT currently uses the Los Angeles abrasion test as one of the tests to establish aggregate quality. The LA abrasion test, however, may not adequately represent the aggregate durability. The Micro-Deval test was investigated to determine if it provided a better means of establishing aggregate quality for use in pavements.

During the summer of 1999, ODOT purchased a Micro-Deval abrasion tester to evaluate aggregate durability of known and new sources. The results of the testing are presented in this report.

1.1 STUDY OBJECTIVES AND METHODOLOGY

The objective of the study was to test known aggregate sources and compare the test results to in-service performance and provisional specification limits. A future objective is to test new project aggregates to begin establishing a baseline for an Oregon specification if/when the Micro-Deval abrasion test is used instead of the LA abrasion test.

Initially, twenty samples from an established source were tested with the Micro-Deval equipment to insure proper equipment set-up and operation. All testing was done on *grading A* material (19.0 mm to 4.74 mm).

Once the equipment was working properly, 14 samples, two from each of seven known aggregate sources, were tested to determine the relationship between test results and in-service performance.

Finally, 30 samples, two from each of 15 new project sources, were tested. Besides the Micro-Deval testing, all samples were subjected to LA abrasion tests, and a few samples received Nordic Ball Mill tests.

2.0 BACKGROUND

ODOT continues to investigate methods to minimize studded tire wear on pavements. Of all the parameters that have been studied, durability of the coarse aggregate has been found to have the most influence on pavement wear resistance. More than half of the pavement's wear resistance is due to the quality of the aggregate, and a further 20 percent is attributable to the amount of coarse aggregate (*Hofmann, et al 1997*).

NCHRP Report 405, *Aggregate Tests Related to Asphalt Concrete Performance in Pavements*, identifies several aggregate test methods that may predict actual pavement performance (*Kandhal 1998*). Included is a test method that can be used to determine toughness and abrasion resistance – the Micro-Deval test. The test is similar to the Los Angeles abrasion test described below, except that the entire test is done with water. ODOT obtained the test equipment in 1999 and has been evaluating the test to differentiate aggregate resistance to studded tire damage.

The current test method used to measure aggregate resistance to abrasion is the Los Angeles abrasion test (LAR). According to the *Standard Specifications for Transportation Materials and Methods of Sampling and Testing*:

> The LAR is a measure of the degradation of mineral aggregates of standard gradings resulting from a combination of actions including abrasion or attrition, impact, and grinding in a rotating steel drum containing a specified number of steel spheres. …After the prescribed number of revolutions, the contents are removed from the drum and the aggregate portion is sieved to measure the degradation as percent lost (*AASHTO 1990*).

Other aggregate abrasion testing was done in 1996. At that time, ODOT sent 14 aggregate samples to the Alaska Department of Transportation for Nordic Ball Mill testing. The Nordic Ball Mill method simulates the abrasive action of traffic on coarse aggregates used in the pavement surface layer. The test is reported to provide more reliable results than the Micro-Deval method, when hard aggregates are tested. The method includes rotating an aggregate sample in a drum with steel balls and water. The degradation is measured as the percent loss after passing the sample over a 2 mm sieve (*DRAFT European Standard 1993*).

A comparison of the test methods is presented in Table 2.1.

Table 2.1: Comparison between Los Angeles Abrasion, Micro-Deval, and Nordic Ball Mill tests

	Los Angeles Abrasion Test	Micro-Deval Test	Nordic Ball Mill Test
Aggregate Material Size	2.36 to 25.0 mm (four grading types)	4.75 to 16.0 mm (three grading types)	11.2 to 16.0 mm
Cylinder Size (Inside Diameter)	711 +/- 5 mm	194 +/- 2.0 mm	206.5 +/-2 mm
Inside Cylinder Length	508 +/- 5 mm	170 +/-2.0 mm	335 +/-1 mm w/ three ribs
Rotation Speed	30 to 33 rpm	100 +/-5 rpm	90 +/-3 rpm
Total Revolutions	500	9500 to 12,000	5400
Ball Bearing Size	Approximately 46.8 mm in diameter	9.5 +/-0.5 mm in diameter	15.00 +0.01/-0.05 mm in diameter
Abrasion Charge	2500 to 5000 g depending on grading	5000 +/-5 g	7000 +/-10 g
Sample Preparation	• Wash and dry to constant mass at 110 +/-5°C. • Separate the aggregate into the individual size fractions, recombine to the grading that most nearly corresponds to the range of sizes in the aggregate furnished for the work. • Total mass is 5000 +/- 10 g. • After the prescribed number of revolutions, remove the material and make a preliminary separation of the sample on a sieve coarser than the 1.70 mm(No. 12). Wash the material coarser than the 1.70 mm sieve. Oven dry at 110 +/- 5°C to constant weight and weigh to nearest gram. • %Loss=100(Initial dry mass-dry mass after test)/initial dry mass	• Wash aggregate until water is clear. • Oven dry to constant mass at 110 +/- 5° C for 15 hrs +/- 2 hours. Cool to room temperature. Weigh sample. • Half of mass of sample is 9.5 to 12.5 mm; three gradings possible. • Total mass of sample is 1500 +/-5g. • Saturate with 2000 +/-50 ml tap water for 1 hr. • Place in drum, add steel balls, and run. • Pour through 4.75 mm sieve and 1.18 mm sieve until clean. • Oven dry combined material to 110 +/-5°C. • %Loss=100(Initial dry mass-dry mass after test)/initial dry mass	• Wash and dry to constant mass at 110 +/-5°C. • Sieve the sample on the 11.2, 14.0, 16.0 mm sieves include 60-70% of 11.2 to 14.00 mm; 30-40% of 14.0 to 16.0 mm. • Mass of sample varies from 996 to 1147 g depending on particle density. • Place in drum, add 2000 +/- 10 ml water add steel balls, and run.. • Wash the sample including ball charge on the 14, 8, 2 mm sieves. • Dry aggregate to 110 +/-5°C. • Weigh the aggregate fractions together. • Nordic Abrasion = 100(initial dry mass – dry mass after test)/initial dry mass.

3.0 ANALYSIS

3.1 INITIAL MICRO-DEVAL TESTING

In order to confirm proper equipment set-up and operation, twenty tests were performed on aggregate from the same source. Two technicians each tested 10 samples, half in the top drum of the equipment and half in the bottom drum. The test results are shown in Table 3.1. A graph of the data is presented in Figure 3.1.

Table 3.1: Initial Micro-Deval testing.

	Technician 1					**Technician 2**				
Sample	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Top Drum (percent loss)	11.1%	10.9	11.8	11.9	11.9	10.9	11.1	11.2	11.3	11.0
Bottom Drum (percent loss)	11.1	11.6	11.5	10.9	11.1	10.9	10.9	11.5	10.9	11.1
Average Percent Loss	11.1	11.3	11.7	11.4	11.5	10.9	11	11.4	11.1	11.1

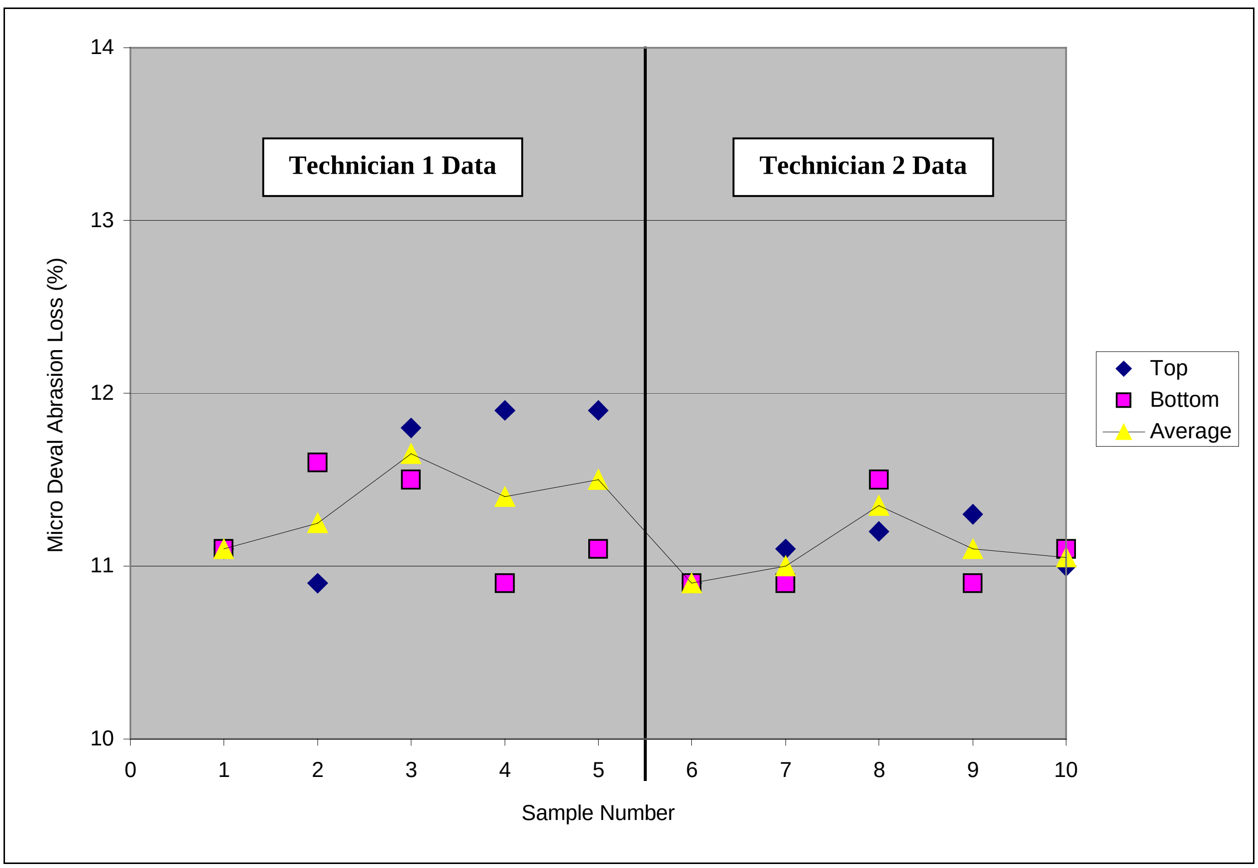

Figure 3.1: Initial Micro-Deval equipment set-up data.

The graph suggests that there may be a difference between technicians performing the test. To determine if there was a statistically significant difference, a two-way analysis of variance (ANOVA) was performed on the data. The variables were technician (1 or 2) and drum (top or bottom). The ANOVA showed that there were no statistically significant differences between the two operators or between using the top or bottom drum (see Table 3.2). The 95% confidence interval for both scenarios is shown in Table 3.2. Because the confidence intervals overlap, no statistical difference is noted. Based on these results, further discussion of test results will be based on the average of the top and bottom drum for a given sample.

Table 3.2: Analysis of variance for Micro-Deval equipment testing results.

Source	Degrees of Freedom	Sum of Squares	Mean Square
Technician	1	0.450	0.450
Drum	1	0.128	0.128
Interaction	1	0.072	0.072
Error	16	1.652	0.103
Total	19	2.302	

Individual 95% Confidence Interval

```
Technician | Mean  | -------+---------+---------+---------+----
    1      | 11.38 |                (----------*----------)
    2      | 11.08 |  (----------*----------)
           |       | -------+---------+---------+---------+----
           |       |      11.00   11.20    11.40    11.60
```

Individual 95% Confidence Interval

```
Drum | Mean  |  --+---------+---------+---------+---------
  1  | 11.31 |              (-------------*-------------)
  2  | 11.15 |     (-------------*--------------)
     |       |  --+---------+---------+---------+---------
     |       | 10.95    11.10    11.25    11.40
```

3.2 FULL SAMPLE TESTING

Two samples from each of seven known sources were obtained and tested to determine the relationship between abrasion test results and in-service performance (field measured wear). The sources included those identified through the ODOT Research Group's studded tire damage project, as shown in Table 3.3. The field measured wear resistance is based on an assessment of actual rut measurements.

Table 3.3: Known sample testing

Source	Number	Field Measured Wear Resistance
Magpie	01-051-5	Very Good
Santosh Pit	05-004-1	Mixed (Very Good to Poor)
Builders Supply	22-001-2	Mixed (Average to Poor)
Kake Pit	09-087-4	Very Good (Except for one Poor)
Kirkland Bar	15-215-3	Mixed (Good to Poor)
Wildish Plant #2	20-048-3	Mixed (Good to Average)
Horse Ridge	09-027-4	Poor

Aggregate from 15 new or recent projects was obtained and tested to evaluate the relationship between Micro-Deval test results, LA abrasion test results and in-service performance. The sources tested are listed below in Table 3.4. Two samples from each project were tested. The average of the two test results was used for comparisons. The general wear experience is based on the observations of ODOT pavement material specialists.

Table 3.4: Aggregate tested from new or recent projects

Source	Number	General Wear Experience
Moon Pit	09-107-4	Mixed
Hap Taylor	09-110-4	Mixed
Twin Bridges	09-102-4	Unknown
Lyle Gap	16-002-4	Unknown
Reed Pit	24-023-2	Good
Turner Lake Sand & Gravel	24-045-2	Good
Stearns Quarry	34-098-2	Mixed
Square Creek	04-028-2	Good
McCoy Creek	24-047-2	Unknown
Krauger Pit	27-016-2	Good
Logco	30-065-5	Good
Quarry 190 (CZ)	29-024-2	Good
190th Gravel Pit	26-022-1	Good
Jones Gravel Pit (Windsor Island)	24-038-2	Good
Deer Island	05-037-1	Good

Additional data was obtained from testing done by the Alaska DOT on ODOT samples in 1996. Samples were sent to Alaska for Nordic Ball Mill testing. The samples tested are listed in Table 3.5.

Table 3.5: Aggregate tested with Alaska's Nordic Ball Mill

Source	Number	Field Measured Wear
Magpie	01-051-5	Very Good
Builders Supply	22-001-2	Mixed (Average to Poor)
Kake Pit	09-087-4	Very Good (Except for one Poor
Kirkland Bar	15-215-3	Mixed (Good to Poor)
Wildish Plant #2	20-048-3	Mixed (Good to Average)
Reed Pit	24-023-2	Good
Horse Ridge	09-027-4	Poor

3.3 AGGREGATE TEST RESULTS AND COMPARISONS

Following is a discussion of the comparisons of LAR and Nordic Ball Mill test results with the Micro-Deval test results. The complete data set of the test results is contained in Appendix A.

3.3.1 Micro Deval versus LAR Test Results

Figure 3.2 shows a comparison between the test results from the Micro-Deval equipment and the Los Angeles abrasion equipment, performed on the Known Samples and the Recent Project Samples. The LAR specification limit of 30% is from the current ODOT Supplemental Standard

Specifications for Hot Mixed Asphalt Concrete.[1] The specification limit for the Micro-Deval test, for an asphalt concrete surface course, was taken from the provisional Micro-Deval test method – AASHTO TP58-00. The specifications for all applications are shown in Table 3.6. The complete provisional test method is included in Appendix B.

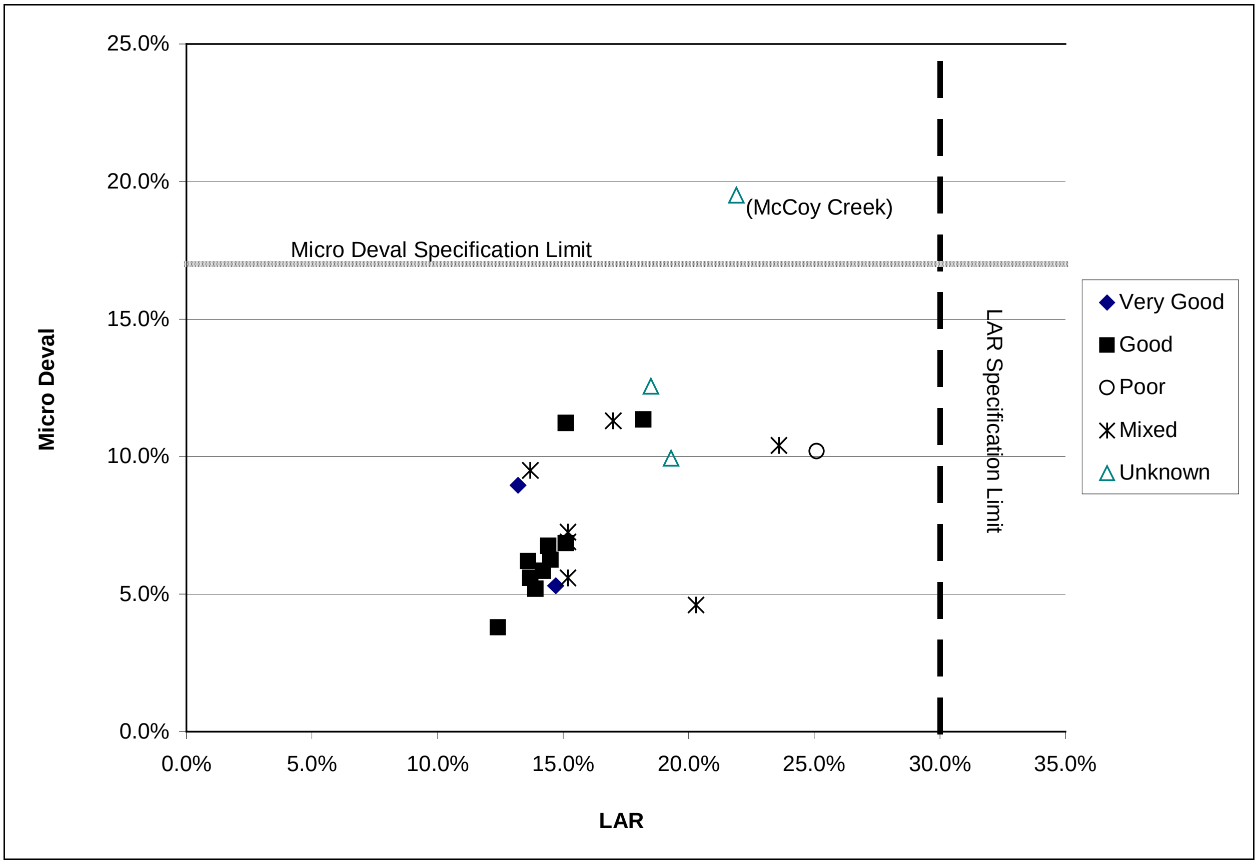

Figure 3.2. Micro-Deval test results compared to LAR test results.

Table 3.6: Micro-Deval specification limits

Application	Maximum Micro-Deval Abrasion Loss (%)
Granular sub-base	30
Granular base	25
Open graded base course	17
Asphalt concrete base course and secondary surface course	21
Asphalt concrete surface course	17[1]

[1] For reference, see Appendix B.

The Micro-Deval specification limits are based on a study done by the Ministry of Transportation in Ontario (*Rogers 1998*). The Micro-Deval test results were compared to field

[1] Available at the ODOT internet site: http://www.odot.state.or.us/techserv/roadway/specs/supplement/0745supl.pdf

performance and their aggregate abrasion acceptance test (AAV). The maximum allowable loss was set at 17% for the Micro-Deval test. The paper states, however, that the aggregates that performed fair or poor and had low Micro-Deval values had poor performance for other reasons than resistance to abrasion. They were usually frost sensitive and had a tendency to pop out.

The graph shows that none of the aggregate tested would have been rejected based on the LAR test, and only one aggregate tested would have been rejected based on the Micro-Deval test. The potentially rejected sample (from McCoy Creek) had an unknown abrasion resistance history, however. The known poor sample tested from Horse Ridge had a relatively high LAR value (25%) but an acceptable Micro Deval test value (10%). Both the LAR and the Micro-Deval tests rated the mixed samples generally the same as good samples.

3.3.2 Micro-Deval versus Nordic Ball Mill Test Results

Figure 3.3 shows a comparison of the test results from the Micro-Deval equipment and the Nordic Ball Mill. Note that only a few samples were tested with the Nordic Ball Mill equipment, and it was not the intent of this study to determine the feasibility of the Nordic Ball Mill test.

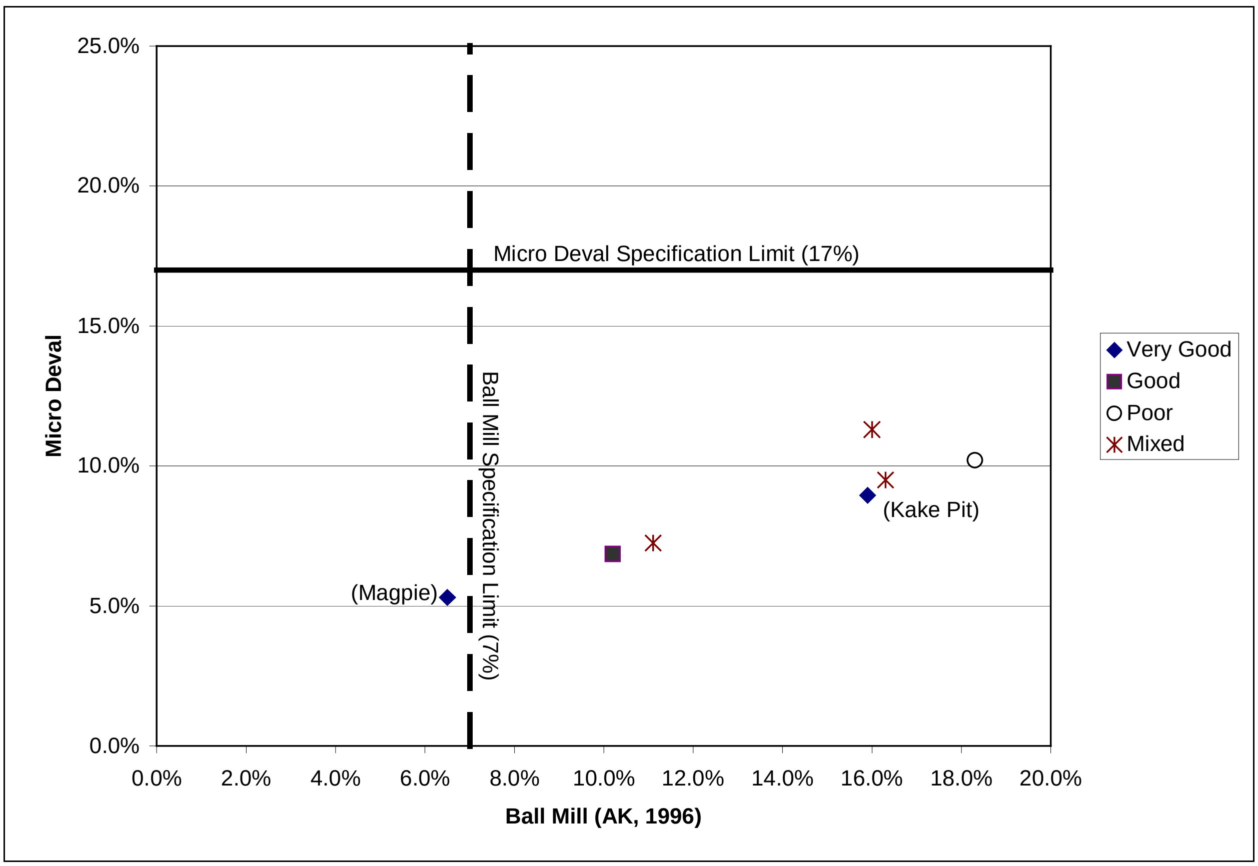

Figure 3.3: Micro-Deval test results compared to Nordic Ball Mill test results.

The results of the Nordic Ball Mill testing indicate that only the sample from Magpie would be acceptable with the specification limit of 7%. The Magpie source was evaluated as very good based on field evaluations. Kake Pit was also listed as a very good source; however, the Nordic Ball Mill results indicated otherwise. With the exception of Magpie, the remaining samples would be rejected based on the Nordic Ball Mill test; but all samples would be accepted based on the Micro-Deval testing.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

Based on the results of the Micro-Deval testing, it does not appear that the equipment is any more discriminating with respect to aggregate abrasive resistance than the Los Angeles abrasion testing. In comparison to the Nordic Ball Mill testing, the Micro-Deval equipment also does not appear to distinguish among varying levels of wear susceptibility. The Nordic Ball Mill test, however, may be able to identify very good abrasive resistant aggregate.

If specification limits are to be established for the Micro-Deval or Nordic Ball Mill equipment, additional data would be necessary to establish the limits.

4.2 RECOMMENDATION

Based on the above conclusions, it is recommended that future research investigate the use of the Nordic Ball Mill test for identifying wear resistant aggregate.

5.0 REFERENCES

American Association of State Highway Transportation Officials (AASHTO). *Standard Specifications for Transportation Materials and Methods of Sampling and Testing.* 1990.

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Rogers, Chris. *Canadian Experience with the Micro-Deval Test for Aggregates*. Ontario Ministry of Transportation. Prepared for presentation at Transportation Association of Canada Soil and Materials Committee meeting. Toronto. June 15, 1997.

APPENDIX A: AGGREGATE ABRASION TEST DATA

Source	Number	MD Top	MD Bottom	MD AVG	LAR/ ODOT	Ball Mill (ADOT, 1996)	LAR (ADOT, 1996)	Field Measured Wear per ODOT's assessment)
1) Calibration								
Pleasant Valley (1)	001-001-5	11.5%	11.2%	11.4%	15.1%			
Pleasant Valley (2)	001-001-5	11.1%	11.1%	11.1%				
2) Known Sources								
Magpie	01-051-5	5.4%	5.2%	5.3%	14.7%	6.5%	13.0%	Very good
Santosh Pit	05-004-1	5.2%	6.0%	5.6%	15.2%			Mixed (very good to poor)
Builders Supply	22-001-2	7.4%	7.1%	7.3%	15.2%	11.1%	14.0%	Mixed (avg to poor)
Kake Pit	09-087-4	9.6%	8.3%	9.0%	13.2%	15.9%	15.0%	Very good (except one poor)
Kirkland Bar	15-215-3	10.7%	11.9%	11.3%	17.0%	16.0%		Mixed (good to poor)
Wildish Plant #2	20-048-3	9.5%	9.5%	9.5%	13.7%	16.3%		Mixed (good to average)
3) Aggregate from New Projects								
Moon Pit	09-107-4	10.3%	10.5%	10.4%	23.6%			
Hap Taylor	09-110-4	4.6%	4.6%	4.6%	20.3%			
Twin Bridges	09-102-4	10.6%	9.3%	10.0%	19.3%			
Lyle Gap	16-002-4	13.2%	11.9%	12.6%	18.5%			
Reed Pit	24-023-2	6.3%	7.4%	6.9%	15.1%	10.2%	14.0%	
Turner Lake Sand & Gravel	24-045-2	6.9%	6.6%	6.8%	14.4%			
Stearns Quarry	34-098-2	7.0%	6.8%	6.9%	15.2%			
Square Creek	04-028-2	5.1%	5.3%	5.2%	13.9%			
McCoy Creek	24-047-2	19.3%	19.7%	19.5%	21.9%			
Krauger Pit	27-016-2	5.7%	6.0%	5.9%	14.2%			
Logco	30-065-5	3.8%	3.8%	3.8%	12.4%			
Quarry 190 (CZ)	29-024-2	6.2%	6.3%	6.3%	14.5%			
190th Gravel Pit	26-022-1	11.1%	11.6%	11.4%	18.2%			
Jones Gravel Pit (Winsor Island)	24-038-2	6.4%	6.0%	6.2%	13.6%			
Deer Island	05-037-1	5.8%	5.4%	5.6%	13.7%			
4) Additional Test Results from Alaska (1996)								
Lakeside #1	05-004-1					6.7%	13.0%	
Lakeside #2	05-004-1					6.9%	13.0%	
MP 318.5	01-069-5					12.3%	10.0%	
Ontario Asphalt	23-097-5					7.7%	19.0%	
Tulana Pit	18-015-4					12.3%	16.0%	
Horse Ridge	09-027-4	10.1%	10.3%	10.2%	25.1%	18.3%	22.0%	
???	29-009-2					14.9%	12.0%	
Wahl's Pit	8-108-3					20.6%		

APPENDIX B: AASHTO TEST METHOD FOR MICRO-DEVAL TEST

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

AASHTO Designation: TP58-00[1]

1. Scope

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

1.2 *This procedure may involve hazardous materials, operations, and equipment. This procedure does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this procedure to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitation prior to use.*

2. Referenced Documents

2.1 AASHTO Standards

T27 Standard Method for Sieve Analysis of Fine and Coarse Aggregates
M92 Standard Specification for Wire-Cloth Sieves for Testing Purposes

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 litres 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 I (X) rpm for 2 hours. The sample is then washed and oven dried. Tie 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 dry, and the use of water in this test measures this reduction in resistance in 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 ± 5"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±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.

6. Apparatus

6.1 Micro-Deval Abrasion Machine - A jar rolling mill capable of running at 100 ± 5 rpm (Figure 1).

6.2 Containers - Stainless steel micro-Deval abrasion jars having a 5-litre 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 (Figure 1).

6.3 Abrasion Charge - Magnetic stainless steel balls

[1]Approved in January 1999, this provisional standard was first published in May 1999.

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 AASHTO M92 specifications: 19.0 mm, 16.0 mm, 12.5 mm, 9.5 mm, 6.7 mm, 4.75 mm, 1.18 mm.

6.5 Oven - The oven shall be capable of maintaining a temperature of 110 ± 5°C.

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

6.7 Laboratory Control Aggregate - A supply of standard 'Brechin quarry' coarse aggregate available from the Soils and Aggregates Section, Engineering Materials Office, Ministry of Transportation, 1201 Wilson Avenue, Downsview, Ontario, Canada M3M 1J8.

7. Test Sample

7.1 The test sample shall be washed and oven-dried at 110 ± 5°C to constant mass, separated into individual size fractions in accordance with T27, and recombined to meet the grading as shown in Section 7.2 below.

7.2 Aggregate for the test shall normally consist of material passing the 190 mm sieve, retained on the 9.5 mm sieve. An oven-dried sample of 1500 ± 5 g shall be prepared as follows:

Passing	Retained	Mass
19.0 mm	16.0 mm	375 g
16.0mm	12.5mm	375 g
12.5 mm	9.5mm	750 g

Suggested revisions to Micro-Deval Test Method, July 13th 1998. AASHTO Technical Subcommittee 1C.

7.3 In a case where the maximum nominal size of the coarse aggregate is less than 16.0 mm, a sample of 1500 ± 5 g shall be prepared as follows:

Passing	Retained	Mass
12.5mm	9.5mm	750 g
9.5mm	6.7 mm	375 g
6.7 mm	4.75mm	375 g

7.4 In a case where the maximum nominal size of the coarse aggregate is less than 12.5 mm, a sample 1500 ± 5 g shall be prepared as follows:

Passing	Retained	Mass
9.5mm	6.7 mm	750 g
6.7 mm	4.75 mm	750 g

8. Test Procedure

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

8.2 Saturate the sample in 2.0 ± 0.05 litres of tap water (temperature 20 ± 5°C) for a minimum of I hour either in the micro-Deval container or some other suitable container.

8.3 Place the sample in the micro-Deval abrasion container with 5000 ± 5 g of steel balls and the water used in 8.2 to saturate the sample. Place the micro-Deval container on the machine.

8.4 Run the machine at 100 ± 5 rpm for 2 hours ± I minute for the grading shown in 7.2. For the grading shown in 7.3, run the machine for 105 ± I minutes. For the grading shown in 7.4, run the machine for 95 ± I minutes.

8.5 Carefully pour the sample over two superimposed sieves: 4.75 mm and 1.18 mm. Take care to remove all of the 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.

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

8.7 Oven dry the sample to constant mass at 110 ± *5°C.*

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

9. Calculations

9.1 Calculate the micro-Deval abrasion loss, as follows, to the nearest 0.1%. Percent Loss = (A-B)/A x 100.

10. Use of a Laboratory Control Aggregate

10.1 Every 10 samples, but at least every week in which a sample is tested, a sample of the standard reference aggregate shall also be tested. The material shall be taken from a stock supply and prepared according to Section 7.

10.2 Trend Chart Use - The percent loss of the last twenty samples of control material shall be plotted on a trend chart in order to monitor the variation in results (Figure 2).

10.3 The mean loss of the Brechin control aggregate in multi-laboratory study of the micro-Deval test is *16.9%.* For acceptance, individual test data must fall within the range 15.6 percent to 18.3 percent loss for 95 percent of the time.

11. Report

11.1 The report shall include the following:

11.1.2 The maximum size of the aggregate tested and the grading used.

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

11.1.4 The percent loss of the control aggregate, tested closest to the time at which the aggregate was tested, to one decimal place.

11.1.5 The percent loss of the last twenty samples of reference Material on a trend chart.

12. Precision and Bias

12.1 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 that 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 (percent)	Coefficient of Variation (percent of mean) [A]	Acceptable Range of Two Results (percent of mean) [A]
5	10.0	28
12	6.4	18
17	5.6	16
21	5.3	15

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

12.2 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.

13. Keywords - Coarse Aggregate, Abrasion Resistance

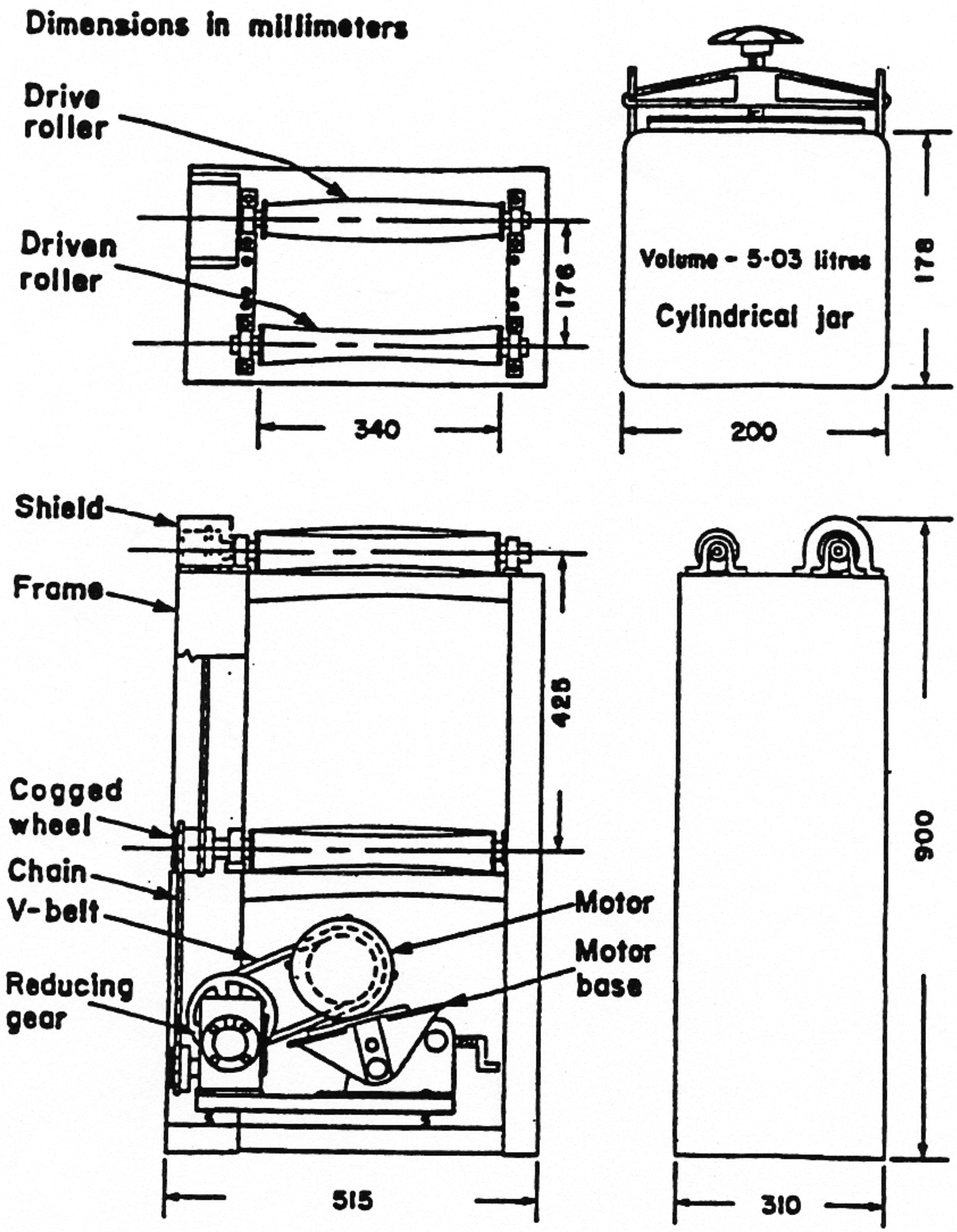

Figure 1

Micro-Deval Abrasion Machine and Container

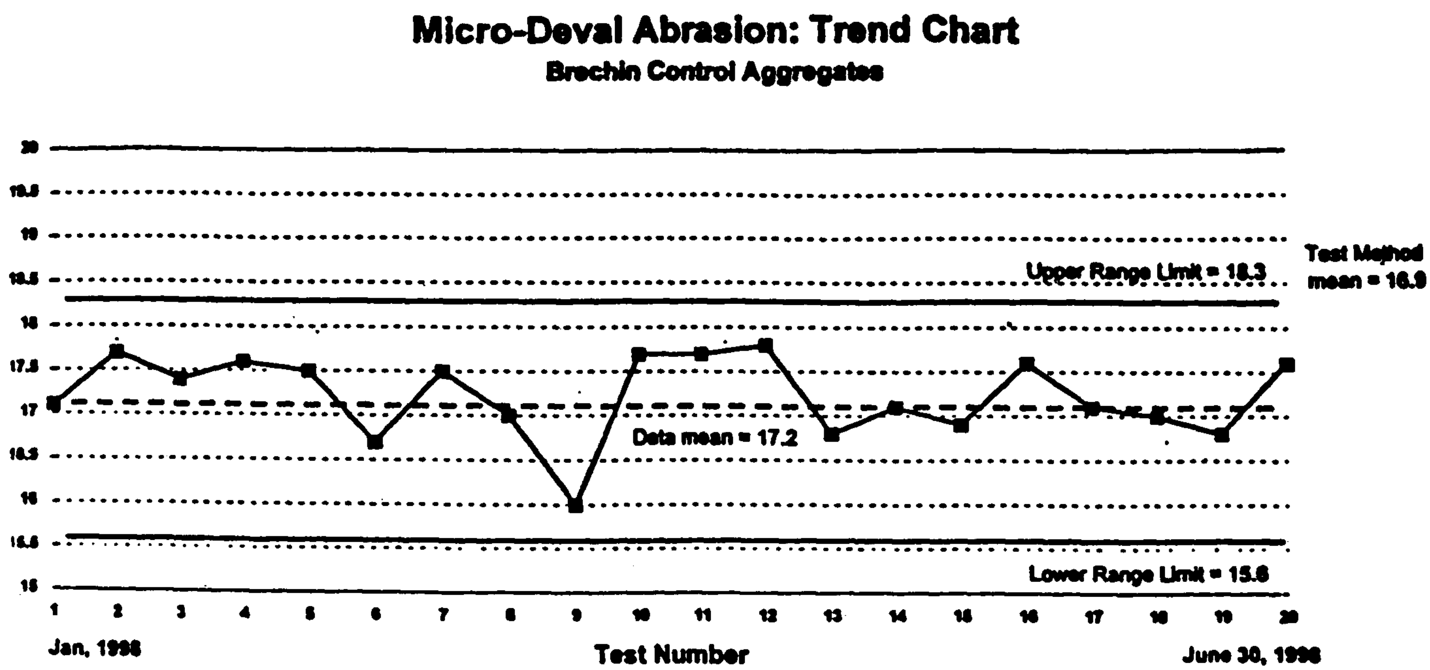

Figure 2. Micro-Deval Abrasion Trend Chart for Brechin Control Aggregates

TABLE 1

Application	*Maximum micro-Deval abrasion loss(%)*
Granular sub-base	30[1]
Granular base	25[1]
Open graded base course	17[1]
Asphalt concrete base course and secondary surface course	21[1]
Asphalt concrete surface course	17[1] 18[2]

APPENDIX
(Nonmandatory Information)

X1. Interpretation of Test Results

XI. In studies of the performance of aggregates in this test (1, 2), the limits in Table I have been found useful for separating aggregates of satisfactory performance from those of fair or poor performance.

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