AN AGGREGATE WEAR INDEX REDUCTION FACTOR FOR UNCRUSHED MATERIAL IN GRAVEL

Summary Report

MICHIGAN DEPARTMENT OF TRANSPORTATION

TESTING AND RESEARCH DIVISION
RESEARCH LABORATORY SECTION

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Summary Report

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SUMMARY

The Michigan Department of Transportation has begun implementation of an Aggregate Wear Index (AWI) to be utilized with traffic volume data for selecting aggregates which are suitably resistant to traffic polishing for use in bituminous wearing course mixtures.

Recent wear track tests conducted on gravels containing uncrushed material have indicated a considerable reduction in friction values due to the effect of the uncrushed, naturally smooth particles.

An AWI reduction factor of 0.258 percent for each percent of uncrushed material in gravel was determined from wear track tests conducted in 1981. The factor is utilized in conjunction with petrographic data to compute AWI values for gravels to be used in bituminous top course mixtures.

Supplemental wear track polishing tests on selected aggregates with varying percentages of uncrushed material were requested to verify the reduction factor. This report presents the results of four sets of comparison polishing tests conducted on crushed and uncrushed gravels, and recommends a reduction factor based upon an evaluation of the test data, as requested on May 17, 1983 by the Department's Aggregate Acceptance Criteria Committee.

CONCLUSIONS AND RECOMMENDATIONS

1) A reduction in wear track polishing values due to uncrushed material occurred in all four sets of comparison tests. The total reductions ranged from 28.7 to 39.6 percent.

2) The average reduction factor based upon the four sets of tests was 0.34 percent for each percent of uncrushed material.

3) The reduction factor of 0.34 resulted in an overcorrection of 5.8 percent when applied to AWI values computed for 18 gravels which were tested on the wear track.

4) The initial reduction factor of 0.258 resulted in a slight undercorrection of 0.2 percent when applied to the 18 computed AWI values.

5) A reduction factor of 0.26 resulted in a zero over/undercorrection when applied to the 18 computed AWI values.

The original AWI reduction factor of 0.258 percent for each percent of uncrushed material in gravel was found to produce computed AWI values comparable to those resulting from computations with the optimum factor of 0.26.

The continued use of the 0.258 reduction factor is recommended for the computation of AWI values from petrographic samples.

INTRODUCTION

In 1971, the Michigan Department of Transportation initiated a study entitled "Study of Aggregate and Mix Requirements for Durable and Skid Resistant Bituminous Mixtures," (Research Project 71 C-13). A second phase of the study included the design and construction of a circular wear track for evaluating the resistance of aggregates to simulated traffic polishing.

The results of wear track polishing tests on aggregates and individual lithologies have been incorporated in the development of an Aggregate Wear Index (AWI) for use in evaluating aggregates for bituminous top course mixtures.

The earlier wear track polishing series tested the polishing resistance of totally crushed aggregates. Later test series have included gravels containing various percentages of uncrushed material. The tests have indicated a considerable reduction in terminal polishing values due to the effect of the uncrushed material.

In 1981, wear track polishing tests were conducted on crushed and uncrushed material from the wear track control gravel source. An AWI reduction factor of 0.258 percent for each percent of uncrushed material in the gravel was determined from those tests. Additional comparison tests to verify the reduction value were requested by the Aggregate Acceptance Criteria Committee.

Two wear track test series containing three additional sets of comparison test sets were conducted in 1982 and 1983. This report presents the results of the initial comparison tests and the three additional test sets.

WEAR TRACK POLISHING TESTS

Wear Track Polishing Procedure

The wear track test slabs were prepared and tested according to procedures outlined in Research Report R-1098 (1). The comparison test aggregates were included in the stated wear track series for testing in the regular wear track program (2).

Comparison Test Aggregates

Four sets of wear track polishing tests were conducted on crushed and uncrushed material, as indicated in Table 1.

TABLE 1

Comparison Test Set, Wear Track Series	Aggregate Source, Carbonate Content, percent	No. of Test Slabs	Uncrushed Content, percent
A (Series No. 15)	Green Oak Pit 47-3 (40% carbonate)	2	0
		2	100
B (Series No. 17)	Green Oak Pit 47-3 (40% carbonate)	2	0
		2	20
		2	40
		2	60
		2	80
		2	100
C (Series No. 19)	Grand Rapids Gravel Pit 70-51 (36% carbonate)	2	0
		2	50
		2	100
D (Series No. 19)	Big Cut Pit 71-15 (85% carbonate)	2	0
		2	50
		2	100

The petrographic composition of the uncrushed material was adjusted to that of the crushed gravels before testing to counteract test bias due to compositional variations.

Results of Comparison Polishing Tests

The average polishing value reduction for each set of comparison tests was determined from friction tests recorded at seven, half-million wheelpass intervals during the wear track polishing segment between the one-million and four-million wheelpass points. The friction test values recorded before the one-million wheelpass point were not included in the averages due to possible transient variability during the early rapid-polishing stage of testing.

Results of the comparison polishing tests are as follows:

Comparison Test Set A

The average polishing value reduction for totally uncrushed material was approximately 29 percent. Table 2 includes the percentage reductions determined by wear track polishing tests.

TABLE 2

Wear Track Polishing, millions of wheelpasses	Polishing Value Reduction, Percent in Specimens With Noted Uncrushed Content, percent	
	0	100
0.0	0.0	26.5
0.5	0.0	27.0
1.0	0.0	26.5
1.5	0.0	29.4
2.0	0.0	30.3
2.5	0.0	32.4
3.0	0.0	28.1
3.5	0.0	28.1
4.0	0.0	25.8
Average = 1.0 to 4.0	0.0	28.7

Comparison Test Set B

The average polishing value reduction for totally uncrushed material was approximately 40 percent. The tests indicated an approximately linear

decrease in polishing value with increase in uncrushed material. Table 3 includes the percentage reductions determined by wear track polishing tests.

TABLE 3

Wear Track Polishing, millions of wheelpasses	Polishing Value Reduction, Percent in Specimens With Noted Uncrushed Content, percent					
	0	20	40	60	80	100
0.0	0.0	11.1	14.8	25.9	29.6	37.0
0.5	0.0	6.8	13.6	29.5	34.1	40.9
1.0	0.0	9.1	18.2	29.5	34.1	38.6
1.5	0.0	7.1	16.7	28.6	33.3	38.1
2.0	0.0	7.5	12.5	27.5	32.5	37.5
2.5	0.0	8.1	13.5	27.0	32.4	40.5
3.0	0.0	8.1	16.2	29.7	35.1	40.5
3.5	0.0	11.1	19.4	30.6	36.1	41.7
4.0	0.0	8.1	16.2	29.7	35.1	40.5
Average = 1.0 to 4.0	0.0	8.4	16.1	28.9	34.1	39.6

Comparison Test Set C

The average polishing value reduction for totally uncrushed material was approximately 36 percent. Table 4 includes the percentage reductions determined by wear track polishing tests.

Comparison Test Set D

The average polishing value reduction for totally uncrushed material was approximately 32 percent. Table 5 includes the percentage reductions determined by wear track polishing tests.

TABLE 4

Wear Track Polishing, millions of wheelpasses	Polishing Value Reduction, Percent in Specimens With Noted Uncrushed Content, percent		
	0	50	100
0.0	0.0	10.9	23.9
0.5	0.0	13.6	34.1
1.0	0.0	14.6	36.6
1.5	0.0	15.4	35.9
2.0	0.0	17.5	37.5
2.5	0.0	13.2	34.2
3.0	0.0	13.5	35.1
3.5	0.0	11.1	33.3
4.0	0.0	13.9	36.1
Average = 1.0 to 4.0	0.0	14.2	35.5

TABLE 5

Wear Track Polishing, millions of wheelpasses	Polishing Value Reduction, Percent in Specimens With Noted Uncrushed Content, percent		
	0	50	100
0.0	0.0	23.1	30.8
0.5	0.0	22.2	33.3
1.0	0.0	21.2	33.3
1.5	0.0	22.6	32.3
2.0	0.0	25.0	34.4
2.5	0.0	20.0	30.0
3.0	0.0	23.3	36.7
3.5	0.0	21.4	28.6
4.0	0.0	24.1	31.0
Average = 1.0 to 4.0	0.0	22.5	32.3

REDUCTION FACTOR DETERMINATION

An average AWI reduction factor for uncrushed material was determined by calculating the average percentage reduction from the results of the four sets of comparison tests. Table 6 lists the percentage reductions determined from the four comparison test sets, and includes the average percentage reduction resulting from the four test sets.

TABLE 6

Wear Track Comparison Test Sets	Wear Track Polishing Value Reduction, percent
Comparison Test Set A	28.7
Comparison Test Set B	39.6
Comparison Test Set C	35.5
Comparison Test Set D	32.3
Average Polishing Value Reduction	34.0

The average polishing value reduction, which compares the terminal wear track polishing values of totally crushed versus uncrushed material, was determined to be 34 percent, resulting in an AWI reduction factor of 0.34 percent for each percent of uncrushed material in gravel.

REDUCTION FACTOR EVALUATION

The reduction factor for uncrushed material determined from the wear track comparison tests was evaluated for undercorrection or overcorrection when applied to computed Aggregate Wear Index determinations. Computed AWI values were calculated with several reduction factors including the original value of 0.258, the average factor of 0.34, and an optimum factor of 0.26 derived by successive approximation. The reduction factors were applied to 18 gravels containing various percentages of uncrushed material which were tested on the wear track.

The results of the calculations indicated that the average reduction factor of 0.34 produced an average overcorrection of 5.8 percent for the 18 gravels; whereas, the original reduction factor of 0.258 produced a small undercorrection of 0.2 percent.

An optimum factor of 0.26 produced a zero over/undercorrection.

Although the supplemental comparison polishing tests indicated a greater polishing value reduction for uncrushed material than the initial tests,

TABLE 7

	Pit Name	Pit No.	Uncrushed Content, percent [1]	Wear Track, AWI	AWI Computed from Petrographic Composition			
					Based on 100 percent Crushed Material	Reduced for Uncrushed Material by Percentage Factor Noted		
						0.34	0.258	0.26
Produced Gravels	County Road Comm.	52-67	10 [2]	470	460	440	450	450
	Bundy Hill	30-35	21(16)	330	330	310	310	310
	Federal Forest	66-33	28(25)	340	380	350	360	360
	Orlando	76-47	41	300	320	270	280	280
	Stratton	79-59	47	290	310	260	270	270
	Plopper	80-20	58	290	330	260	280	280
	Cousineau	62-49	69	250	290	220	240	240
	Green Oak	47-3	100(93) [3]	240	330	230	250	250
Blends of Crushed and Uncrushed Gravel	Green Oak	47-3	0	310	320	---	---	---
			100(98)	230	320	220	240	240
	Green Oak	47-3	0	370	330	---	---	---
			20(17)	340	330	310	310	310
			40(37)	310	330	290	290	290
			60(57)	260	330	260	280	280
			80(77)	240	330	240	260	260
			100(97)	220	330	220	240	240
	Grand Rapids Gravel Co.	70-51	0	360	330	---	---	---
			50(49)	310	330	270	290	290
			100(98)	230	330	220	250	250
	Big Cut	71-15	0	290	270	---	---	---
			50	220	270	220	230	230
			100	200	270	180	200	200
	Average undercorrection (+) or overcorrection (-), percent [4]				+19.2	-5.8	+0.2	0.0

[1] Values in parentheses exclude uncrushed sandstone.

[2] Sample contains 77 percent sandstone.

[3] Sample is composed of produced pea gravel.

[4] Samples of totally crushed material are not included.

NOTE: Ten AWI units approximate one unit on the ARMS pavement friction number scale.

the average reduction factor of 0.34 percent determined from the four comparison test sets produced an average overcorrection of 5.8 percent when applied to the computed AWI values for the 18 gravels. The overcorrection is an indication that the factor of 0.34 percent may cause too great a reduction when applied to produced gravels which contain particles with intermediate exposures of crushed surfaces.

The very low overcorrection produced by the original reduction factor of 0.258 approaches an optimum condition of zero over/undercorrection which occurs with a factor of 0.26.

The adjusted AWI values computed with the reduction factors of 0.258 and 0.26 were identical when rounded to the nearest 10 AWI units for tabulation, indicating that the original reduction factor of 0.258 is suitable for correlation.

Table 7 includes the tabulated results of adjusted AWI values, and the wear track AWI values for the 18 gravels. The table includes the uncrushed content of each gravel, with noted exclusions of the uncrushed sandstone components which exhibit rough surface texture similar to a crushed condition.

REFERENCES

1. Muethel, R. W., "The Michigan Department of Transportation Circular Wear Track—Results of Preliminary Aggregate Polishing Tests, First Progress Report," MDOT Research Report R-1098, March 1979.

2. Muethel, R. W., "The Michigan Department of Transportation Circular Wear Track—Results of Supplemental Aggregate Polishing Tests, Interim Progress Report," MDOT Research Report R-1228, June 1983.