THE MICHIGAN DEPARTMENT OF TRANSPORTATION CIRCULAR WEAR TRACK—RESULTS OF SUPPLEMENTAL AGGREGATE POLISHING TESTS

Interim Progress Report

MICHIGAN DEPARTMENT OF TRANSPORTATION

MATERIALS and TECHNOLOGY DIVISION

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SUMMARY

This report presents the results of additional aggregate polishing tests completed on the MDOT circular wear track constructed by the Research Laboratory Section under Phase 2 of Research Project 71 C-13, "A Study of Aggregate and Mix Requirements for Durable and Skid-Resistant Bituminous Mixtures." The results of the first eight series of tests are contained in MDOT Research Report R-1098 (March 1979).

The additional tests, Series 9, 10, and 11, include two samples of arenaceous carbonates—very sandy limestone and cherty, arenaceous dolomite; samples of glacial gravel from six sources; two blast furnace slag samples; six blends containing gravel plus sandstone from four selected sources; and, two blends containing a high-polishing limestone plus a sandstone anti-skid agent.

The arenaceous carbonates recorded satisfactory to superior resistance to polishing. The glacial gravels containing approximately the same carbonate rock content recorded similar polishing values. Both slag materials recorded superior resistance to polishing. The blends of crushed gravel with sandstone, and limestone with sandstone indicated an increased polishing resistance with increased sandstone content.

Future use of the wear track is planned to investigate the polishing resistance of aggregates incorporated in bituminous pavements. Preliminary tests will include bituminous pavement core specimens encased in mortar test slabs. Later testing is planned to include full-size test slabs of bituminous mixtures containing selected wearing course aggregates or blends.

The Appendix of this report also contains a supplemental figure for conversion of the wear track polishing data to the standard MDOT skid coefficients included as supplemental information in Tables 1 and 2 of the first progress report.

INTRODUCTION

The development and use of the MDOT circular wear track has been described in detail in the first progress report, "The Michigan Department of Transportation Circular Wear Track—Results of Preliminary Aggregate Polishing Tests," Research Report No. R-1098 (March 1979). The report makes reference to future tests of aggregates and blends. This interim report presents the results of the tests, conducted as Test Series 9, 10, and 11.

TEST AGGREGATES

In addition to the control gravel and limestone, the following aggregates were tested in Series 9, 10, and 11:

1) arenaceous carbonates from two quarries,
2) glacial gravels from six sources,
3) blast furnace slag from two producers,
4) gravel blends with sandstone from four sources, and
5) limestone blends with sandstone.

Detailed tabulations of the aggregate sources are included in Tables 1, 2, and 3.

TESTS AND PROCEDURES

Test Slab Preparation

The wear track test slabs were prepared according to the procedures described in the first progress report (R-1098). The use of aggregate passing a 3/8-in., and retained on a No. 4 sieve was continued. Two replicate slabs of each test aggregate were cast and tested on the wear track.

Wear Track Polishing and Skid Tests

Polishing on the wear track was continued to four-million wheel passes in increments of 500,000. Test Series Nos. 10 and 11 include supplemental early friction measurements obtained at 125,000 and 250,000 wheel passes.

TABLE 1
RESULTS OF WEAR TRACK POLISHING TESTS
COMPLETED ON AGGREGATES AND BLENDS
FROM SELECTED SOURCES (SERIES 9)

Aggregate Type and Source	No. of Test Slabs	Wear Track Polishing Values		
		Initial Value	0.5 Million Wheel Passes	4.0 Million[1] Wheel Passes
Crushed Gravel, Approximately 40 Percent Carbonate				
Coit Avenue Gravel Co. Pit No. 41-118	2	500	430	350 (0.48)
Grand Rapids Gravel Co. #16 Pit No. 70-51	2	480	420	350
Beisiegel Pit No. 81-57	2	500	420	340
Green Oak Pit No. 47-3 (control gravel)	2	490	410	340
Bundy Hill Pit No. 30-35	2	450	390	330 (0.46)
Crushed Gravel, Non-Carbonate				
County Road Comm. #3 Pit No. 17-62	2	560	540	440 (0.59)
Quarried Carbonates				
Wallace Pit No. 32-4 (very sandy limestone)	2	610	540	480 (0.65)
Inland Pit No. 75-5 (control limestone)	2	340	220	180 (0.25)

Polishing value = average initial peak force, lb, measured on wear track skid tester.

[1] Values in parentheses indicate correlated 40 mph coefficients of wet sliding friction.

Data Reduction

The skid test data from wear track Series 9 through 11 represent the average initial peak force values computed from skid test values obtained on replicate pairs of test slabs of each aggregate.

As in Test Series 1 through 8, the average initial peak force value for each test aggregate was charted at each test interval to generate polishing curves to monitor the polishing progress. Curves for Series 9 through 11 are included in the Appendix (Figs. A1 through A3).

Wear Track Polishing Test Results

Tables 1, 2, and 3 present the wear track polishing data of Test Series 9, 10, and 11, respectively, at three stages of testing—initial, after 500,000 wheel passes, and after 4,000,000 wheel passes.

The testing of control gravel and limestone aggregates was continued in the three series to provide comparative polishing values for materials that have exhibited satisfactory (crushed gravel, Green Oak Pit No. 47-3) and unsatisfactory (limestone, Inland Pit No. 75-5) polishing resistance in roadway pavements. Continuation of the two control aggregates also provides data to monitor possible drift of test values due to changes in the testing system, and to observe possible effects of interactions between test slabs.

Results of Series 9

The crushed gravels containing approximately the same carbonate percentages recorded similar polishing resistance. One gravel, Pit No. 30-35, contained approximately 22 percent uncrushed material, and recorded slightly lower friction values. The gravel from Pit No. 17-62 contained 31 percent sandstone and had no carbonate content. This material recorded a superior resistance to polishing. The very sandy limestone from Pit No. 32-4 also recorded superior resistance to polishing. As in previous test series', the high-polishing control limestone from Pit No. 75-5 recorded very low resistance to polishing.

Results of Series 10

The gravel-sandstone blends containing 40 percent sandstone recorded terminal polishing values approximately 36 percent higher than the unblended control gravel; the blends containing 20 percent sandstone recorded terminal polishing values approximately 25 percent higher than the unblended control gravel, indicating a generally proportionate upgrading of friction values with increased sandstone content.

TABLE 2
RESULTS OF WEAR TRACK POLISHING TESTS
COMPLETED ON AGGREGATES AND BLENDS
FROM SELECTED SOURCES (SERIES 10)

Aggregate Type and Source	No. of Test Slabs	Wear Track Polishing Values		
		Initial Value	0.5 Million Wheel Passes	4.0 Million[1] Wheel Passes
Crushed Gravel, Approximately 40 Percent Carbonate				
Green Oak Pit No. 47-3 (control gravel)	2	470	360	280 (0.39)
Blend, 80 Percent Crushed Gravel: 20 Percent Sandstone				
Green Oak Pit No. 47-3: Napoleon Pit No. 38-81	2	550	410	390 (0.53)
Green Oak Pit No. 47-3: Grindstone Pit No. 32-64	2	500	410	340
Green Oak Pit No. 47-3: Rowe Rd Pit No. 30-65	2	520	380	330
Green Oak Pit No. 47-3: 11 Mile Rd Pit No. 13-90	2	500	370	330 (0.46)
Blend, 60 Percent Crushed Gravel: 40 Percent Sandstone				
Green Oak Pit No. 47-3: Napoleon Pit No. 38-81	2	550	480	390 (0.53)
Green Oak Pit No. 47-3: Grindstone Pit No. 32-64[2]	1	520	440	370 (0.51)
Quarried Carbonate				
Inland Pit No. 75-5 (control limestone)	2	340	250	190 (0.27)

Polishing value = average initial peak force, lb, measured on wear track skid tester.

[1] Values in parentheses indicate correlated 40 mph coefficients of wet sliding friction.

[2] Duplicate slab data not used due to poor aggregate distribution.

TABLE 3
RESULTS OF WEAR TRACK POLISHING TESTS
COMPLETED ON AGGREGATES AND BLENDS
FROM SELECTED SOURCES (SERIES 11)

Aggregate Type and Source	No. of Test Slabs	Wear Track Polishing Values		
		Initial	0.5 Million Wheel Passes	4.0 Million[1] Wheel Passes
Crushed Gravel				
Galesburg Pit No. 39-69 (24 percent carbonate and 10 percent clay ironstone)	2	520	430	350 (0.48)
Green Oak Pit No. 47-3 (control gravel) (40 percent carbonate)	2	500	390	330 (0.46)
Quarried Carbonates				
Rockwood Pit No. 82-2 Cherty, Arenaceous Dolomite	2	540	430	330 (0.46)
Inland Pit No. 75-5 (control limestone)	2	350	220	160 (0.23)
Slag, Blast Furnace				
U. S. Steel, Gary, Ind.	2	570	530	410 (0.55)
E. C. Levy, Burns Harbor, Ind.	2	550	490	390 (0.53)
Blend, 50 Percent Limestone:50 Percent Sandstone				
Inland Pit 75-5: Grindstone Pit 32-64	2	510	450	360 (0.49)
Blend, 80 Percent Limestone:20 Percent Sandstone				
Inland Pit 75-5: Grindstone Pit 32-64	2	430	330	250 (0.35)

Polishing value = average initial peak force, lb, measured on wear track skid tester.

[1] Values in parentheses indicate correlated 40 mph coefficients of wet sliding friction.

Two of the sandstone blending agents—grindstone, Pit No. 32-64, and Napoleon sandstone, Pit No. 38-81—exhibited high resistance to polishing, and displayed no evidence of wear or rutting. However, the sandstones from Pit No. 30-35 and Pit No. 13-90 became visibly worn by 500,000 wheel passes on the wear track. At four-million wheel passes many of the particles were worn below the nominal test slab surfaces.

This series includes supplemental early friction measurements at 125,000 and 250,000 wheel passes which indicate that one-third to one-half of the total polishing occurs during the first 125,000 wheel passes.

Due to the highly abrasive aggregates tested in this series the wear track test tires became excessively worn at three-million wheel passes, requiring replacement to complete the remaining polishing increments. The slightly below-normal polishing value obtained for the control gravel in this series is attributed to increased polishing action by the worn tires.

Results of Series 11

In addition to the control crushed gravel, a glacial gravel containing approximately 24 percent carbonate material was tested. This material also contained approximately 10 percent clay ironstone material which was shown to provide satisfactory polishing resistance in earlier tests. This gravel produced a terminal polishing value slightly higher than the control gravel.

The sample of cherty, arenaceous dolomite recorded a satisfactory polishing resistance similar to the control gravel.

Both samples of blast furnace slag recorded superior resistance to wear track polishing, repeating the performance of blast furnace slag tested in an earlier test series.

Two blends of high-polishing limestone—the standard control limestone and a sandstone anti-skid agent—were tested to determine an estimated minimum sandstone content required to provide a blend with satisfactory long-term friction values. The blend containing 80 percent limestone and 20 percent sandstone polished to a marginal friction level at four-million wheel passes; the blend containing 50 percent limestone and 50 percent sandstone recorded a terminal polishing value slightly higher than the crushed gravel control aggregate, suggesting that a blend of approximately 65 percent limestone and 35 percent sandstone would be expected to provide adequate long-term pavement friction levels for low to moderate traffic exposure.

Supplemental Correlation of Wear Track Data with the MDOT Workhorse Skid Tester

In our first progress report (R-1098) a set of polishing curves for selected aggregates was listed in Figure 4. This figure related the standard wear track polishing values to skid values correlated with the MDOT GM Skid Test Trailer. Supplemental correlated skid values included in the tabulated results of the wear track tests, however, were expressed in terms of a converted scale of values conventionally reported in summaries of Michigan pavement skid resistance tests. An amended figure based upon this standard skid value scale is included in this report as Figure A4 in the Appendix.

CONCLUSIONS

The supplemental tests completed in Series Nos. 9, 10, and 11 support the contention that the carbonate rock content in gravels and blends directly affects the overall polishing characteristics of the aggregate.

Sandstone blending agents are shown to improve the polishing resistance of both crushed gravels and high-polishing carbonate aggregate. The tests also indicate, however, that some sandstone sources may be unsatisfactory due to poor abrasion resistance.

Blast furnace slag is shown to display superior resistance to polishing.

Selected arenaceous carbonates are shown to display satisfactory resistance to polishing.

The findings in these test series' describe only the behavior of the test aggregates as they interact with the wear track polishing tires. The effects of other bituminous pavement components, environmental conditions, and vehicular traffic could considerably modify the performance of a bituminous surfacing mixture containing a given coarse aggregate.

FUTURE TESTS

Future testing on the wear track includes the development of a procedure for the testing of bituminous mixtures to evaluate the performance of test aggregates in combination with other pavement constituents.

Preliminary work will involve the testing of 8-in. diameter bituminous pavement cores encased in concrete mortar test slabs. Later testing will involve fabrication of bituminous specimens by the Testing Laboratory.

APPENDIX

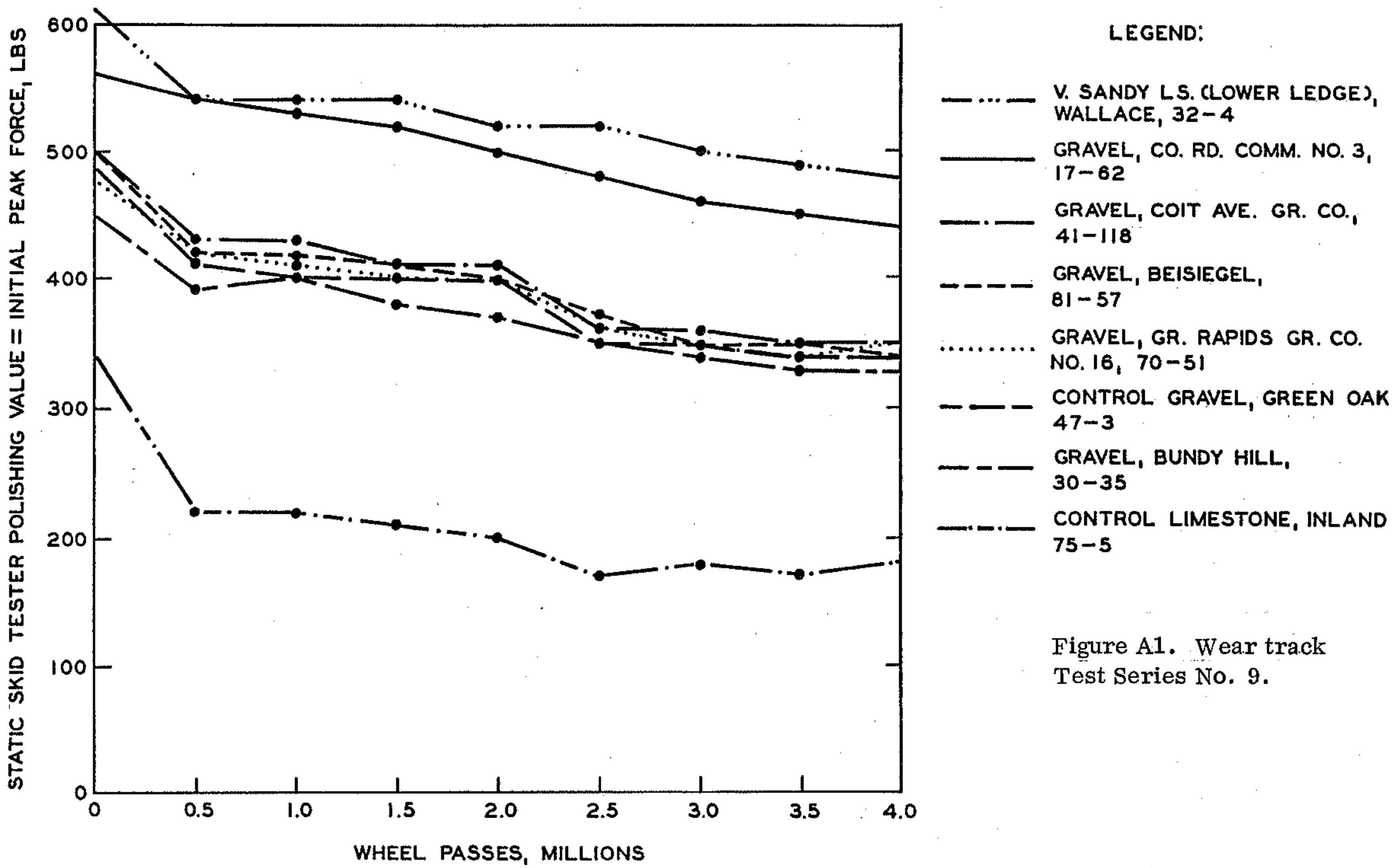

Figure A1. Wear track Test Series No. 9.

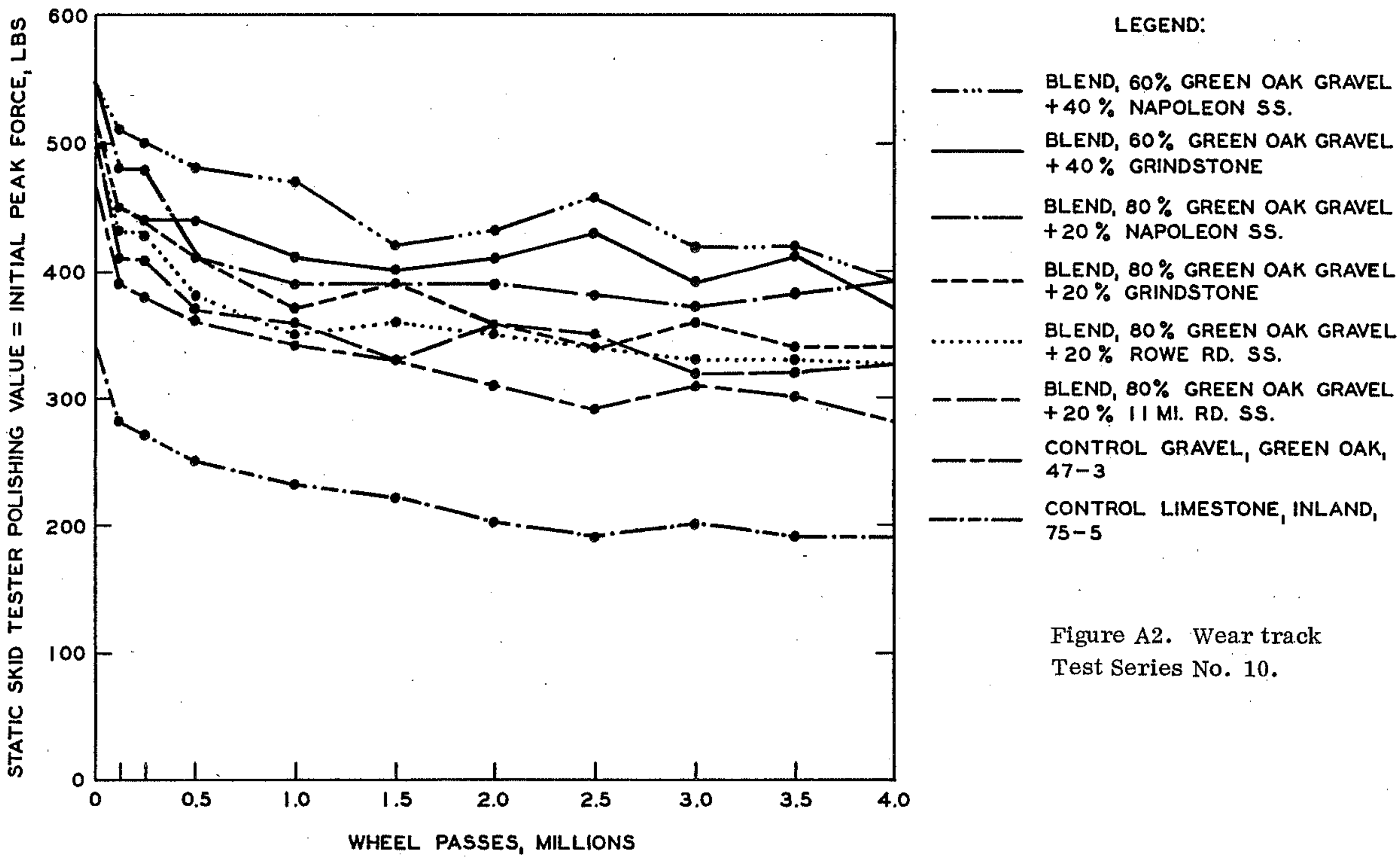

Figure A2. Wear track Test Series No. 10.

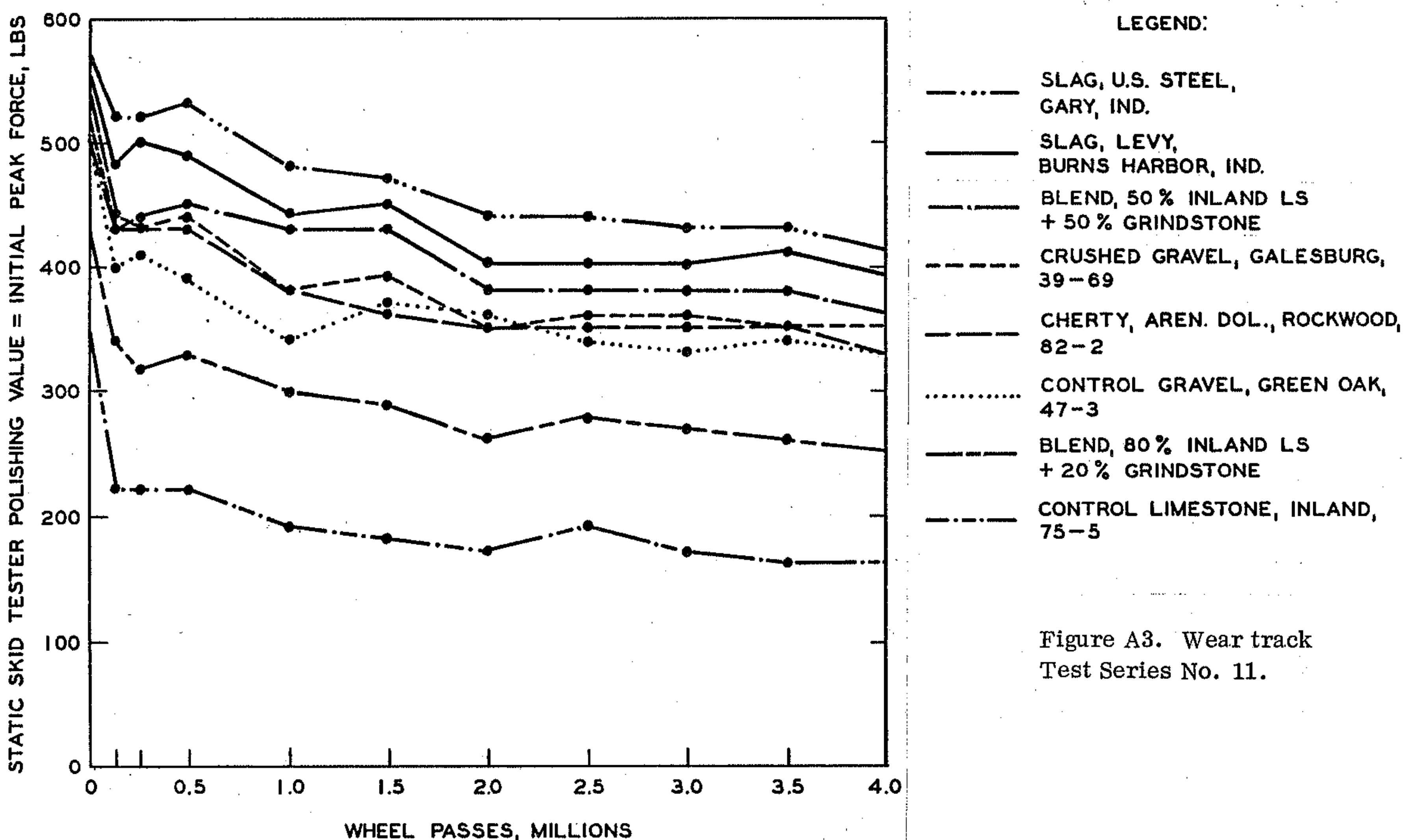

Figure A3. Wear track Test Series No. 11.

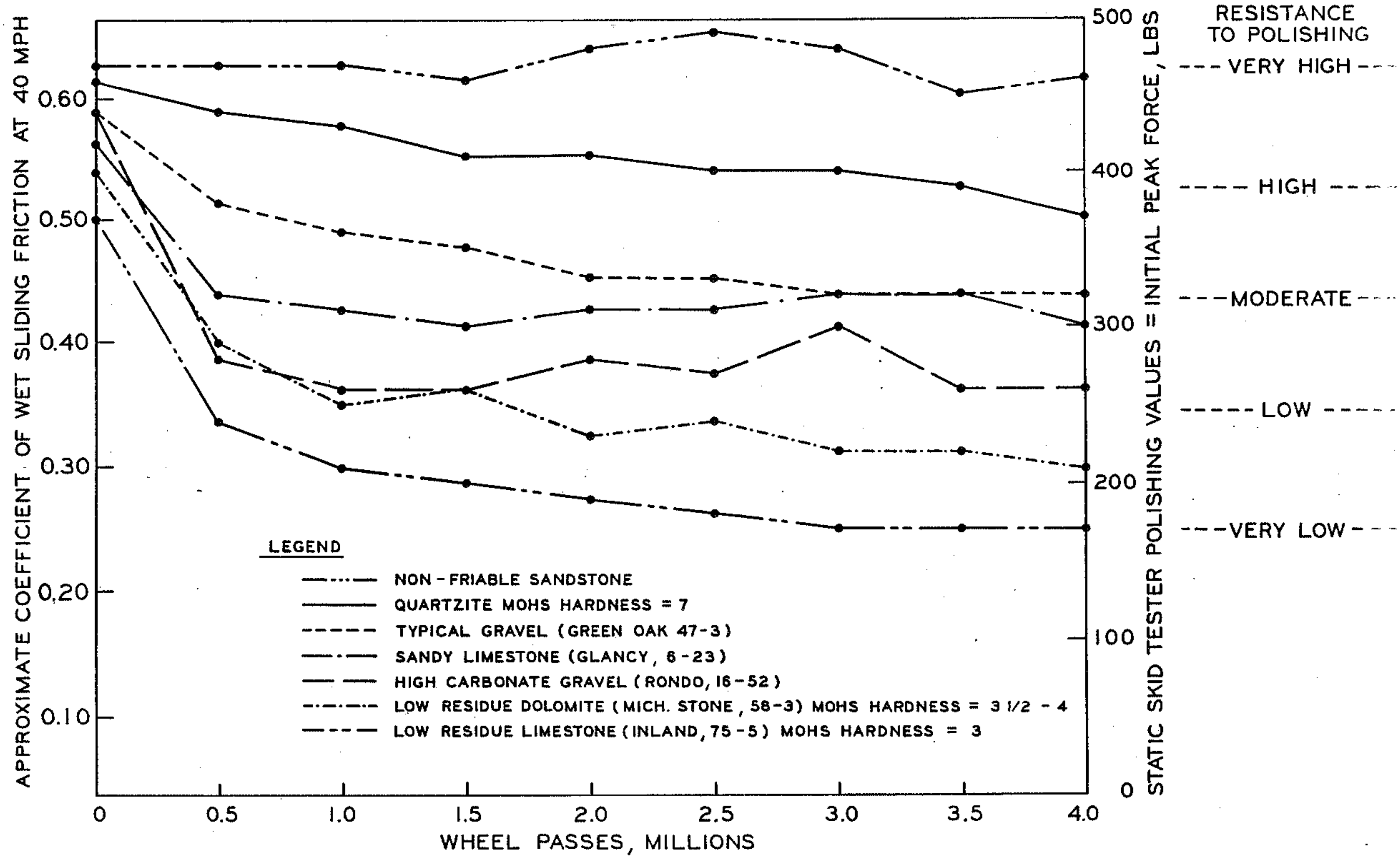

Figure A4. Supplement to Figure 4 of Research Report R-1098. Examples of wear track polishing correlated with the standard MDOT scale of friction values.