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Final Report

MATERIALS and TECHNOLOGY DIVISION

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Final Report

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Michigan Transportation Commission
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Summary

This study was conducted to obtain friction data in order to evaluate the long-term frictional performance of sandy limestone as compared to crushed gravel. The results indicate that the sandy limestone aggregate evaluated in the study is a satisfactory material for use in bituminous top course mixtures. The results also indicate that the AWI values determined by wear track tests provide a measure of in-service polishing resistance to be expected of an aggregate.

Background Information

In an effort to more clearly define the traffic polishing characteristics of various aggregates, the Michigan Department of Transportation constructed a circular indoor wear track at the Materials and Technology Laboratory. Samples tested for aggregate polishing included carbonates from Michigan and out-of-state sources (1). Most of the carbonates were found to display low to very low resistance to tire polishing which generally substantiates field experience. However, the samples of sandy (arenaceous) carbonates exhibited only slightly lower resistance to polishing than crushed gravel, suggesting that the material might serve as a satisfactory substitute for gravel as bituminous wearing coarse aggregate. Other studies have reported similar results (2, 3, 4, 5). Preliminary to approval for general use of this material, a test pavement was constructed to evaluate in-service performance.

The objective of this study was to obtain pavement friction data to evaluate the long-term frictional performance of sandy limestone as compared to crushed gravel.

This report presents the results of in-service monitoring of the experimental pavement containing the subject aggregates. The report also includes the details of a preliminary report issued on the project in July 1979 (6).

Test Pavement

Sandy carbonates in Michigan are quarried from the Bayport Limestone formation in Arenac and Huron Counties. In April 1977, the MDOT Bituminous Advisory Committee recommended that a paving project in this region be selected to include an experimental wearing course containing sandy limestone from the Bayport formation.

In May 1977, the Department accepted bids for the project, described as follows:

Project:	Mb 06071-11004A
Location:	City of Standish; Lincoln Township, in Arenac County
Type of Work:	2.93 miles of bituminous concrete resurfacing
Description:	On US 23 commencing at M 13, thence northerly to the bridge over the Middle Branch of the Pine River in Standish.

The experimental portion of the project was specified as 0.88 miles (Sta. 848+00 to 894+51) to contain bituminous wearing course, Type CM Special. This special provision required that the coarse aggregate furnished for the wearing course be a 25A crushed limestone from the Bayport Limestone formation, and contain 10 percent or more insoluble residue, predominantly discrete, rounded quartz grains, retained on the No. 200 sieve.

The control pavement containing crushed gravel was specified as 1.43 miles (Sta. 772+50 to 848+00) to contain bituminous wearing course Type C with 25A crushed gravel.

Development of bituminous mix designs and the inspection of project asphalt plant operations during paving were assigned to the Testing Laboratory's Bituminous Unit. Paving was completed in July 1977 by the Central Paving Co. of West Branch.

The 1977 MDOT map of average 24-hour traffic flow indicated a total ADT value of 10,900 for the US 23 roadway segment containing the experimental test pavement. The most current available traffic flow information indicated a total roadway ADT increase to 13,400 in 1984. The test pavement is situated in a rural location south of Standish, has two lanes in each direction, and is undivided.

Test Aggregates

As specified, the sandy limestone for the CM Special pavement section was obtained from the Bayport Limestone formation. The aggregate source for this material was the Glancy quarry, Pit No. 6-23, located approximately 10 miles south of Tawas City and one mile west of US 23, in Arenac County.

The crushed gravel for the Type C pavement section was obtained from the Straits Aggregate and Equipment Corp. No. 1, Pit No. 71-15, located approximately three miles east of Millersburg in Presque Isle County.

Petrographic Analysis

Samples of the test aggregates submitted to the Laboratory were analyzed for petrographic composition (7). The sandy limestone sample was found to contain approximately 64 percent arenaceous particles and 36 percent non-arenaceous particles, predominantly limestone.

The crushed gravel sample was found to contain approximately 89 percent carbonate particles (dolomite and limestone) and 11 percent igneous, metamorphic, and non-carbonate sedimentary material.

Insoluble Residue Analysis

Material from both test aggregates were analyzed for insoluble residue content by dissolution in hydrochloric acid (8). The sandy limestone was found to contain approximately 27 percent insoluble material (22 percent

retained on the No. 200 and coarser sieves). The predominant residue was composed of disaggregated quartz grains.

The crushed gravel was found to contain approximately 15 percent insoluble material (14 percent retained on the No. 4 and 3/8-in. sieves). The predominant residue was composed of igneous, metamorphic, and noncarbonate sedimentary aggregate particles. Gradations and detailed descriptions of the insoluble residues are included in Table 1.

TABLE 1
RESULTS OF INSOLUBLE RESIDUE ANALYSES

Sieve Size	Gradation of Insoluble Residues, Percent Retained	
	Gravel, Pit No. 71-15	Sandy Limestone, Pit No. 6-23
1/2-in.	0.00	0.00
3/8-in.	5.95	0.00
No. 4	7.81	3.04
No. 8	0.26	0.70
No. 16	0.10	0.33
No. 30	0.08	0.25
No. 50	0.05	1.12
No. 100	0.04	7.65
No. 200	0.04	9.21
P200	0.42	4.75
Total	14.75	27.05

Note: Insoluble residues retained are expressed as percentages of the sample weight before dissolution in hydrochloric acid.

Description of Insoluble Residue

Gravel, Pit No. 71-15:	Predominantly igneous and metamorphic particles, with a few chert particles and shaley to siliceous fragments.
Sandy Limestone, Pit No. 6-23:	Predominantly disaggregated quartz grains, friable sandstone fragments, and a few chert fragments, siliceous fossils, and pyritic fragments.

Wear Track Polishing Tests

The crushed gravel and sandy limestone aggregates were previously tested for polishing characteristics on the MDOT circular wear track which simulates traffic polishing under most-severe conditions such as high traffic volumes, acceleration lanes, and intersections (1). Table 2 gives the results of the polishing tests. The polishing values at 4.0 million wheel passes represent the MDOT Aggregate Wear Index numbers. The Aggregate Wear Index rating system, developed from wear track research, classifies aggregates according to polishing resistance. Values below 200 are typical of high-polishing limestones. Values near 300 indicate moderate polishing

TABLE 2
RESULTS OF WEAR TRACK AGGREGATE POLISHING TESTS

Millions of Wheel Passes	Polishing Value, Initial Peak Force, Lbf	
	Crushed Gravel Pit No. 71-15	Sandy Limestone Pit 6-23
Initial	430	420
0.5	330	320
1.0	270	310
1.5	260	300
2.0	250	310
2.5	240	310
3.0	250	320
3.5	250	320
4.0	240*	300*

*Aggregate Wear Index Value

resistance. Values above 400 indicate high-friction properties typical of sandstones.

The wear track results indicated that both aggregates would be expected to provide satisfactory polishing resistance under light to moderate traffic conditions, with the sandy limestone providing somewhat higher frictional performance.

Test Pavement Friction Measurements

Annual pavement friction measurements, obtained by the Research Laboratory Pavement Performance Group (9) are given in Table 3.

The pavement friction numbers are typical of satisfactory pavement performance, and indicate that both aggregates maintained satisfactory polishing resistance under the prevailing traffic conditions for the eight-year monitoring period. Slightly lower values in the outer lanes indicated more severe traffic conditions in those lanes.

Field Inspection of Test Pavements

In May 1978, the test pavement segments were inspected for visual appearance. The crushed gravel pavement appeared to be normal, with evidence of tire polishing on the exposed aggregate. The sandy limestone pavement was observed to contain numerous shallow pits due to partial loss of material from the more highly arenaceous particles.

TABLE 3
RESULTS OF ANNUAL PAVEMENT FRICTION MEASUREMENTS

Surface Type	Direction and Lane	Average Friction Number (FN)								
		1977	1978	1979	1980	1981	1982	1983	1984	1985
Bituminous concrete (Type CM) using arenaceous limestone (Station 848 to 894)	NBOL	39	38	40	41	36	35	42	39	43
	NBIL	40	42	43	46	43	41	46	44	47
	SBOL	31	35	36	37	34	33	36	39	36
	SBIL	38	40	45	42	40	42	43	42	44
Bituminous concrete (Type C) using high carbonate gravel (Station 772 to 848)	NBOL	36	34	37	36	32	40	36	34	37
	NBIL	38	38	45	39	40	45	42	45	44
	SBOL	31	35	36	34	32	35	33	36	40
	SBIL	39	40	43	40	39	41	45	41	43

The test pavements were reinspected in June 1980, June 1983, and March 1986. Both pavements were noted to display more highly polished aggregate in the outer lanes.

Conclusions

Pavement friction measurements conducted on the experimental pavement containing sandy limestone in the top course indicated that the pavement maintained satisfactory friction levels for the duration of the eight-year monitoring period.

The sandy limestone aggregate incorporated in the test pavement exceeded the specified 10 percent minimum quartz grain insoluble residue content with 22 percent retained on the No. 200 sieve. The sandy limestone also exceeded the Department's minimum Aggregate Wear Index (AWI) requirement of 240 for a rural ADT/lane count between 2500 and 5000, with an AWI of 300. The AWI requirement, implemented by the Department in 1982 after the inception of this study, matches the polishing resistance of the bituminous top course aggregate to the expected roadway traffic volumes (10).

Pavement friction measurements conducted on the control pavement containing gravel in the top course indicated that the pavement also maintained satisfactory friction levels for the duration of the eight-year monitoring period. The gravel met the Department's AWI requirement at the 240 minimum for the ADT/lane count between 2500 and 5000.

The results of this study indicate that the sandy limestone aggregate evaluated in this study is a satisfactory material for use in bituminous top course mixtures. The results also indicate that the AWI values determined by wear track tests provide a measure of in-service polishing resistance to be expected of an aggregate.

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