STUDY OF CORES FOR POTENTIAL RECYCLED CONCRETE PAVEMENT

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Research Laboratory Section
Testing and Research Division
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Michigan Transportation Commission
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As part of Research Project 78 B-99, "Recycling of Concrete Pavement," 39 pavement cores were submitted to the Petrography and Hydrology Group for examination. The cores were obtained from US 23 north of Lehring Rd, northerly to south of I 75, Construction Project No. 25031 C1, south of Flint. The roadway was reportedly paved in 1957.

Scope of Examination

The cores were examined to describe the general condition of the concrete and coarse aggregate, with specific attention to any evidence of cement-aggregate reaction or freeze-thaw deterioration. The cores were also examined for evidence of concrete deterioration at the base of full-depth cracks. Nominal core length and reinforcement steel depth measurements were obtained.

Examination of the coarse aggregate involved a general inspection of aggregate type and condition, and detailed identification of all coarse aggregate particles which were located in close proximity to pavement cracks.

The cores were also photographed for future reference.

General Condition of the Concrete

The general condition of the concrete in the cores appeared to be satisfactory. No apparent freeze-thaw deterioration or cement-aggregate reaction was observed. A number of deleterious-type particles at shallow depths below the pavement surface were observed to display no evidence of deterioration.

Twenty-two of the 39 cores submitted for examination contained pavement cracks, most of which extended the full depth. The concrete at the base of the cracks was found to be sound, with no evidence of crumbling or lack of integrity adjacent to the cracks.

General Condition of the Coarse Aggregate

The coarse aggregate reportedly used in the pavement was a blend of 4A gravel from the Oxford Pit No. 63-4 and 10A gravel from the Green Oak Pit No. 47-3, or the Groveland Pit No. 63-54, depending upon roadway stationing. Examination of the coarse aggregate verified that the concrete contained particle sizes typical of the stated gradations. A number of particles with maximum dimension as long as 3 in. were noted.

The coarse aggregate was found to consist of heterogeneous glacial gravel containing predominantly well-rounded to subangular particles. A

considerable number of low-specific gravity particles such as sandstone and siltstone were counted, indicating that the coarse aggregate was not heavy media beneficiated.

Crackline Examination

A total of approximately 465 in. of cracklines were noted in 22 of the 39 cores. Most of the cracks were full-depth transverse pavement fractures; a few cores containing cracks in a horizontal plane were included in the examination.

Detailed Examination of Coarse Aggregate

A total of 254 coarse aggregate particles in close proximity to the cracks were identified and categorized according to the following types of interaction with the cracks.

1) Particles intersected by pavement cracks, and
2) Particles circumvented by pavement cracks.

Summary Tabulation

The following summary tabulation indicates the relative fracturing resistance of the three major rock classes—igneous, metamorphic, and sedimentary in the zone of crack development.

Rock Class	Intersected by Pavement Cracks		Circumvented by Pavement Cracks		Totals	
	No. of Particles	Percent	No. of Particles	Percent	No. of Particles	Percent
Igneous	8	3.1	53	20.9	61	24.0
Metamorphic	4	1.6	38	14.9	42	16.5
Sedimentary	102	40.2	49	19.3	151	59.5
Totals	114	44.9	140	55.1	254	100.0

The lithologic distribution of the particle tabulation approximates the general rock class composition of typical heterogenous glacial gravels found in southeastern lower peninsula deposits, indicating that the tabulation contains a reasonably accurate sampling of the coarse aggregate composition.

Due to the small number of particles of minor rock types encountered, detailed rock type comparisons were not attempted. A comparative cracking resistance for each rock class is summarized as follows:

Rock Class	Total No. of Particles	Percent Intersected by Cracks	Percent Circumvented by Cracks
Igneous	61	13.1	86.9
Metamorphic	42	9.5	90.5
Sedimentary	151	67.5	32.5

Resistance to cracking was found to generally correspond to the hardness of the rock particle constituents, and the degree of rock grain cementation. The igneous and metamorphic classes contain hard, well-indurated rock types in contrast to the sedimentary class which contains dense but moderately soft rock types (carbonates) and most of the deleterious rock types including sandstone, siltstone, shale, clay ironstone, and chert. However, the sedimentary particles in general appeared to have somewhat higher cracking resistance than the enclosing concrete matrix.

Detailed tabulations of the crackline examination and core measurements are included in the attached core inspection worksheet.

CONCRETE CORE EXAMINATION WORKSHEET FOR US 23
Construction Project 25031 C1
Research Project 78 B-99

Core No.	Roadway Station	Depth to Top of Longitudinal Steel Bars, in.	Core Length, in.	No. of Particles Intersected by Pavement Cracks								No. of Particles Circumvented by Pavement Cracks							
				Igneous	Metamorphic	Carbonates	Sandstone	Siltstone	Shale	Clay Ironstone	Chert	Igneous	Metamorphic	Carbonates	Sandstone	Siltstone	Shale	Clay Ironstone	Chert
	NB																		
1	315+05	3.5	9-1/2		1	8		1				1	4	4	1				1
2	324+80	2.6	9-1/2																
3	344+20	3.2	9-1/2			5						6	4	2	1	2			
4	352+10	3.5	10																
5	400+00	3.8	10																
6	415+00	4.2	10																
7	473+85	3.6	9-3/4	2		7	1		1		2	2	1						1
	SB																		
17	609+25	3.6	10									3	2	3					
18	607+98	4.9	10			8													
19	602+80	3.2	10			1		1			2	6	1	3					
20	602+50	2.1	10																
21	591+51	3.4	10																
22	590+80	4.7	10	1							1	2	2	5	1				
23	597+85	2.4	10			5	1					6	1	2					
24	597+63	3.8	10			2						2		2					
25	593+10	2.9	10			3				1		1							
26	592+70	2.2	9-1/2	1		1	1					2	1						
27	592+12	4.0	9-1/2		1	5						1	2	1					
28	591+70	3.3	10			1		1				1	1						
29	581+00	4.4	10			5	1					3	2	3					
30	579+75	3.0	10	3		1						4	3	3					
31	575+24	2.2	9-1/2																
32	573+80	4.2	9-3/4			3	1					2	4						
33	568+10	4.2	9-1/2			3	1					2	1						
34	564+56	2.0	10																
35	562+90	2.9	10			3						1	3	4		1			
36	562+00	3.2	9-1/2																
37	556+54	2.5	9-1/2	1		7	2				1	2		2					
38	556+21	1.8	9-1/2																
39	553+00	2.6	9-1/4																
40	552+64	2.6	9-1/2		2	3		1				2		1					
41	537+60	3.9	9-3/4																
42	529+55	4.5	9-1/2																
43	460+80	3.9	10			3		1				1	1	1					
44	445+50	3.5	9-1/2																
45	433+90	2.1	9-3/4								1	2	2	1					
46	413+00	3.5	9-3/4			3				1		1	3	3					1
47	344+70	2.6	9-1/2																
48	331+10	3.9	9-3/4			2													

AIR QUALITY MEASUREMENTS OF MOVABLE ASPHALT PLANTS FOR RECYCLING PAVING ASPHALT

(Progress Report)

J. T. Ellis

Research Laboratory Section
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Michigan Transportation Commission
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Lawrence C. Patrick, Jr., William C. Marshall
John P. Woodford, Director
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Introduction

The stacks of three movable asphalt plants processing recycled paving asphalt were sampled at construction sites during 1979 and one was sampled in 1980. This work was performed at the request of R. A. Welke, Supervisor of the Testing Laboratory's Bituminous Unit. All plants sampled were running a 50 percent recycled - 50 percent virgin aggregate mix.

None of the plants tested met the Federal air quality standards for particulate emissions. A baghouse filter plant did show a capability for compliance. Suggested revisions of wet scrubber systems on system operations are indicated.

Sampling of the stacks tested in 1979 was accomplished using the standard EPA Method 5 Procedure. The sampling procedure used for the one stack tested in 1980 was the 'Sampling Train Type A - Wet Media' method described in Michigan Department of Natural Resources Air Quality Division "Guidelines for Source Testing of Particulates." The procedure is essentially from EPA Method 5 except the dry filter media holder is positioned between the third and fourth impinger and the particulate captured in the impinger water is dried and included as part of the total particulate capture. Standard EPA Method 5 includes only the capture on the dry filter media and washings from the nozzle, probe, and associated glassware ahead of the filter. The Wet Media method usually produces slightly higher results than Standard EPA Method 5. The Wet Media method was used because it is the DNR recommended method for compliance testing of asphalt plants, and it is faster and safer for personnel than EPA Method 5 since it requires less handling and manipulation of heavy and bulky equipment on small elevated platforms.

Project 1

Project 1 was the reconstruction of M 99 from M 34 south to the Ohio State Line (Construction Project MBR 30031). The contractor for the project was Spartan Asphalt Paving Company of Holt. The plant was a Boeing Company drum mixer employing a "pyrocone" combustion control system and a wet scrubber filter exhaust system. This was the same plant that Spartan used for the reconstruction of M 57 near Greenville in 1978, except that the exhaust system had been rebuilt and a new 55-ft stack had been added. The stack was not of uniform diameter. The bottom 35 ft was 10 ft in diameter while the top 20 ft was 5 ft in diameter. The first sampling occurred on July 26, 1979. Stack velocity pressures varied from 0.30 to 0.48 in. of water indicating a stable stack. This is in sharp contrast to the wide variations of 0.03 to 0.98 in. of water found in 1978 before the exhaust system was rebuilt. One complete sampling run of 24 traverse points was

accomplished before the plant shut down for the day. A second sampling of the stack was attempted on August 2; however, shortly after the plant started and before a completed sampling run could be accomplished, the motor on the paver burned out and operations were suspended for the day. Visual observations during the July 26 sampling indicated the plume was mostly water droplets and vapor with little indication of blue hydrocarbon smoke. Large particles (1/16 to 1/8 in. diameter) were emitted (intermittently) usually immediately after the plant started. The particulate concentration found on the July 26 sampling is shown in Table 1. Data from the August 2 sampling are not included because the run was too brief to be meaningful.

TABLE 1
PARTICULATE CONCENTRATIONS
Federal Standard = 0.04 gr/DSCF*
(50 Percent Recycled - 50 Percent Virgin Aggregate)

Contractor	Location	Sampler	Date	Particulate Concentration, gr/DSCF*
Spartan	Hillsdale	MDOT	7-26-79	.208
Lake	Grayling	MDOT	8-16-79	.194, .129
Reith-Riley	Bridgeman	MDOT	9-25-79	.148
		Consultant	9-26-79	.217, .088, .083
		Barber-Greene	10-10-79	.012, .012
Hicks	Cadillac	MDOT	7-30-80	.093, .124

* grains per dry standard cubic foot

Project 2

Project 2 was the reconstruction of a section of I 75 from M 93 to the Otsego County Line (Construction Project I 20015). The contractor was Lake Construction Company of Indian River. The plant was a Boeing Company drum mixer with a "pyrocone" combustion control system and a wet scrubber filter exhaust system. The stack was round, 42 in. in diameter and 30 ft high. Two complete sampling runs of 24 traverse points of the plant stack were accomplished on August 12, 1979. Stack velocity pressures varied from 1.5 to 2.8 in. of water indicating a fairly stable, but high pressure stack. Visual observation of the plume showed mostly water vapor with little indication of blue hydrocarbon smoke. The sampling data are presented in Table 1.

Project 3

Project 3 was the reconstruction of a section of I 94 from Sawyer Rd to Puetz Rd (Construction Project IR 11015) near Bridgeman. The contractor was the Reith-Riley Company. The plant was a Barber-Greene Company drum mixer equipped with "Dual-Zone Thermodrum" temperature control system and a baghouse filter collection system. The stack was rectangular, 75 by 28 in. and 35 ft high. Sampling of the stack was attempted on September 25, but the plant shut down early to make baghouse repairs so only a partial sampling run was accomplished. Stack velocity pressures varied from 0.20 to 2.00 in. of water indicating a very turbulent and high pressure stack. The plume appeared to be mostly water vapor with little indication of blue hydrocarbon smoke. A scheduled September 26 sampling was cancelled when it was learned that a consultant had been contracted by Reith-Riley to sample the stack for compliance on that day. Rather than reschedule the sampling, arrangements were made with the contractor to receive a copy of the consultant's data. The consultant's data, along with the data from our September 25 partial sampling are presented in Table 1. It was learned later that defective baghouse filter bags caused the early shutdown on September 25. The nature of the problem had not been determined, nor completely corrected by September 26 when the consultant performed his test, thus his data also reflect poor filtration of the stack emissions. On October 9 and 10 after the defective filter bags had been replaced, Barber-Greene Company engineers sampled the stack using the standard EPA Method 5 test. The plant was running a 50 percent virgin - 50 percent recycled mix during the October 10 tests. A copy of these results was obtained and also presented in Table 1.

Project 4

Project 4 was the reconstruction of a section of M 55 from 21 Mile Rd to M 115 in Wexford County (Construction Project 16035A). The contractor was Hicks Construction Company of Alma. The plant was a Boeing Company drum mixer with a "pyrocone" combustion control system and a wet scrubber filter exhaust system with a 33-ft stack. The stack was not of uniform diameter. The bottom 23 ft was about 10 ft in diameter while the top 10 ft was 53 in. in diameter. Two complete samplings were accomplished on July 30, 1980. Stack velocity pressures varied from negative to 3.8 in. of water, indicating an extremely turbulent and high pressure stack. The plume appeared to be mostly water vapor with a slight bluish cast indicating the presence of hydrocarbons. The sampling data are also shown in Table 1.

The data from our tests and from the consultant that tested the Reith-Riley plant show that all of the plants tested in 1979 and 1980 failed to achieve Federal air quality standards for particulate emissions (0.4 gr/DSCF*). Barber-Greene's October 10, 1979 tests of the Reith-Riley plant show that they were able to comply with the standard after correcting the defective filter bag problem.

The other three plants tested (Spartan Asphalt, Lake Construction, and Hicks Construction) all used wet scrubber systems with settling ponds as the source of water to operate the scrubbers. The water was pumped from the pond to the scrubber and returned to the pond. Both Spartan and Lake used single settling ponds where the water was pumped from the pond to the scrubber and returned to the same pond along with the aggregate dust particles. Since the water in the pond was constantly circulated many of the particles had not settled and were picked up by the pump and returned to the scrubber. Hicks used two ponds connected by an overflow pipe. Water was pumped from Pond 1 to the scrubber, which drained into Pond 2, which then overflowed back into Pond 1. The two-pond system appeared to allow better settling of the aggregate dust particles and accordingly cleaner water to operate the scrubber. Dust particles already present in the supply water (settling ponds) of the three plants may have been a significant source of particulate emissions from the stacks. Since Hicks Construction had cleaner water to operate their scrubbers this could account for their lower stack emissions.

Conclusions

1) Based on Barber-Greene's data from the Reith-Riley plant at Bridgeman in 1980 and on our 1978 data from the Hicks Construction Company plant in Alma, drum mix plants with baghouse filter exhaust systems have shown that they can comply with Federal air quality standards for particulate emissions when processing recycled paving asphalt.

2) Drum mix plants with wet scrubber exhaust systems have not yet shown they can achieve Federal air quality standards for particulate emissions when processing recycled paving asphalt. These plants may be able to reduce their emissions by using cleaner water to operate their scrubbers. This might be accomplished by using larger or multiple settling ponds or a continuous clean water supply. Lower stack velocity pressures might also result in a reduction in emissions.

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* grains/dry standard cubic foot

Additional tests of plants processing recycled asphalt paving are planned for 1981 and succeeding years. The number of tests performed will depend on construction schedules.