OFFICE MEMORANDUM

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January 24, 1964

To: E. A. Finney, Director
Research Laboratory Division

From: M. G. Brown

Subject: Summary of Bituminous Concrete Skid Test Data Relative to Materials. Research Project R-54 G-74. Research Report No. R-447.

The attached graph and tabulations summarize field skid testing data obtained from 1957 through 1963 on regular trunkline projects of various surface types and also on numerous special test areas. This summary has been prepared according to your request, as reference information for a meeting of the Pavement Selection Committee on January 28, 1964. This meeting was called by the chairman, Howard E. Hill, in his memorandum of January 6, 1964, to discuss the problem of pavement slipperiness. The following digest of the attached data was prepared in consultation with Paul J. Serafin of the Testing Laboratory Division and L. F. Holbrook of the Research Laboratory Division.

Skid Test Methods and Criteria of Safety

All coefficient of friction data were obtained using the "trailer method," primarily in the normal stream of traffic at a steady test speed of 40 mph. The Research Laboratory skid trailer was built from the rear portion of a 1949 Buick chassis, and essentially has not been changed since our field testing began in 1957. Firestone "500" tires have been used continuously on the test trailer throughout the test period (1957-63), to reduce possible variability resulting from tread configuration and tire composition. Our trailer method differs from the conventional "stopping distance method" used by many agencies, in that the test trailer is pulled by a large truck containing water tanks and recording instruments at a steady 40 mph speed as both trailer wheels are locked for about 1-1/4 seconds for each test. The drag force between tires and wet pavement is electronically recorded to calculate coefficient of friction. On the other hand, stopping distance tests involve a conventional car driven on a wetted surface from some initial speed, such as 20 mph, and an average coefficient from 20 mph to 0 mph is obtained from the stopping distance measured. Since wet sliding coefficients of friction are speed-sensitive for most surfaces, our trailer method values at a steady 40 mph are somewhat lower than those obtained by the stopping distance of a car from an initial speed of 40 mph decelerating to zero. The degree of accuracy of our skid trailer system in terms of coefficient is in the neighborhood of $\pm$ .025.

At this point it may be well to mention that the Department and many other agencies have been employing a wet sliding coefficient of friction value of 0.40 (trailer method at 40 mph), as a dividing point between "safe" and "unsafe" pavement surfaces. No such sharp demarcation really exists, however, and surfaces with coefficient values of 0.35 to 0.40 are actually in a "transitional" or "questionable" range. Any project falling below 0.35 under wet conditions could be considered dangerous, depending on prevailing speeds, road alignment, and geometry. Surface friction values obtained at other speeds or by other methods must be converted to 40-mph trailer values, if they are to be appraised in terms of these safety limits of 0.35 and 0.40.

Wear curves plotted in Figure 1 and related data in Table 1 were computed from field skid tests run from 1957 to 1960 on individual projects throughout the state trunkline system. The curves were plotted using the same type of friction-wear data but a slightly different statistical approach than those shown in Research Laboratory Report 295 by E. A. Finney and M. G. Brown entitled "Relative Skid Resistance of Pavement Surfaces Based on Michigan's Experience", presented at the First International Skid Prevention Conference at Charlottesville, Virginia, in 1958. The average coefficient of friction at 40 mph (trailer method) for each project was plotted against a "wear factor" for that project. The wear factor was computed as described in that report: the age of each individual project in years (at time of test) was multiplied by the weighted average daily traffic (ADT) figure per traffic lane, and divided by 1000. The commercial portion of the ADT count was converted to an equivalent number of cars using a truck-to-car weight ratio usually having a value between 5 and 7. The truck-to-car weight ratios were figured from loadometer survey data.

Bituminous Concrete Projects

A total of 615 trunkline projects are represented by the nine curves of Figure 1, as may be seen in the data of Table 1. The curves represent the following major surface types: bituminous concrete using five major limestone sources, bituminous concrete with crushed gravel, bituminous concrete with crushed trap rock and related igneous gravels, bituminous aggregate (20A), and, for comparison, portland cement concrete. The 261 portland cement concrete projects included both gravel and limestone coarse aggregates. Preliminary plotting indicated no substantial difference between wear patterns of projects using limestone coarse aggregate and those using gravel. Apparently the coarse aggregate in portland cement concrete surfaces does not normally become exposed sufficiently to influence the frictional properties of the surface. In bituminous surfaces, however, the asphalt-sand mortar wears off and the coarse aggregate definitely influences

the surface friction properties. Bituminous concrete projects containing crushed limestone were separated into five sub-groups according to major stone sources, since it became apparent that there are inherent differences in the wear or polishing properties of the five limestone sources. It can be seen that all five limestones polish at a faster rate than the crushed gravel in bituminous concrete, but not necessarily to the same degree. Inland limestone wears the fastest and Wallace Stone from Bay Port the slowest of the five sources involved, and they approach different minimum coefficients of approximately 0.23 for Inland and 0.36 for Wallace. The other three limestones (Drummond dolomite, Monon, and National-France of Ohio) have wear curves in between these two extremes for Inland and Wallace. The National Lime and Stone Company and France Stone Company quarries of northern Ohio were combined into one group since preliminary plots indicated they had the same wear pattern. Monon and Drummond seem to approach a possible minimum coefficient of 0.30 as estimated from the graph, while the Ohio limestones approach a 0.32 value. By comparison, the crushed gravel bituminous concrete projects appear to approach a 0.40 minimum and portland cement concrete projects a 0.42 to 0.43 minimum. Bituminous aggregate (20A) projects exhibit an unusual wear curve which may represent a combination of different types of 20A aggregate sources and the effect of lighter traffic densities associated with this surface type. The bituminous concrete surfaces using 25A trap rock and related crushed gravel appear to have excellent frictional values; however, no minimum friction value can be estimated at this time since these projects are generally in light traffic areas, and hence have low wear factors.

Table 1 summarizes individual project skid data by groups and sub-groups as graphed in Figure 1. The itemized project data are also included in this summary for additional reference and will be found in the Addenda following Table 15.

Tables 2 through 8 contain summaries of skid tests on various special bituminous concrete projects being tested on an annual basis. Table 2 lists the skid coefficients of three test areas on US 12 in Dearborn, comparing 25A slag and crushed gravel in bituminous concrete. After eight years all three sections have worn down to about a 0.40 coefficient, indicating that crushed slag and gravel are about equal in wear properties and maintain a satisfactory friction level. Table 3 for the Pontiac test road indicates no significant difference in friction levels for six asphalt sources, and again a 0.40 average value indicates a satisfactory level of friction for the crushed gravel surfaces after nine years. Table 4 contains friction values from projects containing Upper Peninsula mine rock and related crushed igneous gravel; the friction levels for all of these projects (0.49 to 0.64) look very good thus far. However, as mentioned earlier, it is felt that light traffic is a factor. Table 5 summarizes 1958-60 bituminous concrete projects

with 2NS and 3BC sands. The friction level of the two sand types is comparable, although some differences among the projects may be due, in part, to coarse aggregate differences. Table 6 summarizes skid tests to date on Interstate bituminous projects on I 75-US 27 from Clare to Indian River. The friction levels at this early stage are good. It may be worth noting that a number of the projects used Wallace (Bay Port) limestone, Afton Quarry limestone, and several crushed gravel coarse aggregates from adjoining areas. Table 7 contains four recent bituminous concrete projects in the Detroit area using 31A material; so far, two of three slag projects compare closely with the crushed gravel project. Table 8 is the last table concerned with bituminous concrete and summarizes skid tests made periodically on the Wayne County test areas on Merriman Road. Five of the six test sections used 31A material, and it is interesting to note that the lowest friction level was measured on the one section containing 31A limestone (Inland).

Sheet or Sand Asphalt Projects

Tables 9 through 15 contain summaries of several thin sheet or sand asphalt surfacing projects. Table 9, for the Ann Arbor test road on old US 23 south of US 12, shows that under rolling traffic the seven test sections placed in 1958 have maintained satisfactory friction levels (0.41 to 0.47) for more than five years. Section 7 had a low initial coefficient due to excess asphalt on the surface resulting from moisture problems during construction, but this was correcting itself by the end of 1959. Table 10 contains skid data on three sections placed in Charlevoix in October 1960. The rubberized sand asphalt sheet was located north of the bascule bridge to correct a polished stone-sand portland cement concrete pavement having a coefficient of about 0.20 in 1958, and has a coefficient just under 0.40. By comparison, the 31A bituminous surface placed south of the bridge has only about a 0.30 friction factor. Table 11 contains skid test data on a 2NS sand asphalt surfacing placed on US 131 north of Reed City. After two years this project shows a good average friction value of 0.47.

Table 12 summarizes data on a more recent sheet asphalt project on US 131 north of Grand Rapids, placed to correct a slippery pavement condition. Four short test sections using from 7.5 to 5.5 percent asphalt were placed in August 1963, and the balance of the project to the south used 6.5 percent asphalt. Initial skid tests in September, October, and December indicated an increase in friction level. December tests indicated that the friction level increased from 0.38 to 0.48 with a change in asphalt content from 7.5 to 5.5 percent for sections A through D, respectively. Tables 13 and 14 report tests on sand asphalt surfacings at intersections in District 10 using 2NS modified and 3BCS slag sands. These areas

were treated in October 1961, as a result of a series of field skidding tests on high accident intersections described in Research Laboratory Report 362 (July 1961). Most intersections so treated had polished limestone bituminous concrete surfaces with coefficients in the 0.25 to 0.35 range prior to treatment. The sand asphalt surfaces had good coefficients initially and also after one year. After two years, however, the friction level has dropped to the 0.30 to 0.35 range, apparently due to heavy grease and oil drippings in the stopping areas.

Finally, Table 15 contains skid data on four areas of "colored" sheet asphalt surfaces in Detroit. These "Velsipave" or "Wyton" mixes were placed in June 1962, using crushed limestone sand. It is apparent that all four of the test areas are becoming polished (0.18 to 0.27 coefficients) due to the soft nature of the limestone-resin sheet.

Conclusions and Recommendations

In summary, the following conclusions can be drawn from the graphed and tabulated data:

1. Bituminous concrete made with 25A crushed gravel maintains the highest friction level and polishes the slowest of the major aggregate types shown in Figure 1. This surface type comes the closest to the wear curve for portland cement concrete.

2. All five limestone sources studied polish at rates faster than crushed gravel, although they vary in minimum friction values in bituminous concrete. Wallace stone approaches the crushed gravel curve in wear characteristics the closest, and Inland limestone is the worst. Monon, Drummond, and the northern Ohio limestones are intermediate between Inland and Wallace.

3. Waste mine rock and related igneous gravels appear to offer a good potential as a more skid resistant stone for use in bituminous concrete wearing courses, subject to further studies where this material might be used in higher traffic areas.

4. Thin sheet or sand asphalt surfaces maintain satisfactory friction levels under rolling traffic, but are susceptible to glazing by grease and oil drippings at intersections having high traffic densities.

In order to build the highest possible wear or polish resistance into a bituminous concrete or related wearing course, several materials qualifications could be prescribed:

1. Use crushed gravel sources of known wear characteristics in the wearing course.

2. Prohibit the use of straight crushed limestones, in the wearing course mixes only, unless the source has wear characteristics equal to or greater than Wallace Bay Port limestone.

3. In cases where neither of these two requirements are practical, uniformly blend a crushed gravel of low limestone content with crushed limestone in a ratio such as 50-50 by weight.

4. Explore the properties of crushed trap rock or related igneous gravel aggregate by experimental projects in high traffic areas in the Lower Peninsula.

5. Explore new sources of limestone having a high sand content and potential polish resistance for wearing course mixes.

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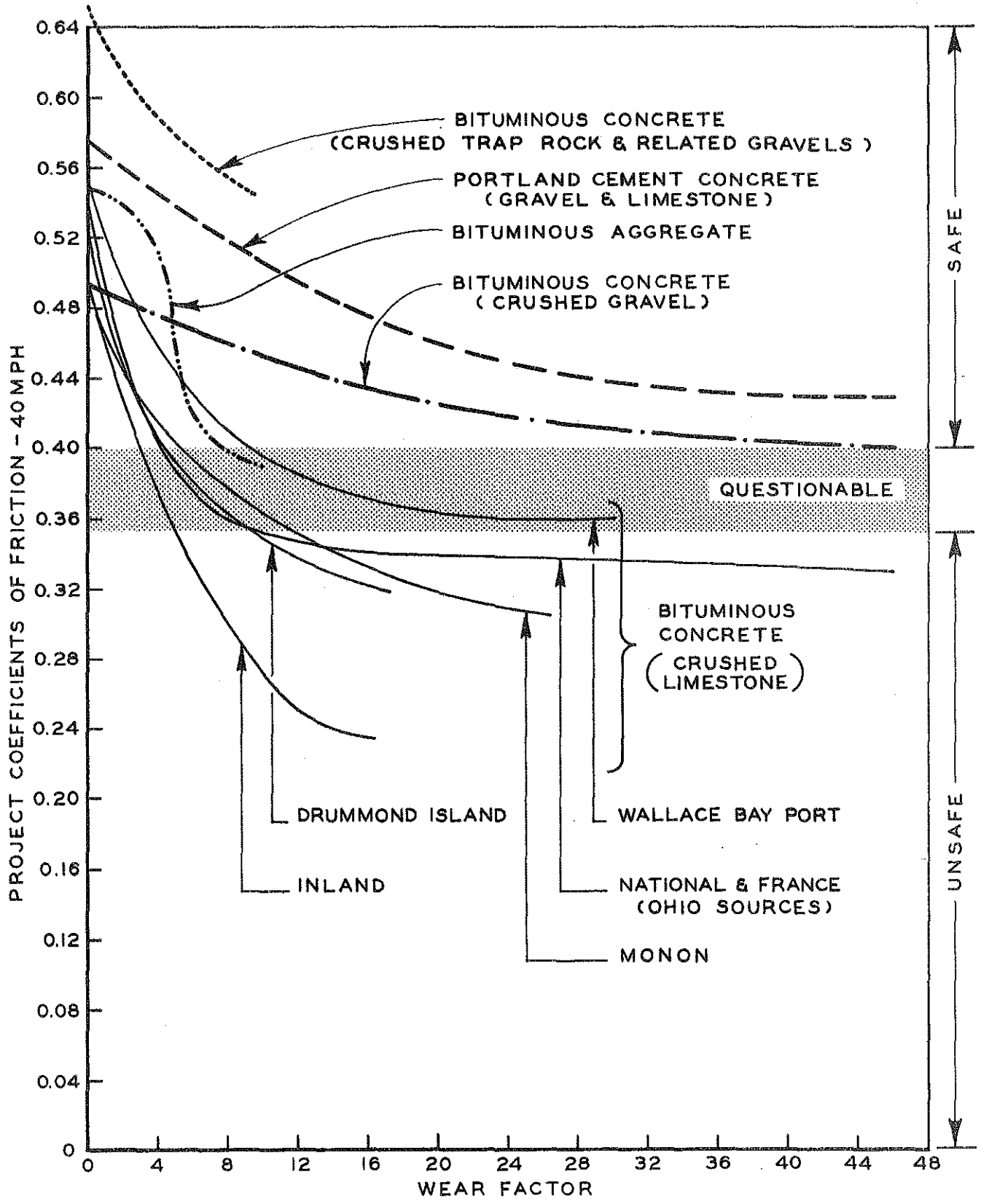

Figure 1. General coefficient-wear curves for various pavement surface types and coarse aggregate sources.

TABLE 1
SUMMARY OF TRUNKLINE PROJECT SKID DATA
BY SURFACE TYPES AND COARSE AGGREGATE SOURCES
Field Tests 1957-60

Surface Type	Total Projects	Frictional Wear Properities		
		Coefficient Range*	Wear Slope	
			Initial (negative)**	Possible Minimum***
Bituminous Concrete - Limestone (25A)				
1. Wallace Stone Co. (Bay Port)	24	.36 to .62	.019	.36
2. National Lime & Stone Co. and France Stone Co. (Northern Ohio)	38	.27 to .53	.023	.32
3. Monon Stone Co.	25	.29 to .54	.014	.30
4. Drummond Island (Dolomite)	24	.22 to .61	.020	.30
5. Inland Lime & Stone Co. (Port Inland)	18	.19 to .49	.024	.23
Bituminous Concrete - Crushed Gravel (25A)				
All Sources	98	.30 to .68	.0045	.40
Bituminous Concrete - Crushed Trap Rock and Related Gravels (25A)				
Western Upper Peninsula	11	.49 to .66	.013	Unknown
Bituminous Aggregate (20A)				
All Sources	116	.23 to .73	.019	Unknown
Portland Cement Concrete (Gravel and Limestone)				
All Sources	261	.30 to .68	.0069	.43

* Low and high coefficient of all projects in the group (includes all ages).
** Estimated from curves in Fig. 1 (from a wear factor of 0 to 8).
*** Estimated from curves in Fig. 1.

TABLE 2
SLAG BITUMINOUS CONCRETE TEST ROAD
US 12, Dearborn (Project M 82-42, C2 and C3)
Surfacing Placed in September 1955

Test Section	Average Coefficients of Friction, 40 mph (Test Date)*								
	9-11-57**	5-2-58**	6-6-58	5-7-59**	5-24-60**	11-23-60	4-27-61 Air 55°	5-1-62 Pav't 70°	9-26-62 Air 59°
No. 1, Bailey St. to US 24 Slag CA & FA	.51	.47	.35	.42	.36	.42	.44	.38	.40
No. 2, US 24 to Outer Dr. Slag CA & Natural FA	.50	.47	.35	.41	.34	.42	.46	.37	.40
No. 3, Outer Dr. to Newlin St., Crushed Gravel CA Natural FA	.47	.47	.35	.42	.35	.43	.46	.39	.42

* Each figure is average of at least six tests per section in each direction. Test value is average of both directions.
** Tests these dates run at 20 mph, corrected to 40 mph. All other tests run at 40 mph.

TABLE 3
PONTIAC TEST ROAD
Old US 10 (Project M 63-30, C8R)
Paved in July and August 1954

Experimental Section	Asphalt Source (60-70 pen.)*	Average Coefficients of Friction, 40 mph, (Test Date)**																			
		Nov. '57		May '58		Apr. '59		Oct. '60		Apr. '61		June '61	June '62		May '63		July '63		Sept. '63		Dec. '63	
		IL	OL	IL	OL	IL	OL	IL	OL	IL	OL	OL	IL	OL	IL	OL	IL	OL	IL	OL	IL	OL
Regular, North End		.48	.37	.47	.42	.44	.38	---	---	.53	.51	.46	.43	.37	.47	.41	.46	.40	.44	.38	.43	.38
6B	East Texas, Talco	---	---	---	---	.46	.41	.48	.42	.52	.49	.46	.41	.40	.46	.42	.46	.41	.42	.40	.42	.40
6A	East Texas, Talco	.49	.40	.49	.41	.47	.41	.48	.44	.53	.48	.45	.42	.36	.47	.42	.48	.40	.44	.39	.42	.40
5B	Arkansas, Smackover	---	---	---	---	.45	.40	.48	.44	.53	.50	.44	.41	.36	.48	.42	.46	.40	.42	.41	.43	.39
5A	Arkansas, Smackover	.47	.38	.49	.42	.45	.43	.48	.45	.54	.50	.46	.42	.36	.48	.41	.47	.42	.44	.40	.44	.39
4B	Winkler - W. Texas	---	---	---	---	.45	.42	.46	.44	.53	.50	.46	.41	.37	.46	.42	.47	.41	.43	.40	.44	.39
4A	Winkler - W. Texas	.49	.41	.51	.40	.46	.41	.47	.44	.53	.50	.46	.43	.37	.47	.42	.47	.42	.42	.40	.43	.39
3B	Wyoming Ref. B	---	---	---	---	.47	.42	.49	.46	.54	.52	.47	.44	.39	.48	.44	.48	.44	.42	.40	.44	.40
3A	Wyoming Ref. B	.47	.40	.50	.43	.46	.41	.49	.45	.54	.49	.45	.41	.40	.47	.42	.47	.43	.42	.40	.44	.39
2B	Venezuela	---	---	---	---	.46	.43	.49	.47	.55	.50	.45	.44	.39	.48	.44	.47	.43	.44	.43	.44	.41
2A	Venezuela	.49	.44	.50	.44	.47	.44	.49	.46	.54	.50	.49	.44	.39	.49	.44	.48	.44	.43	.42	.45	.41
1B	Wyoming Ref. A	---	---	---	---	.46	.41	.48	.43	.54	.48	.44	.41	.37	.47	.41	.45	.42	.40	.39	.43	.39
1A	Wyoming Ref. A	.48	.41	.51	.43	.48	.41	.47	.42	.54	.49	.46	.41	.36	.47	.43	.44	.41	.41	.39	.44	.39
Regular, South End		---	---	.54	.43	.47	.41	---	---	.54	.51	.45										

* Source of stone - Amer. Agg. Oxford and Green Oak

** IL and OL indicate passing and traffic lanes, respectively; values are averages of tests in both directions of traffic.

TABLE 4
UPPER PENINSULA BITUMINOUS CONCRETE
USING MINE ROCK AND RELATED AGGREGATE

	Control Section	Project Number	Route	Location	Year Surfaced	Coarse Aggregate* (25A)	Asphalt Cement (85/100 Penetration)	Average Coefficient of Friction Year Tested and Direction		
								1958	1959	1961
MINE ROCK	66051	66-54, C4	M 26	Mass-Rockland	1956	Mass Pit #66-51 (Waste Mine Rock)	Lion Oil, Eldorado, Ark.; Am. Lib. Oil, Mt. Pleasant, Texas	.60 SB	.69 SB	.62 SB
	27021	27-3, C5	US 2	State Line east to Ironwood	1956	Peterson Mine (Mine Rock)	Lion Oil, Eldorado, Ark.; Am. Lib. Oil, Mt. Pleasant, Texas	.52 EB .49 WB	.50 EB .50 WB	.51 EB
	31011	31-31, C13	M 26	Ontonagon Co. Line NE 3.9 mi	1956	Winona-Waste Mine Rock #31-4	Am. Lib. Oil, Mt. Pleasant, Texas	.62 NB	.67 SB	.64 SB
RELATED AGGREGATE	27024	27-20, C13	US 2	US 45 East	1956	Maher Pit #27-33	Lion Oil Co., Eldorado, Ark.; Am. Lib. Oil, Mt. Pleasant, Texas		.66 EB	
	27051	27-11, C14	US 45	US 2 North 2 mi	1956	Maher Pit #27-33	Lion Oil Co., Eldorado, Ark.; Am. Lib. Oil, Mt. Pleasant, Texas	.48 NB .49 SB	.53 NB	.49 NB
	31012	31-20, C9	M 26	Houghton-Painesdale	1953	Thornton, Hancock	Lion Oil Co., Eldorado, Ark.	.53 SB	.60 SB	.62 SB
	31013	31-21, C4	M 26	Dollar Bay-Lake Linden	1955	Thornton, Hancock (Racetrack Pit #31-1)	Lion Oil Co., Eldorado, Ark.; Am. Lib. Oil, Mt. Pleasant, Texas		.60 NB	.57 SB
	31013	31-25, C4	M 26	Laurium-Lake Linden	1952	Thornton, Hancock	Lion Oil Co., Eldorado, Arkansas	.50 SB	.61 NB	.64 SB
	31051	31-19, C5	US 41	Houghton-Chassel	1952	Thornton, Hancock	Lion Oil Co., Eldorado, Arkansas	.54 EB	.48 NB .59 SB	.58 NB
	31052	C1R	US 41	Hancock-Calumet	1958	Thornton, Hancock	Lion Oil Co., Eldorado, Ark.; Am. Petrofina Co., Mt. Pleasant, Texas	.50 NB	.63 SB	.62 NB
	31052	31-18, C9	US 41	Calumet-Mohawk	1955	Thornton, Racetrack Pit #31-1	Am. Lib. Oil, Mt. Pleasant, Texas	.44 NB	.55 NB	.55 NB
	52041	52-13, C5	US 41	Champion-West	1956	Dishneau Pit #52-1	Lion Oil Co., Eldorado, Arkansas	.54 EB	.51 WB	.50 WB
	52041	52-19, C4	US 41	Marquette Co. Line East	1956	Dishneau Pit #52-1	Lion Oil Co., Eldorado, Arkansas		.56 WB	.56 WB

* Same mineral filler used on all projects; limestone dust from Hurlbut Chemical Co., Green Bay, Wisconsin.

TABLE 5
BITUMINOUS CONCRETE PROJECTS WITH 2NS AND 3BC SANDS

	Project Number		Route	Location and Length	Experimental Section	Coarse Aggregate	Average Sliding Coefficient of Friction, 40 mph*					
	Control Section	Contract Number					1958	1959	1960	1961	1962	1963
SURFACED 1958	SS 79061	C1R	M 81	Watrousville, E&W (4.9 mi)	Sec. #1 (2NS) Sec. #3 (3BC)	Inland L.S., Pt. Inland	.52(11) .48	.53(10) .49	.49(9) .44	.45(5) .42	.43(5) .40	.40(7) .38
		79-23, C4	M 81	Between Sections #1 and #3 (1.45 mi) (comparison section, passed 1952)	Sec. #2 (3BC)	Drummond Dolomite	.38	.44	.41	.41	.41	.34
SURFACED 1959	M 30071 46011	C1R C1R	US 127	From M 34 to US 12 (13.9 mi)	3BC, 3.5% MF 2NS, 4.5% MF 2NS, 2.0% MF 2NS, 0.0% MF	France Stone, Waterville, Ohio		.48(12) .50 .55 .55	.39(9) .49 .44 .39	--- --- --- ---	--- --- --- ---	--- --- --- ---
	M 39042	C6U	M 96	Kalamazoo to Galesburg (6.6 mi)	3BC Coarse sand 2NS	Materials Service, Chicago		.39(12) .42 .46	.40(9) .46 .44	.44(5) .48 .38	--- --- ---	--- --- ---
	BI 41024	C2RN	I 96 (ramps)	Segwun Road Nash Road (M 91) Morse Lake Road Whitneyville Road	2NS 2NS 2NS 2NS	Pickett Gravel, Lowell		.61(12) .61 .60 .62	--- --- --- ---	--- --- --- ---	--- --- --- ---	--- --- --- ---
	F 41051	C1R	US 131 BP	Knapp Rd., North (3.95 mi) (Grand Rapids)	3BC 2NS	Grand Rapids Gravel Co.		.52(12) .48	.58(10) .54	--- ---	--- ---	--- ---
	M 54032	C1U	M 66	In Barryton (1.2 mi)	2NS	Hubscher & Sons, Mt. Pleasant		.51(12)	---	---	---	---
SURFACED 1960	F 81032	C2U, C3R	US 12	In Ypsilanti (1.5 mi)	2NS	Am. Agg., Green Oak		.46(12)	.44(9)	---	---	---
	F 81102	C1R	M 14	Ann Arbor, East (11.6 mi)	3BC 2NS	Am. Agg., Green Oak		.59(12) .58	.52(9) .48	--- ---	--- ---	--- ---
	Fb 19061	C1R	M 21	Pewamo, East (4.5 mi)	2NS	Wms. Bros., Saranac			.48(10)	.51(5)	---	---
	Mrc 25061	C2R	M 15	S. of Davison (5.16 mi)	2NS	Inland L.S., Rogers City			---	.41(5)	---	---
	Mb 25101	C4R	M 15	Davison N. to Co. Line (10.8 mi)	2NS	Inland L.S., Rogers City			---	.42(5)	---	---
	Mb 34041	C1R	US 16 (old)	West to East Co. Lines (24.2 mi)	2NS	Wms. Bros. (34-51)			.52(10)	.47(6)	---	---
	M 41023	C1R	US 16 (old)	Whitneyville Road East (8.49 mi)	2NS	Kellogg Pit (41-46)			.53(10)	.50(6)	---	---
	Mb 47063	C1R	US 16 (old)	E. of US 23 to Co. Line (4.3 mi)	2NS	Am. Agg., Green Oak			.46(9)	.48(5)	---	---

* Month of test is shown in parentheses.

TABLE 6
INTERSTATE BITUMINOUS CONCRETE PROJECTS
I 75-US 27 from Clare to Indian River (Projects listed South to North)

Project Number	Length in Miles	Date Paved (Wearing Course)	Location	Paving Contractor	Source of Coarse Aggregate	Average Coefficient of Friction, 40 mph								
						1961		1962		Apr. 1963		Aug. 1963		
						IL*	OL*	IL	OL	IL	OL	IL	OL	CWF***
18034, C3	6.758	May-June 1962	M 61 to Arnold Rd.	Rieth-Riley	Wallace Stone, Bay Port	.52**	.51**	---	---	---	---	---	---	---
18034, C1	5.902	July-Aug.-Oct.	Arnold Rd. N. to Roscommon Co. L.	Mid-America Eng.	Wallace Stone	.60	.60	.60	.52	---	---			
72013, C2	3.007	July-Aug.-Oct. 1961	Roscommon Co. L. N. 3 Mi.									.58	.47	5.9
72013, C1	9.643	July-Aug.-Sept. 1961	3 Mi. N. of Clare Co. L to 0.5 Mi. N. of M 55	Ann Arbor Const. and Lake-Howell	Afton Quarry (20-35)	---	---	.60	.50	---	---	.57	.44	6.0
72014, C1	6.981	Sept.-Oct. 1961	0.5 Mi. N. of M 55 to 0.5 Mi. N. of Higgins Lake Rd.	Thornton Const.	Pickitt, Schreur, Merritt Pit	.52	.48	.60	.53	---	---	.58	.51	5.8
72014, C3 & 4	4.220	May 1962	0.5 Mi. N. of Higgins Lake Rd. to N. Co. L.	Thornton Const.	Pickitt, Schreur, Merritt Pit	---	---	.54	.48	---	---	.58	.51	2.5
20016, C1 & 3	5.804	May-June 1962	Crawford-Roscommon Co. L. to M 18-M 76	Thornton Const.	Pickitt, Schreur, Merritt Pit	---	---	.51	.48	---	---	.58	.53	2.3
20014, C3	4.874	Aug.-Sept. 1961	M 18-M 76 to 0.5 Mi. S. of M 72	Lake and Howell	Afton Quarry	.43	.43	.56	.43	---	---	.53	.40	4.2
20015, C4	4.534	Sept.-Oct. 1961	0.5 Mi. S. of M 72 to 0.5 Mi. N. of M 93	Saginaw Asphalt	Afton Quarry	.53	.50	.60	.50	.58	.49	.53	.46	4.2
20015, C2	4.864	May-June 1962	0.5 Mi. N. of M 93 to Co. Rd. #612	Thornton Const.	McCready Pit (60-18)			.56	.51	.57	.55	.57	.51	2.4
20015, C3	4.847	Sept. 1961	Co. Rd. #612 to N. Crawford Co. L.	Thornton Const.	McCready Pit	.60	.56	.60	.52	.61	.56	.59	.51	5.4
69013, C1	7.665	Oct. 1961 (1.5 mi) June 1962 (6.1 mi)	Otsego Co. L. North Marlette Rd. to Charles Brink Rd.	Saginaw Asphalt	Afton Quarry			---	---	.57 .56	.49 .47	.59 .59	.54 .47	5.3 2.4
69013, C3	5.385	June 1962	Brink Rd. N. to M 32 (Gaylord)	Spartan Asphalt	Lewiston Pit			---	---	.59	.54	.63	.57	2.5
69014, C3	8.718	June-July 1962	M 32 N. to Vanderbilt	Spartan Asphalt	Lewiston Pit (and Drummond Dolomite)			.54	.52	.60	.58	.58	.57	2.3
69014, C5	3.894	Sept.-Oct. 1962, also	Vanderbilt to 3/4 Mi. N. of Wolverine Rd.	Rieth-Riley	Afton Quarry			---	---	.60	.55	.58	.48	2.3
16093, C1	6.657	June 1963 (2.5 mi)	NB from Alexander Rd. to NYCRR - SB from Co. Line to NYCRR									.51	.47	0.0
16093, C3 & 5	7.942	Aug.-Sept. 1962	3/4 Mi. N. of Wolverine Rd. to 0.5 Mi. S. of M 68	Saginaw Asphalt	Afton Quarry			.56	.52	.62	.55	.60	.50	2.2
16091, C9	2.629	Aug.-Sept. 1962	0.5 Mi. S. of M 68 N. to MCRR	East Shore Asphalt	Big Cut Pit			.62	.58	---	---	.63	.56	2.3

* IL and OL denote passing and traffic lanes.
** Tested on leveling course mix.
*** CWF is wear factor as of August 1963 for traffic lane only.

TABLE 7
BITUMINOUS CONCRETE PROJECTS WITH 31A AGGREGATE

Project Number	Location	Year Paved	Types of Materials	Lane and Direction*	Average Coefficient of Friction, 40 mph		
					Nov. 1960	May 1961	June 1962
Mb 82062, C4U	US 12 (Michigan Ave.) from Washington St. to Brady St. in Dearborn	1960	31A Slag coarse	EBOL	.51**	.41**	.31**
			3BCS Slag sand	EBIL	.51	.42	.32
			60-70 pen. AC	WBOL	.48	.43	.32
				WBIL	.50	.41	.31
Mb 82121, C1U	Gd. River (old US 16) 6 Mile Rd. to Berg Rd.	1960	31A Slag coarse	EBOL	.44**	.40**	.38
			3BCS Slag sand	EBCL	.46	.45	.38
			60-70 pen. AC	EBIL	.47	.43	.40
				WBOL	.49	.44	.39
				WBCL	.46	.44	.39
				WBIL	.52	.45	.40
Mb 82131, C5U	US 10 (Woodward Ave.) Clairmont St. to city limits of Highland Park	1960	31A Crushed gravel	NBOL	.52**	.45**	-----
			3BC Sand	NBIL	.52	.43	-----
			3MF Fly ash	SBOL	.52	.42	-----
			60-70 pen. AC	SBIL	.54	.43	-----
						Nov. 1961	May 1962
Mb 82091C, C5U	Schaefer Rd., Gate 4 to Mellon Rd., Dearborn	1961	31A Open hearth slag	NBOL		.59	.41
			3BCS Open hearth slag	NBCL		.65	.45
			Open hearth slag	NBIL		.64	.49
			31A Blast furnace slag	SBOL		.62	.51
			3BCS Blast furnace slag	SBCL		.66	.49
			Blast furnace slag	SBIL		.64	.53

* EB, WB, etc. denote eastbound and westbound lanes.
OL and IL denote outside traffic lane and inside passing lane.

** These tests were run at 20 or 30 mph and corrected to 40 mph values.

TABLE 8

WAYNE COUNTY BITUMINOUS CONCRETE TEST ROAD

Merriman Road Between Palmer and Marquette Streets

Test Section	Type Stone and Asphalt Content**	Direction	Average Coefficient of Friction (Test Date)							
			7-16-58* Air 70°	9-9-58 Air 60°	5-1-59 Air 47°	10-16-59 Air 48° Pav't 40°	7-8-60 Air 79°	4-27-61 Air 55°	5-7-62 Pav't 83°	8-22-63 Air 84° Pav't 90°
Palmer St. - South End										
1	25A Modified Crushed Gravel, 5.2% AC	SB	.35	.41	.38	.41	.35	.44	.35	.30
		NB	.41	.40	.37	.39	.35	.46	.37	.33
2	31A-1 Crushed Gravel 6.2% AC	SB	.29	.37	.36	.40	.31	.44	.32	.27
		NB	.39	.39	.37	.40	.35	.46	.33	.30
3	31A Inland L.S., Natural Sand, 6.2% AC	SB	.32	.36	.34	.34	.28	.36	.25	.24
		NB	.39	.38	.34	.34	.26	.35	.23	.26
4	31A Crushed Gravel, 6.4% AC	SB	.35	.40	.38	.41	.41	.46	.36	.32
		NB	.44	.45	.40	.41	.38	.48	.36	.32
5	31A Crushed Gravel, 2NS Sand, 5.2% AC	SB	.39	.45	.42	.46	.41	.49	.39	.35
		NB	.45	.43	.39	.46	.36	.49	.36	.34
6	31A Slag, Coarse and Fine Agg., 7.4% AC	SB	.39	.49	.38	.44	.34	.43	.34	.31
		NB	.50	.45	.40	.42	.33	.45	.35	.33
Marquette St. - North End										

* Tests these dates made at 30 mph, all others at 40 mph.

** Asphalt cement was 85-100 penetration grade.

TABLE 9
SHEET ASPHALT TEST ROAD
Old US 23, South of I 94 (Project M 81071, C1R)

Test Section	Materials	Average Coefficients of Friction (Test Dates)[a]							
		7-11-58	7-22-58	9-8-58	9-23-58	10-10-58	4-23-59	5-6-59	10-13-59
1	3SAW + LSF	.43	.44	.45	.50	.50	.43	.46	.52
2	3SAW + FAF	.41	.42	.44	.47	.47	.45	.46	.52
3	2NS + LSF	.43	.42	.43	.46	.47	.42	.45	.51
4	2NS + FAF	.40	.38	.41	.45	.43	.42	.45	.51
5	Slag sand	.50	.49	.49	.52	.53	.44	.48	.53
6	31X + 3BC	.42	.41	.51	.51	.45	.40	.44	.49
7	31W + 3BC	.31	.34	.34	.38	.40	.37	.39	.44
1A	Reg. 25A mix	.47	.49	.46	.50	.49	.39	.41	.51

Test Section	Average Coefficients of Friction (Test Dates)[a]								
	5-24-60*	7-8-60**	8-24-60	4-21-61	6-19-61	10-17-61	4-19-62	9-24-62	7-9-63
1	.39	.48	.43	.55	.51	.48	.42	.46	.46
2	.40	.47	.42	.56	.52	.50	.43	.44	.47
3	.40	.46	.41	.54	.51	.50	.42	.44	.43
4	.40	.46	.41	.55	.50	.50	.45	.46	.44
5	.40	.46	.41	.54	.50	.47	.42	.46	.42
6	.38	.42	.38	.50	.48	.47	.41	.43	.41
7	.35	.41	.36	.50	.46	.42	.37	.42	.42
1A	.39	.43	.38	.51	.49	.47	.39	.44	.42

(a) Each value is average of six tests per section at 40 mph taken in north and southbound lanes.
* Tests made with old worn tires.
** Tested with new tires.

TABLE 10
RUBBERIZED SAND ASPHALT SURFACES
US 31 in Charlevoix (Project Mb 15012, C2U)

Test Area[a]	Average Coefficients of Friction (Test Date)[b]				
	11-12-58*	8-12-59**	10-31-60	9-6-61***	7-12-63
US 31 Bascule bridge N. to Dixon St. (rubberized sand asphalt)	.19	.48	.52	.40	.38
US 31 Bascule bridge South to Party St. (31A mix)	.19	.44	---	---	.29
M 66 Stover St. to Garfield St. (Mb 15031, C1U) (Bit. Agg. mix)	---	---	.54	---	.36

* Initial tests on polished portland cement concrete surface.
** Tests run on temporary seal coat applied in summer of 1959.
*** Tests run August 2, 1962, not valid due to bad gages on skid trailer.

(a) All three areas surfaced in October, 1960.
(b) Tests on US 31 run at 20 or 30 mph and corrected to 40 mph, and M 66 tested at 40 mph. All values are average of at least six tests in north and southbound lanes.

TABLE 11
SAND ASPHALT RESURFACING
US 131, Reed City North (Project Mb 67014, C3R)

Area Tested	Treatment[a]	Average Coefficient of Friction (Test Dates)			
		9-5-61*	1-3-62	11-28-62	7-11-63
Section 1 2.3-2.9 mi N. of Ashton Rd.	.035 gal kerosene per sq yd plus sand	.45	.49	.52	.48
Section 2 1.4-2.3 mi N. of Ashton Rd.	.050 gal kerosene per sq yd plus sand	.37	.46	.52	.47
Section 3 0.9-1.4 mi N. of Ashton Rd.	.040 gal kerosene per sq yd plus sand	.34	.47	.52	.47
Remainder of Project US 10 to 0.9 mi N. of Ashton Rd.	None	.44	.41	.49	---

(a) Areas 0.9 to 2.9 mi N. of Ashton Rd. treated as indicated on November 20, 1961. Original sand asphalt surfacing was placed July 5 through August 9, 1961.

* Initial skid tests run in northbound lanes. All subsequent values are average of six tests at 40 mph in both north and southbound lanes.

TABLE 12
SHEET ASPHALT RESURFACING
US 131: Rockford to Cedar Springs (Project Mb 41013C, C12)

Location			Materials		Average Coefficients of Friction, 40 mph			
Section Designation*	Stationing	Lane	Percent Bitumen	Dust	9-20-63 Air 58° Pav't 62°	9-25-63 Air 67° Pav't 75°	10-24-63 Air 65° Pav't 68°	12-5-63** Air 35° Pav't 35°
A	323+90 to 299+25	SB	7.5	3.5	.35	.33	.31	.38
	323+79 to 314+94	NB	7.5	3.5	.35	.32	.36	.38
	Average				.35	.33	.33	.38
B	314+94 to 297+20	NB	6.5	3.5	.38	.37	.38	.42
C	299+25 to 281+80	SB	6.5	4.5	.41	.40	.36	.42
	297+20 to 281+94	NB	6.5	4.5	.38	.38	.36	.45
	Average				.40	.38	.36	.44
D	281+80 to 264+97	SB	5.5	4.5	.44	.44	.42	.49
	281+94 to 268+93	NB	5.5	4.5	.44	.45	.44	.46
	Average				.44	.44	.43	.48
Kent County Resurfacing (1962)	138+88 to 156+92	SB	31A, Grand Rapids Gravel Co. No. 8 (Pit 41-16)		.35	.34	.35	.44
	138+88 to 156+92	NB			.38	.35	.35	.44
	Average				.36	.34	.35	.44
Balance of Project	90+00 South	SB	6.5	4.5	.46	.40	.39	.47
	90+00 South	NB	6.5	4.5	.47	.40	.43	.46
	Average				.46	.40	.41	.46

* Test areas designated in P. J. Serafin's letter to E. A. Finney, September 16, 1963. Sheet asphalt surfacing placed September 9-13, 1963.

** Average of tests run with two sets of tires; all other skid trailer tests run with the same single set of tires.

TABLE 13
2NS MODIFIED SAND ASPHALT SURFACES
District 10 Intersections

Control Section No.	Intersection Location	Route	Lane and Direction*	Average Coef. of Friction** (Test Date) 11-27/28-61	7-20/21-62	7-9-63
58053	US 24 at US 25 (So. Jct.)	US 25	NBOL	.45	.57	.35
		US 25	NBIL	.51	.53	.34
		US 24 & US 25	SBIL	.50	.50	.33
		US 24	NBOL	.52	.54	.34
		US 24	NBIL	.48	.54	.35
82052	US 24 (SB) at M 17 (N. Jct. - Ames Rd.)	US 24	SBOL	.45	.49	.31
		US 24	SBIL	.46	.49	.32
82052	US 24 at Cypress St.	US 24	NBOL	.45	.49	.28
		US 24	NBIL	.49	.51	.32
		US 24	SBOL	.42	.52	.30
		US 24	SBIL	.46	.53	.30
82052	US 24 at Wick Rd.	US 24	NBOL	.43	.49	.32
		US 24	NBIL	.44	.48	.31
		US 24	SBOL	.44	.47	.32
		US 24	SBIL	.49	.51	.31
82052	US 24 at Goddard Rd.	US 24	NBOL	.45	.45	.30
		US 24	NBIL	.40	.47	.30
		US 24	SBOL	.40	.43	.29
		US 24	SBIL	.41	.47	.30
82052	US 24 at Northline Rd.	US 24	NBOL	.45	.43	.28
		US 24	NBIL	.47	.46	.29
		US 24	SBOL	.47	.47	.30
		US 24	SBIL	.48	.45	.30
82041	M 17 at Pelham Rd.	M 17	EBOL	.42	.47	.29
		M 17	EBIL	.46	.49	.29
		Pelham	NBIL	.46	.45	.29
		Pelham	SBOL	.44	.44	.28
		Pelham	SBIL	.46	.48	.28
	Average of all 2NS Mod. sand lanes			.46	.49	.31

* NBOL, NBIL, etc., denote northbound outside lane, inside lane, etc., as used by traffic.
** Each coefficient value is an average of three tests run in stopping areas at 40 mph.

TABLE 14
SLAG SAND-ASPHALT SURFACES
District 10 Intersections

Control Section No.	Intersection Location	Route	Lane and Direction*	Average Coef. of Friction** (Test Date)		
				Nov. 1961	July 1962	July 1963
82053	US 24 (NB) at 5 Mile Rd.	US 24	NBOL	.55	.46	.32
		US 24	NBCL	.50	.47	.35
		US 24	NBIL	.52	.41	.34
82053	US 24 (NB) at W. Chicago Blvd.	US 24	NBOL	.43	.46	.30
		US 24	NB #3	.48	.46	.32
		US 24	NB #2	.52	.43	.31
		US 24	NBIL	.51	.44	.32
82053	US 24 (NB) at Joy Rd.	US 24	NBOL	.53	.47	.31
		US 24	NB #3	.55	.45	.33
		US 24	NB #2	.54	.45	.35
		US 24	NBIL	.55	.46	.33
82053	US 24 (NB) at Richardson St.	US 24	NBOL	.51	.52	.33
		US 24	NB #3	.54	.58	.34
		US 24	NB #2	.58	.57	.33
		US 24	NBIL	.61	.57	.36
82121	US 16 at Inkster Rd.	US 16	WBOL	.53	.42	.33
		US 16	WBCL	.55	.41	.31
		US 16	WBIL	.55	.42	.31
		US 16	WBPL	---	---	---
		US 16	EBOL	.51	.41	.29
		US 16	EB #3	.49	.42	.31
		US 16	EB #2	.54	.44	.31
		US 16	EBIL	.54	.40	.33
82121	US 16 at Poinciana St.	US 16	WBOL	.53	.41	.34
		US 16	WBCL	.51	.42	.33
		US 16	WBIL	.53	.41	.33
		US 16	PL	---	---	---
		US 16	EBOL	.52	.43	.33
		US 16	EBCL	.53	.44	.34
		US 16	EBIL	.55	.43	.32
		US 16	PL	---	---	---
82121	US 16 at Beech-Daly Rd.	US 16	WBOL	.49	.39	.29
		US 16	WBCL	.53	.44	.26
		US 16	WBIL	.51	.41	.30
		US 16	EBOL	.49	.42	.30
		US 16	EBCL	.48	.40	.29
		US 16	EBIL	.46	.40	.32
82141	M 102 at Inkster Rd.	Inkster	NB	.47	.42	.28
		Inkster	SB	.45	.39	.28
82141	M 102 at Beech-Daly Rd.	M 102	EBOL	.48	.40	.28
		M 102	EBCL	.51	.41	.28
		M 102	EBIL	.66	.45	.34
	Average of All Slag Sand Lanes			.52	.44	.31

* NBOL, NBIL denote the northbound outside lane and inside lane, as used by traffic. In the case of three lanes in the direction of traffic, CL denotes the center lane. In the case of four lanes in the direction of traffic, #2 and #3 are the second and third lanes from the median. PL denotes a parking lane, which was not tested.

** Each coefficient value is an average of three tests run in stopping areas, at 40 mph.

TABLE 15
COLORED BITUMINOUS MIXTURES IN DETROIT

	Test Area	Direction and Lane	Average Coefficient of Friction (Test Date)***		
			7-10/16-62	9-9/11-62	7-14/16-63
(13)*	John C. Lodge Expressway (East of Wyoming) Control Section 82112	EBOL**	.45	.33	.26
		EBCL	.43	.31	.25
	White Velsipave	EBIL	.46	.31	.23
		WBOL	.47	.32	.27
		WBCL	.44	.30	.23
		WBIL	.48	.34	.24
(12)	Randolph Street (one way) (Larned to Jefferson) Control Section 82132	EBOL (blue)	.37	.24	.22
		EBCL (white)	.41	.25	.23
		EBIL (white)	.46	.26	.18
(5)	Grand River Avenue (one way between Farmer and Broadway)	NEBOL (white)	.48	.32	.27
		NEBCL (white)	.44	.29	.22
		NEBIL (blue)	.47	.28	.25
(2)	Third Avenue under RR (one way south of Baltimore)	SB right lane	.48	.32	.25
	White Velsipave	SB left lane	.44	.31	.24

* Number in parenthesis refers to areas listed in Tables 1 and 2 of L. Kole and P. Lazarski's report of June 27, 1962, to P. J. Serafin.

** EB, WB, OL, CL, IL, etc. stands for eastbound or westbound direction and outside, center or inside lane in the direction of traffic.

*** Test values are average of six individual tests. First project tested at 40 mph and the other three were tested at 20 mph with results corrected to 40 mph.

ADDENDA

Trunkline Project Data Used in Figure 1 and Table 1

COEFFICIENT OF WET SLIDING FRICTION - 40 MPH
Bituminous Concrete Pavements (4.12)
25A Wallace Stone Co., Bay Port
3BC Sand

Project No.	Year Const.	Location	Date Tested	Wear. Factor	Coef. Friction
19021 C4	1956	US-16 Ingham-Clinton Co. Line W	6-57	4.0	0.45
19031 C1	1956	US-27 St. Johns S	7-57	3.8	0.55
19032 C4	1952	US-27 St. Johns N	7-57	15.8	0.48
25011 C4	1956	M-13, M-21 S	9-59	5.3	0.47
25021 C1	1959	M-87 Holly W	9-59	0.0	0.47
25033 C7	1953	US-23, BR Fenton N Limits N	11-57	18.5	0.37
25052 C7	1951	US-10, BR Mt. Morris to US-10	11-57	26.4	0.36
25101 C1,C2	1957	M-57, US-23 W	9-59	1.5	0.46
25101 C1,C2	1958	M-57, US-23 W	9-59	1.5	0.46
29011 C9	1957	US-27 Gratiot-Clinton Co. Line N	7-57	0.0	0.58
32021 C3	1958	M-142 Pigeon W	10-59	0.7	0.58
32022 C2	1955	M-142 Bad Axe E	5-58	3.8	0.45
32092 C3	1958	US-25 Port Hope N	10-59	0.4	0.56
43011 C1	1958	M-37 Baldwin S to Co. Line	7-59	0.9	0.43
53022 C5	1955	US-10 Lake Co. Line W	11-57	2.0	0.58
67051 C9	1956	M-115 Muskegon River to M-66	8-57	0.8	0.45
69011 C3	1949	US-27 Gaylord S to Co. Line	11-57	-	0.38
72011 C4,C5	1956	US-27 W Clare Co. Line N	11-57	1.4	0.53
76062 C8	1951	M-21 Corunna E	5-58	13.9	0.36
79022 C7	1956	M-38 Vassar E	10-59	2.6	0.62
79031 C1	1957	M-15 Genesee Co. Line N	5-58	2.2	0.36
79032 C4	1955	M-15 Vassar NW	5-58	7.0	0.39
79051 C2	1958	M-24, M-81 S	10-59	1.2	0.54
79051 C7	1956	M-24, M-46 S	10-59	2.4	0.57
79062 C1,C3	1958	M-81 Cass City W	7-59	1.0	0.60

COEFFICIENT OF WET SLIDING FRICTION - 40 MPH

Bituminous Concrete Pavements (4.12)

25A National Lime and Stone

3BC Sand

Project No.	Year Const.	Location	Date Tested	Wear. Factor	Coef. Friction
12061 C3	1955	M-60 Union City W	7-57	3.9	0.41
13021 C9	1955	M-60 Tekonsha W	7-57	4.1	0.41
13022 C9	1955	M-60 Tekonsha W	7-57	4.1	0.41
25071 C4,C8	1951	US-10 Grand Blanc NW	7-59	27.4	0.35
25072 C12	1951	US-10 Jct. US-10 BR to Flint	7-59	35.0	0.34
30041 C5,C8	1950	M-34 Pittsford E & W	5-59	12.8	0.33
30071 C9	1948	US-127, M-34 N	5-59	13.4	0.30
30082 C4,C5	1949	M-99 Hillsdale to Jonesville	10-57	13.0	0.34
38071 C6	1951	M-50 Brooklyn N	8-59	9.2	0.29
38084 C11	1951	US-12 From Jct. BR E	7-57	21.0	0.30
46011 C1	1948	US-127, US-223 to Addison	8-59	11.6	0.32
46062 C4	1952	US-223 Blissfield E	10-57	16.1	0.34
46062 C8	1951	US-223 Palmyra to Treat Rd.	10-57	23.0	0.33
46072 C4	1951	M-52, M-50 S	5-59	17.9	0.37
50021 C3	1953	M-59 Utica W	10-57	17.5	0.34
50051 C3	1952	US-25, M-29 S	10-57	31.3	0.29
50052 C3	1952	US-25, M-29 S	10-57	31.3	0.29
50052 C14	1952	US-25 New Haven S	10-57	15.8	0.33
63042 C5	1952	M-59, M-150 E	10-57	13.1	0.36
78031 C1	1958	US-131, US-112 S	10-59	1.1	0.53
81031 C4,C14	1953	US-112 Washtenaw Co. L. NE to Saline	8-59	20.7	0.39
81031 C15	1953	US-112 Saline NE	7-57	14.2	0.39

COEFFICIENT OF WET SLIDING FRICTION - 40 MPH

Bituminous Concrete Pavements (4.12)

25A France Stone Co.

3BC Sand

Project No.	Year Const.	Location	Date Tested	Wear. Factor	Coef. Friction
30031 C2	1958	M-99, M-120 N	8-59	0.4	0.50
30061 C7,C8	1945	US-112 Jonesville W	5-59	31.9	0.35
30062 C4	1944	US-112 Jonesville East	10-57	27.3	0.36
33032 C6	1953	US-127 Glendale to Lansing	6-57		0.40
33082 C19	1953	US-16, M-43 W to Kedzie St.	6-57	31.7	0.35
46041 C5	1954	M-34 Adrian City Line W	5-59	8.1	0.38
46061 C29	1955	US-223 Rome Center NW	10-57	2.2	0.43
46062 C12,C13	1954	US-223 Blissfield W	10-57	10.0	0.31
46073 C2	1958	M-52 Clinton Limits, S	8-59	2.1	0.35
46081 C1	1958	M-50 E & W of Tipton	5-59	1.3	0.45
46101 C13	1944	US-112 Hillsdale-Lenawee Co. Line	7-57	28.3	0.36
58011 C3	1952	US-223, M-151 S	9-59	14.9	0.42
58031 C8	1952	US-23, M-50 S	9-59	16.1	0.30
58052 C26	1955	US-24, M-50 S	9-59	30.9	0.32
58071 C2	1957	US-25 Monroe Limits N	9-59	9.4	0.38
58053 C8	1953	US-24 Flat Rock S	9-59	43.0	0.27
58071 C9	1955	US-25, M-151 N	9-59	5.4	0.38

COEFFICIENT OF WET SLIDING FRICTION - 40 MPH
Bituminous Concrete Pavements (4.12)
25A Monon Stone
3BC Sand

Project No.	Year Const.	Location	Date Tested	Wear. Factor	Coef. Friction
08071 C2	1953	M-78 Eaton to Calhoun Barry Co.	8-57	7.1	0.32
10032 C2, C3	1953	US-31 Benzie Co. Line	7-59	5.6	0.39
11052 C3	1953	US-31	7-58	9.6	0.33
11091 C5	1949	M-40 Niles	10-59	25.3	0.45
12021 C8, C10	1955	US-112 Coldwater SW	7-57	4.0	0.44
13032 C6	1956	M-78 Pennfield Twp.	8-57	2.5	0.37
13041 C2	1957	US-12 Kalamazoo Co. Line E	6-59	7.8	0.32
14011 C7	1949	M-40 Dowagiac City Limits	10-59	13.5	0.39
14031 C1,C3	1953	M-62 Jct. US-12 S	10-59	10.3	0.39
14061 C9	1952	M-60 Berrien-Cass Co. Limits	7-57	13.0	0.41
18011 C1	1957	M-115, US-10 N	7-59	1.7	0.44
18032 C1,C2	1957	US-27 Roscommon City Line S	11-57	-	0.48
23011 C2,C4	1953	M-78 Barry-Eaton Co. Line NE	8-57	7.1	0.33
23031 C3,C4	1951	US-27 Olivet S	7-57	10.9	0.40
28011 C3	1953	US-31, M-37 N	8-57	6.4	0.29
28012 C3	1953	US-31, M-37 N	8-57	6.4	0.29
38061 C2	1952	M-60 Concord W	8-59	14.9	0.30
39082 C9	1956	M-43 Richland to Kalamazoo	6-59	6.2	0.35
43022 C10	1956	US-10, 4 mi. E of Baldwin E	11-57	0.6	0.47
67051 C1	1957	M-115, M-66 to M-61	8-57	0.0	0.44
67051 C8	1955	M-115 Wexford Co. Line SE	8-57	1.8	0.40
78011 C1	1952	M-103, US-112 S	10-59	4.3	0.39
78022 C10	1956	US-112 Branch Co. Line W	7-57	2.8	0.47
78022 C9, C10	1952	US-112 Sturgis E	7-57	12.8	0.35
78042 C4	1951	M-60 Three Rivers to Mendon	7-57	10.7	0.37
80071 C9	1956	M-40 Decatur S	10-59	2.3	0.54

COEFFICIENT OF WET SLIDING FRICTION - 40 MPH
Bituminous Concrete Pavements (4.12)
25A Drummond Dolomite
3BC Sand

Project No.	Year Const.	Location	Date Tested	Wear. Factor	Coef. Friction
09041 C1	1957	Old M-20, Midland - Bay City	9-59	4.6	0.34
09042 C2	1956	M-25 Bay Co. Line W	9-59	6.1	0.38
09071 C1	1956	M-15, M-138 S	7-59	6.8	0.40
10041 C1	1957	M-115 @ US-31	7-59	1.7	0.42
49024 C4	1957	US-2 N Mackinac Co. Line S	6-60	0.27	0.47
50052 C12	1955	US-25 New Haven N Limits N	8-59	13.7	0.37
51021 C1	1957	M-55 E Lane Limits E	7-59	1.1	0.34
51021 C10	1956	M-55 Manistee Co. Line W	7-59	1.4	0.47
53032 C5	1954	US-10, US-31 E	10-60	6.3	0.37
55022 C2	1958	US-2, US-41 E	7-59	1.6	0.42
61012 C5	1956	M-20 N Muskegon E	6-59	6.7	0.26
61071 C1	1957	US-31 Ottawa Co. Line N	11-57	0.0	0.47
61073 C4	1956	US-31, 1 mi. N of M-20 N	11-57	3.8	0.48
62031 C4, C5	1958	M-46 & M-37 Muskegon Co. to Grant	6-59	2.2	0.40
70016 C2	1958	US-31 Spring Lake N	11-58	0.0	0.53
61074 C3	1958	US-31 Muskegon S	11-58	0.0	0.58
72091 C1	1958	M-76, M-55 N	10-59	0.9	0.54
73002 C3, C4	1949	M-47, M-46 E	5-58	17.6	0.22
77031 C7	1952	US-25 S St. Clair Co. Line N	8-59	7.8	0.39
77091 C7, C3	1949	M-51 Sanilac Co. Line S	8-59	8.6	0.40
79011 C4	1953	M-138 Tuscola Line to M-25	10-59	-	0.50
79061 C3	1948	M-81 Caro W	10-59	14.2	0.36
79061 C4	1952	M-81 Watrousville W	9-60	7.2	0.42
79081 C3	1948	M-25, M-138 W & S	7-59	11.7	0.28
83011 C1	1958	M-37, M-55 S	10-59	0.5	0.61

COEFFICIENT OF WET SLIDING FRICTION - 40 MPH

Bituminous Concrete Pavements (4.12)

25A Inland Lime & Stone Co.

3BC Sand

Project No.	Year Const.	Location	Date Tested	Wear. Factor	Coef. Friction
02011 C5	1954	US-41 & M-67 N	9-61	2.8	0.37
02042 C10	1949	M-28 Shingleton E	8-57	2.8	0.35
09012 C6	1949	M-47 at US-23	7-59	9.5	0.27
21021 C2	1952	US-2 & US-41 Escanaba W	6-60	7.6	0.19
21023 C7	1952	US-2 at Jct. US-41 & US-2	8-57	11.9	0.20
21024 C7,C8	1951	US-2 Nahma W	6-61	9.1	0.39
21024 C12	1951	US-2 Nahma W	9-61	8.6	0.32
21051 C7,C8	1952	US-41 Delta Co. Line S	9-61	3.7	0.35
21051 C10	1954	US-41 Alger Co. Line S	9-61	3.1	0.41
61023 C8	1951	M-46, M-213 E	6-59	11.6	0.24
75022 C12	1952	US-2 Manistique City E	9-61	8.3	0.32
73031 C2	1958	M-47 to M-57 S	9-59	0.9	0.49
74051 C5	1948	M-51 to M-90 S	10-59	4.7	0.45
75021 C11	1951	US-2 Schoolcraft Co. Line E	9-61	7.9	0.29
75022 C11	1950	US-2 Gulliver E	9-61	9.6	0.38
75061 C6	1949	M-28 Schoolcraft Co. Line W	7-59	3.4	0.42
77033 C4	1947	US-25 Port Huron N	5-58	16.0	0.25
83021 C2	1948	M-55, US-131 to M-155	7-59	9.2	0.24

COEFFICIENT OF WET SLIDING FRICTION - 40 MPH

Bituminous Concrete Pavements (4.12)

Miscellaneous 25A Limestone

3BC Sand

Project No.	Year Const.	Location	Aggregate Source	Date Tested	Wear. Factor	Coef. Friction
11052 C3	1949	US-31 N & W Scottdale	Lincoln Stone	7-57	14.4	0.37
14061 C8	1948	M-60 Cassopolis W	Lincoln Stone	7-57	24.1	0.46
23011 C3	1950	M-78 Bellevue W	Lincoln Stone	8-57	12.4	0.34
78012 C6	1948	US-131, US-112 to Constantine	Lincoln Stone	11-57	11.9	0.52
80111 C4	1951	M-119 Paw Paw S	Lincoln Stone	6-59	8.9	0.39
17061 C2	1958	M-28, M-123 W	Hendrick's Quarry #49-7	7-59	0.5	0.49
48041 C2	1953	M-28, M-135 W	Hendrick's Quarry #49-7	7-59	2.5	0.43
48042 C7	1954	M-28 WB of Sage R. W	Hendrick's Quarry #49-7	7-59	3.2	0.40
11021 C3	1946	US-112, M-60 Three Oaks W	Dolese & Shepherd	6-59	23.5	0.35
13031 C2	1958	M-78, US-12 S	Dolese & Shepherd	10-59	1.7	0.45
05012 C2	1941	US-31 Eastport to Atwood	Petoskey Portland Cement	9-58	8.0	0.42
49022 C1	1957	US-2 M-48 W	Fiborn Quarry	9-61	3.1	0.38
49023 C10	1952	US-2 St. Ignace W	Trout Lake - Moran	9-61	7.8	0.33

COEFFICIENT OF WET SLIDING FRICTION - 40 MPH

Bituminous Concrete Pavements (4.12)

25A American Aggregate, Green Oak

3BC Sand

Project No.	Year Const.	Location	Date Tested	Wear. Factor	Coef. Friction
03091 C2	1946	US-131 Plainwell S	8-57	38.2	0.46
03092 C3,C7	1947	US-131 Martin N	8-57	22.2	0.43
23011 C5	1945	M-78 Charlotte S	8-59	24.6	0.46
33031 C5	1955	US-127 Leslie S to Co. Line	7-57	4.5	0.53
33032 C8,C9	1956	US-127 Jolly Rd. S	6-57	8.0	0.45
33082 C1,C2,C3	1957	US-16 Webberville W	9-57	0	0.37
33082 C4,C6	1946	US-16 E of Williamston	6-57	42.6	0.44
33082 C5,C16	1948	US-16 Meridian Rd. to Burkley Rd.	6-57	49.3	0.42
33082 C11	1949	US-16, M-47 &W of Webberville Rd.	6-57	31.9	0.42
33082 C15	1947	US-16 E Lansing E to RR	6-57	78.3	0.38
38084 C10	1947	US-12 Jackson-Wash. Co. Line W	7-57	39.6	0.35
47012 C8	1956	US-23 M-59 N	11-57	1.8	0.57
47061 C1	1957	US-16 Fowlerville W	9-57	0	0.39
47061 C15	1949	US-16 Livingston-Ingham Co. Line E	6-57	31.8	0.38
47082 C9	1956	M-59 Livingston-Oakland Co. Line W	11-57	1.2	0.55
63031 C1	1959	US-24 11 mi. Rd. S	8-59	0	0.49
63132 C5	1950	M-150, M-59 N	10-57	30.1	0.44
81063 C13	1955	US-112, US-12 W	9-59	20.4	0.42
81081 C1	1959	M-17, US-23 E	9-59	0	0.42
81102 C8	1959	M-14, M-153 SW	9-59	0	0.41
81121 C1	1958	M-153 Washtenaw Co. Line E	9-59	1.0	0.45
82021 C11	1955	US-12 Haggarty Rd. W	9-59	19.3	0.45
82022 C10	1956	US-12, US-24 W	9-59	-	0.42
82041 C5	1947	M-17 US-12 W	9-59	-	0.35
82052 C12	1949	US-24 Goddard Rd. S	9-57	34.7	0.37
82081 C3	1953	M-153 Barry Rd. W	9-59	7.8	0.37
82081 C5	1958	M-153 Canton Ctr. W	9-59	1.7	0.50
82141 C1,C6	1958	M-102, US-24 to Southfield	9-59	8.7	0.57

COEFFICIENT OF WET SLIDING FRICTION - 40 MPH

Bituminous Concrete Pavements (4.12)

25A American Aggregate, Oxford

3BC Sand

Project No.	Year Const.	Location	Date Tested	Wear. Factor	Coef. Friction
13042 C5	1941	US-12 Marshall W	6-59	66.7	0.39
13043 C7	1947	US-12 Albion W	6-59	30.2	0.34
25091 C3	1957	M-15 Genesee Co. Line N	5-58	2.1	0.47
29011 C1	1957	US-27, M-57 N	6-59	5.6	0.45
29021 C1	1957	M-57, US-27 W	6-59	1.1	0.47
38061 C9	1949	M-60 Spring Arbor to Concord	5-59	22.3	0.37
38071 C3	1949	US-127 Jackson S	10-57	25.7	0.42
46101 C18	1948	US-112, M-50 E	7-57	22.0	0.39
50011 C1	1957	M-53, M-59 S	9-59	12.3	0.32
50011 C3	1953	M-53, 14 Mile Rd. N	9-59	27.9	0.40
50012 C3	1949	M-53, M-59 N	9-59	43.5	0.35
50021 C11	1959	M-53, 26 Mile Rd. N	9-59		0.41
63031 C4, C11	1952	US-24, M-58 S; Long Lk. Rd. S	8-59	62.3	0.40
63041 C11	1951	M-59, Livingston Co. E	7-58	14.2	0.44
63042 C6	1956	M-59 Auburn Hts. E	10-57	4.8	0.47
63054 C7	1950	US-10, M-15 NW	11-57	50.8	0.39
63054 C9	1955	US-10 Bridge Lk. Rd. NW	11-57	21.6	0.42
63071 C3	1958	M-15 Clarkston	5-58	0	0.57
63131 C2, C6	1951	M-150, M-59 S	9-59	31.5	0.38
72011 C4	1951	US-27, M-55 S	11-57	5.7	0.49
76011 C6	1946	M-47 Owosso S	5-58	16.3	0.46
76041 C2	1956	M-71, M-78 NW	7-59	5.3	0.47
77011 C1	1958	M-19 Emmett to Memphis	8-59	0.8	0.55
82142 C9	1953	M-102 John Lodge E	9-59	70.5	0.43

COEFFICIENT OF WET SLIDING FRICTION - 40 MPH

Bituminous Concrete Pavements (4.12)

25A Straits Aggregate, Big Cut

3BC Sand

Project No.	Year Const.	Location	Date Tested	Wear. Factor	Coef. Friction
15012 C1	1957	US-31, M-66 N	11-58	-	0.37
20013 C5	1948	US-27, N Jct. M-93 N	11-57	11.5	0.41
20051 C2	1953	M-18 & M-76, US-27 S	7-59	5.8	0.41
24012 C3	1956	US-31 Levering N	11-57	1.1	0.46
24051 C5	1956	M-68, US-31 E	7-59		0.44
35011 C7	1953	M-65 Co. Line N	10-59	4.5	0.39
69012 C9,C10	1956	US-27 S & N of Vanderbilt	11-57	1.2	0.49

COEFFICIENT OF WET SLIDING FRICTION - 40 MPH

Bituminous Concrete Pavements (4.12)
Miscellaneous 25A Gravel Stone
3BC Sand

Project No.	Year Const.	Location	Aggregate Source	Date Tested	Wear. Factor	Coef. Friction
36021 C1,2	1957	US-2 Iron River W	Aisher Pit #36-34	6-60	0	0.68
24011 C8	1953	US-31 Alanson to Petoskey	Bay Shore Pit	11-57	5.6	0.38
24031 C6	1951	US-131 Emmet-Charlevoix Co. L. N	Bay Shore Pit	11-57	6.8	0.43
24051 C3	1952	M-131 US-31 NW	Bay Shore Pit	7-59	5.7	0.38
05071 C3	1951	US-131 Mancelona S	Brady-Millersburg	11-57	5.4	0.48
03031 C2,C5,C6	1943	US-31, M-89 S	Breen Gravel Co.	6-59	5.4	0.39
34041 & 42 C13	1952	US-16 & M-66 E	Bugbee Pit #34-11	11-57	14.2	0.50
36022 C2	1953	US-2 Iron River E	Caspian Sand & Gravel Co.	8-57	5.3	0.56
36023 C2	1952	M-69 Crystal Falle E	Caspian Sand & Gravel Co.	7-59	2.6	0.52
22021 C2	1958	US-2 & US-141, M-95 S	Champion Pit	7-59	2.6	0.50
22023 C2	1957	US-2 Loretto E	Champion Pit	7-59	1.8	0.47
28011 C1	1957	US-31, M-37 W	Concrete Service	7-59	2.6	0.44
49021 C12	1952	US-2 3 mi. E of M-135 E	Duncan Pit #49-58	6-60	8.5	0.36
49021 C4	1954	US-2 East of M-135	Duncan Pit #49-58	9-61	2.9	0.42
49022 C12	1952	US-2 Gould City E	Duncan Pit #49-58	9-61	3.4	0.40
83032 C3,4	1953	US-131 Manton S	Field Stone Local	11-57	6.2	0.57
48032 C3	1953	M-117, M-28 N	Frazer Pit #1	6-60	8.5	0.30
48041 C5	1953	M-28, M-117 W	Frazer Pit #1	7-59	3.4	0.32
08032 C4	1958	M-37 Middleville	Gillisee - G.R.	10-59	1.7	0.58
08052 C2	1958	M-66 Nashville	Gillisee - G.R.	9-59	0.7	0.55
41033 C3,4,5	1959	M-37, M-57 S	Gillisee - G.R.	9-59	-	0.42
03092 C2	1942	US-131 Martin S	Grand Rapids Gravel	8-57	36.5	0.46
03092 C8	1943	US-131 Wayland N	Grand Rapids Gravel	8-57	29.5	0.42
19021 C2,8	1944	US-16, M-100 W & E	Grand Rapids Gravel	10-60	38.0	0.42
34042 C2	1951	US-16 Portland W	Grand Rapids Gravel	8-57	17.3	0.41
39041 C5	1943	US-12 Van Buren Co. Line E	Grand Rapids Gravel	6-59	48.0	0.38
41023 C7	1942	US-16 Cascade E	Grand Rapids Gravel	8-57	33.1	0.43

COEFFICIENT OF WET SLIDING FRICTION - 40 MPH
Bituminous Concrete Pavements (4.12)
Miscellaneous 25A Gravel Stone
3BC Sand

Project No.	Year Const.	Location	Aggregate Source	Date Tested	Year Factor	Coef. Friction
41031 C7	1954	M-37 Caledonia N	Grand Rapids Gravel	10-59	8.2	0.55
41131 C3	1951	US-131 Allegan Co. Line N	Grand Rapids Gravel	8-57	25.6	0.37
41131 C5	1953	US-131 Kellogsville S	Grand Rapids Gravel	8-57	16.8	0.34
59022 C6	1956	M-57 Greenville to M-66	Grand Rapids Gravel	11-57	0.8	0.57
59031 C3	1951	M-91 Montcalm Co. Line N	Grand Rapids Gravel	9-59	14.6	0.46
80022 C4	1942	US-12 Paw Paw E	Grand Rapids Gravel	6-59	39.9	0.38
83032 C3	1951	US-131 Cadillac N	Grand Rapids Gravel	11-57	12.1	0.46
17031 C15	1957	US-2, M-48 NB	Hassett-Kinross	7-59	4.9	0.50
17061 C1	1957	M-28, US-2 W	Hassett-Kinross	6-60	2.4	0.53
83021 C9	1955	M-55, M-37 E	Hersey Gravel	7-59	1.8	0.48
05011 C4,8	1954	US-31 Eastport S	Northland Construction Co.	9-58	2.7	0.33
83021 C8	1953	M-55 Cadillac W	Northland Construction Co.	7-59	4.7	0.50
08081 C3	1955	M-50 at M-66 & M-43	Pickett Pit, H	9-59	-	0.51
03091 C4	1952	US-131 Plainwell N	Postma Gravel Co.	8-57	17.6	0.42
23052 C7,8	1956	M-43 S	Postma Gravel Co.	5-59	1.9	0.50
41062 C11	1953	US-16, M-21 E	Postma Gravel Co.	8-57	20.8	0.37
70041 C3	1953	M-50, Ottawa Co. Line WB	Postma Gravel Co.	10-59	5.1	0.51
16031 C3	1936	US-27 Wolverine S	Ray Sand & Gravel	11-57	17.2	0.52
69012 C7	1936	US-27 3 mi. N Gaylord N	Ray Sand & Gravel	11-57	22.0	0.54
15012 C2	1953	US-31 Charlevoix	Resort Pike Pit	11-58	-	0.35
08012 C2	1957	M-43 Woodland W	Rock Sand & Gr. G.R.	6-59	11.2	0.52
21021 C1	1958	US-2 Alma US-41 W	Romin Pit	7-59	2.0	0.51
49041 C5	1959	M-134, US-2 E	Taylor Pit #49-53	6-60	0.3	0.61
12022 C1	1946	US-112 Coldwater	VanAcken & Thompson	10-59	43.3	0.47
81072 C8,2	1953	US-23 Jct. M-17 WB	Whittaker&Gooding, Chelsea Pit	9-59	42.7	0.39

COEFFICIENT OF WET SLIDING FRICTION - 40 MPH
Bituminous Concrete Pavements (4.12)
25A Upper Peninsula Trap Rock
3BC Sand

Project No.	Year Const.	Location	Aggregate Source	Date Tested	Wear. Factor	Coef. Friction
27021 C5	1956	US-2 State Line E	Maher Pit #27-33	6-61	-	0.51
27022 C5	1955	US-2 Wakefield E	McNichols Pit #27-2	7-59	2.5	0.58
27024 C13	1956	US-2, US-45 E	Maher Pit #27-33	7-59	1.1	0.66
27051 C14	1956	US-45, US-2 N	Maher Pit #27-33	6-61	0.9	0.49
31011 C13	1956	M-26 Lake Roland S	Winona Waste Rock	6-61	3.0	0.64
31012 C9	1953	M-26 Houghton - Painesdale	Race Track Pit	6-61	7.0	0.62
31013 C4	1955	M-26 Dollar Bay to Lake Linden	Race Track Pit	6-61	4.1	0.57
31013 C4	1953	M-26 Lake Linden to Laurium	Race Track Pit	6-61	-	0.64
31051 C5	1952	US-41 Chassell N	Race Track Pit	6-61	7.1	0.58
31052 C1	1958	US-41 Calumet to Hancock	Race Track Pit	6-61	1.7	0.62
31052 C9	1955	US-41 Calumet to Mohawk	Race Track Pit	6-61	8.5	0.55
52041 C5	1956	US-41 Clarksburg to Champion	Dishneau	6-61	2.1	0.53
66051 C4	1956	M-26, M-35 S	Mass Pit #66-51	6-61	1.0	0.63

COEFFICIENT OF WET SLIDING FRICTION - 40 MPH
Bituminous Aggregate Pavements (4.11)
20A Gravel

Project No.	Year Const.		Location	Aggregate Source	Date Tested	Wear. Factor	Coef. Friction
01011 C2-4	1954	M-65	SB Jct. New M-72	Turner Pit #1-36	10-59	0.4	0.44
01012 C1	1958	M-65	NB Jct. M-72	Rose Arno Pit #1-43	10-59	0.1	0.61
01022 C2-5	1954	M-65	SB Jct. M-72	Turner Pit #1-36	10-59	0.8	0.58
01023 C1	1958	M-72	EB Jct. M-65	Rose Arno Pit #1-43	10-59	0.1	0.57
01031 C1	1958	M-171	Iosco Co. Line N		7-59	0.2	0.58
02021 C1	1958	M-94	WB from Chatham	Hodgins Braanse #2-45	6-60	0.7	0.57
02021 C4	1958	M-94	WB Jct. M-28	Hodgins C.L. Pit #2-46	6-60	0.5	0.55
02031 C5	1954	M-67	NB Jct. US-41	Timonen Pit #2-11	7-59	0.8	0.61
02041 C8	1953	M-28	EB Alger Co. Line E	Lewka Pit #52-4	6-60	3.0	0.61
02041 C8	1953	M-28	Munising W	Lewka Pit #52-4	7-59	2.8	0.73
03022 C4	1953	M-89	WB Jct. M-40	H. Pickitt #3-45	10-59	2.2	0.62
03041 C2	1958	M-118	Jct. M-89 & 40 EB	H. Pickitt (Allegan)	10-59	1.1	0.59
03041 C6	1954	M-118	Jct. M-89 & 40 EB + 5.8 mi.	H. Pickitt (Allegan)	10-59	2.4	0.57
03071 C9	1952	M-40	Allegan S	H. Pickitt #3-45	6-59	7.2	0.47
03071 C12	1954	M-40	Allegan S	H. Pickitt #2	6-59	5.3	0.42
05031 C6	1956	M-66	SB Antrim Co. Line	Wagbo #5-56	10-59	0.8	0.61
06021 C4	1954	M-61	EB Aranac Co. Line	Rosevear Pit #65-7	9-59	2.4	0.46
07041 C2	1958	M-35	WB Baraga	Alberta Prison Camp	7-59	0.4	0.55
09081 C2	1959	M-61	Bay Co.	Rosevear Pit #65-7	7-59		0.34
10042 C5	1953	M-115	Jct. US-31 SB	Northland Const. Co.	7-59	1.9	0.48
13091 C5	1954	M-99	Jct. M-60 S		10-59	3.4	0.60
14032 C8	1952	M-62	Dowagiac S		10-59	6.9	0.37
14051 C5	1954	M-19	Jct. M-60 NB	Loupee Pit, Lagrange, Mich.	10-59	1.7	0.62
17022 C8	1952	M-134	Jct. M-48 EB	Miller Pit #17-23	6-60	1.1	0.65
17042 C3	1959	M-48	Jct. US-2 EB + 6 mi.	Sanderson Pit #17-18	6-60	0.1	0.64
17042 C2	1958	M-48	Jct. US-2 EB	Kibble Pit #17-39	6-60	0.4	0.62
17051 C1	1958	M-221	Jct. M-28 NB	Hassett Pit #17-31	7-59	0.3	0.56

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20A Gravel

Project No.	Year Const.	Location	Aggregate Source	Date Tested	Wear. Factor	Coef. Friction
17071 C5	1956	M-129 NB Mackinac Co. + 1 mi.		6-60	1.3	0.60
17072 C1	1958	M-129 NB Jct. M-48	Hassett Pit #17-31	6-60	0.8	0.61
17072 C4	1950	M-129 NB Jct. M-48 + 5 mi.		6-60	3.0	0.61
18041 C5	1952	M-61 Harrison WB	Phillips Pit #18-23	10-59	2.4	0.58
18042 C8	1952	M-61 Jct. US-27 EB	Phillips Pit #18-23	10-59	3.4	0.58
20022 C4 & C5	1959	M-72 Jct. US-27 EB	Ostrander Pit	10-59	0	0.52
21032 C2	1958	M-35 Rock Village Limits N	Lucier Pit #21-21	6-60	0.5	0.56
21032 C6	1952	M-35 Rock SB + 2 mi.	Crushed Aggregate, Inc.	6-60	1.6	0.63
22013 C1 & C2	1959	M-95 Jct. M-69 NB	Byers Pit	6-60	0.7	0.59
22042 C2 & C3	1958	M-69 Jct. M-95 EB	Jacobs Pit	6-60	0.3	0.67
23021 C8	1956	M-79 Charlotte W	Shell Pit	8-58	1.8	0.42
23071 C3	1953	M-100 Potterville N	Nelson Pit	5-59	3.6	0.51
25102 C1	1958	M-57 Jct. M-15 WB	Gooding #4	9-59	0.7	0.55
26022 C2	1959	M-61 Jct. M-30 E	Rosevear Pit #65-7	7-59	0	0.40
26022 C6	1956	M-61 M-30 W to Gladwin	Rosevear Pit #65-7	7-59	2.1	0.50
26032 C1	1959	M-30 Jct. M-61 N	Rosevear Pit #65-7	7-59	0	0.48
30021 C3	1953	M-120 Jct. M-49 WB	K. Gary Pit	8-59	0.7	0.62
30022 C1	1959	M-120 Jct. US-127 to M-99 WB	Hoover Pit	8-59	0	0.43
30041 C10	1954	M-34 Hillsdale S & E	Hillsdale Co. Pit	5-59	9.0	0.34
31021 C2	1958	M-28 Houghton Co. Line EB	Golden Glow Pit #31-5	7-59	0.4	0.63
32051 C6	1953	M-19 Jct. M-142 S	Rudi Pit	7-59	2.8	0.47
32092 C4-6	1954	US-25 Jct. M-142 NB	Rudi Pit	10-59	3.1	0.63
35011 C1	1957	M-65 Jct. M-55 SB	Webster Pit #65-17	10-59	1.1	0.48
35012 C2	1958	M-65 Hale SB	Webster Pit #65-17	10-59	0.5	0.47
35021 C1	1957	M-55 Jct. M-65 W	Webster Pit #65-17	7-59	0.7	0.49
35022 C4	1951	M-55 Tawas City W	Federal Forest Pit #1-32	7-59	4.8	0.53
36011 C10	1952	M-73 Jct. US-2 SB	Caspian-Iron River	6-60	4.0	0.35

COEFFICIENT OF WET SLIDING FRICTION - 40 MPH

Bituminous Aggregate Pavements (4.11)

20A Gravel

Project No.	Year Const.	Location	Aggregate Source	Date Tested	Wear. Factor	Coef. Friction
41071 C3	1952	M-50 Bowen Center E	Grand Rapids Gravel	9-59	2.1	0.58
42011 C8	1955	US-41 Keweenaw Co. Line + 3 mi. NB	C&H Pit #42-14	7-59	2.6	0.58
42013 C4	1955	US-41 Jct. M-26 + 3 mi. NB	C&H Pit #42-14	7-59	1.1	0.63
42021 C2	1949	M-26 Eagle Harbor SB	Phoenix Pit #42-11	7-59	2.3	0.69
43012 C3	1958	M-37 Jct. M-63 SB	Leo Sekanania #43-12	10-59	0.5	0.58
43012 C1	1958	M-37 Jct. US-10 NB	Gary Pit	7-59	1.6	0.56
44012 C3-5	1950	M-24 Jct. M-90 SB	Boyles Pit #44-5	7-59	9.7	0.47
44012 C1, 3 & 6	1950	M-24 Jct. M-90 NB	Boyles Pit #44-5	9-59	7.3	0.43
44061 C1	1957	M-90 North Branch EB	McCoy Pit #44-25	10-59	0.5	0.49
45041 C1	1957	M-204 Jct. M-22 WB	Schaub Pit	7-59	1.2	0.45
46041 C10	1955	M-34 Clayton E & W	Mixed Gravel	5-59	4.7	0.51
48032 C2	1959	M-117 Newberry NB	Carmody Pit	6-60	0.4	0.44
48023 C1	1959	M-117 Jct. M-28 SB	Butkovich Pit #2	6-60	2.0	0.45
49011 C1	1959	M-135 Jct. US-2 NB	McArthur Pit #49-1	6-60	0.1	0.54
49023 C5	1959	US-2 Brevort EB	McArthur Pit #49-1	6-60	1.1	0.40
49031 C1	1958	M-117 Mackinac Co. Line SB	Butkovich Pit #2	6-60	0.8	0.55
49041 C3	1953	M-134 Jct. M-129 EB	Taylor Pit #49-53	6-60	3.2	0.56
49042 C5	1953	M-134 Mackinac Co. Line WB	Millon Pit	6-60	1.7	0.63
49071 C2	1959	M-129 Jct. M-134 NB	Taylor Pit #49-53	6-60	1.4	0.52
51041 C8	1953	M-115 Manistee Co. Line NB	Hannibal Pit	10-59	1.5	0.60
52011 C3	1958	M-95 Jct. US-41 SB	Vierela Pit	6-60	0.7	0.65
57011 C4	1950	M-66 Jct. M-55 SB	Deval Pit #57-5	8-58	4.0	0.47
57011 C5	1952	M-66 McBain SB	Dual Pit	8-58	2.9	0.47
57021 C3	1948	M-55 Jct. M-66 WB	Wexford Co. Pit #83-12	7-59	7.0	0.23
65011 C4	1954	M-30 West Branch S	Rosevear Pit #65-7	7-59	2.3	0.52
65021 C15	1955	M-55 West Branch E	Schmitt Pit #65-16	8-58	4.5	0.44
65022 C1	1957	M-55 Co. Line W	Webster Pit #65-17	10-59	4.7	0.53

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20A Gravel

Project No.	Year Const.	Location	Aggregate Source	Date Tested	Wear. Factor	Coef. Friction
65022 C15	1955	M-55 Co. Line WB +6.0 mi.	Schmitt Pit #65-16	10-59	3.5	0.50
65051 C5	1952	M-33 Jct. M-55 SB	Webster Pit #65-17	10-59	5.4	0.50
66023 C8	1949	M-28 Paynesville EB	Johnson Pit #66-19	7-59	3.0	0.60
66031 C2	1948	US-45 Bruce Crossing S	Humphrey Pit #66-4	8-57	3.2	0.56
66031 C1	1958	US-45 Jct. M-28 + 5 mi. S		6-60	0.4	0.61
66032 C13	1949	US-45 Jct. M-28 N	Johnson Pit #66-19	8-57	2.6	0.55
66033 C3	1948-49	US-45 Rockland N	Arenz Pit #66-43	8-57	2.4	0.59
66051 C11	1949	M-26 Ontonagon Co. Line S	Winona Pit	7-59	3.2	0.71
67031 C11	1951	M-66 Jct. US-10 SB	Miller Pit #54-14	8-58	3.7	0.44
67032 C7	1952	M-66 Osceola Co. Line SB	Butterfield Pit	8-58	2.6	0.48
67061 C1	1958	M-61 Jct. M-115 WB	R. W. Meyer Pit	10-59	0.1	0.53
68012 68042 C2	1952	M-33 - M-72 Fairview to Mio	Federal Forest Pit #4	6-58	3.7	0.48
68041 C2	1958	M-72 Crawford Co. Line E	Stuckey Gravel Roscommon	7-59	0.3	0.58
69021 C5	1952	M-32 Gaylord W	Antrim Pit #3	9-58	4.1	0.35
71021 C4	1958	M-68 Jct. US-23 WB	King Pit #71-50	6-58	0.0	0.66
71021 C8	1956	M-68 Onaway E	Walters Pit #71-45 Freel Pit #71-13	6-58	1.4	0.46
71051 C2	1951	M-65 Posen NB	Hincka Pit #71-36	9-58	1.5	0.29
71071 C8, 9	1952	US-23 Jct. M-65 E	Woyda Pit #71-10	6-58	2.5	0.51
71071 C10	1952	US-23 Alpena Co. Line S	H. Pickitt Pit	6-58	2.4	0.50
71091 C4	1958	Rogers City SB Jct. US-23	King Pit #71-50	8-59	No count	0.56
72021 C5	1956	M-55 Jct. US-27 W	Knapp Pit	7-59	3.8	0.49
72041 C4	1953	M-144 Jct. 76 & 18 EB	Zehle Pit	9-58	1.85	0.47
73011 C1	1957	M-30, M-46 Jct. NB	Hyde Pit #29-15	9-59	1.2	0.50
74023 C2	1958	M-90 Sanilac Co. Line EB	V. Molesworth, Yale	10-59	1.7	0.55
74032 C3 & 4	1957	M-19 Sanilac-Huron Co. Line S	Rooney Pit - Schwader	7-59	0.4	0.58
74052 C16	1956	M-51 Crowell NB	V. Molesworth Spring Pit	10-59	1.8	0.60

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20A Gravel

Project No.	Year Const.	Location	Aggregate Source	Date Tested	Wear. Factor	Coef. Friction
74052 C3	1958	M-51 Applegate NB	Gillette Pit #77-11	10-59	0.5	0.55
74053 C1	1958	M-51 Deckerville NB + 5.6 mi.	Hoadley Pit #74-10	10-59	0.3	0.60
74053 C4	1952	M-51 Jct. M-46 NB	Garavaglia Pit	10-59	3.6	0.56
75031 C1	1949	M-94 Manistique NB	Weinert Pit #75-29	7-59	4.9	0.54
75031 C2	1949	M-94 Manistique City Limits S + 5.0 mi. NB	Weinert Pit #75-29	7-59	1.3	0.55
76011 C4	1952	M-47 Perry SB	Weaver Pit #76-17	7-59	7.1	0.47
80042 C6	1951	M-43 Jct. M-40 W	Yearington Pit #80-26	7-57	4.8	0.44
81011 C2	1958	M-92 Chelsea NW	Whittaker & Gooding	5-59	1.6	0.50
83012 C12	1955	M-37 Mesick SB + 6.5 mi.	McCoy Pit #83-3	10-59	1.5	0.62
83052 C6-7	1958	M-115 Jct. M-55 New Road	McFall Pit #83-50	7-59	1.4	0.51
83052 C8	1955	M-115 Jct. M-55 + 4 miles	Beach Pit #83-20	7-59	-	0.53
83053 C5	1952	M-115 Mesick NB	Hannibal Pit	7-59	2.4	0.53