SKID RESISTANCE IN BITUMINOUS CONCRETE MIXES

AFFECTED BY

FIVE TYPES OF VERMONT MINERAL AGGREGATES

Report 71-5

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VERMONT DEPARTMENT OF HIGHWAYS

John T. Gray, Commissioner

R. H. Arnold, Chief Engineer

R. C. Wiggins, Materials Engineer

Report Prepared By

Bituminous Concrete Section

SUMMARY

1. Granite, because of its strength, low absorption, availability, texture, and good skid resistance values appears to be the best mineral aggregate we have in this State to use in a bituminous concrete pavement.
2. Crushed gravel also is a very strong, durable material and gives good skid resistance values. The availability has become a problem because it has been used so much in the past for all types of road construction. If access is made to a good gravel, the State of Vermont should continue its use in bituminous pavements.
3. Dolomitic limestone from the Winooski area has been used in numerous pavements and will continue to be a major source of aggregate for this area in the future. Its continued use in bituminous concrete mixes is not encouraged from the stand point of skid resistance, but because its exploitation is less expensive than quartzites in the area, it will undoubtedly continue to be used. The values obtained from skid resistance tests were satisfactory as defined as requiring the motorists constant attention during wet weather.
4. Limestones that were tested for skid resistance came from two areas, Swanton and Florence, Vermont. Skid resistance on the Swanton limestone were poor and those on Florence limestone good. The use of limestones in bituminous concrete pavements, here again, should depend on the chemical composition of the limestone which in fact determine its skid resistance.
5. Serpentine Rock in some cases can be a strong, skid resistant aggregate depending on the impurities found in the deposit. The Eden deposit rated unsatisfactory while the Duxbury deposit rated good. It is advisable to chemically test arbitrarily located samples throughout a deposit before a decision is made as to whether the material is suitable for a pavement mix or whether it is too soft and polishable to provide good skid resistance.

INTRODUCTION

In May 1968, members of the Bituminous Concrete Sub-Division of the Vermont Department of Highways and Bureau of Public Roads Personnel conducted a series of skid resistance tests on existing bituminous concrete pavements over a three day period throughout the State.

The testing apparatus used and provided by the BPR was of the towed trailer type. With this equipment segments of Vermonts highways were tested where there had been an indication that the skid resistance was poor. Other highways thought to be representative of specific types of pavements containing specific mineral aggregates in their composition were also tested to obtain enough information to compare and analyze the skid resistance values obtained for each type of aggregate used. With this information, an effort has been made to determine how skid resistance of pavements could be improved by the use of those aggregates that had the most favorable skid resistance values when tested in a bituminous concrete mix.

PROCEDURE

All skid tests with the skid trailer were from the speeds of 20 to 60 miles per hour with the majority of tests being taken at 40 m.p.h. (The skid resistance values referred to in this report were those obtained at speed 40 m.p.h. only). The wheels on the skid trailer were locked for $2\frac{1}{2}$ seconds each time a test was made. At the end of this $2\frac{1}{2}$ second interval, the wheels were unlocked, data recorded and the testing party and their equipment continued on to the next test location which had been previously marked.

As mentioned in the introduction, areas of roadway that had been suspected of having poor skid resistance were tested. These areas were determined for the most part by the District Engineers and a sheet showing these locations (designated by Route No., Town, District, and Route Log Station) was compiled (Table 2). These slippery spots were not the only sections of roadway tested, however, an effort was made to test as many of these slippery areas as possible within the allotted time schedule. The location of normal or non-slippery test sections were made adjacent to the selected slippery areas without retracing the route already acovered. All areas were staked in the field prior to the arrival of the skid trailer.

RESULTS AND DISCUSSION

A. PAVEMENTS WITH GRANITE AGGREGATES

The fact that granite is a hard and durable rock with low absorption has been well established through its use as a building material. It has a granular texture and when it is crushed it fractures into smaller sizes that are strong, rough and consistent in shape. All of these qualities make granite a well suited material to be used in bituminous concrete mix.

Another advantage in using granite is that the State of Vermont has large quantities of it in certain locations. Presently, the main source of granite is in the Barre area where it is removed in large quantities mostly for construction and monumental purposes. The State, however, is not limited to using just Barre granite. During 1968 and 1969, a considerable amount of granite was taken from the Bethel-Randolph area and used on Interstate 89 between South Royalton and Brookfield, both as a crushed rock subbase and in bituminous concrete (both top and plant mixed base courses). Not only is granite a very durable, abundant material, it has shown good results when tested for skid resistance values. When pavements with granite used as an aggregate in them were tested, the friction factors ran from the upper 50's to the upper 60's with one reading as high as 74. These are very favorable results. As pointed out in Table I, pavements with friction factors of 55 or higher are considered good safe surfaces which will, under normal driving conditions, provide the operator of a motor vehicle ample braking and cornering friction.

B. PAVEMENTS WITH CRUSHED GRAVEL AGGREGATES

By definition, gravel is loose or unconsolidated coarse granular material, larger than sand grains resulting from erosion of rock by natural factors. The particles in gravel range from the No. 10 sieve up to boulder size and are usually rounded.

The gravels used in bituminous concrete mixes for the State of Vermont must be crushed and are required to have, by representative samples, at least 50% particles that have one or more fractured faces. Example:

Gravel Particle (Stone)  at least one fractured face
smooth face

By this stipulation, prerounded or polished gravel particles in hot mix are kept to a minimum which insures better skid resistance as well as greater interlocking of aggregate particles for a stronger pavement. The friction factors collected on pavements composed of a crushed gravel mix ran from the mid 50's to mid 60's with an average of 60. The only material tested that gave higher test values was granite which averaged 62. Crushed gravel has shown itself to be a dependable aggregate when the proper control is used. To date, in the State of Vermont, many pavements have been made with crushed gravel as the mineral aggregate mostly because of its availability. Gravel pits are scattered throughout the State and the majority of material excavated meets the specifications set by the State of Vermont for use in bituminous concrete pavements. From the view point of skid resistance, the use of crushed gravel in future pavements will be in the interest of the highway users safety.

C. PAVEMENTS WITH DOLOMITE & DOLOMITIC LIMESTONE AGGREGATES

Dolomite is a mineral of definite chemical composition, 47.7% carbon dioxide, 30.4% lime and 21.9% magnesium. The term dolomite is also commonly applied to rocks approximating the mineral dolomite in composition or consisting predominantly of the mineral dolomite. Dolomite is of different chemical composition than limestone, thus normally will not polish or break in the same manner.

Dolomitic limestone such as that found in the Winooski-Burlington area of the State is a limestone containing the mineral dolomite but in which $CaCO_3$ is dominant. The following chart from the Glossary of Selected Geologic Terms classifies

by percentages of chemical constituents five types of mineral aggregates all of which may appear to be limestone to the naked eye.

Type	% Calcite	% Dolomite	% MgO
1. Limestone	over 95	less than 5	0 to 1.1
2. Mag. Limestone	90-95	5-10	1.1-2.1
3. Dolomitic Limestone	50-90	10-50	2.1-10.8
4. Calcitic Dolomite	10-50	50-90	10.8-19.5
5. Dolomite	less than 10	over 90	19.5-25.6

As indicated by this chart, dolomitic limestone has less calcite and more dolomite than does limestone making the dolomitic limestone the more durable of the two. The friction factors measured on pavements with dolomitic limestone used as the main aggregate ran in the high 40's to the mid 50's with an average value of 52. Here again we see that the chemical composition has a definite bearing on skid resistance. Through the information that we have collected and analyzed up to now it can be stated that dolomite, although it is not up to the standard of granite, is still more skid resistant in a bituminous concrete mix than the limestone from Swanton but less skid resistant than the more silicious variety of limestone located in Florence, Vermont.

D. PAVEMENTS WITH LIMESTONE AGGREGATES

As defined in The Glossary of Geologic Terms, limestone is a bedded sedimentary deposit consisting chiefly of calcium carbonate ($Ca\ CO_3$) which yields lime when burned. The strength of limestone varies much with the texture; the more porous the limestone, the weaker it is. A good dense limestone may have a crushing strength of up to 40,000 p.s.i., whereas some of the more porous limestones will scarcely exceed 3,000 p.s.i. The texture may vary from fine grained to crystalline due to impurities found within the limestone. It is important to keep in mind that

polishing and gradual deterioration will depend on the texture, absorption, and the amount of water that a specific limestone is exposed to.

There is an extensive amount of limestone throughout the State of Vermont with the largest deposits occurring on the western side of the Green Mountain chain. Due to this abundance of limestone, it has been used as an aggregate in bituminous concrete mixes for all types of pavements at numerous locations. The skid resistance data obtained showed pavements that contained limestone as the basic aggregate tended to have both high and low friction factors and is gnerally unpredictable as to aggregate polishing and the location of same. The friction factor average values for limestones ran from the low 40's (Swanton Lime as source) to the low 60's (limestone from Vermont Marble, Florence, Vermont). This discrepancy in friction values is due to the difference in characteristics of the two limestones tested. A further study of the limestone at Vermont Marble and Swanton Lime would offer more information, but the basic differences in the two limestones that we are concerned with is the chemical composition. The aggregate at Vermont Marble in Florence, Vermont has a greater siliceous residue than that at Swanton Lime, thus making it more skid resistant. The Swanton aggregate is also finer textured and purer, thus polishing easier than the Florence aggregate. Of course as the aggregate in a pavement polishes, the road becomes more slippery, hence the low readings in the Swanton area compared to those in the Florence area.

As a result of these findings, further studys of specific limestones in the State of Vermont should be conducted and perhaps predetermine whether their use in a bituminous concrete mix would be advisable from the stand point of skid resistance and safety on our highways.

E. PAVEMENTS WITH SERPENTINE AGGREGATES

The term serpentine is commonly used incorrectly to identify both a mineral and a rock. The mineral serpentine is very soft with a dull greasy appearance. Serpentinite rock, (an impure form of the mineral serpentine) may contain much

mineral matter not altered from its original state. Skid resistance, as a result may vary according to the type and quantity of these other minerals found in the "serpentine".

Several paving jobs completed in 1961 had "serpentine" from Eden, Vermont used as an aggregate in the bituminous concrete mix. In 1968 when skid resistance tests were taken, the pavements tested with "serpentine" in them were 7 years old. It was anticipated that the friction factors would run low, and the Eden material did, averaging 48, or unsatisfactory. However, the values obtained from the Duxbury deposit averaged near 61 or a good rating. There is a logical explanation for the skid resistance values obtained. The aggregate used, although classified as serpentine, was in actuality serpentinite rock containing associated materials that imparted varying degrees of skid resistance. From Eden, the associated material was asbestos and from Duxbury the associated material was talc. It is again important here to emphasize the value of accurate and modern aggregate testing methods. An aggregate that meets gradation, fracture, and thin and elongated requirements will not necessarily be a good aggregate to use in a bituminous concrete mix if it will not, over the life of the pavement, provide ample skid resistance.

Materials such as the serpentine, even though from general appearances and description wouldn't appear to provide good skid resistance, should be tested for confirming evidence before incorporating it into a bituminous mix.

CONCLUSIONS

The degree of skid resistance in a bituminous concrete pavement isn't affected by the aggregate alone. Other factors such as asphalt content, consistency of mix, and conditions under which the pavement was placed make a difference in skid resistance.

To date, there are specifications controlling the quality of bituminous concrete mixes, but there are no specifications controlling the types of aggregate and their initial or final effect on skid resistance. After conducting this initial survey the importance of good quality aggregate, in regards to skid resistance in pavements, hopefully will be recognized. Members of the Materials Division realize this importance and through further study and research will strive to attain a basis for controlled use of those aggregates most beneficial to good skid resistance in all types of pavements.

A brief reference should be made at this point to mention that at the time these skid resistance tests were being performed on various aggregate types, a section of Vt. Route 9 in District 2 that had been "skinny-mixed" was tested. This pavement was placed in 1965 or 1966, but our records of this mix were somewhat lacking as to source and type of aggregate. However, this mix was undoubtedly a natural sand and it was noted to have friction factors from 68 to 74 which is excellent. It is therefore, worthy to note that this type of siliceous overlay should be seriously considered for correcting slippery locations of roadways.

TABLE I

EXPLANATION OF SKID RESISTANCE VALUES

FRICTION FACTOR	SKID RESISTANCE OF PAVEMENT
BELOW 40	VERY POOR
40-45	POOR
45-50	*UNSATISFACTORY
50-55	*SATISFACTORY
55-60	GOOD
60-65	VERY GOOD
ABOVE 65	EXCELLENT

*1. Unsatisfactory is used here to describe a pavement surface that requires extra caution on the part of the motorist, when wet weather conditions are present.

*2. Satisfactory is used here to describe a pavement surface that requires the motorists constant attention when wet weather conditions are present.

Note: All factors are obtained under conditions similar to those encountered in wet weather driving at 40 m.p.h.

TABLE II SLIPPERY SPOTS

HIGHWAY DISTRICT NO.	ROUTE	TOWN	ROUTE LOG STATION	AVG. FRICTION FACTORS
4	VT 14	RANDOLPH	337+00	54
	VT 14	RANDOLPH	287+00	*
	VT 12	BETHEL	153+00	*
	VT 100	ROCHESTER	315+00	*
5	US 7	CHARLOTTE	159+57	44
	"	"	184+48	44
	"	"	246+94	44
	"	"	283+94	44
	I 89	RICHMOND NB	77.400	55
	"	"	78.200	55
	I 89	S. BURLINGTON NB	88.300	47
	"	"	89.700	47
	I 89	S. BURLINGTON SB	88.300	47
	"	"	89.700	47
	I 89	WINOOSKI *(all ramps @ exit 15)		45
	I 89	COLCHESTER SB	91.100	58
	"	"	92.000	58
6	VT 14	WOODBURY	370+00	*
	VT 100B	MORETOWN	280+00	*
	VT 100	DUXBURY	293+00, 318+00	*
	I 89	MIDDLESEX	56-2540+00	*

TABLE II SLIPPERY SPOTS

HIGHWAY DISTRICT NO.	ROUTE	TOWN	ROUTE LOG STATION	AVG. FRICTION FACTORS
7	VT 25	BRADFORD	200+00	58
	US 5	SUTTON	50+00	*
	VT 5A	SUTTON	20+00	*
	VT 15	HARDWICK	260+00	*
	VT 15	WALDEN	350+00	*
8	VT 100C	JOHNSON	89+80	*
	US 7	ST. ALBANS	92+20	45
9	PROSPECT STREET	NEWPORT		*

*Slippery spots where skid tests were not taken due to time limitations

AGGREGATE - GRANITE

SOURCE & LOCATION - WELLS LAMSON, WEBSTERVILLE, VERMONT

PROJECT	TYPE OF MIX	AGE OF PAVEMENT	TESTING SPEED	FRIC. FACTOR
I 89-2(3) BERLIN-MONTPELIER	361-D Top	3 yrs.	40	66
	"	"	40	66
	"	"	40	70
	"	"	40	74
				Avg. 69
I 89-2(3) CONTRACT II (BRIDGE)	361-B Top	8 yrs.	40	55
	"	"	40	64
				Avg. 59
I 89-2(3) CONTRACT I	361-B Top	8 yrs.	40	57
				Avg. 57
BARRE TOWN M 702 RTE #14	361-D	3 yrs.	40	59
	"	"	40	59
	"	"	40	59
				Avg. 59
MA 702 WILLIAMSTOWN RTE #14	361-D	3 yrs.	40	62
	"	"	40	60
	"	"	40	62
	"	"	40	62
	"	"	40	60
	"	"	40	62
	"	"	40	64
	"	"	40	64
	"	"	40	66
				Avg. 62
BRADFORD MA 314	361-C Top	7 yrs.	40	57
	"	"	40	59
	"	"	40	57
				Avg. 57
BARRE F 111(9) RTE US 302	361-B Top	9 yrs.	40	62
	"	"	40	60
	"	"	40	59
	"	"	40	62
	"	"	40	55
				Avg. 59

AGGREGATE - GRAVEL

SOURCE & LOCATION - NORTHFIELD SAND & GRAVEL, NORTHFIELD, MASS.

PROJECT	TYPE OF MIX	AGE OF PAVEMENT	TESTING SPEED	FRIC. FACTOR
I 91-1(4)	361-B Top	10 yrs.	40	62
GUILFORD-VERNON	"	"	40	59
	"	"	40	62
				Avg. 61
I 91-1(5)	361-B Top	10 yrs.	40	59
VERNON-GUILFORD	"	"	40	62
	"	"	40	70
	"	"	40	72
				Avg. 66
I 91-1(9)	361-B Top	7 yrs.	40	53
BRATTLEBORO	"	"	40	53
DUMMERSTON	"	"	40	53
PUTNEY	"	"	40	68
	"	"	40	66
				Avg. 59
I 91-1(10)	361-B Top	7 yrs.	40	59
PUTNEY	"	"	40	59
CONTRACT I	"	"	40	60
				Avg. 59
CONTRACT II	"	"	40	51
	"	"	40	51
	"	"	40	53
	"	"	40	62
				Avg. 54
CONTRACT III	"	"	40	60
	"	"	40	62
				Avg. 61

AGGREGATE - GRAVEL

SOURCE & LOCATION - DAILEY, SO. SHAFTSBURY

PROJECT	TYPE OF MIX	AGE OF PAVEMENT	TESTING SPEED	FRIC. FACTOR
F 019-2(1)		6 yrs.	40	55
US 7		"	40	57
DANBY-MT. TABOR		"	40	57
		"	40	51
		"	40	59
		"	40	57
				Avg. 56
F 019-2(12)		2 yrs.	40	64
US 7		"	40	70
		"	40	62
				Avg. 65
F 019-1(3)		8 yrs.	40	60
US 7		"	40	57
JCT. US 7 -		"	40	62
VT. RTE. 30				Avg. 59
VT. RTE 9		6 yrs.	30	62
		"	40	62
		"	40	60
				Avg. 62
VT. RTE. 9		4 yrs.	40	59
MA 601		"	40	49
				Avg. 54
VT. RTE. 9		3 yrs.	40	70
F-FLH-010-1(3)		"	40	70
		"	40	66
				Avg. 69

AGGREGATE - GRAVEL

SOURCE & LOCATION - LEBANON SAND & GRAVEL

PROJECT	TYPE OF MIX	AGE OF PAVEMENT	TESTING SPEED	FRIC. FACTOR
F 025-1(5)	361-B Top	3 yrs.	40	53
CHESTER	"	"	40	45
	"	"	40	55
				Avg. 51
RTE 14	361-D	3 yrs.	40	49
HARTFORD	"	"	40	51
	"	"	40	49
	"	"	40	51
	"	"	40	60
	"	"	40	53
	"	"	40	49
	"	"	40	49
				Avg. 51
RTE 14	BLADE MIX	4 yrs.	40	60
HARTFORD	"	"	40	57
				Avg. 59
US RTE 5	361-B Top	4 yrs.	40	55
	"	"	40	53
	"	"	40	55
				Avg. 55
STOCKBRIDGE	361-B Top	5 yrs.	40	64
F 022-1(4)	"	"	40	62
	"	"	40	60
				Avg. 62
MA 603	361-B Top	4 yrs.	40	60
PITTSFIELD	"	"	40	62
	"	"	40	62
	"	"	40	57
				Avg. 60

AGGREGATE - GRAVEL

SOURCE & LOCATION - COLD RIVER SAND & GRAVEL

PROJECT	TYPE OF MIX	AGE OF PAVEMENT	TESTING SPEED	FRIC. FACTOR
I 91-1(11) CONTRACT III PUTNEY WESTMINSTER	361-B Top	6 yrs.	40	57 Avg. 57
F 025-1(3) ROCKINGHAM	361-B Top " "	6 yrs. " "	40 40 40	57 51 49 Avg. 53
S 0134(3) CHESTER	361-B Top " " "	3 yrs. " " "	40 40 40 40	51 55 60 51 Avg. 54
F 016-2(1) SPRINGFIELD	361-B Top "	2 yrs. "	40 40	57 57 Avg. 57
I 91-1(11) PUTNEY WESTMINSTER	361-B Top " " " " "	6 yrs. " " " " "	40 40 40 60 60 60	51 53 55 Avg. 52 45 44 44

AGGREGATE - GRAVEL

SOURCE & LOCATION - VT. PAVING, CLARENDON

PROJECT	TYPE OF MIX	AGE OF PAVEMENT	TESTING SPEED	FRIC. FACTOR
MA 8	Unknown	8 yrs.	40	59
US RTE 7	"	"	40	62
	"	"	40	64
				Avg. 62
AP 019-3(8)	361-B Top	1 yr.	40	55
US RTE 7	"	"	40	55
CLARENDON	"	"	40	53
				Avg. 55

SOURCE & LOCATION - EATON JONES, NEWPORT, N.H.

F 020-2(3)	361-B Top	7 yrs.	40	66
BRDG. WATER	"	"	40	65
	"	"	40	72
	"	"	40	66
				Avg. 67

SOURCE & LOCATION - TWIN STATE SAND & GRAVEL

F 022-1(4)	361-B Top		40	57
BETHEL	"		40	57
RTE 107	"		40	55
				Avg. 56

AGGREGATE - DOLOMITE

SOURCE & LOCATION - DEMERS, WINOOSKI, VERMONT

PROJECT	TYPE OF MIX	AGE OF PAVEMENT	TESTING SPEED	FRIC. FACTOR
F 028-1(1) MILTON-SO. HERO	361-B Top	8 yrs.	40	57
	"	"	40	57
	"	"	40	57
				Avg. 57
MA 808 GRAND ISLE	361-D SEAL	2 yrs.	40	55
	"	"	40	49
	"	"	40	51
	"	"	40	47
	"	"	40	51
	"	"	40	55
				Avg. 51
VT I 89-3(18) WINOOSKI RAMP B	361-B Top	6 yrs.	40	45
	"	"	40	38
				Avg. 41
RAMP A	361-B Top	6 yrs.	20	32
	"	"	35	44
	"	"	30	44
	"	"	30	42
I 89-3(18) RTE #15	361-B Top	6 yrs.	30	45

AGGREGATE - DOLOMITE

SOURCE & LOCATION - DEMERS, WINOOSKI, VERMONT

PROJECT	TYPE OF MIX	AGE OF PAVEMENT	TESTING SPEED	FRIC. FACTOR
I 89-3(29)	361-B Top	4 yrs.	40	44
CONTRACT I	"	"	40	45
				Avg. 45
COLCHESTER	"	"	20	59
	"	"	20	62
	"	"	20	62
	"	"	30	51
	"	"	30	53
	"	"	30	53
	"	"	50	40
	"	"	50	47
	"	"	50	47
	"	"	50	--
	"	"	60	42
	"	"	60	40
	"	"	60	40
	"	"	70	38
	"	"	70	36
	"	"	70	36
I 89-3(29)	361-B Top	4 yrs.	40	78
CONTRACT II	"	"	40	76
COLCHESTER	"	"	40	74
				Avg. 76
	"	"	40	53
	"	"	40	62
	"	"	40	59
	"	"	40	60
				Avg. 58
I 89-3(18)	361-B Top	6 yrs.	40	55
S. BURLINGTON	"	"	40	51
WINOOSKI	"	"	40	42
	"	"	40	42
	"	"	40	47
	"	"	40	47
				Avg. 47

AGGREGATE - DOLOMITE

SOURCE & LOCATION - DEMERS, WINOOSKI, VERMONT

PROJECT	TYPE OF MIX	AGE OF PAVEMENT	TESTING SPEED	FRIC. FACTOR
I 89-3(16)	361-B Top	6 yrs.	40	44
S. BURLINGTON	"	"	40	49
				Avg. 46
I 89-3(17)	361-B Top	6 yrs.	40	49
BURL.-S. BURL.	"	"	40	45
	"	"	40	47
	"	"	40	47
				Avg. 47
F 019-4(2)	361-B Top	5 yrs.	40	47
CHARLOTTE	"	"	40	51
	"	"	40	47
	"	"	40	44
	"	"	40	42
	"	"	40	44
	"	"	40	44
	"	"	40	38
	"	"	40	36
	"	"	40	38
	"	"	40	45
	"	"	40	44
	"	"	40	40
				Avg. 43
I 89-3(22)				
WINOOSKI	361-B Top	6 yrs.	40	44
COLCHESTER	"	"	40	45
				Avg. 45

AGGREGATE - DOLOMITE

SOURCE & LOCATION - DEMERS, WINOOSKI, VERMONT

PROJECT	TYPE OF MIX	AGE OF PAVEMENT	TESTING SPEED	FRIC. FACTOR
I 89-3(23)	361-B Top	5 yrs.	40	51
WILLISTON	"	"	40	47
S. BURLINGTON	"	"	40	55
	"	"	40	47
				Avg. 50
I 89-2(11)	361-B Top	5 yrs.	40	51
WILLISTON	"	"	40	53
				Avg. 52
I 89-2(10)	361-B Top	5 yrs.	40	55
WILLISTON	"	"	40	55
RICHMOND				Avg. 55
I 89-2(8)	361-B Top	4 yrs.	40	57
BOLTON-RICHMOND	"	"	40	55
CONTRACT IV				Avg. 56
		(CARTIER CRUSHER)		
I 89-2(8)	361-B Top	4 yrs.	40	72
BOLTON-RICHMOND	"	"	40	70
CONTRACT III	"	"	40	55
	"	"	40	57
				Avg. 64

AGGREGATE - LIMESTONE

SOURCE & LOCATION - VERMARCO, FLORENCE, VERMONT

PROJECT	TYPE OF MIX	AGE OF PAVEMENT	TESTING SPEED	FRIC. FACTOR
F 019-3(10)	361-B Top	5 yrs.	40	72
	"	"	40	62
	"	"	40	62
				Avg. 65
F 019-3(11)	361-B Top	5 yrs.	40	64
	"	"	40	68
	"	"	40	66
				Avg. 66
MA 906	361-B Top	1 yr.	40	64
BENSON-ORWELL	"	"	40	64
	"	"	40	64
	"	"	40	62
	"	"	40	66
	"	"	40	66
	"	"	40	66
				Avg. 64
F 020-2(6)	361-B Top	3 yrs.	40	51
SHERBURNE	"	"	40	59
	"	"	40	59
				Avg. 56
	"	"	30	72
	"	"	60	51
	"	"	60	51
	"	"	60	51
	"	"	50	59
	"	"	50	59
	"	"	50	59
SHERBURNE	361-C	6 yrs.	40	62
MA 405	"	"	40	57
				Avg. 60

AGGREGATE - LIMESTONE

SOURCE & LOCATION - SWANTON LIME, SWANTON, VERMONT

PROJECT	TYPE OF MIX	AGE OF PAVEMENT	TESTING SPEED	FRIC. FACTOR
ALBURG	361-D (Seal)	2 yrs.	40	49
MA 808	"	"	40	45
	"	"	40	42
	"	"	40	47
	"	"	40	49
	"	"	40	47
	"	"	40	45
	"	"	40	51
	"	"	40	49
	"	"	40	40
				Avg. 46
SWANTON	361-B Top	4 yrs.	40	44
GOLF COURSE	"	"	40	44
AREA	"	"	40	36
MA 621	"	"	40	36
	"	"	40	44
	"	"	40	36
	"	"	40	44
	"	"	40	42
	"	"	40	34
				Avg. 40

AGGREGATE - SERPENTINE ROCK

SOURCE & LOCATION - DUXBURY QUARRY NO. 2

PROJECT	TYPE OF MIX	AGE OF PAVEMENT	TESTING SPEED	FRIC. FACTOR
I 89-2(6)	361-B Top	8 yrs.	40	62
WATERBURY	"	"	40	66
	"	"	40	62
	"	"	40	68
	"	"	40	66
				Avg. 65
I 89-2(5)	361-B Top	8 yrs.	40	40
CONTRACT I	"	"	40	49
WATERBURY	"	"	40	49
MIDDLESEX	"	"	40	57
	"	"	40	66
	"	"	40	64
				Avg. 54
I 89-2(4)	361-B Top	8 yrs.	40	62
CONTRACT II	"	"	40	62
	"	"	40	66
	"	"	40	70
				Avg. 65

SOURCE & LOCATION - EDEN MINES

I 89-2(7)	361-B Top	7 yrs.	40	47
CONTRACT III	"	"	40	45
WATERBURY-BOLTON	"	"	40	55
	"	"	40	57
				Avg. 51
I 89-2(7)	361-B Top	7 yrs.	40	47
CONTRACT II	"	"	40	49
	"	"	40	47
	"	"	40	59
	"	"	40	59
				Avg. 51
I 89-2(7)	361-B Top	7 yrs.	40	47
CONTRACT I	"	"	40	45
				Avg. 46

SOURCE & LOCATION - CAL. S & G, WATERFORD (PLAINFIELD PLANT)

I 89-2(4)	361-B Top	8 yrs.	40	47
CONTRACT III	"	"	40	45
				Avg. 46

(Note: Includes gravel with Eden Mines)