

SKID RESISTANCE PERFORMANCE
OF
NJDOT SURFACE COURSE MIXES

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16. Abstract

As a result of earlier research, crushed gravel was identified as an exceptionally skid resistant aggregate and is now specified for resurfacing New Jersey pavements where particularly high skid resistance is required. This report presents the results of an investigation undertaken to determine whether crushed gravel still displays its marked performance advantages compared to conventional (crushed stone) aggregates.

The report contains a brief history of the development of New Jersey surface course mixes, an analysis of their skid resistance performance, and a discussion of recent cost information for each mix. A synopsis of current Department skid resistance research is also presented.

The report findings confirm that crushed gravel is indeed the most skid resistant mix currently available to the Department. It is concluded that until a suitable alternate aggregate is identified through ongoing research efforts, the Department should continue its policy of specifying crushed gravel surfacing for pavements requiring superior skid resistance.

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INTRODUCTION

In the mid-1960s, the New Jersey Department of Transportation initiated a program designed to determine the prevailing level of skid resistance on the state highway network and to develop measures for achieving needed improvements. To this end, a number of experimental pavement sections employing a variety of aggregates (e.g., slags, crushed gravels, crushed stone) were placed and closely monitored to determine their skid resistance performance. In addition, skid resistant mixes/treatments such as open-graded friction course and slurry seals have been evaluated and adopted for use where warranted.

As a result of this continuing program of field testing and related research efforts, crushed gravel was identified as an exceptionally skid resistant aggregate and is now specified in areas where particularly high skid resistance is required. Open-graded friction course was also found to be an effective anti-skid mix, although not quite as uniformly durable in all areas. The change of the standard surfacing mix from FABC to MABC has also resulted in better overall skid resistance due to the coarser surface texture of the latter.

Since crushed gravel is not as readily available as crushed stone, there have been occasional problems obtaining this aggregate. Due to this supply problem, the New Jersey Asphalt Pavement Association has requested, through the Chief Engineer of Design, that the Department make a comparative analysis of our crushed gravel and I-4 MABC mixes to determine if the difference in their skid resistance levels justifies specifying the crushed gravel mix. To fulfill this request, the following information on current New Jersey surface course mixes is presented.

HISTORICAL BACKGROUND

CRUSHED GRAVEL

In 1969, the NJDOT's first crushed gravel friction course was placed in the resurfacing of Route 1 north of the Brunswick Circle in Trenton. Based on the continuing high levels of skid resistance exhibited at this installation after exposure to several million vehicle passes, it was recommended the crushed gravel be used at the Route 1 and 130 traffic circle in New Brunswick where an anti-skid surface was essential. The circle and its approaches were paved with a crushed gravel surface course in 1971 by Department forces. The first contract work employing a crushed gravel mixture was constructed in 1974 on Route 1 and 9, Section 6E.

Since that time many gravel friction courses have been placed with only minor modifications being made to the original mix design requirements. These modifications include the use of either an FABC or MABC mixture grading to allow for alternate sizes of crushed gravel, and the use of alternate sands (stone vs. natural). Both of these changes were made to reduce production costs of the mixture and had no discernible effect on the skid resistant properties of the mix. Since crushed gravel is used in a dense-graded mix, durability of the material has, as expected, proven to be similar to conventional surface mixtures.

OPEN GRADED

An open-graded friction course was first used by the Department in 1973 on Route 73 near Pattenburg. This project exhibited high skid resistance and excellent drainage characteristics. Consequently, during the next several years, more than a dozen open-graded friction course projects were placed by Department forces and contractors.

These early projects presented many problems both at the plants and the project sites. These problems included:

1. Difficulty in controlling the temperature at the plant.
2. Mix segregation.
3. The occasional excessive use of fuel oil as a release agent in truck beds resulting in pools of diluted asphalt cement appearing in the mat.

These and other problems were resolved through appropriate specification modifications. In addition, as asphalt plant personnel became more familiar with this mix, fewer problems were encountered at the plants.

Despite these problems, the open-graded friction course used in these early projects has demonstrated satisfactory skid resistance performance. Due to its internal drainage characteristics, open-graded friction course also greatly reduces the potential for hydroplaning.

Since the open-graded friction course is designed for a 3/4 inch total thickness, it was expected to require an overlay after about seven years' service. However, many projects have been in service this length of time and longer; and although aesthetics (i.e., color fading, surface marring) and internal drainage characteristics have deteriorated, they are expected to provide acceptable skid resistance levels for several more years.

MABC

In the mid 1970s, the Department changed the gradation requirements of standard surfacing mixes from a fine to a coarse aggregate. This change was designed primarily to achieve a relatively coarser surface texture and thus, higher average skid resistance.

Unfortunately, the early MABC mixes were nothing more than slightly modified FABC and generally did not provide the desired coarser texture. It was not until 1979 that so-called "true" I-4 MABC mixtures, containing larger aggregate sizes, were actually supplied. Consequently, the amount of data representative of our current I-4 MABC mixes is somewhat limited.

SKID RESISTANCE

Historical skid data is available to provide comparisons between various Department surface mixtures. The average skid numbers after each year of service for crushed gravel and open-graded projects placed between 1975 and 1978 is tabulated and plotted in the attachments, along with average skid numbers for I-4 MABC projects placed in 1979.

It is clearly evident from the attached data that crushed gravel produces the most skid resistant mix currently available. The crushed gravel projects not only provided the highest initial level of skid resistance, but maintained this level year after year throughout the six year analysis period.

The open-graded and MABC mixes both maintain high skid resistance after four years' service. The MABC projects will be monitored over the next several years to determine if this level is maintained.

It should be noted that the level of skid resistance provided by a particular MABC project ultimately depends on the polish resistance of the specific coarse aggregate used in the mix.

CONSTRUCTION COSTS

The most recent available cost data (1981-82) for bituminous mixtures indicates the average weighted unit price for MABC was \$19.75 and \$19.25 respectively. During this period, the average bid price for crushed gravel friction course was \$21.75 and \$22.00, respectively and accounted for only about 10% of the total surface course tonnage. No open-graded friction course projects were constructed during this period. However, open-graded mixes historically have cost two to three dollars a ton more than conventional (FABC and MABC) mixes. It is interesting to note that although MABC is generally less expensive than crushed gravel mixes, on several projects (where the tonnage was comparable) the reverse has been true.

CURRENT RESEARCH

The Department has a continuing research program aimed at achieving improved skid resistance at lower costs. The results of this research are expected to identify available sources of relatively low cost polish resistant aggregates other than crushed gravel which can be specified for use in anti-skid mixes. This effort basically involves laboratory work to determine the polish resistance of aggregates using a British Polishing Wheel. Samples are being collected from all quarries that supply aggregates for use in surface course pavements. Samples will be tested in accordance with the procedures outlined in ASTM Standard Test Method D3319-81, "Accelerated Polishing of Aggregates Using the British Wheel". As projects containing aggregates from these sources are completed, they will be skid tested periodically and the results correlated with the polish values obtained in the laboratory.

In addition, the Department will continue to make regularly scheduled skid resistance measurements on our various types of surfacing so as to develop a representative skid resistance profile for each of the various mixes over its service life.

SUMMARY

When an anti-skid mix is deemed necessary, crushed gravel friction course has usually been specified since it historically has yielded the highest levels of skid resistance (see attached table), adds structural strength, and is expected to be more durable than an open-graded mix. Open-graded mixes typically require a levelling course prior to placement and greater care in mixing, transporting, and placing. They can, however, be used to improve skid resistance in those cases where an upgrading in structural strength is not required.

For most situations, MABC provides adequate levels of strength, skid resistance, and durability.

Until such time that additional polish resistant aggregates are identified, crushed gravel friction course should be specified where the highest levels of skid resistance are deemed necessary, particularly where there is also a need to improve structural strength. It is well worth the extra cost to be confident that adequate skid resistance levels are provided at critical locations.

AVERAGE SKID NUMBERS BY SURFACE COURSE TYPE

Pavement Years in Service	Crushed Gravel		Open-Graded		I-4 MABC	
	Avg SN	Number Projects	Avg SN	Number Projects	Avg SN	Number Projects
1	52	11	47	23	45	11
2	51	11	47	23	43	12
3	50	11	46	23		
4	50	7	45	18	45	12
5	50	4	45	12		
6	54	2	45	8		

NOTES:

Data for crushed gravel and open-graded mixes consists of skid measurements taken each year between 1976 and 1981 on projects placed between 1975 and 1978.

All I-4 MABC projects were placed in 1979 and skid measurements taken in 1980, 1981, and 1983.

The apparent increase in the average skid number for crushed gravel mixes after six years' service is not considered significant since the result is an average of only two projects.

JDO SURFACE COURSE E

AVERAGE SK D U BER

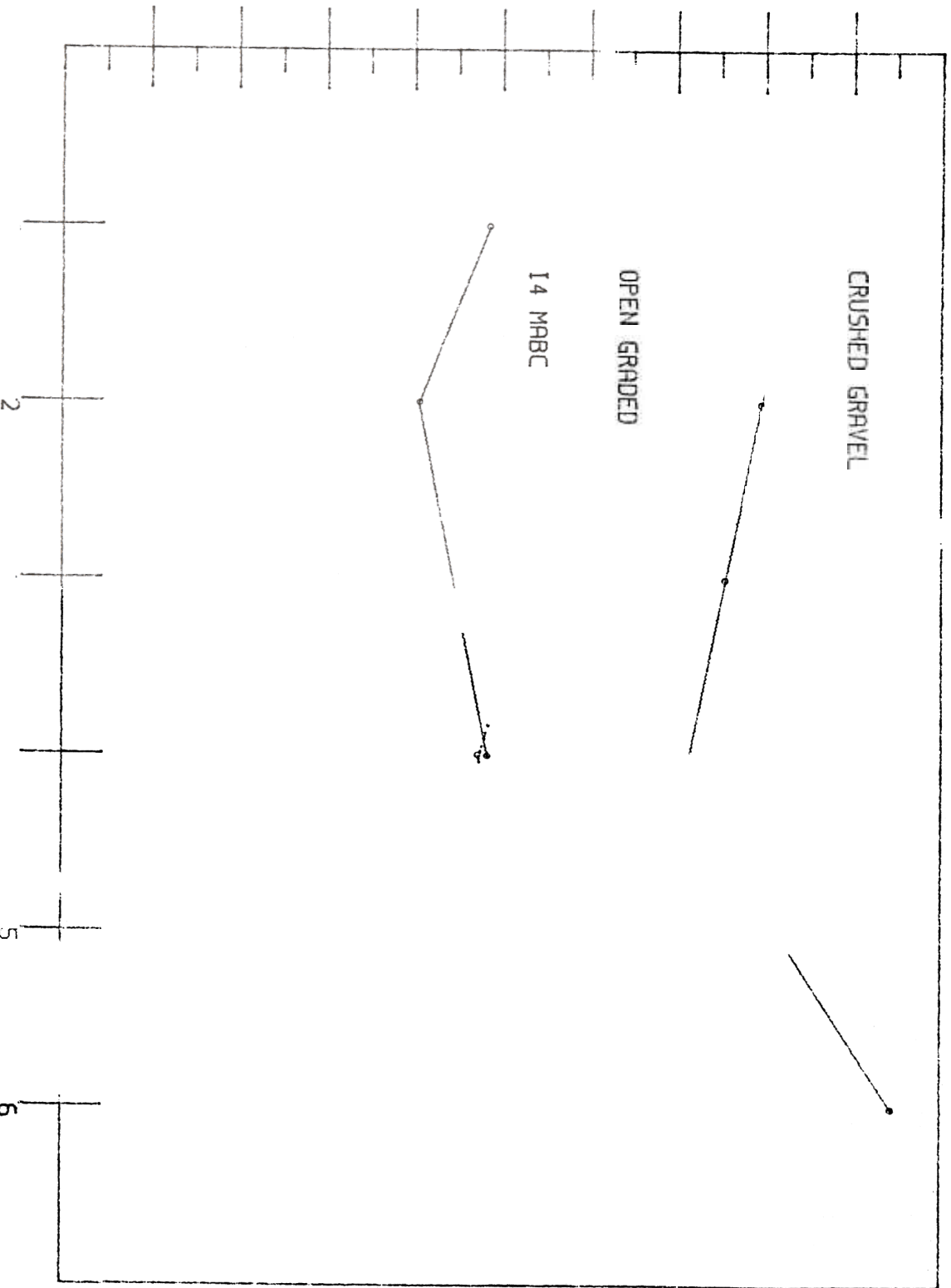
55

35

CRUSHED GRAVEL

OPEN GRADED

14 MRBC



YEARS IN SERVICE