# Effect of Aggregate Mineralogy on Polishing Rate and Skid Resistance in Pennsylvania

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• THE PENNSYLVANIA Department of Transportation began its research in skid resistance in 1960 with a series of pavement friction tests in a limited area of the state. This pilot study revealed that of 19 sites selected for suspected slipperiness 11 were classified as slippery; the pavements at these 11 sites exhibited polished carbonate aggregate. A continuing program of measuring skid resistance on Pennsylvania highways has been conducted in annual skid surveys following the recommendations of the study report, and formal research projects dealing with slipperiness and polishing have been under way.

A review of the data collected from this work by early 1968 indicated that there was no satisfactory construction or material specification to ensure that a bituminous pavement surface would have adequate skid resistance throughout its life.

Figure 1 shows the results obtained from the annual skid surveys taken from 1962 to 1967. The 687 tests shown were subjectively chosen for suspected slipperiness and would not necessarily be representative of the skid-resistance values of Pennsylvania highways. The skid resistance of normal bituminous concrete pavement surfaces in Pennsylvania is generally related to the type of coarse aggregate used. Of the pavements tested, the average skid resistance of the surface courses constructed with gravel and sandstone are considerably higher than those constructed with carbonates. Where slag and other types of aggregates have been used, intermediate skid measurements have been obtained.

Although average skid values are shown for each of the general types of aggregate, a wide range of values was found within each type. The controlling aggregate parameters have not been clearly defined within each type to permit specifications to be written that would accept all those aggregates giving adequate skid resistance and omit those polishing excessively.

In order to evaluate these parameters in carbonate aggregates, a series of test sections was planned and constructed.

## TEST STRIP PLANNING

As the skid research data accumulated, it became apparent that the coarse aggregate in a bituminous mix was the most influential in contributing to skid resistance. Other factors such as surface type of gradation have lesser significance. Laboratory polishing work generally agreed with the field observations, showing that relatively pure carbonate aggregates polish uniformly and become slippery but, as the amount of insoluble sand-sized material within the aggregate particles increased, the skid-resistance properties improve.

A review of the approximately 340 sources producing aggregates showed a wide variety of properties. It is imperative from an economic standpoint that all sources that could supply aggregates providing an adequate skid-resistance level throughout a normal pavement surface life be permitted in any specification.

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Paper sponsored by Committee on Bituminous Aggregate Bases and presented at the 49th Annual Meeting.

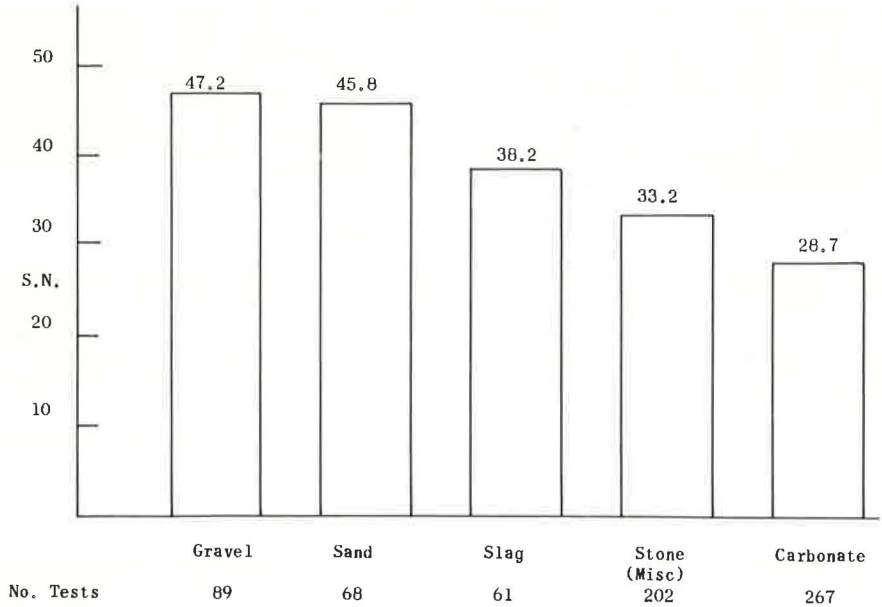


Figure 1. 1962-1967 skid surveys.

Insoluble residue tests were run on a cross section of carbonate aggregates produced from rock from various geologic areas in Pennsylvania. This permitted a selection of 20 carbonate aggregates, including limestones and dolomites with insoluble residues ranging from less than 1 percent to more than 35 percent as shown in Figure 2.

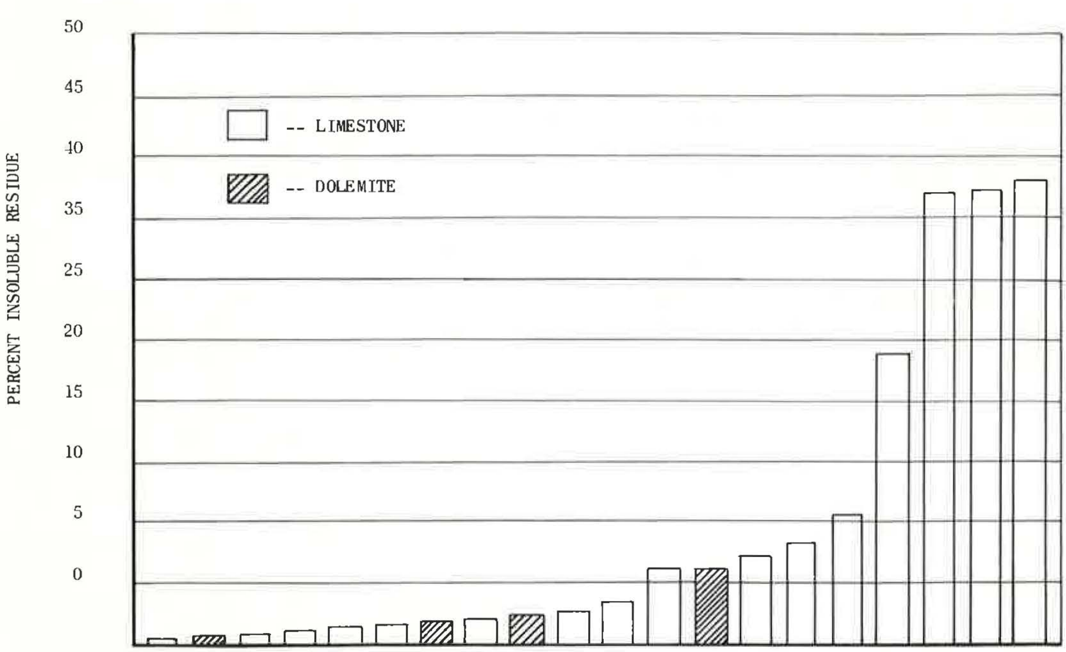


Figure 2. Percentage of insoluble residue of +200 sieve size on test strips 1 through 11.

Other representative types of aggregates produced in the general location of the 20 carbonate aggregates selected were chosen for incorporation into the test strips to permit determination of the skid levels they might produce under similar conditions. Each test strip then included one or more of the carbonates, gravel, slag, and other rock types as available. A number of blends of carbonates with other aggregates were also included to determine the effect of blending on skid resistance. A minimum length of 1,000 ft was set for each section to allow for skid testing.

## TEST STRIP SITES

The test strip road locations were selected from projects planned as part of the normal construction program in order to expedite construction. The sites were selected with sufficient length to accommodate all planned sections in one lane and to have a reasonably high traffic count uniformly throughout the length. A minimum of side traffic turning movements was wanted, and excessive grades and curves were avoided so that uniform polishing would be obtained.

The criteria resulted in 11 test strip locations to accommodate all the aggregates selected.

## TEST STRIP CONSTRUCTION

The test pavements were constructed during 1968 and 1969 by using Pennsylvania ID-2A hot-mix surfaces that have a maximum ½-in. size of aggregate. All of the mixes for each of 10 of the test strips was supplied from a single plant in the area. Regular production procedures were used, with only the substitution of the coarse aggregate that was supplied from the selected source. The fine aggregates were those normally used by that plant. The eleventh test strip had material supplied from a number of plants in addition to the one plant supplying mixes with all of the selected aggregates.

## TEST STRIP AGGREGATES

Samples of all of the aggregates used in the wearing courses of the test strips have been examined petrographically and identified for stratigraphic unit. Acid insoluble tests have also been run.

Information for the test strip aggregates is given in Table 1. Over 43 lane-miles of pavement were required to accommodate the 156 aggregate sections containing 64 sources and blends.

Figure 3 shows a typical test strip plan. It shows the random arrangement of test sections within a lane and each test section occurring in both lanes. The same section is repeated in the same lane at several sites to provide replicates, and several test aggregates are included in 2 sites to evaluate the effect of geographic location and other variables.

## EVALUATION PROGRAM

Traffic counts have been obtained on the 11 test strips, and a periodic program of skid testing on each of the test sections is under way. These data will permit the development of a skid history curve for each aggregate by plotting accumulated traffic passes versus skid number. Table 2 gives the type of data being collected. The numbers shown are purely for illustrative purposes and have not been corrected for surface temperatures or evaluated for weather conditions.

Both core and slab samples have been taken from each test section and are being investigated in laboratory work to evaluate polishing and test techniques. This phase is directed at devising quick laboratory methods that will predict field performance of aggregates.

TABLE 1

TEST STRIP MATERIALS

| Type | Source | Section | Length (mile) |
|---|---|---|---|
| Carbonates | 20 | 59 | 25.43 |
| Slags | 8 | 20 | 3.73 |
| Gravels | 9 | 18 | 3.83 |
| Others | 12 | 30 | 5.62 |
| Blends | 15 | 29 | 5.27 |
| Total | 64 | 156 | 43.88 |

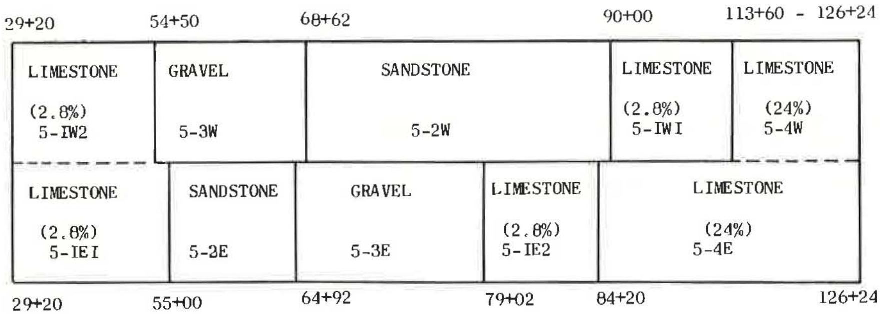


Figure 3. Plan of test strip 5.

TABLE 2

DATA COLLECTED FOR TEST STRIP 5

| Item | Test Date | |
|---|---|---|
| | 10-23-68 | 9-10-69 |
| Traffic passes | 180,000 | 1,800,000 |
| Aggregate, average skid reading | | |
| Limestone, 2.8 percent | 48 | 42 |
| Silt-sandstone | 49 | 52 |
| Gravel | 48 | 51 |
| Limestone, 24 percent | 48 | 42 |

The slab samples are placed under a loaded test wheel that spins in place at a constant speed and load. A planned cycle of water and sand is introduced between the tire and the specimen, and the tractive force on the sample is recorded over several hours of running. A steady state of force is reached at the end of the test.

The core samples are being evaluated in an apparatus developed in earlier polishing studies at Pennsylvania State University. This technique uses a reciprocating rubber shoe sliding over the core and measures the power required for polishing. Tests are also made of the final friction values.

Samples of aggregates used in the test strips are undergoing tests in a drum apparatus. The aggregates are glued to metal sections that are mounted as segments on a revolving drum that runs against a polishing tire. Friction values are also obtained periodically and at the conclusion of polishing.

## SUMMARY

The aggregates included in the test strip program represent a cross section of the rock types commonly used in the wearing surfaces of pavements in Pennsylvania. The aggregates have been identified petrographically, and their properties have been determined. Continued exposure to traffic and period skid testing should provide an evaluation of the skid-resistance potential of many of the rock formations in Pennsylvania. Suitable aggregate specifications can then be prepared that provide adequate skid resistance throughout the life of the pavement.

The supplemental laboratory testing of the same aggregates is directed at developing a method to allow prediction of field performance of any aggregates proposed for use.