# SURVEY OF PAVING AGGREGATES USED IN DISTRICT 6

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# PREFACE

With continued construction and maintenance of our State Highway System, coupled with increasing traffic volumes and more consideration given to economic factors, greater demands are being placed on quality materials from local sources. This report summarizes laboratory and field studies made on most of the aggregates used in District 6 including those locally produced as well as several imported from nearby areas.

## ABSTRACT

Fifteen aggregate sources and three test-core sites located in District 6 and four sources from adjacent areas have been examined for geological nature and engineering properties. Data from laboratory studies including physical testing and the accelerated polish test have been compared with service performance and results from skid-trailer testing. Field studies and very limited skid-trailer readings suggest that under low to moderate traffic the bituminous pavements containing either crushed limestone aggregate or siliceous gravel lose their skid-resistant character in time varying from 2 to 4 years. In contrast, service records and limited skid-trailer data indicate that both HMAC pavements and seal coats which utilize rhyolite aggregate or a rhyolite blend appear to provide a skid-resistant surface throughout the economic life of the pavement surface. However, when even the slightest flushing occurs, regardless of age or aggregate type, desirable skid properties as measured by the skid-trailer are lost.

## I. SUBJECT

The presentation of geological and engineering data, collected from field and laboratory studies made on aggregate sources used in District 6, is the subject of this report.

## II. PURPOSE

The purpose of this study is to provide concerned Departmental personnel data from both field and laboratory testing obtained on paving aggregates used by District 6.

## III. SUMMARY AND CONCLUSIONS

1. Rock materials from 22 sites located within and adjacent to District 6 have been examined for physical and engineering properties by means of laboratory testing, petrographic analyses, geological surveys and service performance.

2. Pavement sites, selected on the basis of aggregate type, age and traffic count, were examined for surface conditions, photographically documented and tested with a skid-trailer.

3. Petrographic analyses of the various aggregates indicated that mineralogical composition, texture and relative hardness of the mineral constituents relates to measured polish value and in some degree to abrasion and soundness losses.

4. Limited skid-trailer data restricted the understanding of the polishing behavior of most of the materials under study; however, service

records along with the available skid data indicated that the rhyolite-type aggregate had acceptable skid properties throughout the economic life of the pavement surface.

5. Observations at pavement sites as well as the skid data indicated that skid properties varied from inside to outside lanes and that desired skid resistance was lost when flushing occurred.

## IV. MATERIALS AND METHODS

### A. Location and geologic setting of aggregate sources.

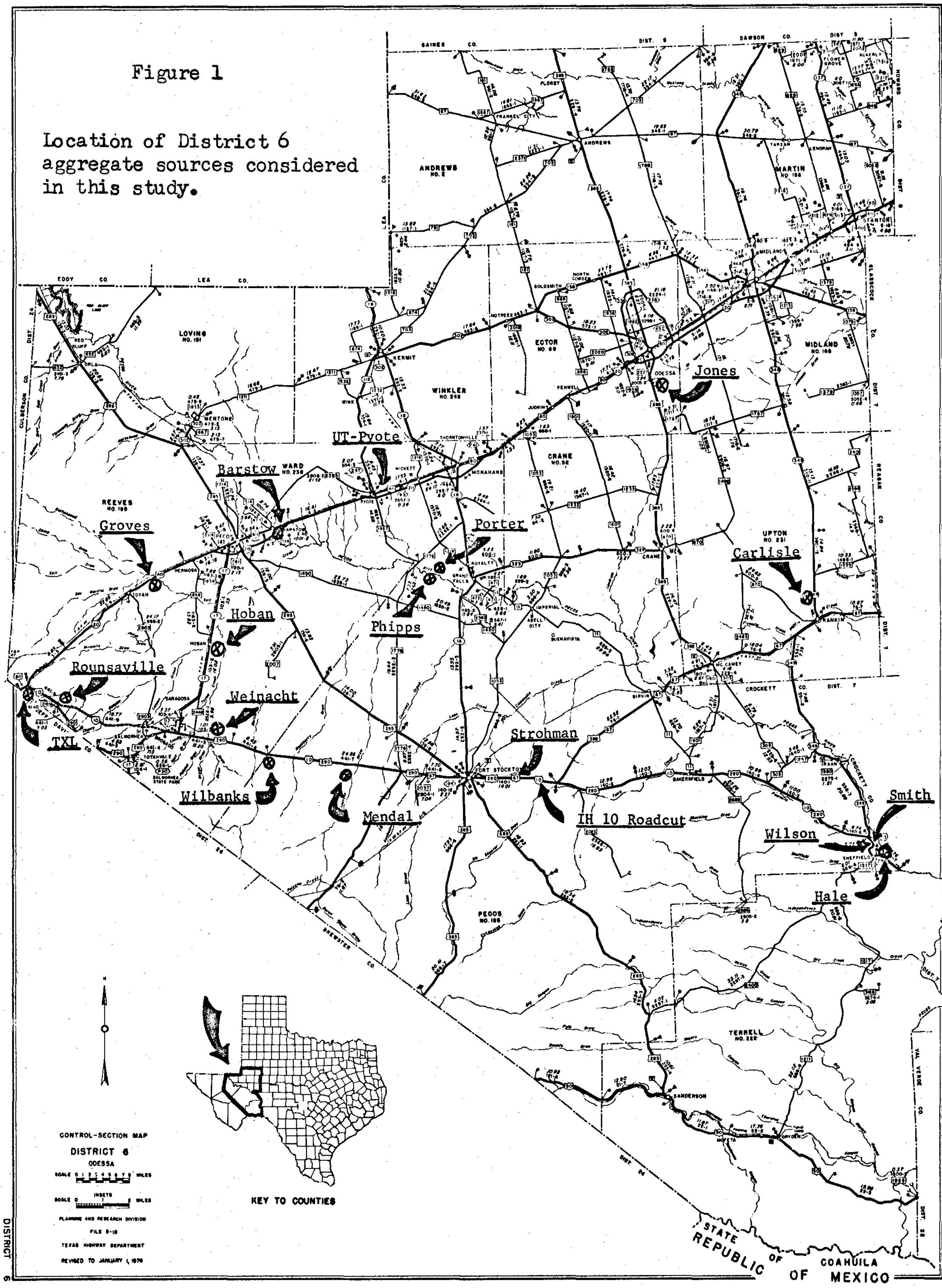
Generalized locations for the material sources considered for this study are indicated on the general highway map in Figure 1.

Geologically, the twenty aggregate sources listed and discussed in this study can conveniently be categorized into two major groups according to type of deposit: (1) surface and river terrace gravels, and (2) quarried rock (limestone or rhyolite). Table I lists the sources in their appropriate group. The sources marked with an asterisk are those located outside of District 6. The basic rock type for each source is also given in the Table.

The surface gravels in Reeves County, especially in the Balmorhea area, represent materials eroded and "washed" out of the Davis Mountains. The gravels are primarily composed of rhyolite (a volcanic rock) and various types of siliceous materials (quartz, chert, flint, agate, etc.). The river gravels deposited by the Pecos River and its tributaries in the area of Toyah, Pecos and Grandfalls contain both rhyolite and siliceous types along with hard limestones. The latter is probably from source

Figure 1

Location of District 6 aggregate sources considered in this study.



areas in Culberson County and southern New Mexico. The limestone gravels from the Pecos River in the Iraan-Sheffield area are derived from nearby limestone formations on the western edge of the Edwards Plateau. The quarried limestone from sources in the Upton-Ector County region are also from Cretaceous age formations on the western edge of the Edwards Plateau. Much of the area has surface sand and caliche deposits. In some areas local deposits of caliche have been mined and extensively used for base materials. The quarried limestone from Brownwood is of Pennsylvanian age. The quarried rhyolite from Allamoore (Hudspeth County) is part of a metamorphic-rock complex of Pre-Cambrian age.

## B. Aggregate Samples

Initial samples examined for this survey were collected and submitted by District 6 personnel. Additional samples from some of the sources were collected by the writer during the field survey. The samples were taken from normal production stockpiles by standard methods. In some instances, the river gravels were crushed in the laboratory for comparison with normally uncrushed production samples. Cores from three potential sites were taken, examined petrographically and tested for polish value.

## C. Petrographic Analyses

Representative rock particles, selected on the basis of color, texture and apparent composition, were taken from the submitted samples and prepared for petrographic analysis using a polarizing microscope in accordance with ASTM Recommended Practice C 295. Thin sections of the rocks were prepared which involved cutting, mounting on glass microscope slides and grinding to about 25 microns (1/1000 in.) in thickness. The specimens were then viewed microscopically utilizing transmitted polarized light. Mineral compositions were determined by their respective optical and crystalline properties.

D. Polish Value Determinations

Samples from the various sources treated herein were subjected to the "Accelerated Polish Test" in accordance with Test Method Tex-438-A. Material from some of the river gravel sources were tested both crushed and uncrushed for comparative purposes.

E. Skid Trailer Readings

Skid trailer data was obtained by District 6 personnel on several pavement sites containing some of the aggregates discussed herein. In evaluating this data a number of factors such as pavement type, surface conditions and traffic conditions were considered.

F. Pavement Surface Observations

Approximately 35 pavement sites in District 6 were selected on the basis of type, aggregate composition and age (or traffic conditions). The primary purpose of the pavement examination was to evaluate the micro and macro-texture of the aggregates exposed at the surface. The overall condition of the pavement (raveling, flushing, etc) was also noted. Also, each site was identified to enable the skid-trailer to make measurements at the same site.

G. Physical Testing

Additional laboratory testing including Los Angeles Abrasion and Soundness was conducted on many of the aggregate materials treated in this study. Records from previous tests on material from the more active and commercial sources were also reviewed for comparison purposes.

V. RESULTS

Petrographic examinations were performed on all samples treated in this study; however, detailed thin-section analysis was used primarily on the limestones and rhyolites. The limestones ranged from fine-grained, crystalline and relatively high purity types such as Rounsaville, Carlisle, IH 10 Roadcut and Brownwood to the softer, relatively impure types such as the Strohman, Mendal, TXL, Willbanks, Moss and Jones Pits. The limestone gravels such as Hale and Barber Pits also showed wide ranges of properties. The rhyolite gravels from the Hoban, Groves and Weinacht were essentially the same in composition. Although the siliceous river gravels from the Pecos River at Barstow and near Grandfalls were primarily composed of a mixture of quartz, chert, jasper, quartzites and rhyolite, about 20-30 percent of the materials were limestone. The limestone ranged from the light-colored relatively soft rock from the nearby Edwards Plateau area to the dark-colored, crystalline, hard types derived from sources further west in Texas and southeastern New Mexico. The various aggregates were checked for relative hardness in terms of the Mohs' scale. The siliceous gravels, composed primarily of varieties of quartz had a hardness range of 6.5-7.5. The rhyolites composed mainly of feldspars and some quartz had a hardness of 6.0-7.0. The limestone gravels had a hardness of 3.0-3.5, whereas, the quarried limestones had a wide range from 1.0-3.5.

Results of the "Accelerated Polish Test" are summarized in Table II. As shown, the gravel samples had values listed for both crushed and uncrushed types except when one or the other was not available. If crushing facilities were not available at the plant, the samples were laboratory crushed. In most cases crushing had an appreciable effect on the polish-value results of the gravels. Obviously, the quarried-stone samples reflected values on "crushed" materials. A few sources show a range of polish values which represent tests on multiple samples submitted over a period of time.

Skid trailer readings were taken (June 1974) on pavement sites in District 6 which utilized several of the aggregate materials discussed in this study. Information as to placement date, average daily traffic (ADT) and skid number at 40 mph is included in Table III. As shown, multiple sites containing gravel from Hoban, Porter and Phipps were tested with the skid-trailer. The three sites with Hoban aggregate were four-lane roadways which permitted inside and outside lanes to be tested. One site with Phipps material was tested in both directions.

A summary of the physical testing, which included Los Angeles Abrasion and magnesium sulfate soundness, is also listed in Table I. Most of the results are from samples submitted to the Materials and Tests Division; however, some of the results were obtained from District 6 files. A few of the soundness-test values represent results from only four cycles of $MgSO_4$ rather than the standard five cycles. These latter modified tests were conducted by District laboratory personnel.

Photographs taken at some of the pavement examination sites have been selected to show details of the pavement surfaces, including: aggregate shape, gradation, texture and degree of polish. Figures 2-9 illustrate pavement surfaces containing the major sources discussed in this study. The aggregate types represent both river gravel and quarried-rock sources. They vividly show textural features as well as relative degree of polishing by traffic. A detail description of the material, the pavement type, site location, placement date and traffic count are given in addition to both skid-trailer and polish-value information.

TABLE I

SURFACE OR RIVER TERRACE GRAVELS

| Map No. | Producer | Pit | Rock Type | Range L.A.Wear(%) | Range MgSO4(%) |
|---|---|---|---|---|---|
| 1 | Trans Pecos | Hoban | Crushed Rhyolite | 16-21 | 2.4-4.5 |
| 2 | Trans Pecos | Groves | Rhyolite & Limestone | 17-24 | 1.1-5.1 |
| 3 | Delaware Basin | Barstow | Siliceous & Limestone | 14-24 | 1.7-2.7 |
| 4 | Porter & Son | Grandfalls | Siliceous & Limestone | 16-23 | 1.7-4.6 |
| 5 | Phipps | Grandfalls | Siliceous & Limestone | 14-22 | 1.4-5.1 |
| 6 | Portable Aggr. | Hale | Limestone | 19-31 | 0.9-4.5 |
| 7 | Border Road | Weinacht | Crushed Rhyolite | 18-20 | 2.2-5.2 |
| 8 | *Janes Gravel | Vealmoore | Siliceous | 19-28 | 1.7-5.0 |
| 9 | *Big Rough | Barber | Limestone | 22-29 | 4.2-13.7 |
| | | | QUARRIED ROCK | | |
| 10 | Portable Aggr. | Strohman | Limestone | 24-31 | 12.2-20.7 |
| 11 | Strain Bros. | Mendal | Limestone | 32-33 | 5.5-17.7 |
| 12 | Border Road | TXL | Limestone | 25-29 | 4.5-14.8 |
| 13 | Border Road | Rounsaville | Limestone | 25-31 | 2.1-11.9 |
| 14 | Border Road | Wilbanks | Limestone | 28 | 77+ |
| 15 | Anderson | Carlisle | Limestone | - | 22+ |
| 16 | Jones-Rochester | Jones | Limestone | 30-36 | 13.4-21.3+ |
| 17 | Strain Bros. | IH 10 Roadcut | Limestone | 30-32 | 3.0-3.4 |
| 18 | *White's Mines | Brownwood | Limestone | 19-28 | 4.4-9.4 |
| 19 | *Gifford-Hill | Allamoore | Rhyolite | 19-30 | 7.5-29.2 |

*Sources located outside District 6
+Four-cycle test

TABLE II

| Map No. | Producer | Pit | Polish Value Uncrushed | Polish Value Crushed |
|---|---|---|---|---|
| 1 | Trans Pecos | Hoban | 35-39 | 43 |
| 2 | Trans Pecos | Groves | 34 | |
| 3 | Delaware Basin | Barstow | 27 | 32 |
| 4 | Porter & Son | Grandfalls | 31 | 37 |
| 5 | Phipps | Grandfalls | 30 | 37 |
| 6 | Portable Aggr. | Hale | 29-30 | 33 |
| 7 | Broder Road | Weinacht | | 42 |
| 8 | Janes Gravel | Vealmoor | 25 | |
| 9 | Big Rough | Barber | 33 | 33 |
| 10 | Portable Aggr. | Strohman | | 33 |
| 11 | Strain Bros. | Mendal | | 37 |
| 13 | Border Road | Rounsaville | | 31 |
| 15 | Anderson | Carlisle | | 35 |
| 17 | Strain Bros. | IH 10 Roadcut | | 34 |
| 18 | White's Mines | Brownwood | | 27-32 |
| 19 | Gifford-Hill | Allamoore | | 36-40 |
| 20 | *Smith Estate | Sheffield | | 33 |
| 21 | *Wilson Estate | Sheffield | | 35 |
| 22 | *University of Texas | Pyote | | 35 |

*Core samples from test pits

TABLE III

| Map No. | Producer | Pit | Skid Trailer Data Placement Date | ADT | SN40 Inside Ln. | SN40 Outside Ln. |
|---|---|---|---|---|---|---|
| 1 | Trans Pecos | Hoban | 1971 | 2620 | 56 | 51 |
| | | | 1968 | 1410 | 37+ | 31+ |
| | | | 1970 | 3940 | 50 | 23* |
| 2 | Trans Pecos | Groves | 1968 | 4460 | | 46 |
| 4 | Porter & Son | Grandfalls | 1969 | 710 | | 27* |
| | | | 1967 | 390 | | 28 |
| 5 | Phipps | Grandfalls | 1971 | 2620 | | 37,39 |
| | | | 1964 | 730 | | 37 |
| | | | 1970 | 7440 | | 37 |
| | | | 1972 | 1790 | | 31 |
| | | | 1971 | 5640 | | 44 |
| 6 | Portable Aggr. | Hale | 1969 | 1630 | | 25 |
| 8 | Janes Gravel | Vealmoor | 1967 | 740 | | 28 |
| 9 | Big Rough | Barber | 1973 | 9390 | | 41 |
| 11 | Strain Bros. | Mendal | 1973 | 2640 | | 56 |
| 12 | Border Road | TXL | 1971 | 3590 | | 50 |
| 13 | Border Road | Rounsaville | 1972 | 1420 | | 56 |
| 15 | Anderson | Carlisle | 1966 | 560 | | 43 |
| 20 | Gifford-Hill | Allamoore | 1967 | 1570 | | 52 |

+ Emulsion application had been applied to this surface.
* Flushed surface

Figure 2 AGGREGATE TYPE: Crushed Rhyolite Gravel

SOURCE-LOCATION: Trans Pecos - Hoban Pit

17 miles south Pecos

PAVEMENT SITE: US 385 South Bn. Ln.

5 miles south Odessa

Ector County

SURFACE TYPE: Seal Coat

TIME OF PLACEMENT: 1971

TRAFFIC COUNT: ADT 2220(1970), 2620(1973)

SKID TRAILER DATA: Avg. 56 (Inside Ln.) Avg. 51 (Outside Ln.)

POLISH VALUE DATA: PV=35-39 (Uncrushed) PV-43 (Crushed)

Figure 3 AGGREGATE TYPE: Crushed Rhyolite

SOURCE-LOCATION: Gifford Hill-Allamoore

7 miles W. Van Horn, Hudspeth Co.

PAVEMENT SITE: US 290

1 mile W. Toyahvale

Reeves County

SURFACE TYPE: Seal Coat

TIME OF PLACEMENT: 1967

TRAFFIC COUNT: ADT 1070 (1970), 1570 (1973)

SKID TRAILER DATA: Low 49, High 56, Avg. 52

POLISH VALUE DATA: PV-36-40

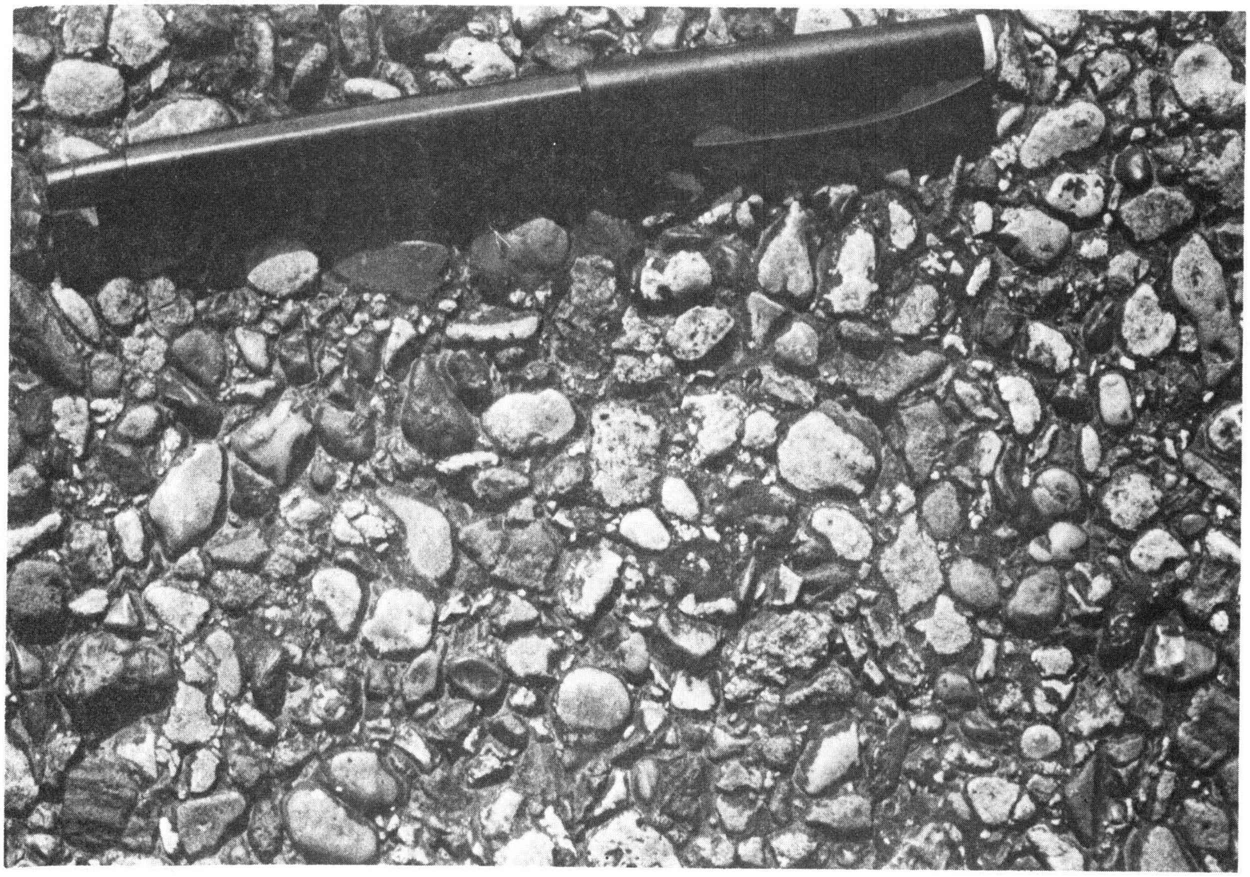


Figure 4 AGGREGATE TYPE: Siliceous and Limestone Gravel

SOURCE-LOCATION: Phipps Sand & Gravel

9 miles west Grandfalls

PAVEMENT SITE: Loop 338 East Bn. Ln.

2 miles East US 385 Intersection

5 miles North Odessa, Ector Co.

SURFACE TYPE: Surface Treatment

TIME OF PLACEMENT: 1964

TRAFFIC COUNT: ADT 470 (1970) 730 (1973)

SKID TRAILER DATA: Low 33, High 43, Avg. 37

POLISH VALUE DATA: PV=30 (Uncrushed) PV=37 (Crushed)

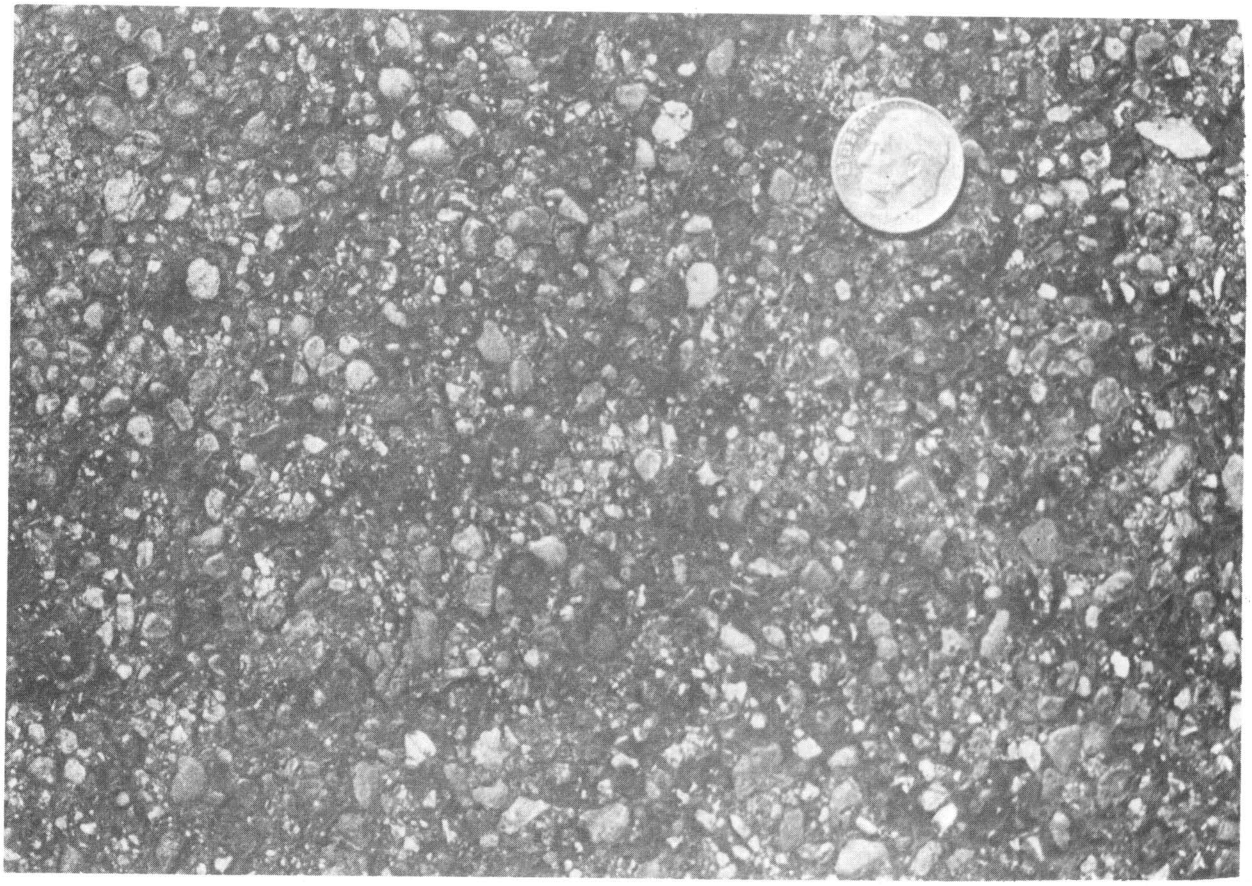


Figure 5 AGGREGATE TYPE: Siliceous and Limestone Gravel

SOURCE-LOCATION: Porter & Son Gravel

7 miles W. Grandfalls

PAVEMENT SITE: FM 1257

3 miles W. SH 349, 10 mi. W. Iraan

Pecos County

SURFACE TYPE: Surface Treatment

TIME OF PLACEMENT: 1969

TRAFFIC COUNT: ADT 620 (1970), 710 (1973)

SKID TRAILER DATA: Low 21, High 35, Avg. 28

POLISH VALUE DATA: PV-31 (Uncrushed) PV-37(Crushed)

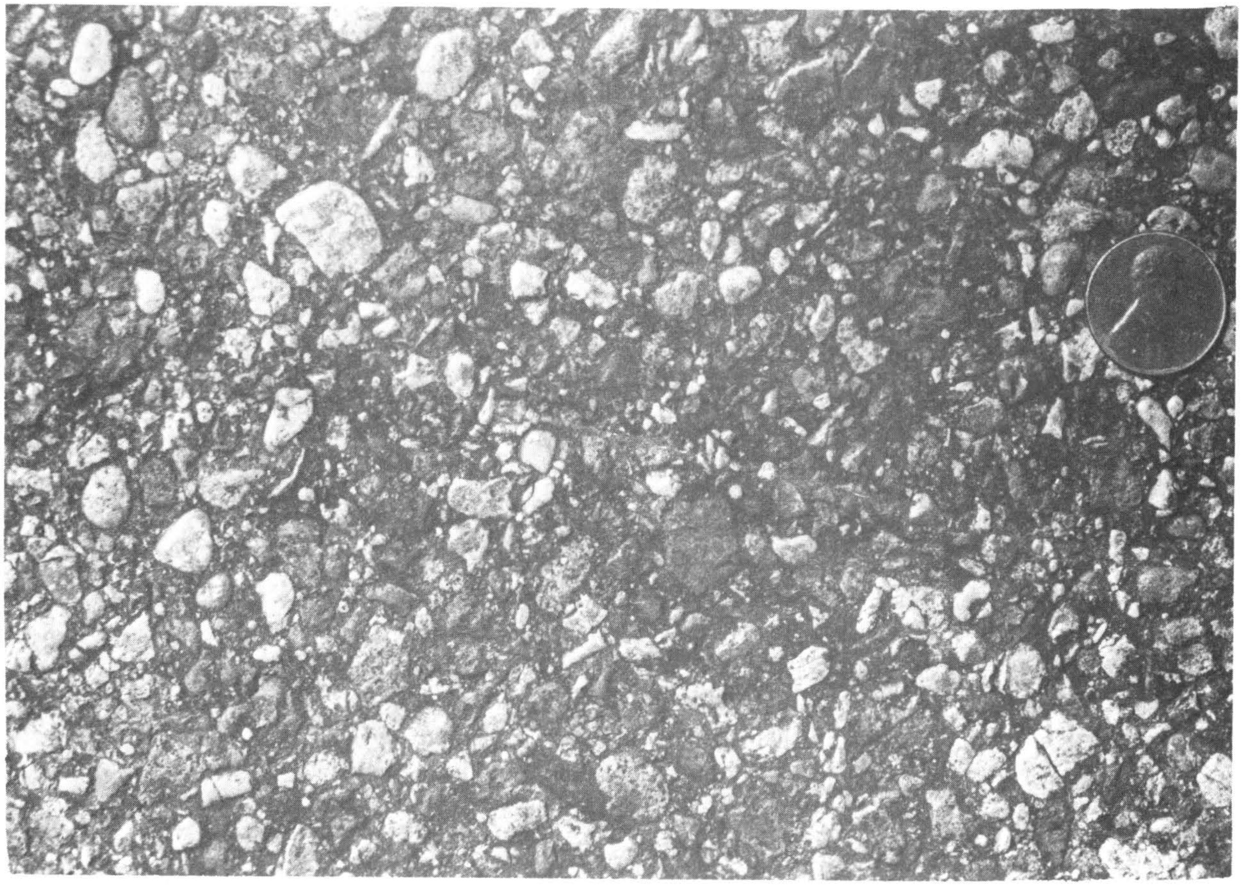


Figure 6 AGGREGATE TYPE: Rhyolite and Limestone Gravel

SOURCE-LOCATION: Trans Pecos-Groves Pit

13 miles W. Pecos, Reeves Co.

PAVEMENT SITE: IH 20

3 miles E. US 285, SE Pecos

Reeves County

SURFACE TYPE: HMAC

TIME OF PLACEMENT: 1968

TRAFFIC COUNT: ADT 3310 (1970) 4460 (1973)

SKID TRAILER DATA: Low 45, High 47, Avg. 46

POLISH VALUE DATA: PV=34

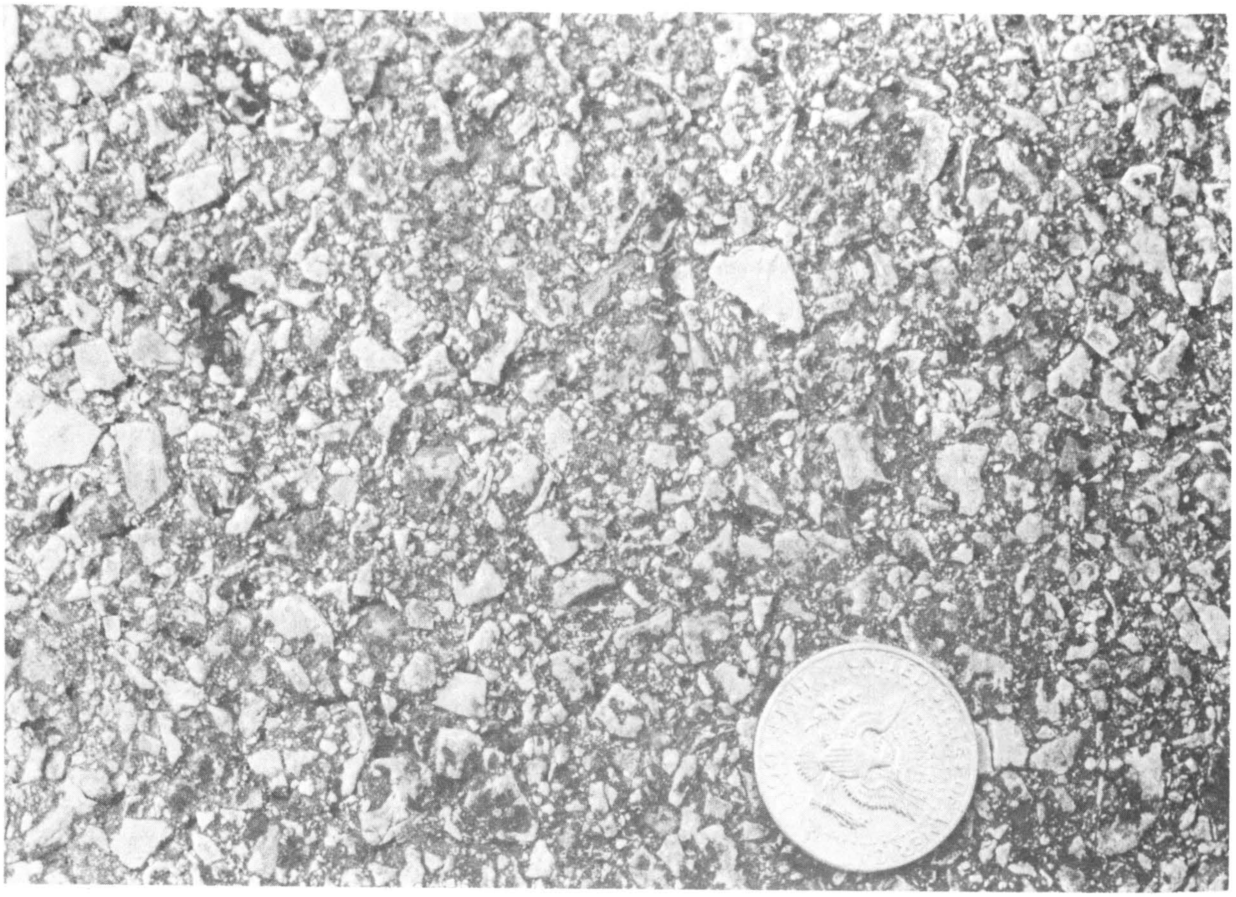


Figure 7 AGGREGATE TYPE: Crushed Limestone

SOURCE-LOCATION: Border Road-Rounsaville Pit

18 miles W. Balmorhea, Reeves Co.

PAVEMENT SITE: IH 10 East Bn.

4 miles East IH 20 Intersection

Reeves County

SURFACE TYPE: HMAC

TIME OF PLACEMENT: 1972

TRAFFIC COUNT: ADT 1420

SKID TRAILER DATA: Low 52, High 60, Avg. 56

POLISH VALUE DATA: PV=31

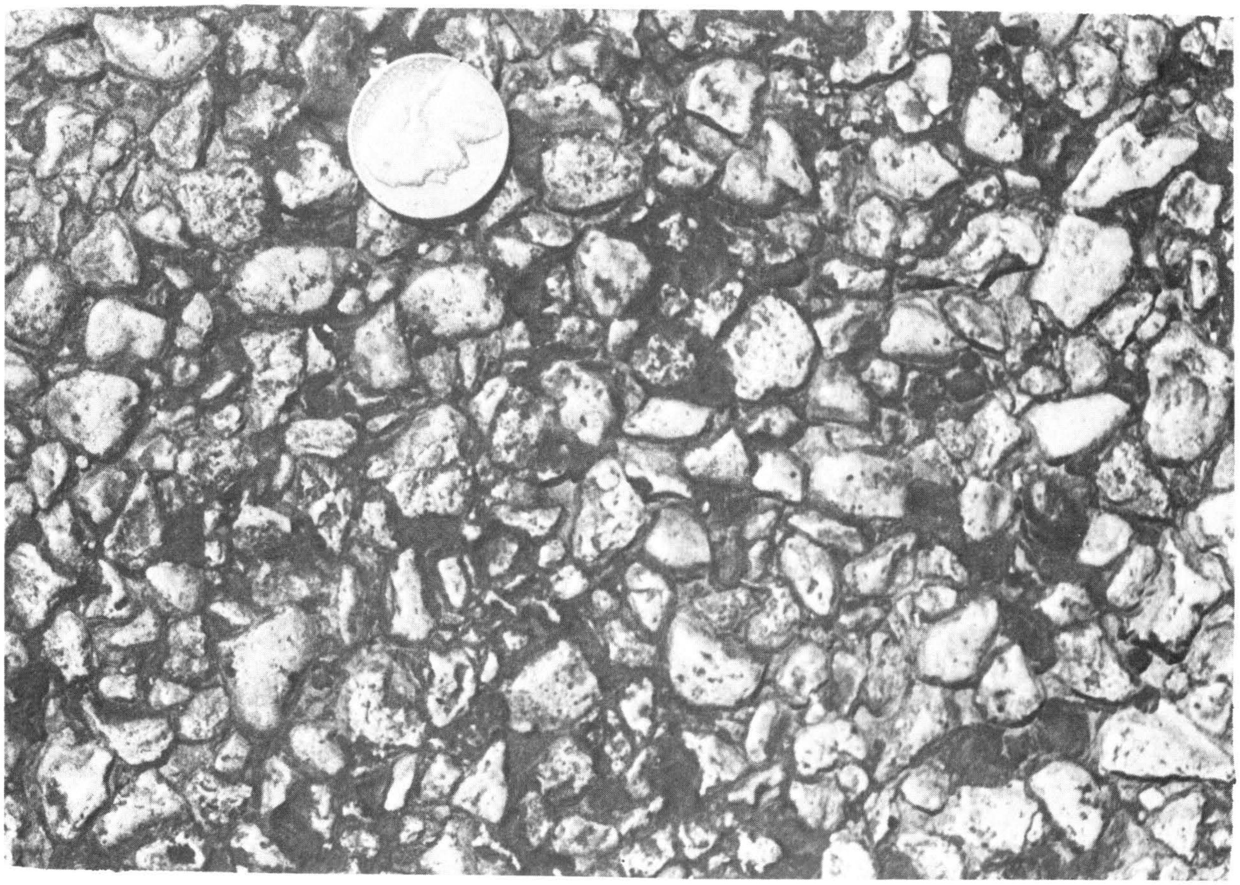


Figure 8 AGGREGATE TYPE: Limestone Gravel

SOURCE-LOCATION: Portable Aggr.-Hale Pit

1 mile East Sheffield

PAVEMENT SITE: US 290 East Bn.

10 miles East Bakersfield

Pecos County

SURFACE TYPE: Surface Treatment

TIME OF PLACEMENT: 1969

TRAFFIC COUNT: ADT 1190 (1970), 1630 (1973)

SKID TRAILER DATA: Low 23, High 27, Avg. 25

POLISH VALUE DATA: PV-29-30 (Uncrushed), PV-33 (Crushed)

Figure 9 AGGREGATE TYPE: Siliceous Gravel

SOURCE-LOCATION: Janes Gravel-Vealmoore

24 miles North Big Spring

PAVEMENT SITE: FM 87 West Bn. Ln.

2 miles West FM 1212

7 miles W. Tarzan, Martin Co.

SURFACE TYPE: Seal Coat

TIME OF PLACEMENT: 1967

TRAFFIC COUNT: ADT 610 (1970), 740 (1973)

SKID TRAILER DATA: Low 21, High 33, Avg. 28

POLISH VALUE DATA: PV-24-25

## VI. DISCUSSION

The majority of the aggregate sources considered for use in District 6 are in close proximity to Interstate Highways 10 and 20. Several represent non-commercial or contractor's sources which have been used on parts of the Interstate system either as base material or as paving aggregates. Three or four of the gravel pits along the Pecos River and its tributaries have been active commercial sources for 20-30 years or more. Innumerable small caliche and gravel pits exist in the District 6 area and many have played important roles in the construction and maintenance of the vast network of Farm-to-Market roads and State Highways. The fourteen pits, IH 10 Roadcut, three test-core pits within the boundaries of the District, in addition to the four commercial sources located in adjacent Districts, were selected for this study by District 6 personnel.

In reviewing the physical test data assembled for this study it was found that a detailed petrographic analysis provides a key to understanding the results of the other tests and probably a link to field performance. Petrographically, both the rhyolite and siliceous river gravels were found to be relatively stable chemically, showed little or no secondary alteration or weathering, exhibited low porosity and were high on the Mohs' scale of hardness (none lower than H-6). These properties strongly reflect the comparatively low abrasion and soundness values. On the other hand, it was noted during pit-site inspections and verified petrographically that the quarried limestones contained marl and shale layers. These materials also exhibited higher and wider ranges of abrasion and soundness losses. The limestone from the Wilbanks, Jones and Carlisle pits had exceptionally high loss on the $MgSO_4$ soundness test even after only four cycles. Microscopically, the rocks from these sources were found to vary widely in clay content and grain size. The Strohman source (in-depth study earlier reported, August 1972, Field Service Project #5-20-72-056) contains both thin-bedded limestones and chalk with high clay content.

Petrographic analysis also indicated that the limestones from the various sources had sand-sized insoluble residue (mainly quartz and chert) estimated to range from less than 1 to about 10 percent. This property has been found to have a significant influence on the polish-values of limestone aggregates. Limestones of relatively high purity (insoluble residue range 1-3%) tend to polish rapidly and have polish-values of 24 to about 32. Sandy limestones will range to the upper 30's in polish-value. Textures resulting from porosity and fossils can also influence the polish-values of limestones.

Note that the limestones examined for this study have only a single polish-value listed (except Brownwood). Although some limestones tested from other areas of the State have a polish-value spread of only 2-3 points, some have a 5-6 point spread. Therefore, before detailed comparative studies can be made in terms of polish-values, a much greater history of testing is needed on the District 6 limestone sources.

The polish-values for the river gravels ranged from a low of 25 for the well-rounded quartz gravel from the Vealmoore source to 39 for the rhyolite at the Hoban Pit. The polish-values measured on fully-crushed rhyolite range from 40 (for the Allamoore material) to 43. Crushed material from the Groves Pit (presently inactive) was unavailable. Only crushed material from the Weinacht Pit (rhyolite gravel) was available for testing. From the examination of stockpiled material at the Weinacht Pit, as well as from samples taken by the District for routine testing, scoria (a vesicular lava similar in origin to rhyolite) was identified. This type of material has previously been studied in detail and found to have exceptionally high polish-values (Project 3-20-71-033, October 1971).

Based on the single samples tested it appears that crushing made a significant contribution to the polish-values of the Porter and Phipps material and some improvement in the Hale Pit gravel. The limestone from the Barber Pit tested the same after crushing. Also because only a single test sample was taken from the quarried limestone sources (except Brownwood) little can be said about polish-value ranges. The test cores taken from the Smith, Wilson and University of Texas Lands were laboratory-crushed before testing for polish-value.

The problem of insufficient data also applies to the skid-trailer information. Ideally, in order to fully appreciate skid-data, multiple readings on roadways containing a specific aggregate should be taken over periods of time and/or traffic counts. A single average of a few readings on a pavement section provides only one point where several are necessary to establish a reliable curve showing the polishing behavior of a certain aggregate.

Based on very limited skid-data, but a substantial history of service behavior, the rhyolite gravel from the Hoban Pit appears to maintain potential skid-resistance through the economic life of the pavement surface both as a seal coat or HMAC. However, as found during pavement-site inspections and indicated by the skid-data presented herein, on flushed pavements the skid-resistance properties are greatly reduced. The rhyolite portion of the gravel from the Groves Pit apparently attributes to its acceptable skid-resistance. Pavement sites containing the Barstow gravel were not examined. The gravels from the Porter and Phipps sources reflect low to marginal skid-readings. However, the readings on pavements with the Phipps gravel appear to be significantly higher than those with Porter.

In general, the skid-data on the limestone material is even more inadequate to draw any hard conclusions. But if the site tested with the Hale material is indicative of what the limestones in the area will do under time and traffic, it suggests that under moderate traffic, polishing will occur. The values on the other limestones tend to be high primarily as a reflection of low number of traffic applications at time of skid-testing. Skid-readings in a couple of years may begin to show polishing trends.