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16. ABSTRACT


This report discusses a single bituminous surface treatment using an asphalt-rubber binder and pre-coated aggregate over a bleeding and cracked asphalt concrete highway.

Tests and evaluations include: a pavement condition rating, core sample descriptions, subgrade soils, pavement deflection measurements and pavement serviceability.

An asphalt-rubber single bituminous surface treatment is more than twice the cost of a standard surface treatment.

The asphalt-rubber treatment will have a three year evaluation. The roadway condition and the cost effectiveness will be evaluated at the end of that time period.


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# DISCARDED TIRES IN HIGHWAY CONSTRUCTION

using

PRECOATED AGGREGATE

KINGFISHER, OKLAHOMA

by

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Under the Supervision of:

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Oklahoma City, Oklahoma

November 1982

## EXECUTIVE SUMMARY

This report discusses the application of a single bituminous surface treatment using an asphalt-rubber binder and pre-coated aggregate over a bleeding and cracked two lane asphalt concrete highway (SH 33 east of Kingfisher, Oklahoma).

The goals of this September, 1981 treatment were to improve the performance of the roadway surface by stopping or slowing reflective cracking and the control of bleeding.

The old surface was tested and rated prior to the application of the asphalt-rubber treatment. Tests and evaluations include a pavement condition rating, core sample descriptions, subgrade soils, pavement deflection measurements and pavement serviceability.

The 4.0 miles of treatment were applied with a specially calibrated spray bar. The distributor truck was equipped with a heat source and an agitation apparatus.

The cost of the treatment is roughly twice that of the conventional surface treatment. The Kingfisher project cost $1.64/yd^2$. The results of the in-place evaluation period will give a more valid indication of the cost effectiveness of the treatment.

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# PREFACE

This constitutes an interim report of the construction procedures of Research Project 81-06-1, "Kingfisher County, Discarded Tires In Highway Construction". A study of the roadway was made to determine its condition prior to applying the surface treatment. The factors observed were climate, regional location, dominant soils, traffic and roadway history.

This project was given financial assistance by the Federal Highway Administration, Region 15 Demonstration Projects Division for construction and evaluation. It was part of the Demonstration Project No. 39 series.

Special thanks go to the Field Division IV personnel: R.L. Stringer, Division Engineer, S.C. Byers, Division Maintenance Engineer, Jim Lewis, Field Maintenance Engineer, and Jim R. Womack, Construction Superintendent.

# INTRODUCTION

The Oklahoma Department of Transportation (ODOT) has several standard operations used for treating road surface problems. Among these are the commonly used single and double bituminous surface treatments. But, these "chip seal" treatments don't always work properly. For example, free bitumen often bleeds through the new surface. Cracks from the old pavement quickly appear in the same place on the new surface and this is known as reflective cracking. These problems have led the highway industry to search for improved methods of surface treatment.

A recently developed asphalt-rubber product holds the promise of helping to control surface problems. This product involves the use of granulated tire rubber in hot asphalt cement in large proportions. The asphalt and rubber mixes to form a homogenous substance at temperatures exceeding 400$^{o}$F (222$^{o}$C). The hot substance is then diluted to a sprayable state that is applied to the roadway by a well regulated spraybar.[1]

Asphalt-rubber was first introducted to Oklahoma's roadway system in the late 1970's.[2] This project pioneered the path for further experimental projects on ODOT highways.

The first project had its problems. This project lost 80 percent of all the cover aggregate five months after construction. The aggregates were extremely dusty, which probably nullified some of the adhesive properties of the asphalt-rubber binder.

Since then, the asphalt-rubber manufacturers have made several improvements in their recommended methods of application. One major improvement concerns the use of pre-coated aggregates to control dust and adhesion problems. Equipment, technical skill, and knowledge in the area of mixing and application of asphalt-rubber have also been considerably advanced.

Division Four (Perry, Oklahoma) Engineers, coordinated with Research and Development Engineers to apply the second asphalt-rubber bituminous surface treatment on a highway that exhibited several surface condition problems. The 3.7 miles (6.0 km) of roadway chosen for treatment were located just east of the city of Kingfisher on State Highway 33. Most of this road showed signs of fatigue. It exhibited random block and alligator cracking with a one-half (0.8 km) mile section having a serious bleeding problem. Also, an occasional base failure was evident. Most have been repaired. See Figure 1 for an illustration of the surface problems.

A contract was awarded to Sahuaro Petroleum and Asphalt Company of Phoenix, Arizona, to work in conjunction with the Division Four maintenance crew to repair the roadway. Sahuaro developed a design formula after preliminary testing was done on the characteristics of the asphalt cement using the Rostler parameter[3]. They also supplied the special equipment needed to mix and apply the asphalt-rubber binder to the roadway surface.

Figure 1A. The cracked condition of the surface prior to the Asphalt-Rubber treatment.


Figure 1B. The flushed condition of the surface prior to Asphalt-Rubber treatment.

Construction started during mid-September of 1981 and the asphalt-rubber treatment was completed in two working days. Equipment and construction methods are described in this report.

## BACKGROUND

This project lies on State Highway 33 in Kingfisher County, Oklahoma. It begins at the east edge of Uncle John's Creek in the city of Kingfisher and extends eastward for 3.7 mi (6.0 km). The roadway is 22 ft (6.7 m) wide and rests on a 36 ft (11 m) wide subbase.

Kingfisher County is located in the central part of the state. It is situated in the eastern sector of the main wheat growing area in Oklahoma. Today, the county is in the middle of an oil boom with Kingfisher being the hub of heavy oil field traffic.

## HISTORY

State Highway 33 from Kingfisher, Oklahoma to the Kingfisher-Logan County line has the following construction history:

1935 The first construction contract was a one mile (1.6 km) section, 36 feet (11 m) wide and 2 inches (50 mm) thick, of a gravel surface base.

1936 State forces realigned the roadway and a gravel surface 36 feet (11 m) wide and 2 inches (50 mm) thick was laid in two contracts totaling 13.77 miles (22.16 km) eastward to the Logan County line.

1939 A contract was awarded for a 22 ft (6.7 m) wide Traffic Bound Surface Course (TBSC) and a bitumen type treatment, for 7 miles (11.3 km). An additional contract was awarded for the remaining 7.77 miles (12.5 km) eastward to the Logan County line.

1949 An asphalt concrete surface was placed in two contracts with a 22 foot (6.7 m) wide and 3 inch (76 mm) thick pavement for 14.7 miles (23.7 km) starting at the Logan County line, and continuing westward. For the remaining 0.07 miles (0.11 km) ending at the Kingfisher city limits, a TBSC was laid.

1965 State forces applied 2 inches (50 mm) of asphalt concrete overlay starting at the Kingfisher city limits eastward for 7 miles (11.3 km).

1976 State forces applied a Type II Slurry Seal. It started at the Kingfisher city limits and extended eastward 6 miles (8.4 km).

1981 State forces along with Sahuaro Petroleum and Asphalt Company applied a 3.0 mile (4.8 km) experimental asphalt-rubber seal coat. A connecting 1.0 mile (1.6 km) was treated with an asphalt-rubber seal coat using non-coated aggregate.

# CLIMATE

Weather records at Kingfisher's weather station reveal an average annual rainfall of 29.5 inches (750 mm) with May and June being the highest rainfall months. Humidity averages about 57 percent. In the five year period between 1976 and 1981 the summer season's highest temperature was 111°F (44°C) and the winter season's lowest temperature was -6°F (-21°C). The maximum frost penetration depth is 20 inches (510 mm). Oklahoma's central weather station in nearby Oklahoma City, recorded ninety freeze thaw cycles in 1980[4].

# GEOLOGY

The project lies in the Central Redbed Plains of the nearly level mid-continental sedimentary geologic strata. The tilt of the geologic strata is southwestward at about 15-30 ft (5-10 m) per mile.

The Cedar Hills, Hennessey and Alluvium geologic strata underlie the project. The Cedar Hills unit consists of predominantly reddish-brown silty, blocky shale and some massive, orange, silty-sandstone and siltstone beds. A massive, orange, fine-grained sandstone about three feet (1 m) thick, which weathers to a dark red and forms vertical cliffs along creeks, marks the base of the unit. The top of the unit is a greenish-gray siltstone bed about sixteen inches (400 mm) thick which serves as a good marker bed. The unit has a maximum thickness of an estimated 190 to 200 feet (58 to 61 m).

Topographically, the unit forms gently rolling hills. The base of the unit generally forms a gently rolling hill with a fair amount of relief which overlooks the underlying Hennessey unit. The slightly more rugged topography of the unit helps distinguish it from the underlying Hennessey and overlying Flowerpot units which are typically more flat lying.

The Hennessey unit consists of red platy to blocky clay shales and mudstone. The mudstones are hard and appear blocky. The red clay shale of the Hennessey unit is characterized by numerous bands or streaks of white or light green color ranging from a few inches to four feet in thickness. The total thickness of the unit is about 400 feet (120 m).

Topographically, the unit is nearly level to gently rolling and is generally grass covered or cultivated.

There is only a 0.5 mile (0.80 km) strip along the project of the Alluvium unit. Here, alluvium consists of deposits of sand, silt, clay, gravel, or combinations of these materials. Alluvium is found along the flood plains (bottom land) of streams and is normally present at places along all streams.[5]

The Cedar Hills and Hennessey rock strata are predominantly soft and poorly indurated shale. This situation produces the gently rolling to nearly level landscape. The roadway grades are gentle, less than 3 percent, with only occasional areas where poor drainage has caused a soft subgrade problem.

# SOILS

Nineteen different soil types underlie SH-33 between the city of Kingfisher eastward to the Logan County line. Seven of those are located in the asphalt-rubber section. The dominant soil on the project is the Kingfisher soil series. A description of two Kingfisher soil types underlying the project are as follows:

> Kingfisher silt loam has a 3 to 5 percent slope. Severe erosion will occur if it is not protected. It has a deep silt loam topsoil with compact clay subsoil. It underlies 70 percent of the project.
>
> Kingfisher silt loam has a 1 to 3 percent slope. It is similar to the soil described above but with a lesser slope. It lies on the upland areas and on the divides of watersheds. It underlies 10 percent of the project.

The other minor soil units located underneath the roadway include the Kingfisher-Lucien, Port silt loam, Alluvial and broken land, Bethany silt loam, and Renfrow clay loam.[6]

These soils are not known to possess properties that cause roadway problems. Generally the silty clay loam subsoils do not have enough clay to cause severe shrink-swell or drainage problems.

# TRAFFIC

The average daily traffic count is 3,670 vehicles with 11.9 percent of those being heavy trucks and 5.8 percent being light trucks. Traffic in the wheat belt has its share of farm equipment loads. This area of Oklahoma is currently receiving additional truck traffic from oil-field activity.

This traffic information was compiled by the ODOT Traffic Studies Branch. It was a one time sample taken in December, 1981 about two months after completion of the project.

## PRE-EXISTING ROADWAY

Approval, was given to the project work plan on May 27, 1981. The Research and Development Division of ODOT started the collection of data from the preliminary surveys and tests of the roadway on June 3, 1981. The results of the tests are compiled in the Appendix.

The rideability of the surface was the first characteristic measured. Oklahoma's ride meter consists of a two wheel, suspension mounted trailer. The trailer has a transducer mounted on the axle. When the suspension system moves, the transducer sends a signal to a chart recorder. The chart provides information on inches of roughness per mile.

A new, high quality bituminous road will produce roughness values in the range of 90 to 100 inches (2290 to 2540 mm) per mile. State Highway 33 from Kingfisher extending eastward for 4 miles (6.4 km) gave an average reading of 168 inches (4270 mm) per mile. This is considered to be a roadway surface of average ride quality.

A detailed crack survey was made in six randomly selected 200 ft (61 m) sections within the treated area. Control sections were established outside of the asphalt-rubber treatment area for comparison. A time schedule was established covering a three year period. Each section will be inspected annually to determine the type of cracks, if any, that are present in the surface. The typical patterns on the pre-existing surface were block and alligator cracking.[7]

Core samples were extracted from the road. They were approximately 10 inches (25 mm) in length. A description is given in the Appendix.

Soil samples were taken from the roadbed at the core locations, and sent to the ODOT Materials Division for analysis. The soil was tested for gradation, liquid limit, plasticity index, and particle sizes. The tests indicated the material to be suitable for roadway subbase.

Deflection tests using a Benkelman beam and rut depth measurements rounded out the preliminary study. Measurements were taken every 0.2 mile (0.32 km). Rut depths indicated a small amount of level patching was needed. The deflection measurements indicated that the roadway had adequate load supporting ability, with the only major maintenance needed being a surface treatment.

## MATERIALS

The basic formulation of asphalt-rubber binder has stabilized over the past decade. Sahuaro's granulated-crumb rubber contains a minimum of 80 percent vulcanized rubber produced by the grinding of vehicle tires mixed with 20 percent of unknown granulated crumb rubber. The ground rubber is packaged in 60 lb (27 kg) bags. The rubber portion of the binder is 25 percent by weight. See Table 1 for granulated rubber types.

TABLE 1

Granulated Rubber Types

| Sieve Sizes | Percent Passing Type I | Type II | Type III |
|---|---|---|---|
| No. 8 (2.36 mm) | 100 | -- | -- |
| No. 10 (2.00 mm) | 95-100 | -- | -- |
| No. 16 (1.18 mm) | -- | 100 | 100 |
| No. 30 (0.600 mm) | 0-10 | 60-90 | 95-100 |
| No. 50 (0.300 mm) | 0- 5 | 0-20 | 30- 60 |
| No. 80 (0.180 mm) | -- | 0- 5 | 15- 35 |
| No. 200 (0.075 mm) | -- | -- | 0- 10 |

An 85-100 penetration grade asphalt was selected by Sahuaro. Total Petroleum Company supplied the asphalt from their refinery at Ardmore, Oklahoma.

A diluent, kerosene, was added to the composition at 4.8 percent by weight of the total asphalt-rubber binder. The diluent was stored in two holding tanks.

TABLE 2

Aggregate Gradations

| Sieve Size(mm) | Percent Passing No. 3 Aggregates |
|---|---|
| 3/4 in (19.0) | -- |
| 5/8 in. (16.0) | 100 |
| 1/2 in. (12.5) | 90-100 |
| 3/8 in. (9.5) | 40- 75 |
| No. 4 (4.75) | 0- 15 |
| No. 8 (2.36) | 0- 5 |
| No. 200 (0.075) | 0- 2 |

Number 3 cover aggregates were specified. See Table 2 for aggregate gradations. They were pre-coated with MC-800, a cutback asphalt, in a drum dryer by Cummins Construction Company of Enid, Oklahoma. The first 100 tons (91 metric tons) were coated at 0.70 percent by weight of untreated aggregate. The film produced at this rate was too thick and caused a fusing of the aggregates in the stockpile. The fusing of the aggregates would prevent a proper flow through the chip spreader. The coating rate was reduced to a more acceptable 0.40 percent for the remaining 700 tons (635 metric tons).[8] The lower rate produced a satisfactory film thickness. See Table 3 for materials used on the Kingfisher project.

TABLE 3

Materials Used on Kingfisher Project

| Materials | Quantities |
|---|---|
| AC-3A (85-100 penetration) | 79.7 tons (72.3 metric tons) |
| Emulsion (SS-1) | 750 gallons (2839 liters) |
| Granulated Crumb Rubber | 27.2 tons (24.7 metric tons) |
| Diluent (Kerosene) | 1,605 gallons (6075 liters) |
| Precoated Aggregate | 800 tons (726 metric tons) |
| Non-coated Aggregate | 267 tons (242.2 metric tons) |
| MC-800 Cutback Asphalt | 3.5 tons (3.2 metric tons) |

# CONSTRUCTION

One week prior to the asphalt-rubber "chip seal" construction at Kingfisher, Division Four's maintenance forces placed a leveling course of hot mix patching material on the roadway.

By September 16, 1981, all the equipment and material were mobilized on the job site. On the day of application, Sahuaro's heat tank was filled with 85-100 penetration grade asphalt. See Figure 2 for storage of liquid asphalt. It was connected to the mechanical blender that has an upper storage silo for the rubber and a lower mixing tank. Two diluent holding tanks were placed adjacent to the blending machine. Three specially modified distributor trucks with internal mixing paddles and furnace heaters were used.

ODOT Division Four provided the chip spreader, dump trucks, power broom, steel wheel and pneumatic rollers, and a distributor truck used in applying a tack coat. See Table 4 for equipment used on the Kingfisher project.

The pre-coated aggregate was stockpiled at the end of the construction site. The pallets of bagged crumb rubber were conveniently located near the blender.

For the next two days, construction proceeded as planned. The sky was clear with morning temperatures in the low 60's$^{O}$F (15$^{O}$C) and evening temperatures in the mid 70's$^{O}$F (21$^{O}$C).

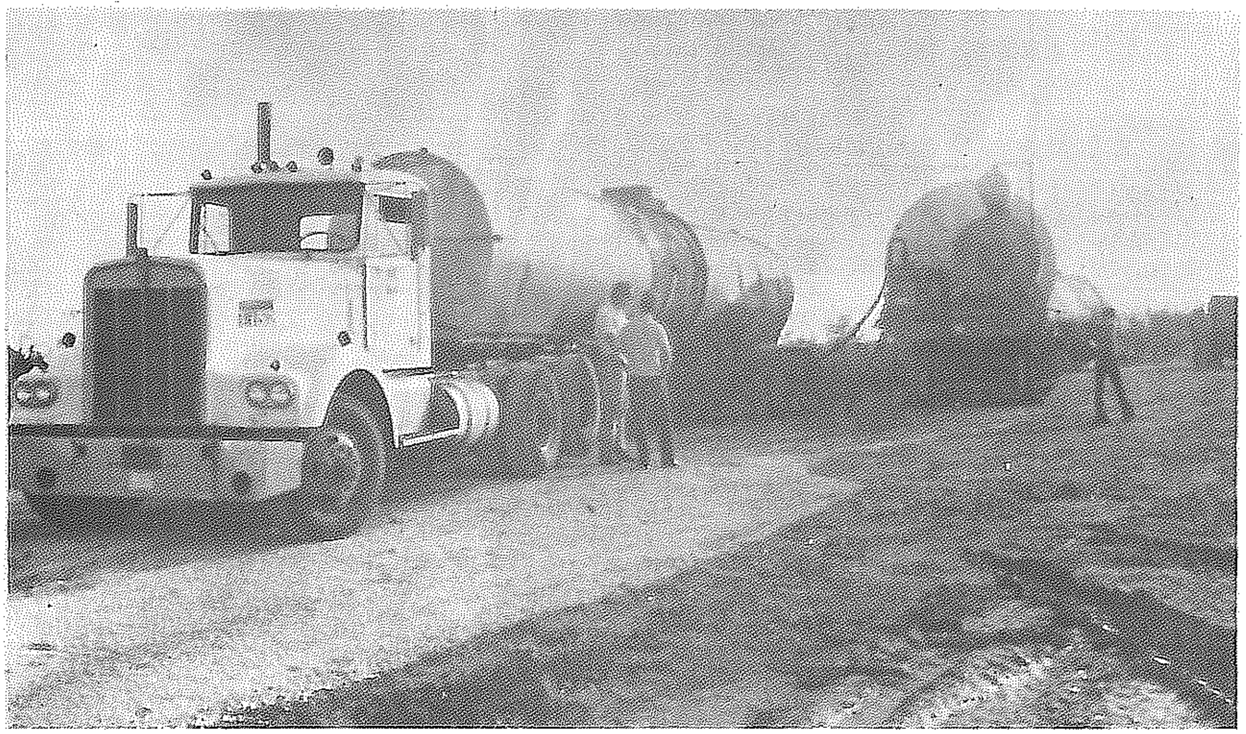

Figure 2. Filling the Asphalt Heat Tank with 85-100 per asphalt.

Figure 3. The blending of asphalt and rubber.

Pallets of bagged ground rubber were fork lifted to the front of the blending machine. There, the bags were broken and the granulated crumb rubber particles were conveyed to the storage silo atop the blending machine. The heated asphalt was pumped to the bottom of the blending machine and from there into the mixing tank. Then a specific quantity of rubber was fed into the mixing tank and blended with the asphalt for approximately one and one-half minutes at 425$^{O}$F (218$^{O}$C). The mixture was then pumped to the modified distributor truck that was connected to the blending machine. See Figure 3 for blending of asphalt and rubber.

One at a time, the specially modified distributor trucks were filled to their recommended capacity. Then they were disconnected and moved alongside the diluent tanks. The diluent, kerosene, was added to the mixture in the distributor tank to make the asphalt-rubber binder less viscous. The final mixture was agitated in the tank for a mininum of 45 minutes before being applied to the roadway surface.

Sahuaro took a one gallon (3.8 liter) container and duplicated the design mixture as in the distributor truck tank. A hand viscosity meter was used on the design mixture as a final check before disconnection. See Figure 4 for Viscosity Instrument.

Traffic control consisted of several standard warning and road construction signs at both ends of the project. Two flagmen were spaced approximately one-half mile (0.8 km) apart,

Figure 4. Final check with the hand Viscosity Instrument.

Figure 5. Loading the dump trucks with pre-coated aggregate.

each equipped with a walky-talky and a sign that indicated "stop or slow". One lane of the highway was kept open at all times.

While the traffic control was being set, the dump truck was being loaded with pre-coated aggregate. See Figure 5 for aggregate loading. Traffic control allowed enough time (about 15 minutes) for the tack coat to be applied to the roadway and to set. The tack was 1 part emulsion and 3 parts water and was applied at a rate of 0.1 gallons/yd$^2$ (0.45 l/m$^2$).[9]

TABLE 4

Equipment Used on the Kingfisher Project

| Quantity | Equipment | Supplier |
|---|---|---|
| 1 | Asphalt Heat Tank-18,000 gals (68,130 l) | Sahuaro |
| 1 | Asphalt-Rubber Mechanical Blender | Sahuaro |
| 3 | Modified Distributor Trucks 3,500 gals (13,248 l) | Sahuaro |
| 1 | Fork Lift | Sahuaro |
| 1 | Hand Viscosity Meter | Sahuaro |
| 1 | Holding Tank - 1,200 gals (4,542 l) | Sahuaro |
| 1 | Holding Tank - 800 gals (3,028 l) | Sahuaro |
| 1 | Distributor Truck | ODOT |
| 1 | Front End Loader | ODOT |
| 6 | Dump Trucks | ODOT |
| 2 | 9-Wheel Pneumatic Rollers | ODOT |
| 1 | Static Steel Wheel Rollers 5-8 ton (4.5 to 7.3 metric ton) | ODOT |
| 1 | Static Steel Wheel Roller 8-12 ton (7.3 to 10.9 metric ton) | ODOT |
| 1 | Self-propelled Chip Spreader | ODOT |
| 1 | Power Broom | ODOT |

All the necessary equipment moved into place after the tack coat had set. See Figure 6 for the arrangement of the chip sealing equipment. The "chip seal" operation began.

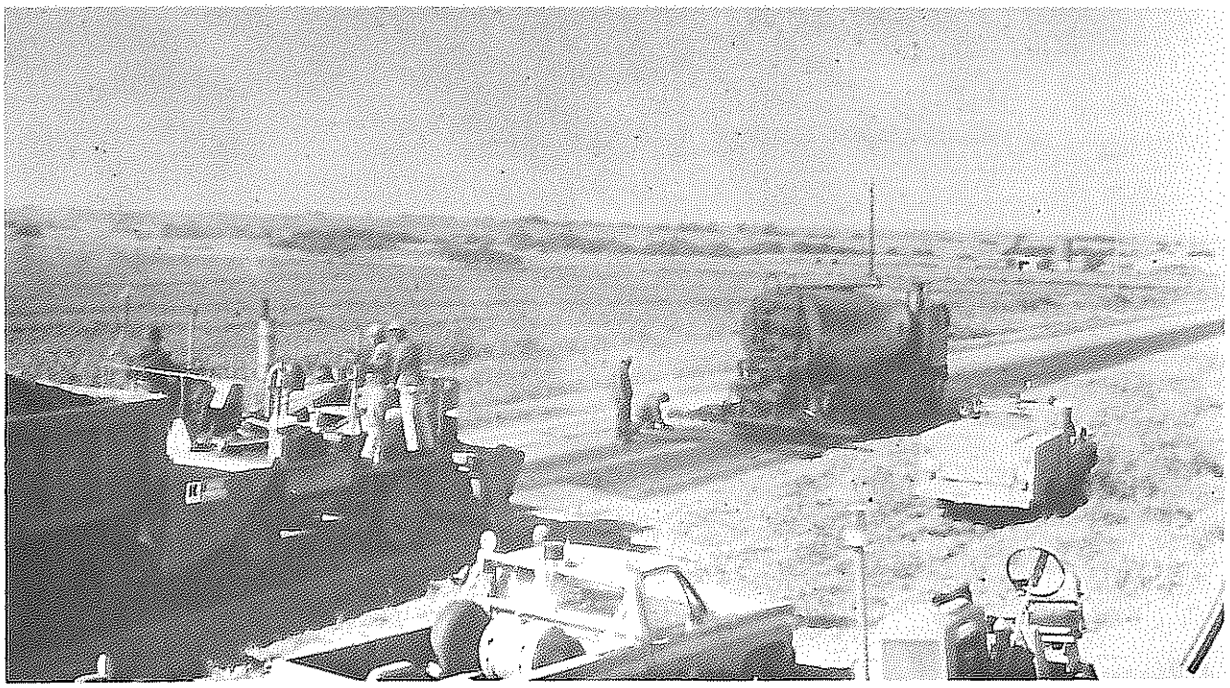

Figure 6. The arrangement of the chip sealing equipment on the roadway.

Figure 7. The application of asphalt-rubber by the modified distributor.

The specially modified distributor applied 0.54 gal/yd$^2$ (0.24 l/m$^2$) of asphalt-rubber on the roadway for about 200 yd. (183 m). See Figure 7 for application of asphalt-rubber. The application rate was regulated from a control panel in the cab. See Figure 8 for panel control. The chip spreader was filled by a dump truck. The spreader would travel behind the distributor as closely as possible, releasing 40 lbs/yd$^2$ (22 kg/m$^2$) of the aggregate. See Figure 9 for the placing of aggregate. Two, nine wheel pneumatic rollers would make two passes and the two static steel wheel rollers 5-8 ton and 8-12 ton (4.5 to 7.3 and 7.3 to 10.9 metric ton) would perform the final rolling. See Figure 10 for rolling procedures. Traffic would then be held off of the new surface for a minimum of 10 minutes.

By the end of the second day with three miles completed, the pre-coated aggregate was exhausted. The remaining tonnage of asphalt-rubber binder was "chipped" with washed, non-coated aggregate that covered one full width mile. See Figure 11 for new Asphalt-Rubber surface.

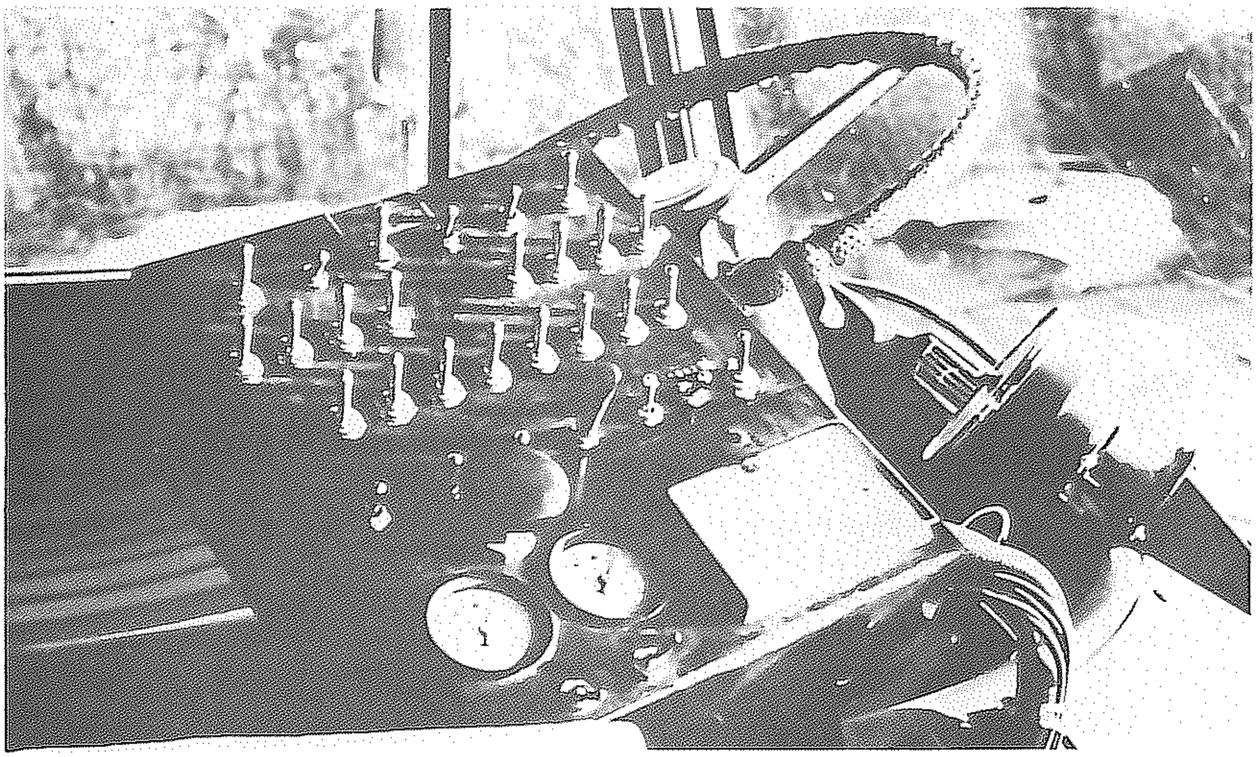

Figure 8. The control panel in the modified distributor truck.

Figure 9. Placing of aggregate with the Chip Spreader.

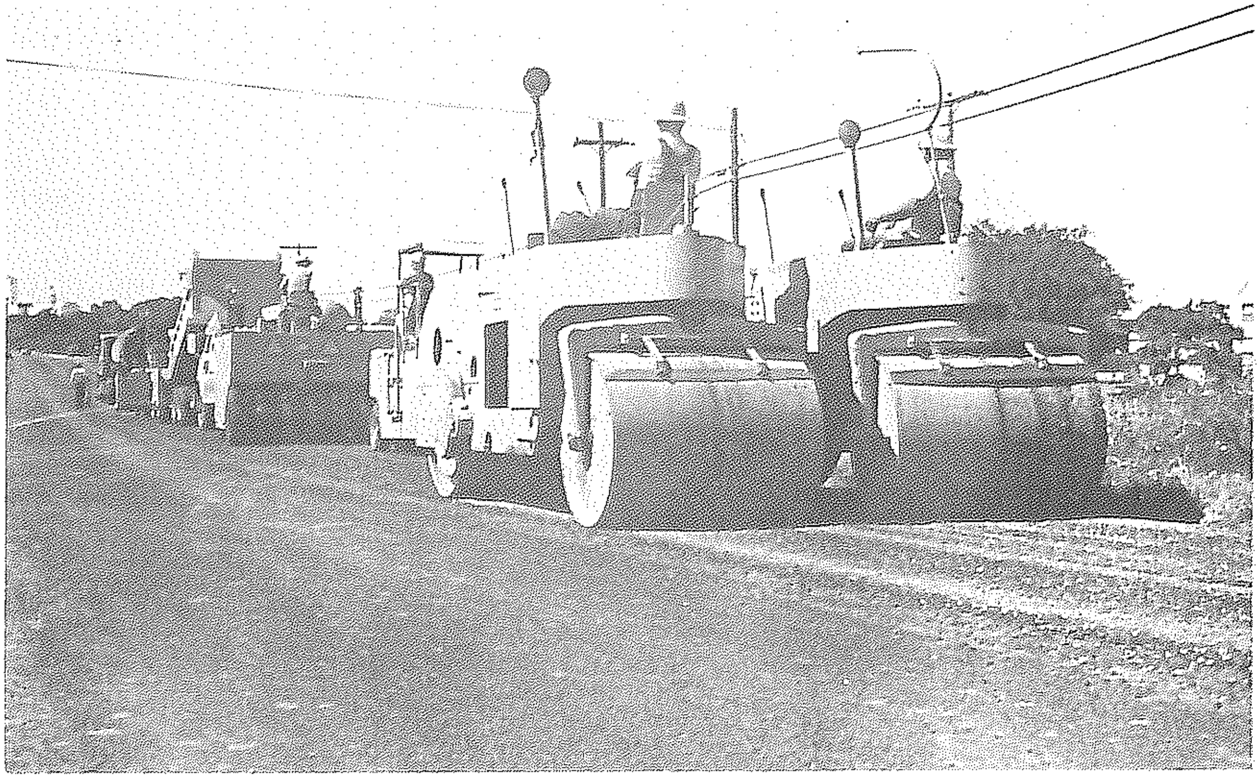

Figure 10. The rolling procedure required for proper aggregate embedment.

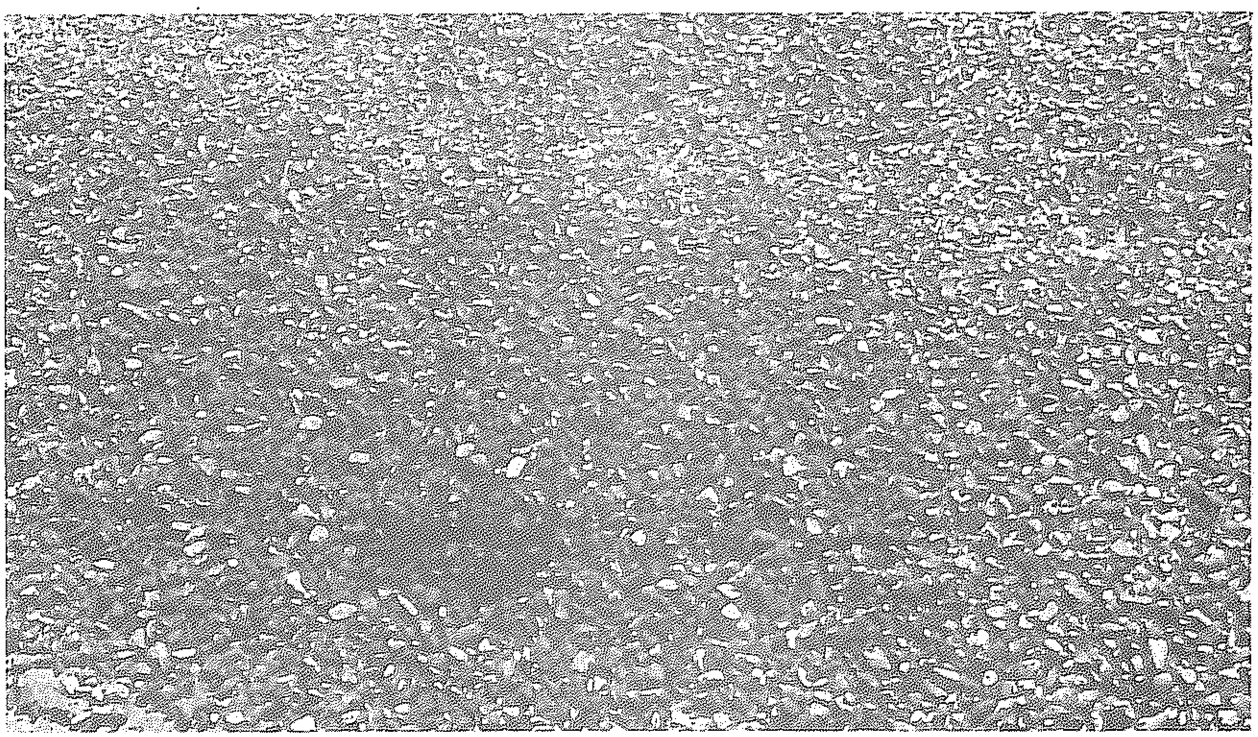

Figure 11. A new asphalt-rubber surface.

## COST ESTIMATES

A single bituminous surface using an emulsion binder costs approximately \$.73 per $yd^2$*. This is the most commonly used surface treatment in ODOT's Maintenance Divisions.

The Kingfisher project asphalt-rubber surface treatment cost approximately \$1.64 per $yd^2$*. The project used both a pre-coated and non-coated aggregate.

Table 5 gives a complete list of materials available for both an emulsion and an asphalt-rubber "chip seal".

*Note: All prices are based on bids in 1981, including Table 5.

TABLE 5

Surface Treatment Cost Comparison and Summary

| Type of Material | Quantity (tons) | FOB Costs/Ton | Total Cost | Cost/$yd^2$ |
|---|---|---|---|---|
| A-R Binder | 112 | $515.00 | $57,834 | $1.12 |
| A-R Binder[1] | - | 400.00 | - | .87 |
| Emulsion Binder (SS-1) | - | 177.00 | - | .24 |
| Pre-coated Aggregate | 800 | 22.00 | 17,600 | .45 |
| Non-coated Aggregate[4] | 267 | 11.40 | 3,043 | .24 |
| Non-coated Aggregate[2] | - | 15.00 | - | .24 |

[1]Lowest recent bid price, Spring 1982 for large quantities.
[2]Average cost of aggregate estimated from previous projects.

Estimated Cost of Surface Treatments ($yd^2$)

| Materials/Labor | Kingfisher Project | A-R @ $515 | A-R @ $400 | Emulsion Project |
|---|---|---|---|---|
| Binder | $1.00 | $1.12 | $ .77 | $ .24 |
| Aggregate | .39[3] | .45 | .45 | .24 |
| ODOT's Labor[4] | .25 | .25 | .25 | .25 |
| Total | $1.64 | $1.82 | $1.47 | $ .73 |

[3]Cost includes 79% pre-coated aggregate and 21% non-coated aggregate.
[4]Estimation based on Field Maintenance Engineer's calculation.

Note: Cost for one inch of Type "C" dense graded AC overlay = $1.15 $yd^2$ (1980).

# CONCLUSION

The construction of an asphalt-rubber surface treatment, "chip seal", is very similar to a standard bituminous surface treatment. The differences lie in the amount of additional time, and the special equipment and materials utilized for a project. These special needs require a larger construction site and some additional planning of traffic control.

The time it takes to mix the asphalt-rubber binder and start the project is approximately four hours. The binder material can be continuously mixed if enough distributors are available. The Kingfisher project was appropriate for a continuous application operation.

The premature exhaustion of the pre-coated aggregate was the only significant problem that arose. The aggregate's application was calculated at the maximum rate as in a standard "chip seal" operation. This rate proved to be too low because of the increased application rate and greater film thickness of the asphalt-rubber binder material.

## RECOMMENDATION

The dust free pre-coated aggregate is a vital material in Sahuaro Petroleum & Asphalt Company's asphalt-rubber surface treatment operation. The application of aggregate should be approximately 5 lb/yd$^2$ (2.7 kg/m$^2$) greater than the standard surface treatment which is usually 35 lb/yd$^2$ (18.9 kg/m$^2$) of No. 3 aggregate.

Asphalt-rubber surface treatments are essentially as easy to apply as the standard treatment and more effective, provided <u>clean</u> aggregates are used. Pre-coated aggregates can assure a dust free adhesion for bonding. Dust causes a bonding problem between the aggregate and asphalt-rubber binder.

Asphalt-rubber has proved to be an effective surface treatment through its elimination of the roadway defects. The cost effectiveness will be reviewed at the end of the three year period.

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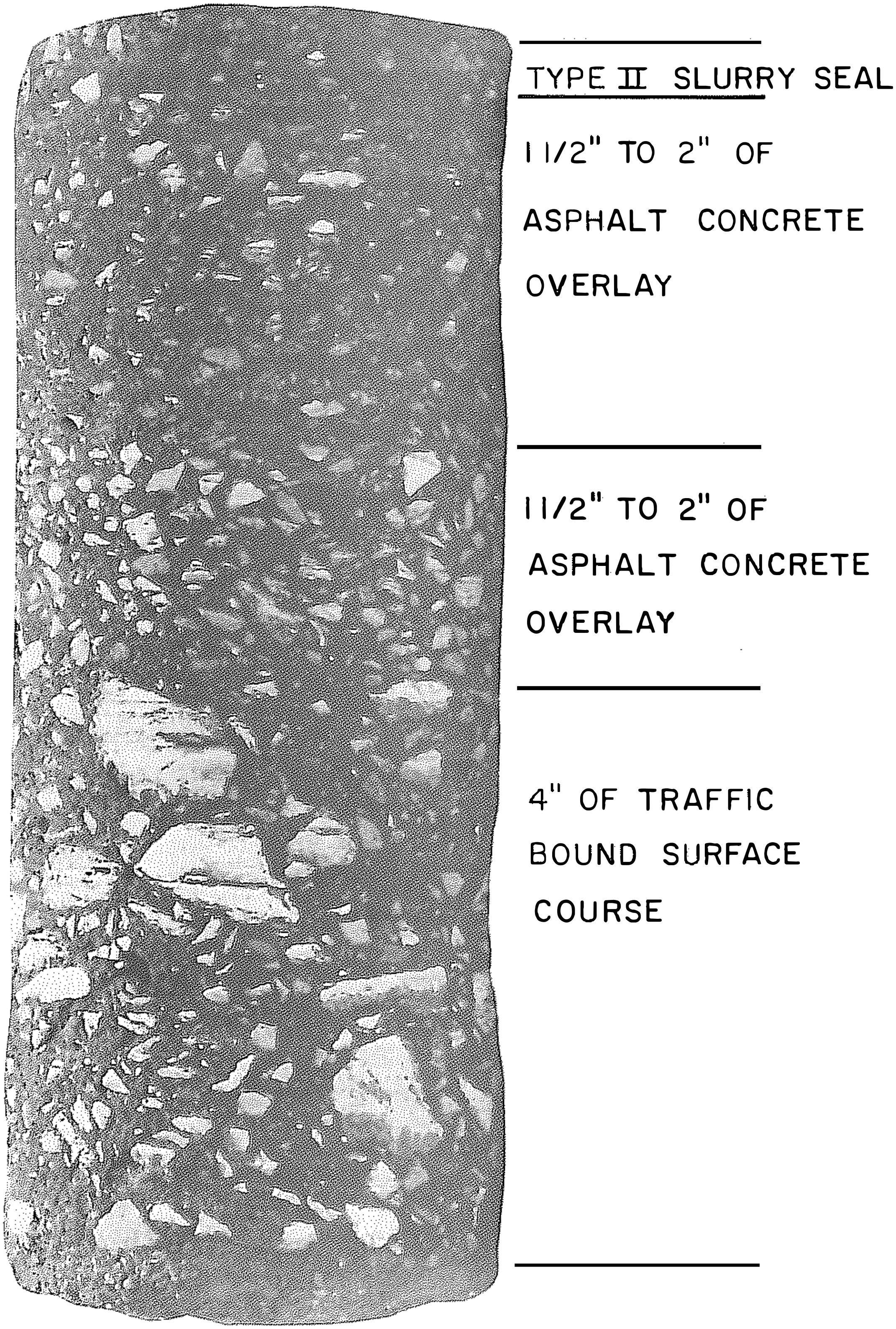
APPENDIX

# TYPICAL ASPHALT CORE



CONDITION RATING
FOR
FLEXIBLE PAVEMENTS

DATE: June 3, 1981

LOCATION: SH-33 - Begginning at Uncle Johns Creek, estending eastward of Kingfisher

LENGTH: 7 miles   MILES SURVEYED BY: Pourkhosrow, Brewer

| Condition Rating | I Cracking | II Surface Roughness | III Distortion | IV Ravelling | V Base Failure |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | 1 | 1 | | | |
| 3 | 2 | 2 | 1 | 1 | |
| 4 | 3 | 3 | 2 | 2 | 1 |
| 5 | 4 | 4 | 3 | 3 | 2-3 |
| 6 | 4 | 4 | 4 | 4 | 4 |

1 = less than 5%
2 = 5% to 15%
3 = 15% to 30%
4 = more than 30

| Mileage Location | Condition Rating | I | II | III | IV | V | % Condition Rating | Beam Deflection | S.W.L. | Rut Depth | S. F. Patching |
|---|---|---|---|---|---|---|---|---|---|---|---|
| .2 | 5 | 3 | 2 | 3 | 1 | 2 | 64 | | | | |
| .4 | 5 | 4 | 1 | 2 | 1 | - | 60 | | | | |
| .6 | 5 | 4 | 1 | 2 | 1 | - | 60 | | | | |
| .8 | 4 | 4 | 1 | 1 | - | - | 65 | | | | |
| 1.0 | 4 | 4 | 1 | 1 | - | - | 65 | | | | |
| 1.2 | 4 | 1 | 2 | 2 | - | - | 65 | | | | |
| 1.4 | 4 | 1 | 2 | 2 | - | - | 65 | | | | |
| 1.6 | 4 | 1 | 2 | 2 | - | - | 65 | | | | |
| 1.8 | 4 | 2 | 2 | 2 | - | - | 65 | | | | |
| 2.0 | 3 | 3 | 1 | 1 | 1 | - | 80 | | | | |
| 2.2 | 3 | 2 | 1 | 1 | 1 | - | 85 | | | | |
| 2.4 | 3 | 3 | 1 | 1 | 1 | - | 80 | | | | |
| 2.6 | 4 | 3 | 1 | 1 | 1 | - | 78 | | | | |
| 2.8 | 4 | 3 | 1 | 1 | 1 | - | 78 | | | | |
| 3.0 | 4 | 2 | 1 | 1 | 1 | - | 78 | | | | |

Note: 100% rating is a new and very smooth roadway with no flaws.

CONDITION RATING
FOR
FLEXIBLE PAVEMENTS

DATE: June 3, 1981

LOCATION: SH-33

LENGTH: 7 miles MILES SURVEYED BY:

| Condition Rating | I Cracking | II Surface Roughness | III Distortion | IV Ravelling | V Base Failure |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | 1 | 1 | | | |
| 3 | 2 | 2 | 1 | 1 | |
| 4 | 3 | 3 | 2 | 2 | 1 |
| 5 | 4 | 4 | 3 | 3 | 2-3 |
| 6 | 4 | 4 | 4 | 4 | 4 |

1 = less than 5%
2 = 5% to 15%
3 = 15% to 30%
4 = more than 30%

| Mileage Location | Condition Rating | I | II | III | IV | V | % Condition Rating | Beam Deflection | S.W.L. | Rut Depth | S. F. Patching |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.2 | 3 | 3 | 1 | 1 | 1 | - | 80 | | | | |
| 3.4 | 4 | 3 | 2 | 1 | 1 | - | 68 | | | | |
| 3.6 | 5 | 3 | 1 | 1 | 1 | 2 | 64 | | | | |
| 3.8 | 4 | 4 | 1 | 1 | 1 | 1 | 70 | | | | |
| 4.0 | 4 | 4 | 1 | 1 | 1 | 1 | 70 | | | | |
| 4.2 | 5 | 4 | 2 | 1 | 2 | 2 | 53 | | | | |
| 4.4 | 5 | 4 | 2 | 1 | 2 | 1 | 55 | | | | |
| 4.6 | 5 | 4 | 2 | 1 | 2 | 1 | 55 | | | | |
| 4.8 | 5 | 4 | 2 | 1 | 1 | 1 | 60 | | | | |
| 5.0 | 5 | 4 | 2 | 1 | 1 | 1 | 60 | | | | |
| 5.2 | 5 | 4 | 2 | 1 | 1 | 1 | 60 | | | | |
| 5.4 | 5 | 4 | 2 | 1 | 1 | 2 | 55 | | | | |
| 5.6 | 6 | 4 | 3 | 2 | 1 | 2 | 45 | | | | 2,000 |
| 5.8 | 6 | 4 | 3 | 2 | 1 | 2 | 45 | | | | 400 |
| 6.0 | 6 | 4 | 3 | 2 | 1 | 3 | 40 | | | | 400 |

CONDITION RATING
FOR
FLEXIBLE PAVEMENTS

DATE: June 3, 1981

LOCATION: SH-33

LENGTH: 7 miles MILES SURVEYED BY:

| Condition Rating | I Cracking | II Surface Roughness | III Distortion | IV Ravelling | V Base Failure |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | 1 | 1 | | | |
| 3 | 2 | 2 | 1 | 1 | |
| 4 | 3 | 3 | 2 | 2 | 1 |
| 5 | 4 | 4 | 3 | 3 | 2-3 |
| 6 | 4 | 4 | 4 | 4 | 4 |

1 = less than 5%
2 = 5% to 15%
3 = 15% to 30%
4 = more than 30

| Mileage Location | Condition Rating | I | II | III | IV | V | % Condition Rating | Beam Deflection | S.W.L. | Rut Depth | S. F. Patching |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.2 | 6 | 4 | 3 | 2 | 1 | 2 | 45 | | | | 400 |
| 6.4 | 6 | 4 | 3 | 2 | 1 | 3 | 40 | | | | 1,000 |
| 6.6 | 4 | 3 | 1 | 1 | - | - | 65 | | | | |
| 6.8 | 5 | 4 | 2 | 1 | 1 | - | 62 | | | | |
| 7.0 | 5 | 4 | 1 | 1 | - | - | 64 | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
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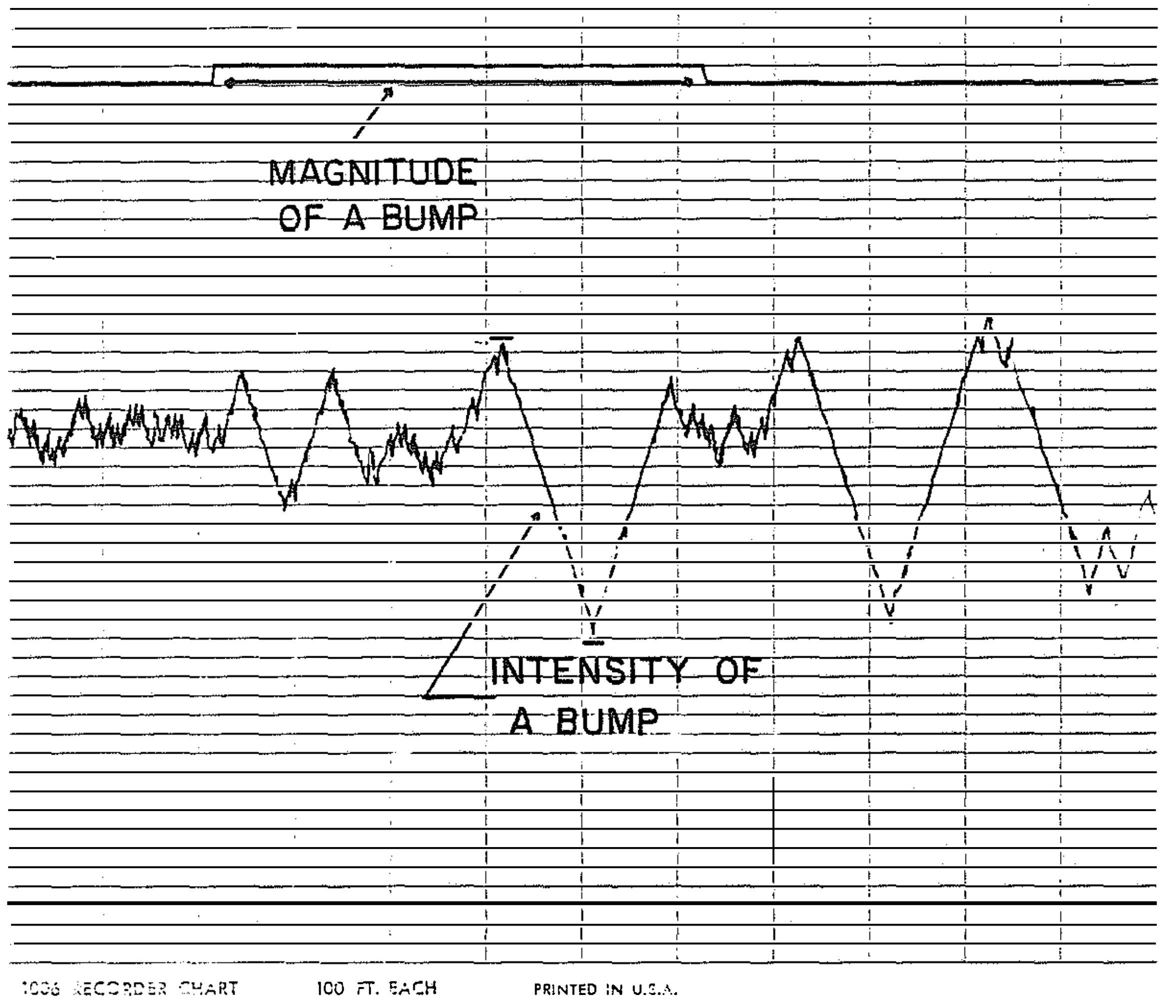


Pavement Roughness
(Section of Mayes Ride Meter Chart)

STATE OF OKLAHOMA
DEPARTMENT OF TRANSPORTATION
Materials Division

SOILS SECTION

C.S. No.

Report No. 3-5010 3-5020 - 65896

Report on Samples of Soil

Project No. Item No. 2411 (35291)

Sample Received at Laboratory 6-25 1981 County Kingfisher Div. 4
Received on Project Sampled 6-25-81 By Wilson Brewer
From Identification (Shown Below) Quantity
Resident Engineer Address
Contractor Tested By Soils Section
Source of Material
Examined for Grad., LL, PI, Hydrometer Test for Information

| Laboratory No. | | # 2613 | # 2614 | # 2615 | |
|---|---|---|---|---|---|
| Sieve Size | Required (%Passing) | Found | Found | Found | Found |
| 1-½" | | | | | |
| 1" | -- | 100 | 100 | 100 | 100 |
| ¾" | | | | | |
| ⅜" | | | | | |
| No. 4 | -- | 100 | 99 | 100 | |
| No. 10 | -- | 100 | 96 | 100 | |
| No. 40 | -- | 99 | 69 | 99 | |
| No. 200 | -- | 92.4 | 36.8 | 90 | |
| L.L. | -- | 31 | 26 | 27 | |
| P.I. | -- | 14 | 12 | 8 | |
| % Sand | -- | 7.6 | 63.5 | 9.7 | |
| % Silt | -- | 62.9 | 15.5 | 66.3 | |
| % Clay | -- | 29.5 | 21.0 | 24.0 | |

BENKLEMAN BEAM TEST RESULTS

Division 4   County: Kingfisher   Test Date 7 22 81

Project Number: 2411 S33, 37, 10E

Description
SH33 Between US81 & SH74F

| Rut Depth (0.1 in) | Milage Extents | Beam Deflection (ins) | Load Supporting Ability (lbs) | Inches of A.C. Equivalent Required 9000 Wheel Load Design |
|---|---|---|---|---|
| 4 | 0.20 | 0.024 | 13235 | 0.0 |
| 2 | 0.40 | 0.014 | ***** | 0.0 |
| 2 | 1.00 | 0.023 | 13919 | 0.0 |
| 2 | 1.20 | 0.010 | ***** | 0.0 |
| 4 | 1.40 | 0.030 | 10160 | 0.0 |
| 2 | 1.60 | 0.050 | 5546 | 3.8 |
| 2 | 1.80 | 0.025 | 12610 | 0.0 |
| 0 | 2.20 | 0.018 | 18611 | 0.0 |
| 2 | 2.40 | 0.014 | ***** | 0.0 |
| 1 | 2.60 | 0.017 | 19915 | 0.0 |
| 1 | 3.00 | 0.030 | 10160 | 0.0 |
| 3 | 3.20 | 0.018 | 18611 | 0.0 |
| 3 | 3.60 | 0.035 | 8464 | 0.6 |
| 2 | 3.80 | 0.040 | 7225 | 2.0 |
| 3 | 4.00 | 0.033 | 9075 | 0.0 |

1 inch = 0.254 mm

1 mile = 1.603 km

1 pound= 0.453 kg

Table A-4