A Study of Bituminous Surface Maintenance in Texas

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Winter Maintenance for Bituminous Pavements

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The opinions, findings, and conclusions expressed in this publication are those of the author and not necessarily those of the Bureau of Public Roads.

Abstract

This publication consists of a state-of-the-art report on maintenance of bituminous highway surfaces in the state of Texas. The publication reflects a review of the literature and a field survey of materials, equipment, and techniques used for typical bituminous surface maintenance operations. Descriptions of the successful maintenance operations are included for use as guidelines for field practice. The problem areas are also described for further research and developmental work.

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Introduction

Performing economical and high quality bituminous surface maintenance for this age of automobile transportation is a problem of primary concern to all of the state highway departments. This high level of concern is due to the recent increases in cost, volume, and complexity of the bituminous surface maintenance operations. These recent increases in cost, volume, and complexity of bituminous maintenance work have brought the need for research and developmental work into sharp focus.

The Texas Highway Department is currently sponsoring a study of the materials, equipment, and procedures used for bituminous surface maintenance operations. This study of materials and bituminous surface maintenance operations is in progress at the Texas Transportation Institute. This research work consists of a review of the literature and a field survey of operations and techniques.

Summary of Published Material

A HRIS (Highway Research Information Service) search was conducted for stored information relating to pavement maintenance, bituminous pavement maintenance, and cold weather operations. Information sources and brief summaries of the stored information are included for further study and evaluation. Information sources and summaries are as follows:

Stabilization of Transverse Ridges in Flexible Pavement Surfaces

Saskatchewan Department of Highways
Materials - Research Section
Regina, Canada 1965

Culley, R. W.

Treatment consisted of one part lime to two parts water. The slurry was injected through 6-inch diameter holes extending 12 inches into the subgrade material. Each transverse crack in the pavement surface had holes drilled at 5-foot intervals over its length. The lime slurry was injected in the holes in an amount equal to about 5 percent of the subgrade weight. Similar injections were also made using five parts of water and one part of quaternary ammonium chloride for about ½ percent of the subgrade weight. The injections were designed to reduce or eliminate the seasonal fluctuations in surface elevation caused by volume changes and the associated distress in the asphaltic concrete overlays. Precise level surveys to determine surface elevations and possibly profilometer surveys will be analyzed to evaluate the effects of the procedure.

Reports Issued: Experiences With Soil-Lime Mixtures in Saskatchewan, R. W. Culley, Proceedings of the Soils and Surfacing Group, Western Association of Canadian Highway Officials, April, 1965.

Copies may be obtained from the author at the project address.

Sealing Large Cracks in Flexible Pavements

Ontario Department of Highways
Downsview, Canada 1965

Leslie, A.

This is a laboratory and field investigation of the effectiveness of hot-poured, rubberized-asphalt crack sealing material. Reflected cracks on an old concrete or cement treated base were sealed. Measurements of cracks are made together with roughness measuremnts and visual examinations.

The Maintenance of Bituminous Pavements

Road Research Laboratory
Riv. Strada, Italy 1966
Vol. 35, No. 294, pp 47-53, 6 Ref

Centolani, G.

Nearly 100,000 km of suburban roads in Italy are maintained merely by surface treatment. A few provinces have used seal coats for the construction of flexible bituminous pavements. This article deals with the development and application of flexible pavement techniques such as the use of slurry seals, cation emulsions, and retreading agents for current highway pavement needs.

Flexible Pavement Maintenance Requirements as Determined by Deflection Measurement

Highway Research Record, Highway Research Board
No. 129, pp 60-75, 8 Fig., 5 Tab, 4 Ref 1966

Zube, E. and Forsyth, R.

This paper discusses the results of the use of the deflection method developed by the California Division of Highways for the evaluation of existing flexible pavements and the recommendation of suitable reconstruction. Since 1960, some 80 projects including state highways, county roads, and city streets, have been subjected to deflection investigation by the Materials and Research Department of the California Division of Highways. The primary purpose of these investigations was the recommendation of appropriate corrective treatment. As a result of this intensive program, a large volume of data on the deflection attenuation properties of various roadway materials has been accumulated and is presented in this report, along with the results of individual deflection studies. The test procedure, method of evaluation of deflection data, and design criteria which have evolved are examined in detail. In addition, economical and practical factors involved in making a specific recommendation are discussed. A separate section of the report is devoted to a review of current deflection research, including work now being done on the establishment of maximum deflection criteria which may be adjusted for variations in traffic volume. A brief analysis of radius of curvature data obtained with the Dehlen curvature meter is also included.

A New Patching Material for Pavement Failures

Highway Research Board 1966
No. 146, pp 1-16, 5 phot, 7 Ref, 3 App

McDonald, C. H.

An economical patching material for repair of elastic type failures on flexible bituminous pavements is described. These failures, caused by fatigue of the surface from repeated deflection by heavy traffic, appear as chickenwire or alligator pattern cracks. Short-term repairs may be made by overlaying or other costly methods. A unique and better method involves a thin application of a hot asphalt and rubber compound with high elasticity and flexibility as well as low temperature susceptibility.

Economical Solutions to Airfield Seal Coat Failure

Navy Civil Engineer 1967
Vol. 8, No. 2, pp 28-29, 4 Phot.

Schellhardt, L. R. and Lippard, A. R.

Forrest Sherman Field was constructed in 1954 with two runways, one of 8,000 ft. and one of 6,000 ft. using portland cement concrete paving for a distance of 500 ft. on each end of the 8,000 ft. runway, and on one end of the 6,000 ft. runway. All other paving consisted of asphaltic concrete. The base course was constructed in two 6-inch layers (compacted thickness) of dead reef oyster shells, 70% by weight, and select native sand. Compaction was to 98% modified Proctor and the CBR base course rating consistently exceeded 100. In 1956 the flexible pavement was seal coated. The runways became slick when wet resulting in frequent use of emergency arresting gear to stop landing aircraft. Cationic emulsion RS-3K seal coat was applied to correct this condition. Eight months later, it was observed that aircraft tires were picking up seal coat material (aggregate and asphalt) on warm days. It was agreed that some method of imbedding more aggregate into the free asphalt would reduce bleeding to tolerable amounts. A paving heater-planer machine was obtained and tested on test strips, using concrete sand as the aggregate on one and on the other a crushed slag aggregate. The heating element was moved slowly over the prepared surface heating both aggregate and underlying asphalt. Inspection of completed test strips showed that slag produces a better finished surface and this was applied to repair the runways. The resultant surface provided excellent traction for aircraft in both wet and dry weather, and no significant bleeding or loss of aggregate was observed after six months of service.

Other sources of material relating to the maintenance of bituminous surfaces are listed as follows:

Asphalt in Pavement Maintenance

Manual Series No. 16
First Edition, 1967

The Asphalt Institute

This manual (150 pages) discusses the sources of bituminous maintenance problems, defines the operations, and emphasizes the need for a well timed and adequately implemented program for bituminous surface maintenance. The maintenance operations are discussed with respect to cause, prevention, and required maintenance work. Information is also included regarding the selection of asphalt mixtures, care of equipment, and specifications for stockpiling patching mixtures. The manual also contains a chapter describing the use of asphalt for the maintenance of portland cement concrete pavements.

Copies of the manual may be obtained from:

Franklin J. Shenkir, District Engineer
The Asphalt Institute
Suite 108, 2400 West Loop South
Houston, Texas 77027

Principles of Pavement Design

John Wiley & Sons, 1959

E. J. Yoder

Chapters 19 and 20 (pages 503-554). Chapter 19 contains information regarding the symptoms of pavement distress, performance and evaluation surveys, and maintenance practices. Chapter 20 contains a discussion of basic principles relating to surface maintenance, pavement evaluation, and the use of overlays for the strengthening of rigid and flexible pavements. Formulas are included for the determination of the required thickness of an overlay.

Highway Engineering

Second Edition, Ronald Press Co., 1960

Ritter and Paquette

Chapter 20 (pages 687-721). This chapter contains information regarding the scope of highway maintenance work, costs, and a description of typical surface maintenance operations. The basic operations are well described even though the material is in need of updating.

Highway Engineering

Second Edition, John Wiley & Sons, 1963

Oglesby and Hewes

Chapter 20 (pages 709-717). This chapter contains a general description of the scope of highway maintenance work. Information relating to bituminous surface maintenance is very brief.

Highway Design and Construction

Third Edition, International Textbook Co., 1950
Bruce and Clarkson

Chapter 14 (pages 572-587). This chapter contains a general description of the scope of highway maintenance work. Very little information is included regarding bituminous surface maintenance work.

Iowa State Highway Maintenance Study

Highway Research Board Special Report 65 (2 reports), 1959-1960

Highway Needs and Economy Division
Bureau of Public Roads in cooperation with the Iowa Highway Commission

Special Report No. 65 and Supplement No. 1 contain detailed information regarding highway mainte-

nance operations, time utilization, productivity, and management. This is a very comprehensive report on highway maintenance work. However, the specific bituminous surface maintenance operations are not covered in detail.

Virginia Maintenance Study, Parts I through IV

Prepared by Roy Jorgensen and Associates

Part I	Organizing for Highway Maintenance	1963-65
Part II	Performing Highway Maintenance Operations	1963-65
Part III	Maintenance Quality Standards	1963-66
Part IV	Managing Highway Maintenance	1963-66

These four reports deal primarily with the organization, management, and general standards for performance and quality.

Other Selected References:

1. "The Design of Airfield Overlay Pavements," Progress Report of the Air Transport Division, ASCE Paper 777, 1955.
2. Bone, Alexander K., and Louis W. Crump. "Current Practices and Research on Controlling Reflection Cracking." HRB Bulletin 123, 1956.
3. Erickson, L. F. and Philip A. Marsh. "Pavement Widening and Resurfacing in Idaho." HRB Bulletin 131, 1956.
4. Fickes, L. A. and C. C. Rhodes. "A Field Study of Joint and Crack Resealing Methods and Materials." HRB Bulletin 166, 1957.
5. Stackhouse, J. L. "Rejuvenating Highway Pavements." HRB 123, 1956.
6. Zube, Earnest. "Wire Mesh Reinforcement in Bituminous Surfacing." HRB Bulletin 131, 1956.

Description of Field Survey

The on-site survey of bituminous surface maintenance was planned to serve a dual purpose. This dual purpose field survey was conducted for the collection of the following information:

1. Information regarding effective and economical maintenance practices that have been developed by maintenance personnel (information suitable for dissemination).

2. Information relating to problem areas (materials, equipment, and operations) that are worthy of further research and developmental work.

In order to obtain a representative sample of the typical maintenance operations and problems, the survey was originally limited to seven of the twenty-five districts. At a later date, the Dallas District was included in order to obtain better coverage. The eight districts surveyed are shown in Figure 1 and listed as follows:

District No. 2 — Fort Worth
District No. 4 — Amarillo
District No. 7 — San Angelo
District No. 15 — San Antonio
District No. 17 — Bryan
District No. 18 — Dallas
District No. 19 — Atlanta
District No. 20 — Beaumont

A "grassroots" survey of the bituminous surface maintenance work was conducted in the eight districts listed above. Information was obtained from field observations and personal interviews with maintenance personnel. A special effort was made to obtain some response from the maintenance engineer and the maintenance construction foremen in each of the eight districts surveyed. A questionnaire was designed for the collection of information (materials, equipment, and techniques) relating to ten typical surface maintenance problems. These maintenance problems are listed as follows:

1. Surface cracks.
2. Pot holes or chuck holes.
3. Edge raveling.
4. Level-up or build-up of low places.
5. Rutting and shoving (longitudinal).

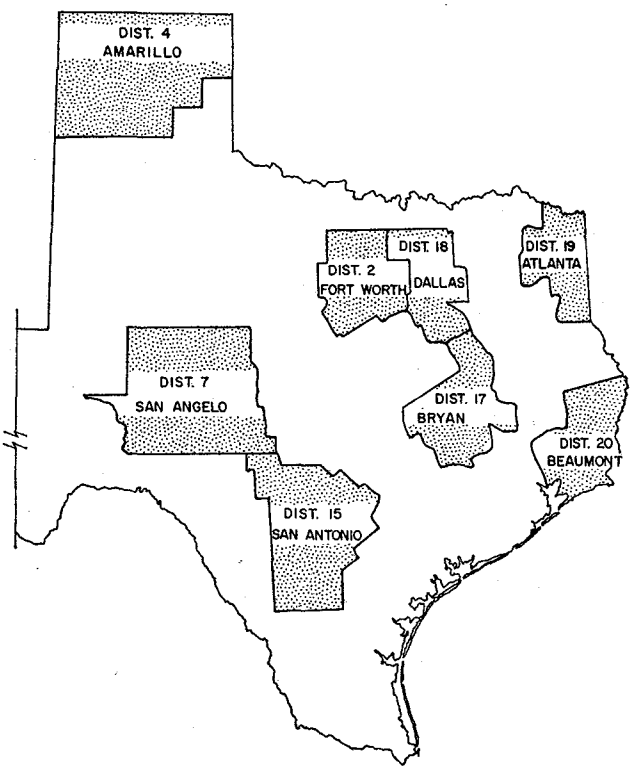


Figure 1. Districts surveyed for bituminous maintenance operations.

6. Raveling of seal coats.
7. Fat spots or areas of bleeding.
8. Slick surfaces.
9. Raveling and surface failures on paved shoulders.
10. Localized failures in flexible pavement system.

A brief summary of each district's operations is included to reflect significant differences regarding materials, equipment, and techniques. These significant observations are summarized in the following section.

Summary of Bituminious Surface Maintenance by Districts

District No. 2 — Fort Worth: The materials used by District 2 for bituminous surface maintenance consist primarily of RC-2 (RC-250) asphalt, emulsified asphalt, catalytically blown asphalt, cold mixes, hot mix-cold lay material, and hot mixes when plants are available.

The operations conform to the general pattern observed throughout the area surveyed. However, the field survey reflected the following observations and refinements:

1. Cold weather (cold and wet) is not conducive to the performance of high quality maintenance on bituminous surfaces. Therefore, it is necessary to perform temporary repairs during unfavorable weather conditions with the idea of performing permanent and high quality maintenance during warm and dry weather.

2. The use of weathered cold mix or hot mix-cold lay material for filling dry weather cracks. This material is enlivened with kerosene or diesel fuel.

3. The use of dilute applications of emulsified asphalt to arrest stripping and enliven bituminous surfaces (paved shoulders and roadway).

4. Treatment of pavement edges with RC-2 (RC-250) or RC-2 cutback with kerosene to enliven the surface and prevent edge raveling.

5. Cold mixes containing rock asphalt are preferred for cold weather or winter patching in view of the workability of this material.

6. The problems of primary concern are surface level-up, pot holes, and edge raveling.

The following problems were reported:

(a) Providing a durable and waterproof joint between concrete pavements and asphalt shoulders.

(b) Seal coats were reported stripping from lime-treated base courses.

District No. 4 — Amarillo: The materials used by District 4 for bituminous maintenance consist primarily of RC-2 asphalt, catalytically blown asphalt, cold mixes, hot mix-cold lay material, and hot mixes when plants are available.

Even though the maintenance operations conform to a general pattern, the survey reflected the following observations and refinements:

1. Temporary or "stopgap" maintenance operations are performed during adverse weather conditions with the idea of performing permanent and high quality maintenance work during favorable weather conditions.

2. Base material (caliche) is used for temporary repair of pot holes during cold weather (roads carrying low traffic volumes).

3. Pavement edges are treated with RC-2 (one nozzle shot) to prevent raveling.

4. The use of a fluid mixture of RC-2 asphalt, kerosene, and sand (asphalt mastic) to seal localized areas of surface cracks. A squeegee is used to work the mastic into the cracks.

5. Cold mixes containing rock asphalt are preferred for winter maintenance in view of the workability of this material.

6. The bituminous surface maintenance operations of primary concern are level-up, strip sealing, and repair of pot holes.

The following problem areas were observed or reported:

(a) Excessive surface cracking without significant changes in the riding characteristics (vertical alignment) of the surface.

(b) The surface cracking problem warrants an investigation of the combined effects of capillary rise, pumping, and freezing.

(c) Wheel loads in excess of the maximum load limit are causing distress in some of the bituminous pavements.

District No. 7 — San Angelo: The materials used by District 7 for bituminous surface maintenance consist primarily of MC-3 asphalt, emulsified asphalt, and hot mix-cold lay material.

The maintenance practices in use in District 7 differ from the general pattern observed in the other districts. The principal differences result from an extensive use of emulsified asphalt. The following observations and refinements in techniques were revealed during the field survey:

1. Cold weather (cold and wet) is not conducive to the performance of high quality maintenance on bituminous surfaces. Therefore, it is necessary to perform temporary repairs during unfavorable weather conditions with the idea of performing permanent and high quality maintenance during warm and dry weather.

2. Localized areas of surface cracks are sealed with a mixture of MC-3 asphalt, kerosene, and sand (asphalt mastic). The material may be worked into the cracks with a squeegee.

3. The 600-gallon distributors are modified by attaching tool compartments for the equipment and hand tools required for typical maintenance operations.

4. Rock asphalt screenings are used for a surface finish on patches and level-up work. The surface is tacked with emulsified asphalt, or MC-3 cutback with

kerosene prior to the application of the rock asphalt screenings. This procedure produces a high quality waterproof surface.

5. Light applications of emulsified asphalt are applied to seal coats that are stripping (with precautions regarding the development of slick surfaces).

6. Pavement edges are treated with MC-3 during the fall and spring to enliven the surface and prevent edge raveling.

7. Cold mixes containing rock asphalt are preferred for cold weather or winter patching in view of the workability of this material.

8. The maintenance problems of primary concern are level-up, edge raveling, and surface cracks.

The following problems were reported:

(a) The design and production of cold mixes, and hot mix-cold lay materials with a dependable level of workability.

(b) The problem of sealing localized patterns of surface cracks is worthy of further study and research work.

(c) There is a need for mechanical equipment which will facilitate strict control over the quantity or rate of application of tack coats.

District No. 15 — San Antonio: The materials used by District 15 for bituminous surface maintenance consist primarily of RC-2 asphalt, cold mixes, hot mix-cold lay material, and hot mixes when plants are available. The maintenance operations performed by District 15 conform to the general pattern observed throughout the area surveyed. The following observations and refinements were reflected by the field survey:

1. Cold weather (cold and wet) is not conducive to the performance of high quality maintenance on bituminous surfaces. Therefore, it is necessary to perform temporary repairs during unfavorable weather conditions with the idea of performing permanent and high quality maintenance during warm and dry weather.

2. The areas that are confronted with problems relating to drainage and base materials are also confronted with a large volume of bituminous surface maintenance work.

3. A small vibratory roller is used to compact surface patches on primary routes to a high level of density.

4. Pot holes on heavily traveled routes are repaired during adverse weather conditions by a locally prepared mixture of sand, crushed stone, and RC-2 asphalt. The mixture is heated during cold weather (within safe limits) to improve the workability.

5. Large surface cracks were filled with sand prior to sealing.

6. The maintenance problems of primary concern are level-up and repair of raveled edges.

The following special problems and needs were reported:

(a) When seal coats are applied to recently constructed (hot mix) paved shoulders, the rate of application of asphalt must be increased to prevent stripping.

(b) A heater-planer is needed to simplify level-up problems on thick bituminous surfaces.

(c) There is a need for a workable mix for damp and cold weather maintenance operations.

District No. 17 — Bryan: The materials used by District 17 for bituminous surface maintenance consist primarily of RC-2 asphalt, catalytically blown asphalt, emulsified asphalt, cold mixes, hot mix-cold lay materials, and some locally prepared mixes.

The maintenance operations performed by District 17 conform to the general pattern observed throughout the area surveyed. However, the field survey reflected the following observations and refinements:

1. Cold weather (cold and wet) is not conducive to the performance of high quality maintenance on bitmuminous surfaces. Therefore, it is necessary to perform temporary repairs during unfavorable weather conditions with the idea of performing permanent and high quality maintenance during warm and dry weather.

2. Locally prepared mixes are used for a limited amount of pot hole repair work.

3. Base material is used for temporary repair of pot holes.

4. Pavement edges are treated with a light application of RC-2 asphalt to enliven the surface and prevent raveling (applications about 2 feet wide with 6 inches on the pavement and 18 inches on the shoulder).

5. Mixes containing rock asphalt are preferred for winter patching in view of the workability of this material.

6. Surface level-up is the bituminous surface maintenance problem of primary concern. However, base related surface failures are considered worthy of further study and consideration.

The problems and needs reported are described as follows:

(a) Asphalt seal coats stripping from lime treated base courses.

(b) The development of air bubbles in applications of emulsified asphalt for seal coats. The air bubbles give rise to surface leakage.

(c) There is a need for more sophisticated equipment for the sealing of surface cracks with catalytically blown asphalt.

(d) The joint between portland cement concrete pavements and the asphalt shoulder is worthy of further investigation.

(e) Additional information is desired regarding the use of slurry seal coats (use and value of slurry seal coats).

District No. 18 — Dallas: The materials used by District 18 for bituminous surface maintenance consist primarily of RC-2 asphalt, catalytically blown asphalt, emulsified asphalt, cold mixes, hot mix-cold lay materials, and hot mix when plants are available.

The maintenance operations performed by District 18 are not significantly different from the general pattern observed in the area surveyed. The field survey did reveal the following techniques and refinements:

1. Cold weather (cold and wet) is not conducive to the performance of high quality maintenance on bituminous surfaces. Therefore, it is necessary to perform

temporary repairs during unfavorable weather conditions with the idea of performing permanent and high quality maintenance during warm and dry weather.

2. District 18 maintains an open requisition for the purchase of small quantities of hot mix from the plants in Dallas for maintenance work. The locally produced hot mix is workable, has a high level of stability, and costs less than cold mixes or hot mix-cold lay materials.

3. A procedure suggested for the repair of large pot holes during wet weather holds definite promise. The procedure consists of a compacted layer of crushed stone tacked with RC-2 asphalt and covered with a layer of cold mix or hot mix. A seal coat is then applied to the cold mix to waterproof the surface.

4. Pavement edges are strip sealed with RC-2 asphalt to prevent raveling and build up the outer edge of the pavement (4 feet strip along the edge).

5. Dilute applications of emulsified asphalt are used to arrest stripping and enliven old pavements. A dilute application is produced by adding 1000 gallons of water to 50-100 gallons of emulsified asphalt. Two or more applications are required.

6. A heater-planer has been used to remove high spots and fat spots (an excess of asphalt). The cost of the equipment is approximately $65 per hour.

7. Cold mixes containing rock asphalt are preferred for winter maintenance in view of the workability of this material.

8. The bituminous surface maintenance problems of primary concern are surface level-up and the repair of pot holes. However, base related surface failures are considered worthy of further study and consideration.

The reported problems and needs are described as follows:

(a) Construction practices that will insure a dependable level of waterproofing for the joint between portland cement concrete pavements and asphalt shoulders.

(b) Insulated compartments to prevent major temperature changes in hot mixes during transportation and laying operations.

(c) More sophisticated equipment for the injection of catalytically blown asphalt into surface cracks.

District No. 19 — Atlanta: The materials used by District 19 for bituminous surface maintenance consist primarily of RC-2 asphalt, catalytically blown asphalt, cold mixes, and hot mix-cold lay materials.

The maintenance operations performed by District 19 are not significantly different from the general pattern observed in the area surveyed. The field survey did reveal the following techniques and refinements:

1. Cold weather (cold and wet) is not conducive to the performance of high quality maintenance on bituminous surfaces. Therefore, it is necessary to perform temporary repairs during unfavorable weather conditions with the idea of performing permanent and high quality maintenance during warm and dry weather.

2. The use of a flame thrower (weed killer) was reported for heating cracked areas and obtaining good penetration of the joint sealer into the surface cracks.

3. Mixes containing rock asphalt are preferred for winter maintenance in view of the workability of this material.

4. Seal coating slick pavements with lightweight aggregate is considered an effective solution for the problem of pavement surfaces becoming slick due to wear or surface polish.

5. The bituminous surface problems of primary concern are surface level-up and repair of raveled edges. A conservative estimate for the total cost of level-up work by hand is approximately $15 per ton for cold mix in place.

The following problems and needs were observed or reported:

(a) The need for cold mixes with a dependable level of workability.

(b) The need for mechanical equipment for the application of cold mixes for surface level-up and repair.

(c) The need for a small roller or mechanical equipment for the compaction of patches or areas repaired with cold mixes or hot mix-cold lay materials.

(d) More sophisticated equipment for the injection of catalytically blown asphalt into surface cracks.

District No. 20 — Beaumont: The materials used by District 20 for bituminous surface maintenance consist primarily of RC-2 asphalt, cold mixes, and hot mix-cold lay materials.

In general, the operations and techniques conform to a typical pattern observed throughout the area surveyed. However, the field survey reflected the following observations and practices:

1. Cold weather (cold and wet) is not conducive to the performance of high quality maintenance on bituminous surfaces. Therefore, it is necessary to perform temporary repairs during unfavorable weather conditions with the idea of performing permanent and high quality maintenance during warm and dry weather.

2. The sealing of joints or cracks in rigid pavements, and rigid pavements covered with asphaltic concrete overlays, was discontinued during 1965.

3. Pot holes are repaired during wet and rainy weather by dusting the surface of the pot hole with dry cement and adding some cement to the cold mix.

4. Cold mixes containing rock asphalt are preferred for cold weather or winter maintenance in view of the workability of this material.

5. A mechanical spreader ("road runner") was used for the application of thin courses (approx. 35 lbs. per sq. yd.) of cold mix or hot mix-cold lay material to existing surfaces.

6. The maintenance operations of primary concern are level-up, repair of raveled edges, and repair of pot holes.

The following problems were reported:

(a) Localized areas of pumping in connection with flexible pavements.

(b) Construction practices that will insure a dependable level of waterproofing for the joint between concrete pavements and asphalt shoulders.

The field survey of techniques and materials revealed a high level of uniformity in practices used by the Texas Highway Department for the maintenance of bituminous surfaces. The principal variations resulted from significant variations in prevailing conditions and actual needs. The personal interviews also revealed a high level of competence and a keen desire to perform high quality work.

Typical Bituminous Surface Maintenance Operations

Surface Cracks

Bituminous surface cracks are categorized as follows:

(a) Thermal and dry weather cracks.

(b) Flexure or deformation cracks.

Thermal cracks develop during the fall and winter due to a contraction of the pavement with decreasing temperatures. Thermal or contraction cracks generally appear in a direction normal to the center line of the highway. Dry weather cracks develop during dry seasons in soils susceptible to shrinkage. Dry weather cracks frequently appear in the general direction of the highway.

Flexure or deformation cracks in bituminous surfaces result from wheel loads that produce stress-strain conditions that exceed the range of elastic deformation for the bituminous mixture. Flexure or deformation cracks may result from surface hardening, inadequate foundation support or a combination of these factors. Figure 2 shows cracks resulting from the asphalt surface becoming hard and brittle, whereas Figure 3 shows a pattern of alligator cracks resulting from inadequate foundation support (excessive deflections).

The sealing of all surface cracks to prevent the intrusion of water into the foundation structure of the highway is considered a maintenance operation of primary concern. Thermal and small dry weather cracks are sealed with oxidized asphalt. The cracks should be sealed prior to the normal periods of seasonal precipitation and under weather conditions that facilitate effective sealing operations. The cracks may be cleaned with a jet of compressed air prior to sealing. Figure 4 shows a heating kettle and pour pots used for crack sealing. Figure 5 shows the use of pour pots for the application

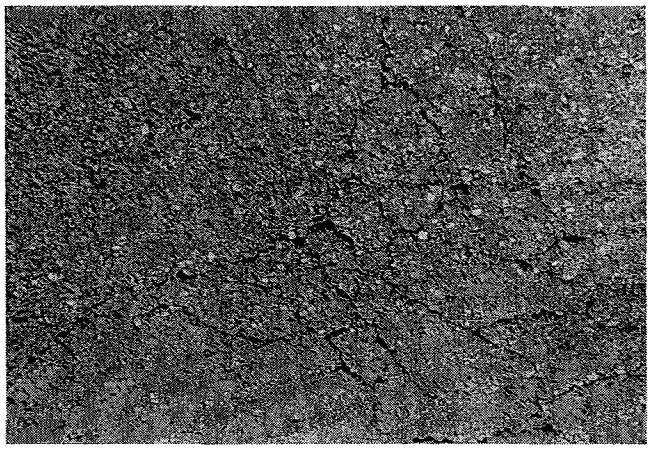


Figure 2. Deformation cracks caused by surface hardening.

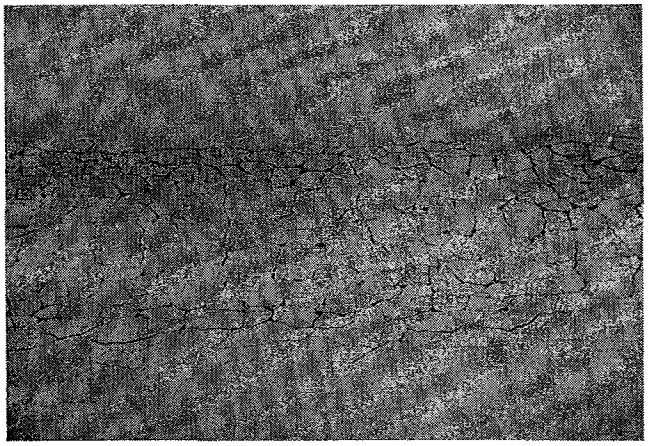


Figure 3. Deformation or alligator cracks caused by inadequate base material.

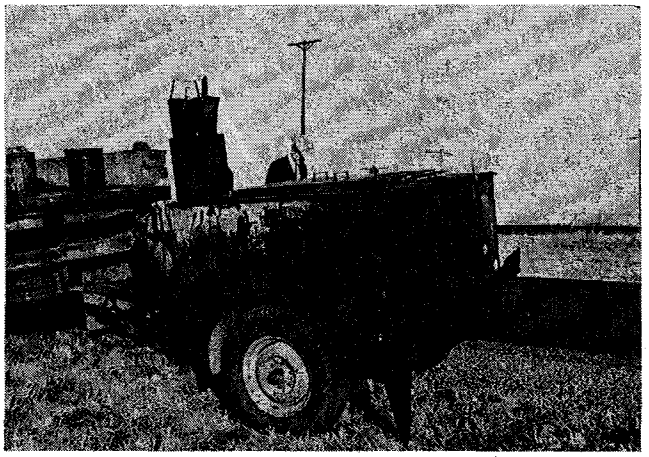


Figure 4. Asphalt kettle with pour pots.

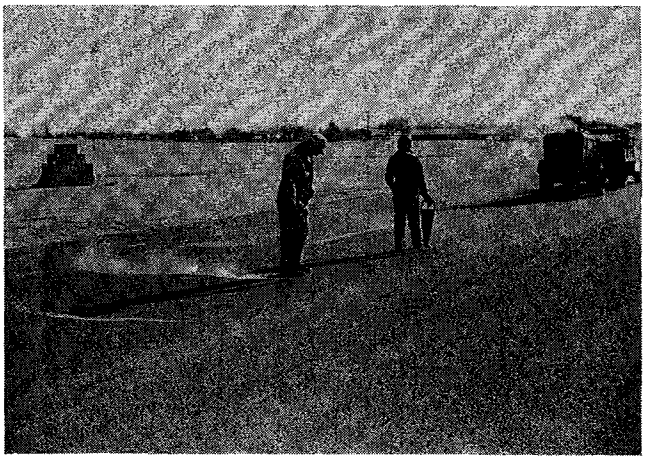
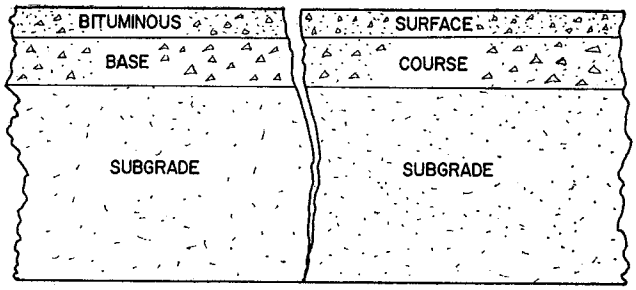
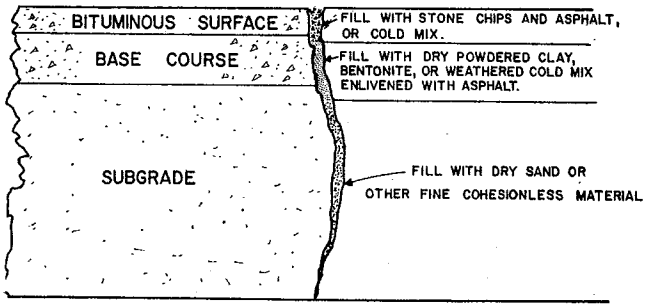


Figure 5. Sealing thermal cracks with oxidized asphalt.



(A) LAYERS OF FLEXIBLE PAVEMENT AFFECTED BY LARGE DRY WEATHER CRACKS



(B) MATERIALS FOR FILLING DRY WEATHER CRACKS

Figure 6. Procedure for sealing large dry weather cracks.

of oxidized asphalt to thermal cracks in a bituminous surface.

Large dry weather cracks are frequently filled with sand to support the cold mix or surface material. When this construction practice is used extra precautions should be taken to waterproof sand filled cracks. Sand filled cracks that are not sealed at the surface may serve as vertical aquifers and cause swelling and heaving throughout a large area. Figure 6 shows a suggested procedure for sealing dry weather cracks with bentonite or powdered clay to prevent the infiltration of water into the subgrade.

Deformation cracks as shown in Figure 2 should be sealed with catalytically blown asphalt or an asphalt mastic prior to the application of a seal coat or overlay. Patterns of alligator cracks as shown in Figure 3 reflect a base related failure which cannot be corrected by surface sealing.

The use of an asphalt membrane is suggested for waterproofing the joint between portland cement concrete pavements and asphalt concrete shoulders. Figure 7 shows the details for constructing the suggested membrane sealed joints between concrete pavements and asphalt shoulders.

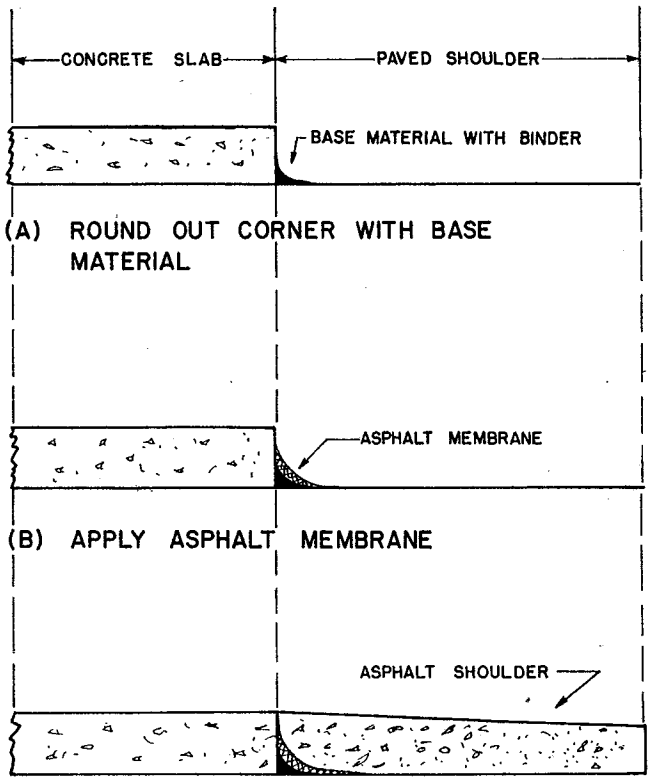
Pot Holes or Chuck Holes

Pot holes are small localized failures reflected in bituminous surfaces. These failures are caused by surface deterioration which in time exposes the foundation structure to the weathering elements (moisture, freezing, etc.).

Pot holes are repaired by removing the loose and unstable base and surface material, tacking the surface of the hole with asphalt, and compacting cold mix or hot mix in the hole. After cleaning, the face of the pot hole should be compacted to insure adequate foundation support. Coarse crushed stone may be tamped in the pot hole to increase the stability of the supporting material. The pot hole is tacked with RC or MC asphalt to facilitate adhesion and waterproof the pavement structure (RC-2 cut with kerosene is used extensively for tacking). The cold mix should be well aeriated and compacted in the pot hole to a high level of density (in two layers if necessary). Pot hole repairs on primary routes and during inclement weather warrant special considerations.

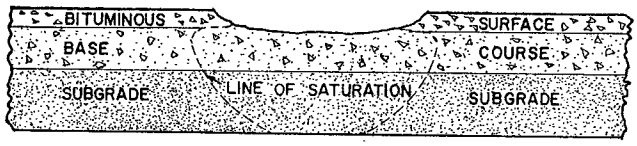
Special considerations suggested for the repair of pot holes on primary routes during wet weather are shown in detail on Figure 8. The crushed stone increases the stability of the area weakened by exposure to the weathering elements. The voids in the layer of crushed stone will serve as a temporary drainage space for entrapped moisture and any excess asphalt that is applied to the pot hole. Since cold mixes do not possess a high level of imperviousness at the time of placement, extra precautions should be taken to seal or waterproof the surface of pot holes and other repairs that may be subjected to rainy weather.

The quality of pot hole repair work around metropolitan areas may be upgraded by a more extensive use

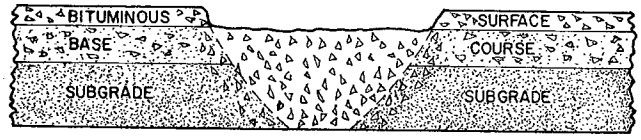


(C) CONSTRUCT CONVENTIONAL ASPHALT SHOULDER

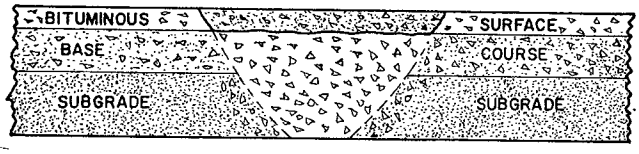
Figure 7. Membrane sealed joints between concrete pavements and asphalt shoulders.



1. EXTENT OF DAMAGE RESULTING FROM A LOCALIZED SURFACE FAILURE.



2. (A) CLEAN OUT LOOSE AND SATURATED MATERIAL.
(B) COMPACT COARSE AGGREGATE IN BASE AND SUBGRADE SOIL.
(C) FILL HOLE TO BASE GRADE WITH WELL COMPACTED COARSE AGGREGATE.



3. (A) SEAL COARSE AGGREGATE AND TACK EDGES.
(B) COMPACT COLD MIX TO CONFORM WITH SURFACE GRADE.
(C) SEAL OR WATERPROOF SURFACE DURING SEASONS OF RAINY WEATHER.

Figure 8. Suggested maintenance for localized surface failures.

of hot mix. Since the quantity of bituminous mix required for an average "crew day" operation (pot hole) is approximately 4 cubic yards, the use of a heated bin or compartment is recommended for transporting hot mix material for pot hole repair work.

The need for a cold mix with dependable level of workability was brought into sharp focus by the field survey.

Edge Raveling

Edge raveling consists of a disintegration or crumbling of the bituminous surface at the pavement edge. Figure 9 shows a typical example of edge raveling. The primary factors that contribute to edge raveling are as follows:

(a) Loss of edge support due to erosion of shoulder material (erosion by wind and water).

(b) Loss of edge support due to water, freezing, and a variation in the level of moisture in the supporting soil.

(c) Loading conditions — increase in traffic volume, increase in the intensity of the wheel load, and the "on and off actions" at the pavement edge.

(d) The asphalt pavement becoming hard and brittle.

(e) Low level of edge support resulting from construction and compaction procedures used.

Figure 9. Typical example of edge raveling.

Raveled edges are repaired by removing loose and undesirable material, compacting the supporting material, tacking the surface, and compacting a bituminous mix in the raveled area to the desired lines and grades. The maintenance of raveled edges on highways that are not scheduled for reconstruction should include provisions for adequate edge support and a further densification of the supporting soil prior to the application of the bituminous material. Extensive edge raveling repairs should be complemented by the application of a seal coat. Figure 10 shows a bituminous surface in need of a seal coat to complement recent maintenance along the edge.

Highway shoulders and pavements that are reflecting losses in density due to fluctuations in moisture and minor frost damage may be strengthened by a carefully planned and a well controlled program of surface rolling. Special consideration should be given to the use of mechanized and long range preventative measures that will keep edge raveling and other maintenance operations to a minimum. The need for further mechanization of highway maintenance work is emphasized by significant increases in highway mileage and the cost of labor.

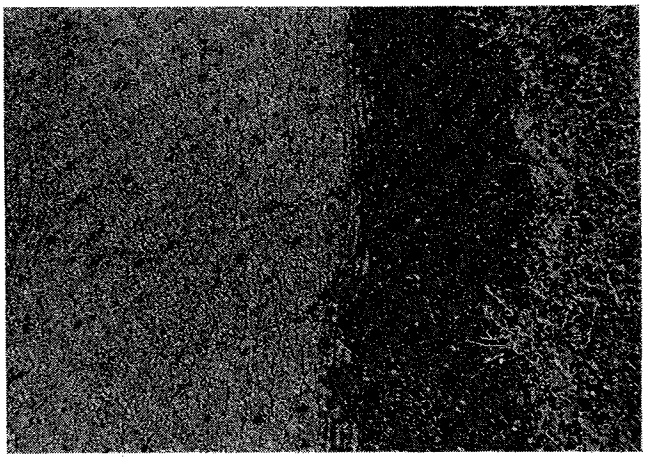


Figure 10. Pavement in need of a seal coat to complement edge raveling maintenance.

Pavement edges that are subjected to severe eroding action (water or wind) should be protected or reinforced to withstand this deteriorating action. This may be accomplished by seal coating or shooting a light application of asphalt along the pavement edge. The same treatment will also provide the pavement edge with some protection against poor surface drainage.

Level-up or Build-up of Low Places

Level-up or build-up of bituminous surfaces consists of the application of a tack coat to low places in the existing surface and adding courses or layers of hot mix-cold lay material to obtain the desired lines and grade. This is recognized as a maintenance operation of primary concern. The low places are reflected by swelling or differential settlement in the subgrade material.

Small or localized low places are leveled up by hand raking and compacting cold mix in the critical area as shown in Figure 11. When the low places extend over a large area, the level-up operation is performed mechanically as shown in Figure 12. The thickness of level-up courses should be restricted to two inches or less. A coarse or harsh mix may be used for the first layer in multi-lift construction. The cold mix used for each layer should be well aeriated and thoroughly compacted. Since cold mixes do not possess a high level of imperviousness at the time of construction, extra precautions should be taken to seal or waterproof the surface when threatened with rainy weather. Light applications of asphalt and stone screenings may be rolled into the surface of level-up construction threatened by wet weather.

Cold mixes with a dependable level of workability are needed for level-up operations performed by hand raking.

Rutting and Shoving

The rutting and shoving described in this report consists of a longitudinal movement of the bituminous surface by wheel traction. This type of rutting and shoving is caused by wheel traction on steep grades or at intersections requiring abrupt stops. Shoving of this

Figure 11. Hand raking hot mix-cold lay material for surface level-up.

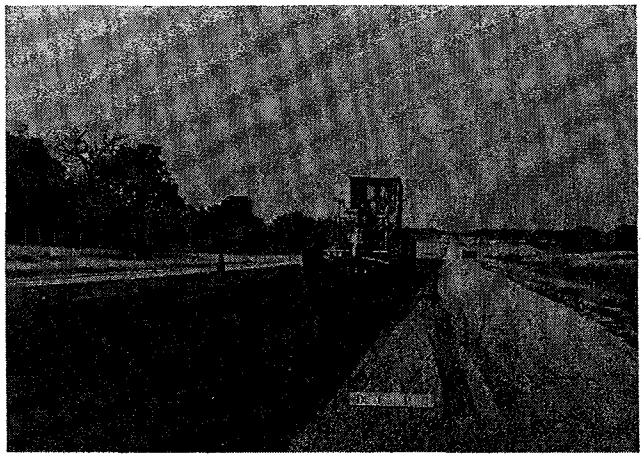


Figure 12. Machine blading hot mix-cold lay material for surface level-up.

type in the bituminous surface may be attributed to inadequate stability in the surface course or a lack of bond between the surface course and the base course. Factors contributing to rutting and shoving in the surface layers are the use of aggregate combinations that yield low stability mixes, and a surplus of asphalt.

In most cases, it is necessary to cut out the displaced surface and base material and replace it with a high stability mix. High stability hot mixes should be used when plants are available. Coarse graded mixes with a low asphalt content should be used in areas that are subjected to critical levels of shear stress (wheel traction).

Raveling of Seal Coats

Raveling of the seal coats consists of a loss of bond or adhesion between the aggregate particles and the asphalt binder. The raveling may result from inadequate asphalt binder or from a deterioration of the adhesion between the asphalt and aggregate particles.

This condition is normally corrected by seal coating or with an overlay. However, light applications of emulsified asphalt may be used to arrest raveling resulting from a deficiency of asphalt.

The significance of this maintenance problem is decreasing in view of the current developments in seal coating technology.

Fat Spots or Areas of Bleeding

Fat spots or areas of bleeding consist of an accumulation of an excess of asphalt at the pavement surface.

Accumulations of asphalt at the surface of bituminous concrete pavements may be attributed to the use of mixes containing an excess of asphalt, migration of the asphalt to the surface, or a combination of these two conditions. Fat spots on seal coated surfaces may be attributed to rates of application in excess of actual needs, raveling resulting from inadequate rates of application, stripping and raveling, degradation of the aggregate, and submersion of the aggregate in the base course.

This condition may be arrested by spreading a blotter of sand or stone chips over the critical area.

Precautions should be taken to prevent the development of a slick surface as a result of the use of aggregates with low or unreliable friction values. Lightweight or other friction textured aggregates should be used when bleeding pavments threaten highway safety. Lightweight aggregates should be rolled into the surface during hot weather. Light applications of lightweight aggregate fines may be applied under traffic for the control of low levels of bleeding.

Slick Surfaces

The primary factors contributed to slick bituminous surfaces are listed as follows:

(a) Fat spots or areas of bleeding.
(See preceding paragraphs for causes.)

(b) Polishing of aggregates in service.

(c) Surface asperity or texture.

(Fine textured surfaces give rise to hydroplaning.)

(d) Surface coatings or road films that alter the friction characteristics of highway surfaces.

The factors listed above may contribute individually or collectively to the development of a slick surface condition.

Slick surfaces are corrected by overlaying or seal coating the slick area. Lightweight aggregates have been used effectively for the construction of wearing surfaces with high level friction values.

Raveling and Surface Failures on Paved Shoulders

Raveling and surface failures on paved shoulders are caused by the same factors that cause raveling and surface failures on other bituminous surfaces (traffic lanes). Shoulder maintenance may consist of a combination of the operations previously described. The typical operations consist of crack sealing, pot hole repairs, skin patches (seal coats), and reinforcement with an overlay or seal coat.

Paved shoulders that carry a large volume of traffic usually reflect structural failures in the flexible pavement system. Surface maintenance is not the solution for this type of failure.

Shoulder maintenance may be minimized by periodic applications (3-5 years) of a seal coat to enliven and waterproof the existing surface. A medium cure asphalt may be used to minimize the effects of oxidation and hardening of asphalt binder.

Localized Failures in the Flexible Pavement System

Localized failures in flexible pavement are failures resulting from a deterioration in the structural performance of the layered system. In most cases these are base-related failures. Typical maintenance consists of the removal of unstable material and replacing it with granular material or other materials stabilized with cement, lime, or asphalt. Stabilized areas requiring increases in moisture should be allowed to cure and consolidate prior to the application of a prime coat and bituminous surface. The area may be resurfaced with a seal coat, hot mix, or cold mix.

This is a problem of primary concern even though it is not strictly a surface related maintenance problem.

Recommendations

1. Large dry weather cracks should be effectively sealed to prevent the sand filler from serving as a vertical aquifer (see Figure 6).

2. Field testing of a membrane sealed joint between concrete pavements and asphalt shoulders (see Figure 7).

3. The use of granular material for the repair of pot holes on primary routes during wet or rainy weather (see Figure 8).

4. Further research work for the development of a new or improved method for the application of oxidized asphalt to (into) surface cracks.

5. Further research and developmental work for the control of temperature and workability of asphalt mixes used for pot hole repairs (use of heated bins or compartments for transporting material).

6. Further research work for the design of hot mix-cold lay material with a dependable level of workability.

7. Further research for the development of tests and specifications for the control of the workability of hot mix-cold lay materials.

8. The use of a questionnaire for a survey of materials, techniques, and problems relating to bituminous surface maintenance in the remaining seventeen districts.

9. A field inspection of the significant techniques and problems reported by the remaining seventeen districts (response to questionnaire).

10. Consider a well planned program of surface rolling to restore density and stability to pavements and shoulders.