PAVEMENT TEXTURING BY MILLING

Final Report for
Iowa Highway Research Board
Project HR-283

January 1987

Highway Division
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DISCLAIMER

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January 1987

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ABSTRACT

Experience has shown that milling machines with carbide tipped teeth have the capability of profiling most asphalt concrete (ac) and portland cement concrete (pcc) pavements. Most standard milling operations today leave a very coarse, generally objectionable surface texture. This research utilized a Cedarapids Wirtgen 1900C mill modified by adding additional teeth. There were 411 teeth at a 5 millimeter transverse spacing (standard spacing is 15 mm) on a 6 ft. 4 in. long drum. The mill was used to profile and texture the surface of one ac and two pcc pavements.

A 1000 ft. section of rutted (1/2 in. deep) ac pavement was milled. The automatic sensing unit of the mill was used to remove approximately 1/2 in. of the surface. This removed almost all of the rutting. With a drum speed of 100 r.p.m. and a forward speed not to exceed 30 ft. per minute, a very acceptable surface texture was obtained.

The mill was also used to profile a 1500 ft. section of badly faulted pcc pavement containing a crushed limestone coarse aggregate and a 200 ft. section of pcc pavement containing a gravel coarse aggregate. This milling operation did cause objectionable spalling of the transverse contraction joints on the pcc pavement. The spalling can be prevented by filling the transverse joints with a rapid set patching material prior to the milling operation.

One year after the milling operation there is still some noticeable change in tire noise but the general appearance is good. The milling operation with the additional teeth provides an acceptable surface texture with improved Friction Numbers when compared to a nonmilled surface.

INTRODUCTION

The introduction of milling with carbide tips has opened many new alternatives to pavement rehabilitation. Soon after the introduction of the carbide tipped milling operation, beginning in 1978 many miles of curb were removed from Iowa pcc pavements. The Iowa road system includes over 34,000 miles of pavement with 13,000 miles being pcc and 21,000 being ac. Many of these miles are over 25 years old and in need of some type of rehabilitation. Much of our pcc pavement is nondoweled, jointed pavement. A serious problem with many of these jointed pavements today is joint faulting. In recent years, pavement grinding with diamond blades has been used to improve the profile of these faulted pavements. The diamond grinding has been an effective surface rehabilitation practice but is also quite expensive.

PROBLEM STATEMENT

The unit cost of diamond grinding has limited the surface restoration program. There are many more miles that need surface restoration but the funding is not available. The diamond grinding operation is relatively slow with most equipment being less than 3 ft. wide. The number of diamond grinding contractors interested in Iowa projects also seems to be very limited.

Profiling and/or retexturing of old pavement surfaces has been achieved by milling at a few locations. In general, current milling practices yield a relatively coarse textured surface that is objectionable to a substantial number of motorists. It generates increased tire noise and a potential for instability with motorcycles and subcompact cars. Milling is, however, generally less expensive than diamond grinding per unit cost.

OBJECTIVE

The objective of this research is to produce an acceptable surface texture with a milling machine modified with an increased number of cutting teeth.

TEST SECTIONS AND LOCATIONS

Asphalt concrete pavement is generally relatively easy to mill. The difficulty of milling pcc pavement varies depending upon the type of coarse aggregate. It is much more difficult to mill a pcc pavement with a gravel coarse aggregate than a pavement constructed with a limestone or dolomite coarse aggregate. For this reason, it was decided to select one test section of each of these three general types of pavement. In the case of Sections 1 and 2 below, deficiencies were also corrected. No surface problems were corrected in Section 3. It was selected to provide a particular type of milling. The three sections selected for experimental milling were:

1. A 1000 ft. section of rutted ac pavement on US 218 (K Avenue) beginning at the railroad tracks between 8th and 9th Streets in Vinton and extending southerly.
2. A section of faulted pcc pavement with crushed limestone coarse aggregate was selected on US 30 between Clarence and Lowden near Milepost 290.
3. A 200 ft. section of pcc pavement produced with gravel coarse aggregate was selected on IA 130 east of Tipton at Milepost 3.

CONTRACTUAL ARRANGEMENTS

Milling machines produced by a number of different companies are currently being used in the United States. Some of these major companies producing milling machines were contacted to invite interest in adding additional carbide teeth to their milling drum to determine if a more satisfactory pavement texture could be obtained. Some of these companies did express interest in participating in such research. Only Cedarapids, Inc. of Cedar Rapids, Iowa, however, was willing to make a commitment to alter a milling machine by adding additional teeth to provide a finer textured surface. A contract was executed with Cedarapids, Inc. to conduct this research. The research period began October 7, 1985, and continued through January 31, 1986.

EQUIPMENT

The information obtained from the major producers of milling machines was interesting and in some cases very educational. A number of the major milling manufacturers were marketing mills approximately 6 ft. wide. The number of teeth on the drum varied from 110 to 170 teeth. The standard lateral spacing of these teeth was approximately 5/8 in. Obviously, the drum rotation speed would have a definite bearing on the number of teeth needed to yield an acceptable texture. This information was not requested from the manufacturer, but should be readily available.

Cedarapids, Inc. made a commitment to the Iowa Department of Transportation to alter a Cedar Rapids Wirtgen 1900C mill by adding additional carbide cutting teeth. The standard drum on a 1900C mill is 6 ft. 4 in. long with 137 carbide teeth spaced at 15 mm which is approximately 5/8 in. The tool holders on this machine are bolted to the drum, thereby, making provision for changing the tool holders to accommodate additional teeth. One set of 5 mm spaced tool holding segments were obtained to equip the drum with 411 teeth. The drum speed on the 1900C mill is a constant 100 r.p.m. Both ends of the drum are capable of hydraulic vertical adjustments that are controlled by an electronic sensing device. This provides profile control from a string line, a shoe at the base of the drum for matching another surface or from a rolling ski.

MILLING OF THE EXPERIMENTAL SECTIONS

On November 5, 1985, a 1000 ft. section of rutted (1/2 in. deep) ac pavement on US 218 just south of the railroad tracks between 8th and 9th Streets in Vinton was milled. The automatic sensing unit of the mill, which seemed to function very well, was used on shoes riding at the centerline and 1/4 points to cut approximately 1/2 in. deep at both edges while making a 6 ft. 4 in. pass either side of centerline. The rutting on this roadway was generally less than 1/2 in. deep but some rutting greater than 1/2 in. deep was present. In the areas where the rutting was greater than 1/2 in. deep, the entire surface was not milled based on the decision to remove only 1/2 in. The first pass began at the railroad track in the southbound lane adjacent to centerline and proceeded 1000 ft. up the hill. The second pass was made by using the shoe to match the centerline elevation and using the shoe on the right hand side in the northbound lane set to yield a depth of 1/2 in. This pass began at the upper part of the hill and proceeded back to the railroad track. The southbound section was milled at a forward speed of 17 ft. per minute and the northbound section was milled at 28 ft. per minute. The texture varies with the forward speed on this mill as the drum speed is a constant 100 r.p.m. The slower the speed the smoother and finer the texture. It appears that a speed of 30 ft. per minute is the maximum speed for this mill. Forward speeds greater than 30 ft. per minute result in a diagonal corrugation from the spiral tooth arrangement.

In making the milling passes of the outside 6 ft. of both lanes, the sensing unit was used on a rolling ski to achieve the 1/2 in. depth at the outer edge of the pavement. The left sensing unit was used on the shoe to match the previously milled section. The southbound outside 6 ft. pass was also made at a forward speed of 17 ft. per minute. The northbound outside pass was again made at 28 ft. per minute. Both of the speeds appeared to provide satisfactory texture. A short section of the northbound lane near the railroad tracks was milled at a forward speed greater than 30 ft. per minute with undesirable diagonal corrugations occurring.

The milling operation removed almost all of the rutting and left a very acceptable texture. There is some difference in tire noise but it is definitely not objectionable. The surface appears relatively tight, but would appear to have enough texture to yield good friction properties.

On November 6 and 7, 1985, the mill was used on a 1500 ft. section of badly faulted (up to 3/4 in.) US 30 pc pavement near Milepost 290 (from Station 1129 to Station 1144) between Clarence and Lowden. This pcc pavement has a crushed limestone coarse aggregate which mills more easily than pavement containing gravel coarse aggregate. Not only is this pavement faulted, but the midpanel of all slabs is low due to slab curl. Essentially, all of this section was milled against the normal direction of traffic, at a forward speed of 28 ft. per minute.

The inside pass of the westbound lane from Station 1129 to Station 1131 was milled with the sensors controlled by stinglines on both sides. The joints were cut sufficiently deep to mill all surface including the low point at the midpanel. This provides a very good profile but resulted in substantial joint spalling. The balance of this section was milled using a relatively short rolling ski for grade control which was adjusted to mainly remove the faulting and not to mill all of the surface.

The milling yielded a very smooth texture that by visual inspection should provide good friction properties. There is a significant difference in tire noise from the nonmilled surface to the milled surface. No undersealing or slab stabilization was used in conjunction with this research, as the main objective was to determine if this operation would yield an acceptable surface texture.

A 200 ft. section of pcc pavement produced with gravel aggregate on IA 130 east of Tipton at Milepost 3 (Station 160-162) was milled on November 8 at 15 ft. per minute. It yielded a very nice appearing texture and resulted in some joint spalling but substantially less spalling than was encountered on the pcc on US 30. Very little wear of the teeth occurred through the three milling operations on US 218, US 30 and IA 130. The weather during this period of time was not completely desirable due to rain and cold temperatures. Work was suspended due to cold, rainy weather. Some of the milling was conducted in very undesirable outside working conditions. Milling of the three sections noted above expended all of the time agreed to by the contract.

EFFORTS TO REDUCE THE UNDESIRABLE SPALLING OF PCC JOINTS

An additional quote was obtained from Cedarapids, Inc. to conduct additional milling during the spring of 1986. This additional research was conducted to try various methods of reducing the undesirable spalling at the contraction joints. The various methods included:

1. Filling the joints with wet concrete sand.
2. Filling the joints with rapid set patching material.
3. Using a slower, forward speed through the joints.
4. Milling the joints transversely with a smaller mill.

This additional milling research began with joint preparation on April 28, 1986. Most joints were 1/4 in. wide and had substantial bituminous sealing material but the seal had failed. A 2000 PSI

Vanguard water blaster was unable to dislodge the sealant material. A crack saw with a 3/8 in. wide blade was used to cut 35 joints approximately 3/4 in. deep. Care was necessary to avoid straying from the joint and cutting a new joint adjacent to the old joint.

Beginning about 4 p.m with a strong wind, a light rain and a temperature of 46°F, 16 full width joints were filled with commercially available rapid set patching materials (8 with neat Set 45 and 8 with neat L & M material). Five full width joints were filled with wet concrete sand the next morning.

Milling on April 29 began on the 1400 ft. section (Station 1144 to 1158), 6 ft. wide, westbound on the inside 1/2 of the eastbound lane. This pass was stringlined and went very slowly. Plexiglas templates were placed in sawcuts and wooden blocks to cause the sensor to raise the drum and prevent cutting at the joint. It was afternoon before this pass was completed. The weather was sunny and 70-75°F most of the day.

The forward speed of the milling machine was controlled at approximately 28 ft. per minute. The mill was slowed down to a speed of approximately 5 ft. per minute through approximately 10 contraction joints to determine if this would reduce the spalling at the joints. Milling at this slower, forward speed through the joints did not prevent or reduce the spalling.

The mill was allowed to travel at a smooth profile through the filled joints cutting on both sides of the joint. The joints filled with wet concrete sand spalled like nonfilled joints. There was no spalling of the joints filled with either of the rapid set patching materials.

After completion of the longitudinal milling with the 1900C mill, the milling of the transverse joints that had been jumped was attempted with a Wirtgen 1000C mill. The head on this mill is 39 in. wide and the teeth are spaced at 15 mm, (approximately 5/8 in.). This mill was approximately 12 ft. long and the drive wheels with much of the machine weight were on the front. They were also the steering wheels. The mill was between the rear wheels. These wheels controlled the depth of the milling. The milling operation with the standard teeth spacing left a very coarse texture and spalled the transverse joint substantially. The spalling was more adverse if the teeth were spaced a greater distance from the transverse joint. Five of these joints were milled transversely and the results were very undesirable. On the sixth pass across the pavement, the front drive wheels of the mill encountered a relatively soft area in the shoulder and quickly settled into the shoulder. After pulling the mill free, this operation was suspended.

ESTIMATED COST

The cost of profiling and texturing with this type of mill has not been established. An estimate of the cost of milling only would be $5000 per day while accomplishing 1/2 mile of 24 ft. wide pavement.

This would result in a cost of 71¢ per sq. yd. compared to $5 per sq. yd. for diamond grinding.

TESTING AND EVALUATION

Almost all of the rutting was removed by removing 1/2 in. from the ac section. The average friction number of the unmilled adjacent sections of the US 218 ac surface averaged 38. The average friction number of the milled section of the asphalt surface was 44.

Profile testing of the faulted section of US 30 was conducted with a 25-Foot Profilometer before and after the profile milling operation. The profile index prior to milling was 65 in. per mile. This was reduced to 20 in. per mile after milling. The mill was not operated at a depth to mill the entire surface and the midpanel of each slab was not milled. A much lower profile index would be expected if all of the surface had been milled.

The average friction number of the unmilled, adjacent section of US 30 pcc was 37. The milled section of this pcc yielded an average friction number of 50.

CONCLUSIONS

From this research on pavement texturing by milling, it can be concluded that:

1. Profiling with a mill equipped with carbide teeth spaced at 5 millimeters will produce an acceptable surface texture.
2. With a given drum speed and carbide teeth configuration there is a maximum forward speed above which unacceptable transverse corrugations will occur.

3. Profile milling of ac pavement with an appropriate carbide teeth arrangement would be an acceptable method of rehabilitating rutted ac pavement.
4. Faulted pcc pavements could be effectively profiled with a milling operation.
5. Profile milling results in substantial spalling of transverse contraction joints in pcc pavement.

ACKNOWLEDGEMENT

The author wishes to extend special appreciation to Lou Fairchild, Larry Peyton, Gordy Swick and other personnel of Cedarapids, Inc. for the excellent cooperation on this research. Special appreciation is also due Gary Marlow and Larry Hildebrand of the Iowa Department of Transportation for assisting in the transportation of the 1900C mill. Traffic control and assistance was provided by the Stanwood and Tipton maintenance garages. Vern Dorsey and Central Maintenance personnel provided the equipment and labor to clean and prepare the transverse contraction joints. Richard Smith of the Iowa DOT Office of Materials also assisted in the transverse joint research. Appreciation is also extended to other District 6 personnel who assisted with this research.