Effect of Pavement Breaker Rolling on Crack Reflectance in Bituminous Overlays

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• THE USE of a heavy roller to crack old portland cement concrete pavement and to seat it on the subgrade before resurfacing with bituminous mixtures was tried experimentally in Minnesota in 1959. The project is located on T.H. 212 between Bird Island and Stewart in central Minnesota. It is a typical widening and resurfacing project, in which the bituminous mixtures were placed directly on the old pavement.

A report on the project was made in 1961 which included detailed information on such items as the design of the old pavement, the size of the roller, the immediate effects of rolling on the pavement, typical sections, costs of the reconstruction, and performance of the project during the first six months. This report was published in Highway Research Board Bulletin 290.

Briefly, some of the pertinent items can be summarized as follows. The concrete pavement was 28 years old, having been constructed in 1931. It was 20 ft wide with a 9- by 7- by 9-in. cross-section. Panels were generally 40 ft 4 in. long with every other joint an expansion joint. All the joints were doweled, and the panels were reinforced at the edges, along centerline and along the joints.

The entire project was 18 mi long, of which only 1½ mi were rolled. In this 1½-mi experimental section, each lane was covered by ten passes of a 59-ton roller which produced a great number of transverse cracks in the old pavement. The roller had four wheels on a single axle, and the tire air pressure was 90 psi. Actual pressures on the slab averaged 83.5 psi as determined from the gross contact areas of the tires.

The rolling caused 1,868 new cracks in the two lanes of the pavement, and nearly all of these were transverse cracks. When the old cracks and the joints were included, there were nearly 3,000 openings in the pavement. In other words, there was a transverse crack or a joint about every 5 ft after rolling.

The bituminous mixtures for widening and resurfacing were all hot-mixed. The typical section on the project consisted of a 1½-in. wearing course, a 1½-in. binder course and a 1½-in. leveling course for a total of 4½ in. of bituminous mixture. However, on the rolled section, three different thicknesses were used (namely, 5, 6, and 9 in.); the difference being in the thickness of the leveling course. Therefore, the pavement that was rolled was divided into three test sections corresponding to the variations in the thickness of the overlay. For comparison purposes, three control sections were selected in the unrolled portion of the project where the overlay was 4½ in. thick.

PROJECT PERFORMANCE

Since completion of the project in October 1959, seven crack surveys and several rutting and roughness measurements have been made to evaluate the performance of the test sections over the 2½-yr period following construction. The results of these studies and the conclusions drawn from them are reported in this paper.

The crack survey data have been reduced to curved line graphs for the purpose of showing the general trends of crack progression with age. This required the striking of averages to establish certain portions of the curves, particularly at the early ages. However, the curves have been drawn to fit as many points as possible, and generally the terminal points of the curves at the age of 30 months coincide with the survey data.

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Transverse Joint Reflectance

Nearly all of the transverse cracking in the portion of the bituminous surface over the old pavement has occurred at the joints. Figure 1 shows the progression of joint reflection with age. The dashed lines for sections 1, 2, and 3 represent the unrolled control sections with 4½ in. of bituminous overlay, and the solid lines represent the rolled sections with 5, 6, and 9 in. of bituminous overlay.

In section 1, 98 percent of the transverse joints reflected as cracks in the bituminous surface almost immediately after construction. The other two control sections reacted very much alike, progressing to about 90 percent joint reflection in 18 months and to 95 percent in 30 months.

In contrast to this rapid reflection of joints, the 5- and 6-in. rolled sections had about 50 percent reflection in 18 months and 75 percent in 30 months, a sizable decrease in the number of cracks that would require maintenance. This reduction in joint reflection is largely due to the effects of the rolling. The 9-in. rolled section showed the least cracking over the joints, reaching only 60 percent in 30 months. The difference between this 9-in. section and the other rolled sections is probably due to the additional thickness of the bituminous overlay.

Centerline Joint Reflectance

Figure 2 shows the progression of cracking over the centerline joint in the old pavement. Here again, section 1 stands out as a poor performer, with centerline cracking starting immediately after construction and progressing to 94 percent in 30 months. In comparison, centerline cracking did not become significant during the first 12 months on all the other test sections. However, sections 2 and 3, which were not rolled, were about 90 percent cracked on centerline at an age of 30 months.

The 6- and 9-in. rolled sections had very similar amounts of centerline cracking, reaching 70 to 75 percent at 30 months. The 5-in. rolled section was the slowest to start cracking; but, at 30 months, had nearly the same amount of centerline cracking as the unrolled sections, reaching 87 percent.

These data indicate that rolling had a slight beneficial effect in retarding cracking over the centerline joint in the old pavement. The effect of the thickness of the bituminous overlay does not seem to be well defined, though at 30 months the 9-in. rolled section had the least centerline cracking.

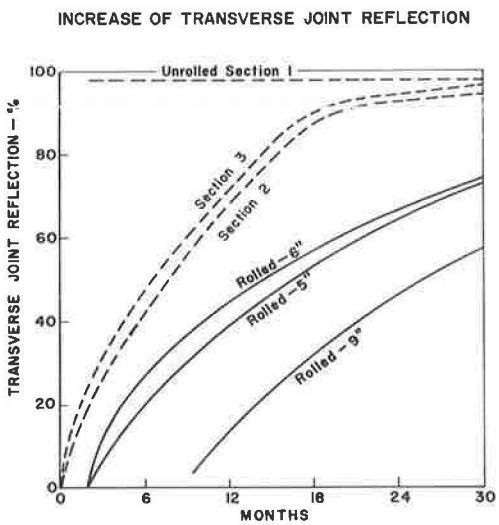

Figure 1. Progression of reflectance cracks over joints in the old concrete pavement.

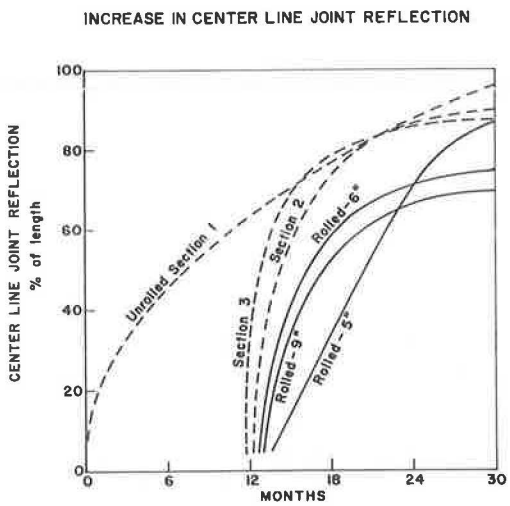

Figure 2. Progression of centerline joint reflection cracking.

Transverse Cracks in the Widening

Contrary to what one might think, pavement breaker rolling had quite an effect on the cracking in the bituminous widening outside the edges of the old pavement. Figure 3 shows the progression of transverse cracks across the widening strip by plotting the average feet of cracks per station against the age of the project in months.

Section 1 again showed a tendency to crack sooner than the other sections, but section 3 surpassed section 1 at 30 months with 38 ft of cracks per station as compared to 34 ft per station.

Section 2 started cracking soon after construction, like the other unrolled sections, but only progressed to 16 ft per station at 30 months, about the same as the rolled sections. However, the rolled sections did not start to crack until after 6 months for the 6-in. section and after 12 months or more for the 5- and 9-in. sections. The 9-in. section was the slowest to develop transverse cracks in the widening; but, at an age of 2½ yr, this thick section was no better than thinner sections with 4½ and 5 in. of bituminous overlay.

One might conclude, therefore, that rolling was beneficial in retarding transverse cracking in the portion of the bituminous surface outside the old concrete pavement, and that the thickness of the overlay was not particularly significant in this case.

A number of the transverse widening cracks occurred without relation to cracks or joints in the old pavement. This so-called random cracking was quite variable among the sections, ranging from 4 to 26 percent of the total. Generally, there was more random cracking in the sections with the most cracks.

Longitudinal Widening Cracks

There is one more type of crack that is typical of widening and resurfacing projects such as this, and that is the longitudinal crack which generally develops at the edge of the old pavement. Figure 4 shows the progression of this cracking by plotting the percent of the total length cracked against age in months.

Section 1 was the first to develop longitudinal widening cracks, being 20 percent cracked in 12 months and 29 percent in 30 months.

Section 3 started to crack along the edge of the old pavement at 6 months and progressed quite rapidly to 40 percent at 30 months. Indications are that this section will continue to crack at a fairly rapid rate.

Section 2 was the last of the unrolled sections to develop widening cracks, starting about one year after construction and being 17 percent cracked at 30 months.

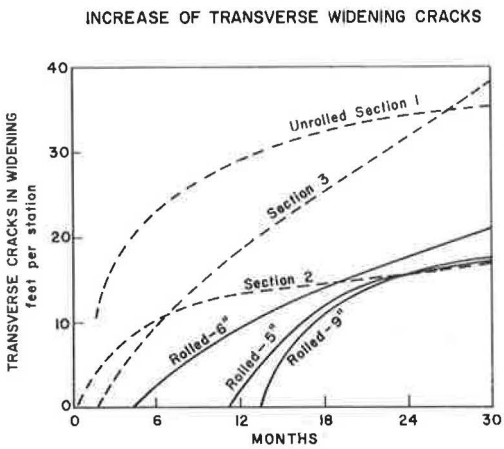

Figure 3. Progression of transverse cracks in widening.

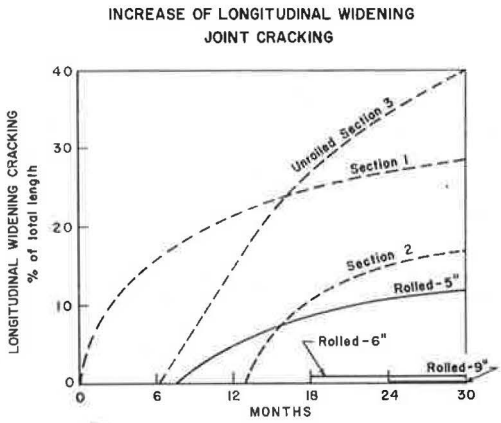

Figure 4. Progression of longitudinal widening cracks at edge of old pavement.

The 5-in. rolled section started cracking at about 7 months and progressed to 12 percent at 30 months. The other two rolled sections have practically no longitudinal widening cracks—only 1 percent for the 6-in. section and none for the 9-in. section in 2½ years. This is quite a remarkable performance considering the clay soils in the subgrade, the prolonged freezing, and subsequent severe spring breakup periods experienced in Minnesota. Apparently, the combination of the rolling with the thicker overlays was effective in controlling longitudinal widening cracks.

Rutting in Wheel Tracks

Cross-section measurements on the bituminous surface have been made on six occasions over a 2-yr period following construction to determine distortion or rutting in the wheel tracks. These measurements were made at three locations in each test section, except section 3.

In the unrolled sections with 4½ in. of bituminous overlay, rutting of less than 0.25 in. was found in section 2 and none in section 1.

In the rolled sections, rutting up to 0.25 in. was found in the 5- and 6-in. sections and none in the 9-in. section. This would indicate that the thickness of the overlay was not a contributing factor.

Because traffic on this highway is not particularly heavy, no serious rutting was expected in this short a period.

Roughness

Roughness measurements were made on five occasions since completion of the project in 1959, the latest readings being made in April 1962. The Minnesota roughometer is similar to the AASHO road roughness recorder, and produces roughness index values expressed in inches per mile.

After construction in 1959, the project averaged 56 in. per mi which increased to 60 in. per mi in April 1960 and to 64 in. per mi in April 1962. Using the April values for comparison purposes, thereby eliminating seasonal effects, the project average increased 4 in. per mi during the 2-yr period ending in April 1962. During this same period, sections 1 and 2 increased 6 in. and 9 in. per mi, respectively, and the rolled sections increased 6 in. per mi.

The roughness indexes on all the sections fell within the range of 62 to 68 in. per mi in 1962, which are very acceptable values for a bituminous surface. Apparently the project is not old enough to show significant changes in roughness.

CONCLUSIONS

The general conclusions which may be drawn from the information obtained on the T.H. 212 project are as follows:

1. Ten passes of a 59-ton roller will produce an optimum amount of cracking in old concrete pavements at a reasonable cost.
2. Pavement breaker rolling will retard the development of cracks in the bituminous overlay above the pavement and in the widening for periods longer than 2½ yr.
3. Thicker bituminous overlays will increase the retardation effect of the rolling, but the increased cost of very thick overlays may offset the additional benefits.
4. No significant rutting in the wheel tracks will develop in overlays up to 9 in. thick under 2½ yr of average rural traffic in Minnesota.
5. No significant change in roughness should occur for 2½ yr after construction.
6. Because the experimental rolled sections on the T.H. 212 project showed a definite reduction in cracking, the Minnesota Highway Department has used pavement breaker rolling on an 8-mi resurfacing project in 1962.