EVALUATION OF VARIABLE THICKNESS OF BITUMINOUS OVERLAY ON CRACKED PCC PAVEMENT
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OF BITUMINOUS OVERLAY
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Special Study No. 375
Annual Report 1981

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MINNESOTA DEPARTMENT OF TRANSPORTATION
INTRODUCTION

The need for new rehabilitation designs is very important as the funding for both maintenance and construction projects becomes increasingly difficult to obtain. The design thickness of a bituminous overlay on a pcc pavement has often been a matter of the past experience of individual engineers who have to make these recommendations.

This special study was undertaken to gather data on three different thicknesses of bituminous overlays on cracked pcc pavement. This study will also provide additional data on the effects of cracking pcc pavement. It is anticipated that data from this study will provide the Design Engineer with information that will be helpful in selecting the thickness of bituminous overlay and specifications for pavement cracking.

This study will continue for a minimum period of 5 years.

BACKGROUND

This special study is part of S.P. 2506-39 (T.H. 52=20) located on T.H. 52 in the vicinity of Hader, in Goodhue County. The construction plan calls for pavement surface widening and bituminous resurfacing. The project is approximately 10 miles in length and the limits are from 1.5 miles north of the junction of C.S.A.H. 1 to 3.2 miles south of T.H. 57 at Hader.

The pcc pavement was placed in 1930. The concrete slab is 20 feet wide and a 9-7-9 design. The pcc pavement was reinforced with one reinforcing bar down each edge and centerline tie steel. The highway was re-designed in 1964 to a divided highway with the old concrete pavement being utilized as the southbound roadway. The present construction project is a rehabilitation of that southbound roadway. The plan calls for a 5 foot bituminous widening to be constructed on the median side of the S.B.L., fracturing the old concrete pavement, and overlaying the concrete with a bituminous structure. The bituminous overlay was specified to have a variable depth leveling course (1 inch minimum) and 3/4 inch bituminous wearing course (2361).

By supplemental agreement, two typical sections were added which were each 2 miles in length. One section required a 2 inch minimum variable depth leveling course and the second section specified a minimum of 3 inches of the leveling course. The typical sections are shown in Figure 1.

-1-
Figure 1. Typical sections.
The subgrade soils are predominately clay loams and silty-clay loams. They are in the AASHTO Group classifications of A-4 and A-6. Group Index numbers ranged between 7 and 9 with the range of R-values being between 18 to 33.

Traffic forecast predicted the 20 year N18 (ESAL) to be 3,348,000 based on the highway being a 10 ton (80,000 lb) route.

Construction began during the 1981 season and will be completed in 1982.

EVALUATION

The effects of constructing different bituminous overlay thickness on cracked pcc pavement will be evaluated by keeping records on the amount of reflective cracking in 500 foot long test sections, and periodically measuring the serviceability rating (PSI) with the PCA Roadmeter.

The Road Rater will be used to measure the amount of deflection on the uncracked pcc pavement, cracked pcc pavement and on top of the bituminous overlay.

A control section will consist of an area where the pcc pavement was previously overlaid with bituminous and will remain unfractured.

The locations of the test sections are shown in Figure 2. The PCA Roadmeter ratings are shown in Table 2.

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</table>

Table #2. PCA Meter Ratings
Figure 2. Test section locations
The Model 2000 Road Rater was used to take deflection measurements on the first two-hundred feet of test sections 1, 2, 3, and 4. The testing was done before the pcc pavement was cracked and again after the cracking was completed. Test section number 4 was not cracked because it is in an area where the pcc pavement had been previously overlaid with bituminous surfacing. The “Before Cracking” data on test section 2 could not be used as it was found that some of this test section had been cracked before the uncracked data had been gathered. The data is shown in Table 1.

<table>
<thead>
<tr>
<th>TEST SECTION</th>
<th>BEFORE CRACKING</th>
<th>AFTER CRACKING</th>
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<tbody>
<tr>
<td>1</td>
<td>D1 3.43 3.02 3.01 2.24</td>
<td>D1 4.55 3.83 3.57 2.74</td>
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<td>2</td>
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<td>5.96 5.29 4.82 3.50</td>
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<tr>
<td>3</td>
<td>2.86 2.05 1.62 1.04</td>
<td>3.44 2.76 2.24 1.49</td>
</tr>
<tr>
<td>4</td>
<td>4.66 4.29 4.21 3.32</td>
<td>- - - -</td>
</tr>
</tbody>
</table>

Table 1. NDT Deflection Data

The deflection values shown in Table 1 are field test data normalized to a force of 3 kips. The field testing was done at a force of approximately 3 kips, but as the force varies slightly during the test the deflections must be adjusted before a meaningful comparison can be made.

The adjustment is made on a linear relationship between force and deflection. Although the actual relationship between force and deflection may not be exactly linear, the force variations is small and the use of the linear relationship should be an acceptable assumption.
Construction operations began on August 19, 1981. One traffic lane was closed to traffic with barricades. The 7-1/2 inch thick bituminous widening sections were constructed prior to when the pavement cracking operations began. Two spade type pavement breakers were used to crack in existing pcc panels. The cracking of the 40 foot concrete panels was done at transverse intervals of approximately 5 feet. At locations where the existing concrete panels were already broken, the proposed crack was eliminated.

The spade type hammer was dropped once and then moved the width of the spade and dropped again. This process was continued until the 10 foot width of the concrete slab was covered. This operation did not produce a visible crack in most cases. When two drops or more were used the top several inches of the pcc slab were shattered. A concrete core taken over the proposed crack after completion of the one drop (over the entire width of slab) had hairline cracks in the bottom 5 inches of the core. Concrete cores were also taken after two blows per hammer width were completed. A drawing of these cores are shown in Figure 3.

Figure 3. Cores of cracked pcc pavement.
The existing joint seals were not removed if they were in good condition.

It was the intention of the specifications that the aggregate interlocks should be maintained. Because of this, the concrete cracking was done using one hammer drop for each spade width. The special provisions required that the cracked pcc pavement be seated by rolling it with a 30 ton test roller.

After cracking, traffic was allowed to drive over the cracked pcc slabs.

A copy of the pavement cracking specifications are included in Appendix A.

The bituminous leveling course was a plant mixed bituminous mixture, Mn/DOT specification number 2331. The placement of the bituminous leveling course was completed during the 1981 construction season.

From the north limits of the project to the town of Hader, the level course had approximately 4.7% AC-1 (120-150 penetration). This area had the bituminous wearing course (Mn/DOT spec. 2361) placed in 1981. From the town of Hader to the south limits of the project, the leveling course was used as "Interim Wearing Course" and the percent of AC-1 was approximately 5.8%. Test Section 1 will therefore have one inch minimum of leveling course at 4.7% AC and test sections 2 and 3 will have leveling courses at 5.8% AC. The differences in the AC content could have some bearing on the experimental results. The project was suspended on November 12, 1981 for the winter.

DISCUSSION

The cracking of the pcc pavement is not simply a matter of using the same method in all cases. The different variables involved such as changes in soil type, changes in soil moisture, reinforcement present, condition of pcc slab, existing voids under the pcc slab, etc., make the amount of force needed to crack the pcc pavement a variable. The contact area of the spade with the pcc pavement may have to be changed to be able to crack the pavement without shattering (punching) it.

It is recommended that on future projects a trial section be set up in the special provisions, where the contractor could demonstrate that he can produce the desired cracking without damaging the aggregate interlock. This would allow both the contractor and the Engineer to try various combinations of pavement breaker force and contact areas to determine the correct force to be used.

-7-
The test sections were surveyed on Feb. 9, 1982. This survey showed that many reflected transverse cracks are present in the bituminous overlay. The majority of these reflected cracks are over the transverse joints in the pcc panels. The percentage of reflected transverse cracks and joints are as follows:

<table>
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<tr>
<th>TEST SECTION</th>
<th>TYPE</th>
<th>% REFLECTED TRANSVERSE CRACKS</th>
<th>JOINTS</th>
<th>CRACKS</th>
<th>TOTAL</th>
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<td>2</td>
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<td>92</td>
<td>12</td>
<td></td>
<td>51</td>
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<tr>
<td>3</td>
<td>3” Level</td>
<td>44</td>
<td>58</td>
<td></td>
<td>50</td>
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<tr>
<td>4</td>
<td>Control</td>
<td>100</td>
<td></td>
<td>**</td>
<td>**</td>
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</table>

*Control section was covered by a maintenance overlay

The 2961 Wearing Course has been placed over test section number 1, but has not been placed on test sections 2 thru 3. As the rate of reflective cracking has been found to be a function of overlay thickness, the amount of cracking to date is more than would normally be expected. To obtain the maximum benefit from the extra overlay thickness, the total overlay thickness must be placed prior to the first winter season.

Based on the large amount of reflective cracking to date, it appears that the pavement cracking has not worked as well as anticipated. One reason for this may be, the steel reinforcing bars which were placed longitudinally down each panel edge are holding the cracked sections together, such that the effects of cracking are negated. Future pavement cracking projects with existing pcc pavement of this design, should include a test section with this longitudinal steel reinforcement cut.
APPENDIX A

S-21 (231) PAVEMENT CRACKING
This work shall consist of fracturing and compacting the existing concrete pavement prior to constructing the bituminous overlays and shall be performed in accordance with the applicable Mn/DOT Specifications and the following:

S-21.1 Existing bituminous overlays shall remain in place and cracking will not be required in these areas.

S-21.2 The 7¼" bituminous base widening must be in place before cracking the inside or left traffic lane and the Class 3 and 5 aggregate shouldering must be in place before cracking the outside or right traffic lane.

S-21.3 No concrete pavement shall be mechanically cracked in excess of two (2) miles in advance of overlaying with the Mn/DOT (2331) bituminous leveling course. All mechanically cracked pavement shall be overlaid with bituminous leveling prior to winter suspension.

S-21.4 The normal 40 foot concrete panels shall be mechanically cracked transversely at approximately the ½, ¼, and 1/8 points. Cracking shall be accomplished with a spade type breaker mounted on a vehicle capable of controlled forward and transverse movement and cracking the pavement to its full depth, all as approved by the Engineer.

S-21.5 After mechanically cracking the concrete pavement, loose bituminous patches, concrete spall and loose or exposed joint seal material shall be removed as directed by the Engineer. Prior to placing the Mn/DOT (2331) bituminous leveling course, the concrete pavement shall be rolled with an approved pneumatic-tired roller (Mn/DOT 2111 Test Roller or equivalent) as directed by the Engineer. The rolling shall be done by making one pass over each strip covered by the width of a tire. All loose concrete spall and joint seal materials shall be disposed of in accordance with Mn/DOT 2104.3C3.

The cracking and rolling of the concrete pavement shall be performed only to the extent that will produce transverse fractures the full depth and width of the slab at intervals as specified above, yet maintain aggregate interlock in the fractured faces, all to the satisfaction of the Engineer.

S-21.6 Pavement Cracking will be measured by length in road stations of 100 feet along the centerline of the roadbed on those sections where pavement cracking is specified and performed. Payment will be made under Item 231.601 (Pavement Cracking) at the Contract bid price per road station, which price shall be compensation in full for all costs incidental thereto, including, but not limited to; (1) removal and disposal of loose bituminous patches, concrete spall and loose or exposed joint seals and (2) mechanically cracking and rolling the existing concrete pavement.