R-686

OFFICE MEMORANDUM

MICHIGAN
DEPARTMENT OF STATE HIGHWAYS

October 25, 1968

To: R. L. Greenman
Testing and Research Engineer

From: L. T. Oehler

Subject: Expansion Joint Spalling on I 75. Construction Project I 09035E, C10. Research Project 39 F-7(14). Research Report R-686.

In accordance with your telephone request in late September 1968, Research Laboratory personnel inspected the removal of a portion of an expansion joint on the subject project for the purpose of determining the cause of spalling. This memorandum reports our findings and gives recommendations to prevent further deterioration of the expansion joints.

Field Inspection

Project I 09035E, C10 is a 6 mile portion of I 75 between Anderson Rd and Neuman Rd, in Bay County. The concrete was placed in one lift and the reinforcement vibrated into position with a mesh installer. Pouring operations were started September 13, 1967 and completed November 14, 1967. According to project engineer V. Gansser the spalling problem is confined to the south portion of the northbound roadway from Sta. 1615 to 1707 which was poured from October 26 to November 14th. In this area at least four expansion joints have spalled.

The joint selected for investigation is located at Sta. 1705+94 NB roadway. The air temperature at time of pour was 36F and the concrete temperature was 46F. A 2-ft wide portion extending 5 ft in from the outside edge of the traffic lane was removed and replaced on October 9, 1968 (Fig. 1). The visible spalled area in Figure 1 is quite small. However, from the spall to the lane edge the concrete had fractured horizontally from 12 to 18 in. back from the joint.

Before removing any concrete, a 4-in. diameter core was cut through sound concrete within the area to be replaced. A compression test of this core revealed that the concrete had a compressive strength of 4,200 psi. Thus, the concrete in the immediate vicinity of the spall meets specification requirements.

After the seal and concrete had been removed to the depth of the horizontal fracture, it was noted that the depth of the fracture at the joint coincided with the bottom of the joint seal groove. The reinforcement had been placed

at the level of the groove bottom and extended to within about 1 inch of the joint. The fracture followed the steel for 12 to 18 in. and then angled up to the surface. The groove had been sawed to a depth of approximately 1-3/4 in. and the remaining concrete to the top of the filler had been chiseled out. This resulted in the groove walls being somewhat tapered in the bottom portion and it appeared that in one area the concrete had not been removed completely to the filler. The groove was sawed about 1/2 in. off center with respect to the filler (Fig. 2). The spall and horizontal crack were located on the side of the groove where incorrect location of the saw cut resulted in the concrete overhanging the filler by at least 3/8 in. The average filler width after the concrete was removed full depth was 7/16 in. The dowel alignment was satisfactory, but a 1-in. bow in the joint groove was noted when a taut string was held from one edge of the roadway to the other.

Another joint exhibiting the same type of distress, located at Sta. 1677+55 NB, was also inspected (Fig. 3). A small portion of loose concrete was removed and it was noted that the groove had been sawed 1/2 in. off center with respect to the filler. As in the case of the joint at Sta. 1705+94 the spall had occurred on the side of the joint where the concrete overhung the filler. The joint groove in the visible area was sawed to correct depth; the reinforcement was not visible although the spall depth was the same as that on the other joint.

On the basis of these observations it appeared that the upward force against the concrete overhanging the filler, induced by compression of the filler during expansion of the pavement, caused the spalls to occur. Placing the reinforcement incorrectly increases the probability of joint spalling if other factors are present, but would not itself cause spalls of the type observed.

Laboratory Work

To verify the apparent failure cause, an expansion joint sample was constructed with the joint groove offset 5/8 in. from its required location, and tested to failure. The concrete blocks used to simulate the slab had a cross-sectional area of 9 by 9 in. and an average compressive strength of 4300 psi, when originally cast about a year ago. Fig. 4 shows the joint sample before testing. The filler width was 0.94 in. and the groove width 1.19 in. just before applying the compressive load in the direction of the pavement alignment and simulating pavement expansion. Groove depth was 2-1/2 in. and the width of concrete overhanging the filler was 1/2 in.

A tensile failure originated in the concrete at the inside corner of the overhang, resulting in the spall shown in Figs. 5 and 6. The width of the filler at time of failure was 0.33 in. and that of the seal 0.58 in. On the basis of

load-deflection curves obtained by testing a sample of seal removed from the joint at Sta. 1705+94 and a sample of filler obtained from a local contractor, the compression in the seal and filler at time of failure would be 100 and 1600 psi, respectively. These compression forces would not in themselves be detrimental in joints where the groove was sawed in the correct location. However, from a plot of the load versus extrusion of the unconfined filler, a load of 1600 psi on the filler results in an average of 0.05 in. extrusion at each side of a 6.5 in. wide filler. This amount of extrusion apparently exerts a sufficient lifting force on the concrete overhanging the filler to cause the type of spalls observed in the field and obtained experimentally in the laboratory.

As mentioned previously, the average filler width at Sta. 1705+94 was measured to be 7/16 in. (0.44 in.) after the concrete was removed. The temperature at the time of this measurement was in the mid-sixties. Further expansion of the concrete resulting from an additional temperature rise of 30 to 40F would undoubtedly compress the filler to such width that extrusion of the filler could cause spalls to develop.

Conclusions

Based on the field inspection and the limited amount of laboratory testing the following conclusions are made:

1. Spalling of expansion joints on the subject project was caused by the contractor failing to saw the joint grooves directly over the filler as specified.

2. The structural quality of the joint partially removed was impaired by the reinforcement being placed too close to the surface and extending to within about 1 in. of the groove.

3. The joint groove at Sta. 1705+94 was not sawed to the required depth, resulting in tapered and irregular groove walls near the bottom, causing high localized stresses at the joint.

Recommendations:

Unfortunately, the quality of a repaired pavement joint never quite approaches that of a joint originally constructed to specified requirements. With this in mind and considering that the subject project is not yet one year old the following repair procedures to be used should restore the quality of the joints to a satisfactory condition.

1. Remove all expansion joints where spalls or loose concrete are found. Even if only one lane exhibits spalls or loose concrete the joint in

both lanes must be removed to minimize unequal compression in the two lanes. The reinforcement must be left intact and a new expansion joint assembly and seal installed. The length in the longitudinal direction to be removed at each location is to be determined by the extent of the joint deterioration.

2. All remaining expansion joints should be carefully inspected to insure that the groove is located over the filler. If the groove is found to be offset more than 1/8 in. from the center of the filler, it should be recut and a seal compatible with the resulting groove width installed.

TESTING AND RESEARCH DIVISION

L Roy T. Oehler

Director - Research Laboratory Section

LTO:JES:sjt

Figure 1 (left). Limits of area removed and condition of joint at Station 1705+94 northbound roadway.

Figure 2 (below). Cross-section of groove after concrete removal. Pencil line on concrete indicates edge of filler. Note taper of groove walls near groove bottom.

Figure 3 (left). Condition of joint at Station 1677+55 northbound roadway.

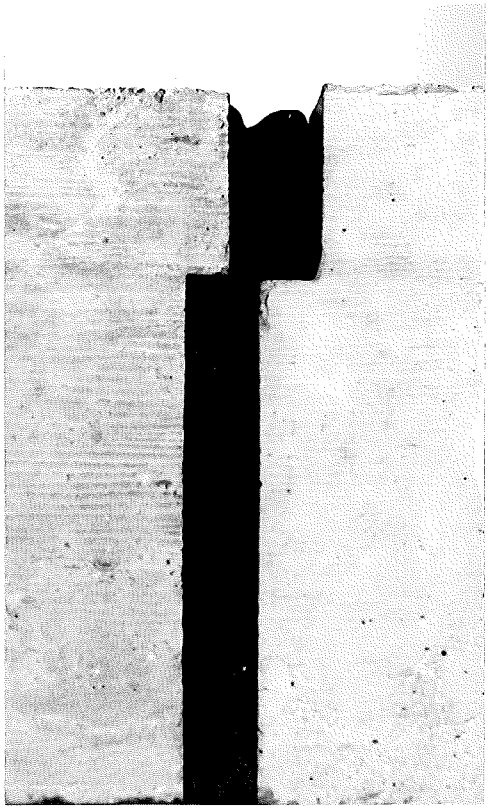

Figure 4 (left). Joint sample before testing. Concrete overhanging the filler by 1/2 in.

Figure 5 (below). Tensile failure crack caused by filler extrusion.

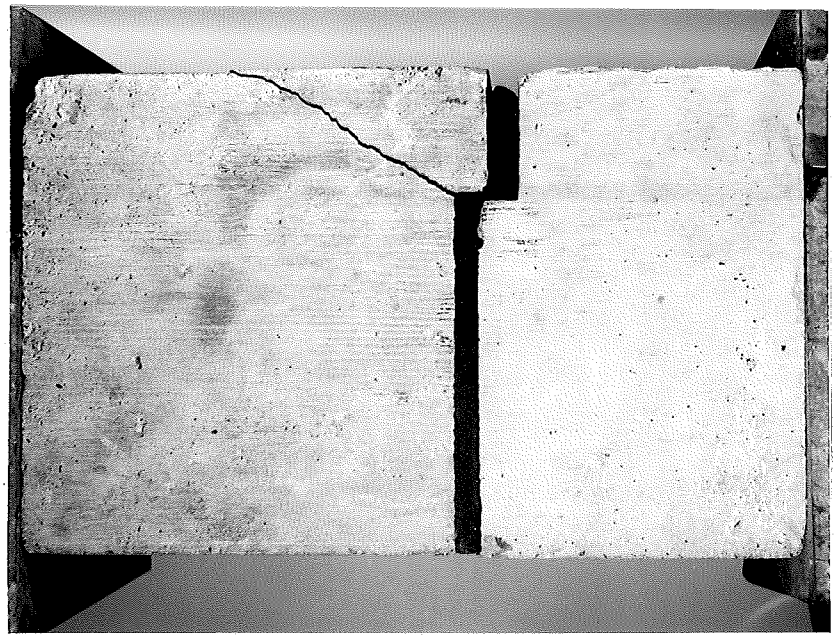

Figure 6 (left). Surface view of joint sample failure.