OFFICE MEMORANDUM

MICHIGAN
DEPARTMENT OF STATE HIGHWAYS

August 26, 1968

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To: R. L. Greenman
Testing and Research Engineer

From: L. T. Oehler

Subject: Joint Spalling on State Project BI 49025G, C22, Mackinac County on I 75 from Junction with M 134 Northerly 6.9 Miles. Research Project 39 F-7(14). Research Report No. R-693.

In accordance with your request of June 26, a field investigation was conducted on the above project by R. Felter of the Research Laboratory on July 1 and 2, 1968. Construction features of the project are as follows:

Construction Project	BI 49025G, C22
Date of Construction	1963
Length of Project	6.937 miles
Pavement Thickness	9-in. uniform
Pavement Width	Dual 24 ft
Pavement Reinforcement	Steel mat
Expansion Joints	None
Contraction Joint Spacing	99 ft
Method of Construction	Formed (no record; probably styrofoam)
Contraction Joint Load Transfer	Dowel bars, 1-1/4 by 18 in., 12-in. cntrs.
Curing	Membrane
Cement	Penn-Dixie, Aetna, and Huron
Fine Aggregate	Kinross Air Force Base (17-63)
Coarse Aggregate	Kinross Air Force Base (17-63)
Contractor	L. W. Edison Co.

It was found that approximately 58 percent of the total number of joints on both roadways are spalled. The spalling was all approximately one inch wide, one to two inches deep, and varied in length from five inches to the entire width of the slab. This depth corresponds to the depth of the free edge of concrete formed by the joint groove. Joints appeared to be clean and in working order.

Concrete samples from the spalled areas were returned to the Laboratory for detailed inspection. This inspection revealed the presence of chert and a significant amount of shale. Concrete pavement core records show the presence of shale in nearly one-half of the cores taken. Upon investigation of the daily aggregate inspection reports, it was noted that considerable amounts of soft

and non-durable particles (shale) were encountered during aggregate production. It was also noted that significant quantities of aggregate were accepted, although exceeding the maximum specified allowable percentage of three percent for soft and non-durable particles. Chert and shale are both absorbent aggregates with very small pores. These small pores hold the water which has been absorbed and, upon freezing, the trapped water expands, causing the aggregate to burst and form a spall. It was also noted in the aggregate inspection reports that most objectionable materials were in the larger size aggregate. Larger aggregate, due to larger area and volume, would create greater pressures and damage upon bursting. (Spalling shown in Figs. 1-6).

A survey conducted on August 14 indicated that pop-outs were numerous over 90 percent of the pavement. For the survey, 56 slabs were selected at random. Pop-outs of the 1/2- to 1-1/4-in. range were so numerous that they were only counted on two slabs which appeared representative, thus there is no entry in the first line of Column 3 below. A tabulation of the survey results is as follows:

Size of Pop-Out	Average Number of Pop-Outs per Slab	Range of Pop-Outs Counted in Individual Slabs
1/2 to 1-1/4 in.	about 400	----
1-1/4 to 2 in	31	0 - 88
2 to 3 in.	12	0 - 34
3 to 4 in.	1+	0 - 8
over 4 in.	0.3	0 - 2

Figures 7 and 8 are examples of pop-outs that were found; Figure 9 shows an overall view of a slab with many pop-outs in evidence. Many pieces of wood and roots as shown in Figures 10 through 12 were also evident in the concrete. As a point of comparison, pop-outs on this project are about four times as numerous as reported for I 196 north of South Haven (Research Report R-513). Coarse aggregate used in the I 196 project came from the Clarence Sweet Pit (3-65).

The concrete spall samples that were returned to the Laboratory also revealed several cases of what appeared to be a failure of the bond between the aggregate and the cement. An inspection of the modulus of rupture tests and the concrete core compression tests was made to determine the strength quality of the concrete. The compressive strength ranged from 4,510 psi to 6,110 psi compared to the minimum specified 3,500 psi. The 7-day modulus of rupture tests ranged from 617 psi to 750 psi compared to the specified minimum of 550 psi; the 14-day ranged from 600 psi to 850 psi compared to the 600 psi minimum. Both tests indicate good con-

crete. The apparent bond failure might, therefore, be attributed to complete disintegration of soft aggregate at these locations.

On the basis of this evidence, it appears that the spalling of the joints on this project is due to the freezing and consequent expansion of water which has been absorbed in the soft shale and chert present in the concrete.

To repair these joints, it is recommended that the spalls be removed and the joints filled with hot-pour sealer. Since the hot-pour would have to stretch only a small percentage, the chances for successful performance would be high.

TESTING AND RESEARCH DIVISION

L. Ray T. Oehler

Director - Research Laboratory

LTO:sjt

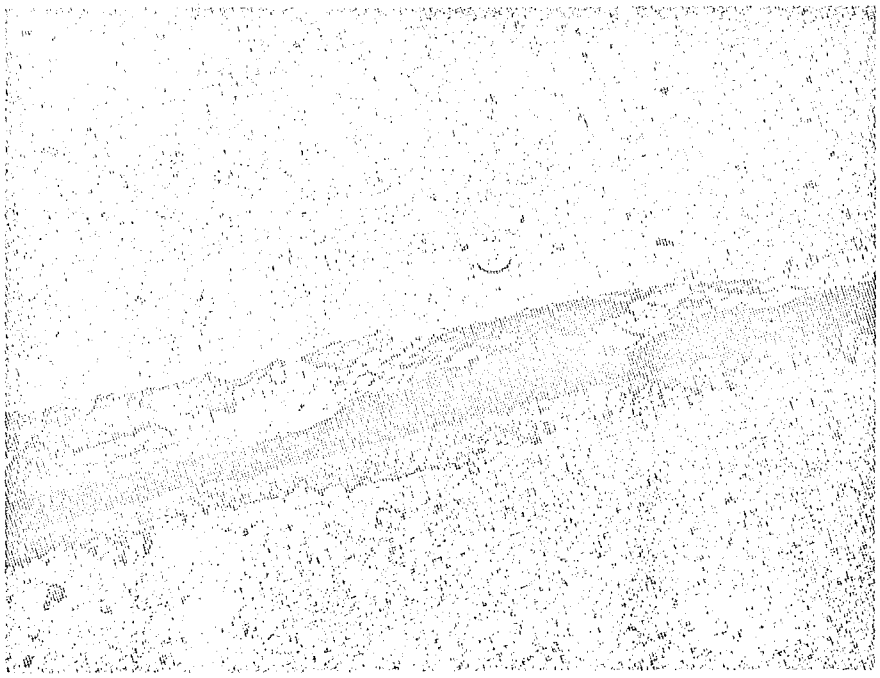

Figure 1. Spalling along joint at 875+90, SB. Note width and depth of spall.

Figure 2. Spalling along joint at 837+25, NB.

Figure 3. Spalling along joint at 975+35, SB. Note width of spall.

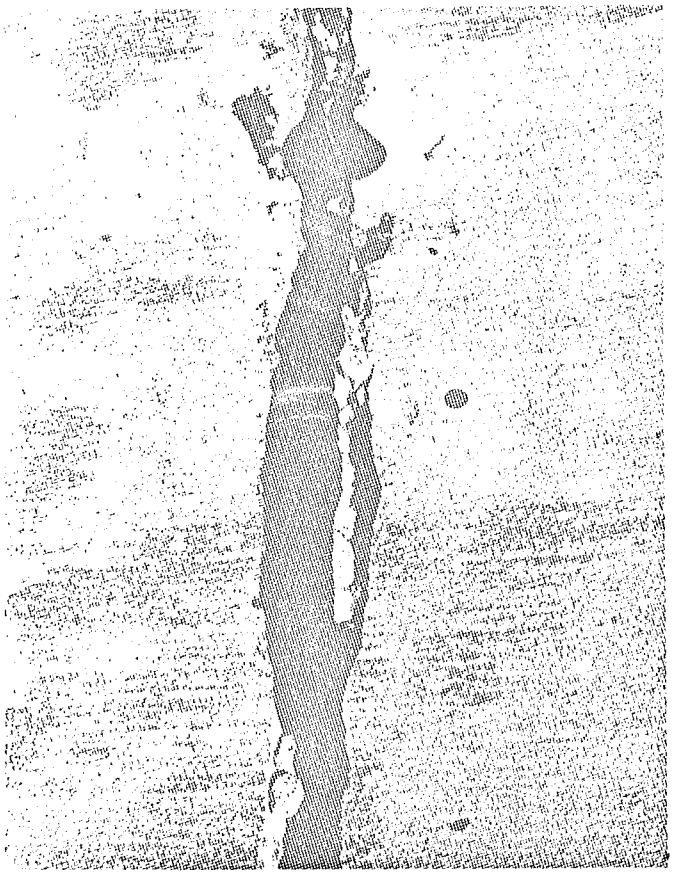

Figure 4. Spalling along joint at 975+35, SB. This is a later stage of spalling similar to that shown in Figure 3.

Figure 5. Spalling along joint at 836+25, NB.

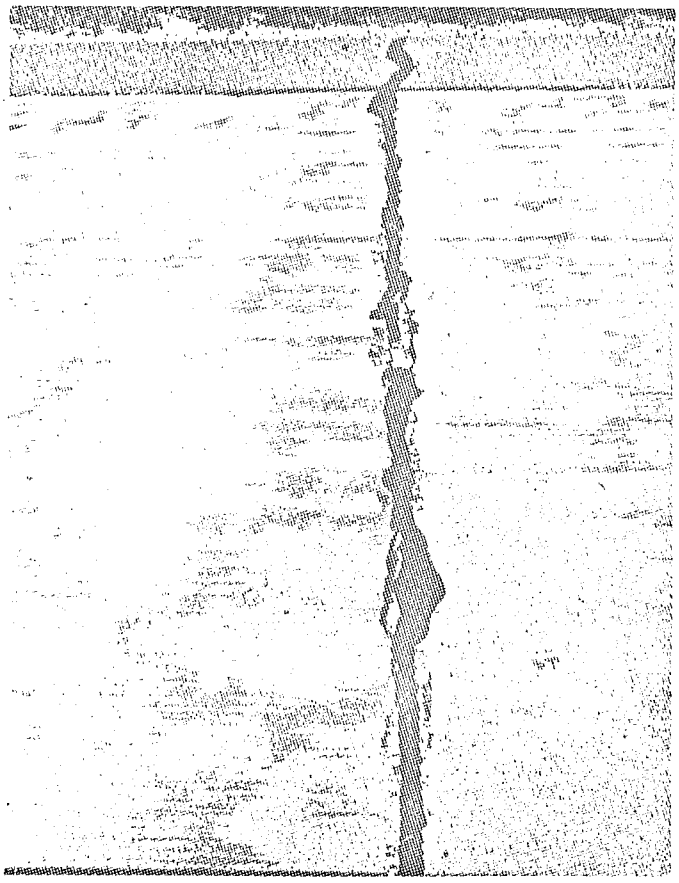

Figure 6. Typical joint.

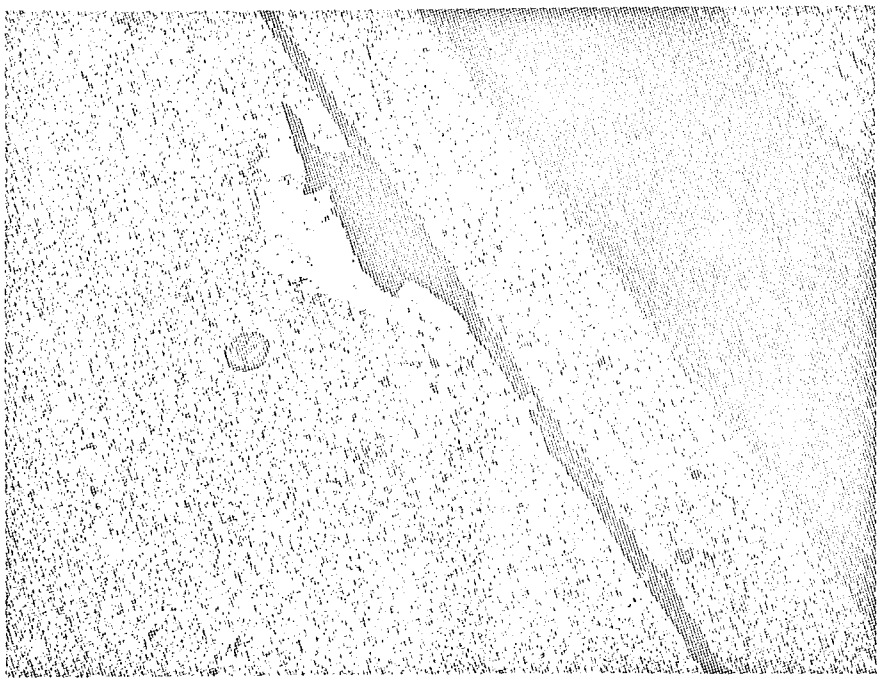

Figure 7. Pop-out along center line at 1041+57, SB. Note outline of disintegrated aggregate.

Figure 8. Pop-out at 1150+88, SB.

Figure 9. General view of slab surface. Note pop-outs in evidence.

Figure 10. Wood embedded in concrete at 880+80, NB.

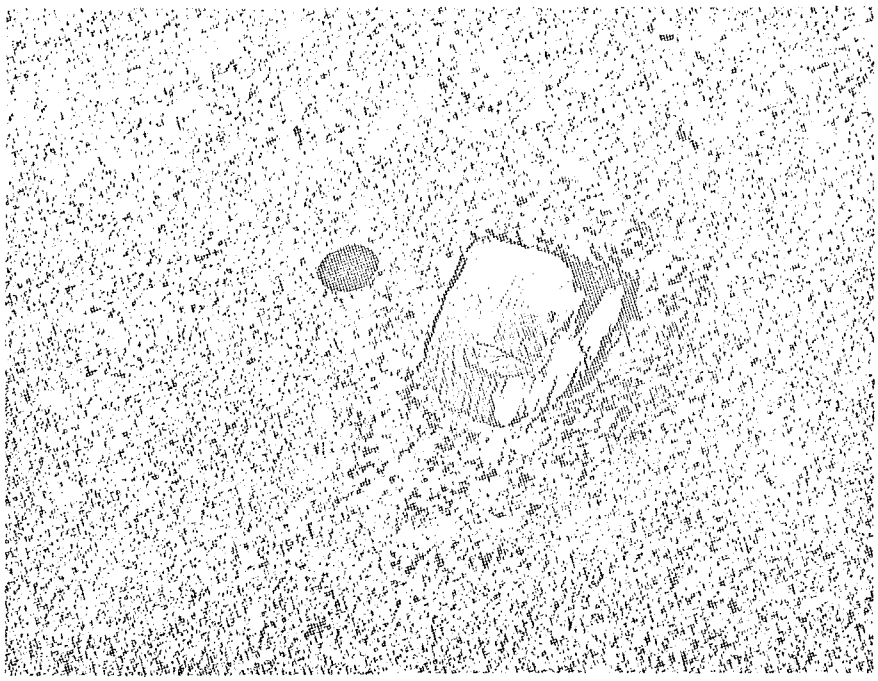

Figure 11. Wood embedded in concrete at 917+70, NB.

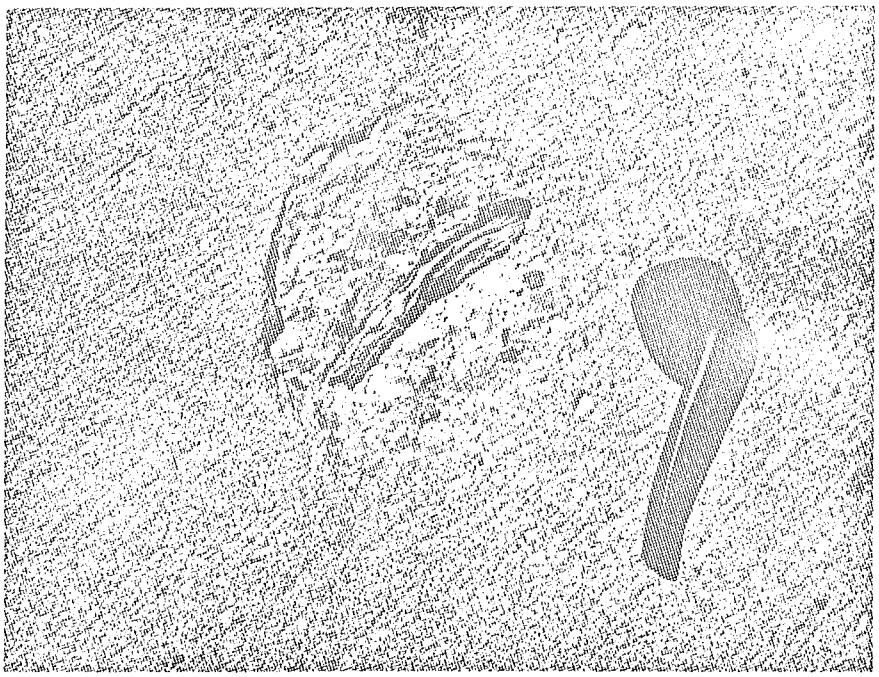

Figure 12. Wood embedded in concrete at 1040+37, SB.