OFFICE MEMORANDUM

MICHIGAN
STATE HIGHWAY DEPARTMENT

February 4, 1966

To: G. R. Cudney, Supervisor
Physical Research Section

From: J. E. Simonsen

Subject: 1965 Failure and Repair of Continuously Reinforced Experimental Pavement: I 96 from Portland Road to M 66. Research Project 57 F-46. Research Report No. R-567.

Three failures on the subject pavement were repaired during 1965--one at Sta. 936+92 on the eastbound roadway and two on the westbound roadway at Stas. 1064+00 and 1070+25. All three failures were in welded wire mesh reinforced sections. The failure on the eastbound roadway occurred at a construction joint and the two on the westbound roadway at laps in the reinforcement.

Previously repaired failures include three in bar mat sections, five in welded wire mesh sections, and two in standard mesh in the conventional pavement sections. Research Report No. R-397 discusses the cause of failure and Research Report No. R-409 the repair procedures used at five locations repaired in 1962. The cause of failure and repair procedures used at the remaining five locations, which were repaired in 1963, are given in Research Report No. R-448. This memo reports on 1965 failures and repairs.

The construction joint failed by blow-up in the early evening hours of June 27, 1965. Temporary repair by the Ionia County Road Commission commenced shortly after the failure occurred and was completed on the morning of June 28. This repair consisted of replacing a narrow, full-depth strip of pavement on the night side of the joint with bituminous material. Although this procedure relieved compressive forces at the joint, the morning side of the joint remained raised about 2 in. above grade, and, therefore, an 8-ft long transition patch of bituminous material was placed on the night side of the joint.

Incipient failure was noted at the other two locations during the regular summer survey in July. Concrete cores, taken later in the month, revealed that the failures had occurred at laps in the mesh reinforcement. Cores were also taken at the construction joint failure in order to find the location of the reinforcement lap. Based on the core investigation and failure conditions, the areas needing replacement at each location were 456, 108, and 192 sq ft at Sta. 936+92 eastbound, and Stas. 1046+00 and 1070+25 westbound, respectively. Repair of these areas by the Office of Maintenance, in accordance with suggested procedures, was recommended in a memorandum dated August 3 from E. A. Finney to H. J. Rathfoot.

Observations of removal operations and regular evaluation survey data indicate the cause of failure at each location, as discussed in the following notes.

Sta. 936+92 Eastbound

A review of pavement performance data shows that the pavement surface in the immediate joint area was in excellent condition. It is clear, therefore, that the blow-up must have originated as a result of deterioration below the surface. The blow-up, according to repair personnel, caused a slab uplift of approximately 4 in. at the joint, suggesting compression failure in the bottom area of the slab end. Removing the entire passing lane section to be replaced on each side of the joint in one piece afforded an excellent opportunity to examine the joint faces and the slab underside. On the night side of the joint, as previously mentioned, a full-depth strip of pavement approximately 12-in. wide parallel to the joint was removed during the temporary repair and an examination of the existing slab at this section showed the concrete to be of sound quality. The slab was 8-in. thick and only a small amount of honeycombing was visible on the slab bottom. The joint face on the morning side slab consisted of sound concrete for 4 in. below the surface. The bottom 4 in. of the slab had separated from the main mass for a distance of 1 to 3 ft back from the joint. Severe honeycombing was noticeable at the steel level and on the slab bottom. The reinforcement was severely rusted at the joint and a few dowel bars not removed during the temporary repair were heavily rusted on the half portion embedded in the morning side.

Because of poor consolidation of the concrete there was little or no bonding to the steel in the first 12 in. on the morning side. Thus, greater bond slippage occurred than at a normal crack or joint, allowing moisture to enter shortly after construction. As reported in a memorandum from Cudney to Oehler, transmitted to McLaughlin July 1, 1965, joint opening increased progressively since the first winter after construction, with a measurement of 0.17 in. in the winter of 1964. This increase in opening indicates that rusting of the reinforcement coupled with tensile stress caused yielding and eventual fracture of the steel.

Based on this evidence it is concluded that initial poor consolidation of the concrete on the morning side resulted in a plane of weakness along the steel level. Moisture entering through the joint, in addition to rusting the steel, seeped into the poorly consolidated concrete and caused further weakening of the concrete. The strength of the bottom concrete layer finally was reduced to the point that it offered little resistance to compressive forces and failure occurred. It should be noted that the July 1 memorandum, on the basis of inspection on June 28 after the temporary repair was completed,

reported that the failure had occurred on the joint's night side. However, removal of the temporary bituminous repair material revealed that the failure had actually occurred on the morning side.

Sta. 1046+00 Westbound

The failure was confined to the traffic lane and originated as a result of a large clay ball. Repair with Embeco mortar was made in 1962. Spalling around the repair patch necessitated another repair in 1964. Because continued spalling required periodic patching with bituminous material, permanent repair was recommended. Although the failure occurred at a lap in the reinforcement there was no evidence of slippage or weld failure in the lap area. The reinforcement was only slightly rusted, except in the clay ball area where several longitudinal wires had rusted through. Therefore, the failure did not occur because of a break in pavement continuity, but rather because of deficient concrete quality.

Sta. 1070+25 Westbound

The first indication of a possible failure (crack opening wider than normal) was noted during the May 1963 performance inspection. Progressively larger crack opening was observed during following inspections. Spalls along the crack were repaired with bituminous cold patch early in 1965. Observations during removal operations showed that except for 14 wires fractured in the center of the passing lane, failure had been caused by a Type 1 failure as described in Research Report No. R-397. Briefly, a Type 1 failure is characterized by a vertical crack extending to the steel level at the center of the lap; then by a horizontal crack between the steel mats to the end of the lower mat, where a vertical crack extends to the bottom of the slab. Bond resistance fails in the last 6 in. of the top mat and movement is possible. It appears that the traffic lane and part of the passing lane failed in this manner first, causing overstressing of steel in the center portion of the passing lane. As a result, these steel wires eventually fractured in tension.

1965 Repair Operations

The repair work was performed under Heavy Maintenance Authorization No. 69-513, in accordance with the suggested procedures given in the August 3 memorandum. The three traffic lane areas were removed and replaced on October 11 and the two in the passing lane on October 18. The replacement steel was lapped 3 ft at each end of the patches with the existing reinforcement. At Sta. 936+92, each lap in the

traffic lane was secured with two 1-in. long welds spaced approximately 18-in. apart. The welds at one end of the patch were completed during regular working hours, and at the other, welding was postponed until just before concrete pouring. Time required for one man to weld one end was 1 hr. The passing lane replacement steel was lapped but not welded. Concrete was supplied by Grand Rapids Gravel Co., which had previously been approved for supplying concrete on State highway projects. Concrete pouring took place between 8 and 10 p.m. Maximum temperature drops to which the newly poured patches were subjected occurred about 11 hr after pour, and were 3 and 18 deg for the traffic and passing lane patches, respectively. An inspection of the repairs shortly after completion revealed only ordinary crack development.

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