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INVESTIGATION OF THREE SPALLED JOINTS
Norton-Glade Expressway, Muskegon
US 16 (Project 61-47, C7)

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At the request of W. W. McLaughlin, Testing and Research Engineer, the Research Laboratory Division made a condition survey of spalled joints on the Norton-Glade Expressway in Muskegon, on August 22, 1960. The condition of these joints was first brought to the attention of N. F. Yonkman, the Department's District Maintenance Engineer, by R. J. Miles, Muskegon Director of Public Works.

Research Laboratory personnel made a photographic record of spalling on Webster and Muskegon Avenues--the "outbound" and "inbound" roadways of the Expressway--between First and Ninth Streets, on August 23. On October 18, three of the worst of the spalled joints in this region, all 1-in. expansion joints and each in the third of four lanes from east to west, were exposed and inspected prior to repair, to determine the cause of the deterioration. Messrs. Miles and Yonkman were present during the inspection, along with Research Laboratory personnel.

A schematic diagram of the Norton-Glade Expressway from Fifth to Ninth Streets is given in Fig. 1, with the three worst joints specifically labeled. It may be noted that the pavement in question was four years old at the time of the joint repair.

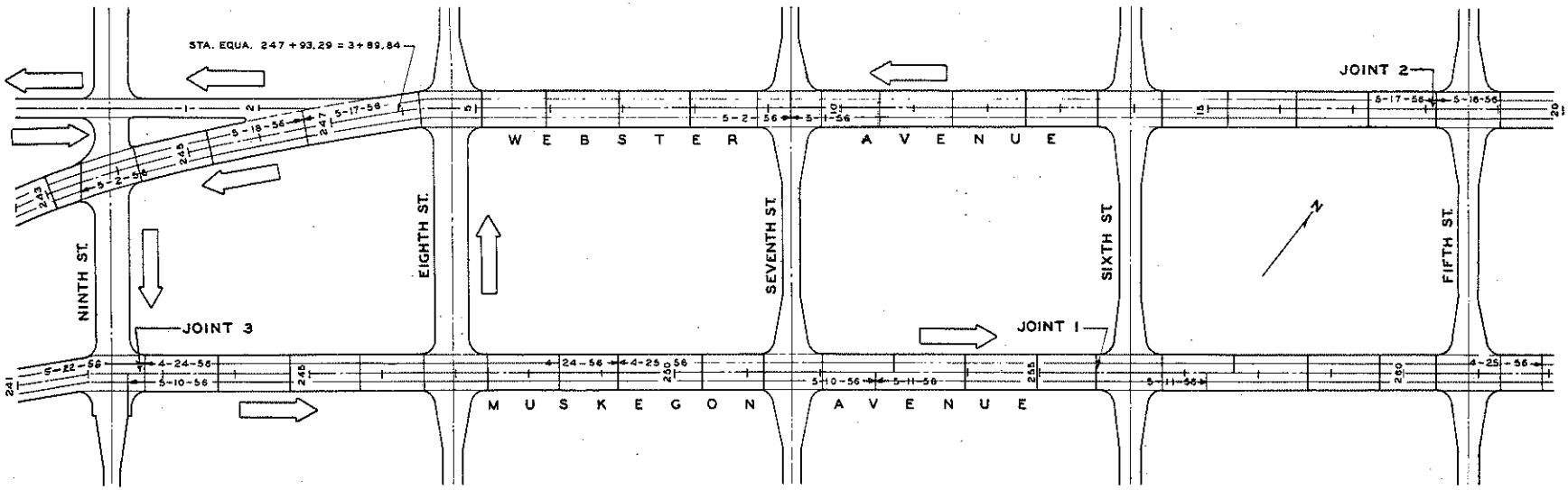

Figure 1. Plan view of a portion of the Norton-Glade Expressway, showing locations of three investigated joints.

Joint 1--Muskegon Ave. at Sixth St.

At the first location, the joint had extensive surface spalling, extending downward into the pavement no more than 2 in. at the joint face, and back from the joint groove about 15 in. where spall depth was about 1/2-in. (Fig. 2).

Since the spalling was not deep, the load transfer system was not exposed and therefore its influence in this spalling could not be determined. However, it was noted that near the surface the spalled concrete was chiefly mortar, with very little coarse aggregate. In addition, over a considerable area, the plane of cleavage between the sound pavement and the spalled surface showed no evidence of broken aggregate, but rather of bond failure between coarse aggregate below and the mortar in the upper surface.

Generally, this indicates that mortar is weak, for bond strength between mortar and coarse aggregate is proportional to mortar strength.

Joint 2--Webster Ave. at Fifth St.

The second joint was a construction joint at the south spring line of the intersection (Fig. 1). Particular attention was given to its south side--the start or morning side of the pour--where concrete had spalled most severely, down to the level of the dowels (Fig. 3). It was noted that all four dowel bars exposed tilted up 1/4- to 1/2-in. in their length. This misalignment is sufficient to cause concrete-to-dowel binding, and appears to have caused the spalling at this joint.

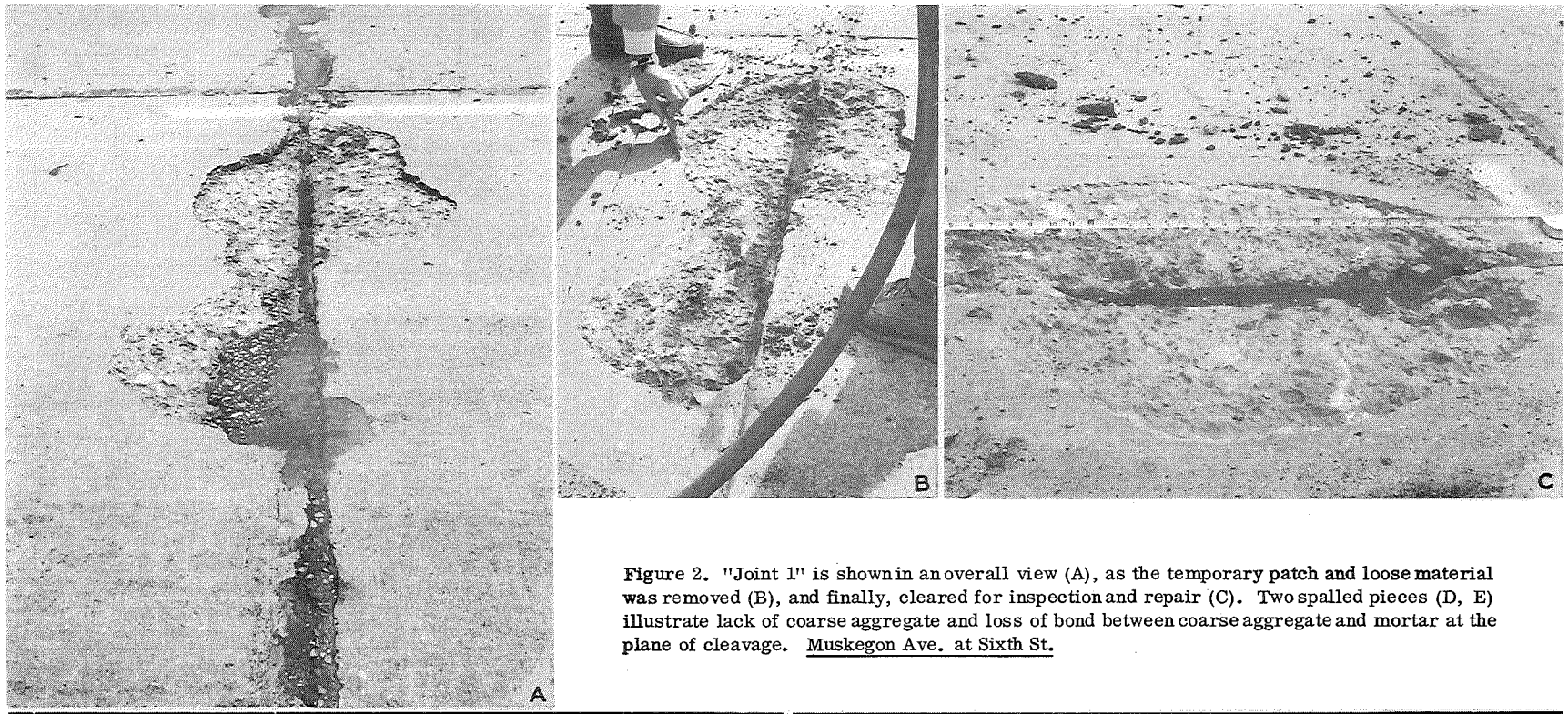

Figure 2. "Joint 1" is shown in an overall view (A), as the temporary patch and loose material was removed (B), and finally, cleared for inspection and repair (C). Two spalled pieces (D, E) illustrate lack of coarse aggregate and loss of bond between coarse aggregate and mortar at the plane of cleavage. Muskegon Ave. at Sixth St.

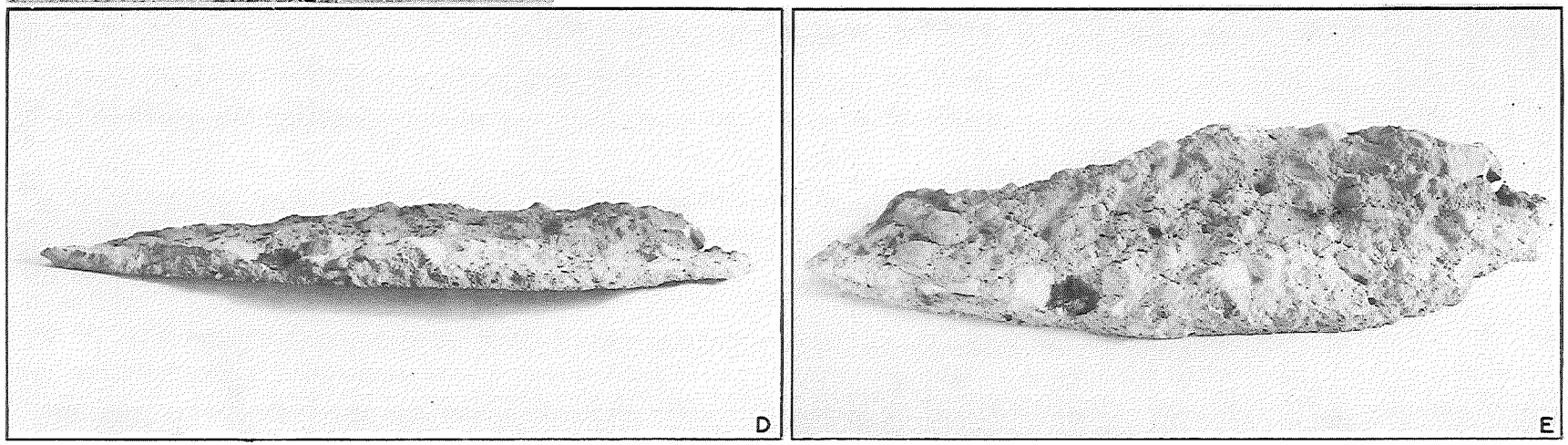

Figure 3. "Joint 2" is shown in an overall view (A). During cleaning for inspection and repair, dowel misalignment (upward tilt) on the morning side of the joint, was clearly visible (B, C). Webster Ave. at Fifth St.

Joint 3--Muskegon Ave. at Ninth St.

At the south side of this joint, the pour of May 22, 1956 ended against month-old concrete on the north side, creating a construction joint. Spalling occurred at the south edge of the joint (Fig. 4). The slab reinforcement was found to be only 7/8- to 1-in. from the surface on the spalled side of the joint. The joint was not moving properly at the joint groove, but was opening 6 in. further south where a crack had opened sufficiently to rupture the steel. The fact that the joint functioned 6 in. south of the proper location meant that only a few inches of the dowels extended across one side of the opening, resulting in absence of proper load transfer. Undoubtedly this condition was partially responsible for the breakage here.

In addition, after more of the reinforcing mat was exposed in the slab south of the joint, it could be seen that the mat was not correctly oriented, being crosswise, with the transverse and longitudinal axes of the mat and the pavement opposed. The No. 00 gage wires at 6-in. spacing were oriented transversely, giving 0.688 sq in. to the linear foot. The No. 4 gage wires at 12-in. spacing were oriented longitudinally, giving only 0.159 sq in. to the linear foot, or less than a fourth the proper steel area.

This incorrect orientation of the steel mat undoubtedly caused the opening of the crack south of the joint, and the early failure of the steel at this point. The load transfer system, however, must have caused considerable binding and freezing at the joint, and caused slab movement to take place 6-in. away from the joint.

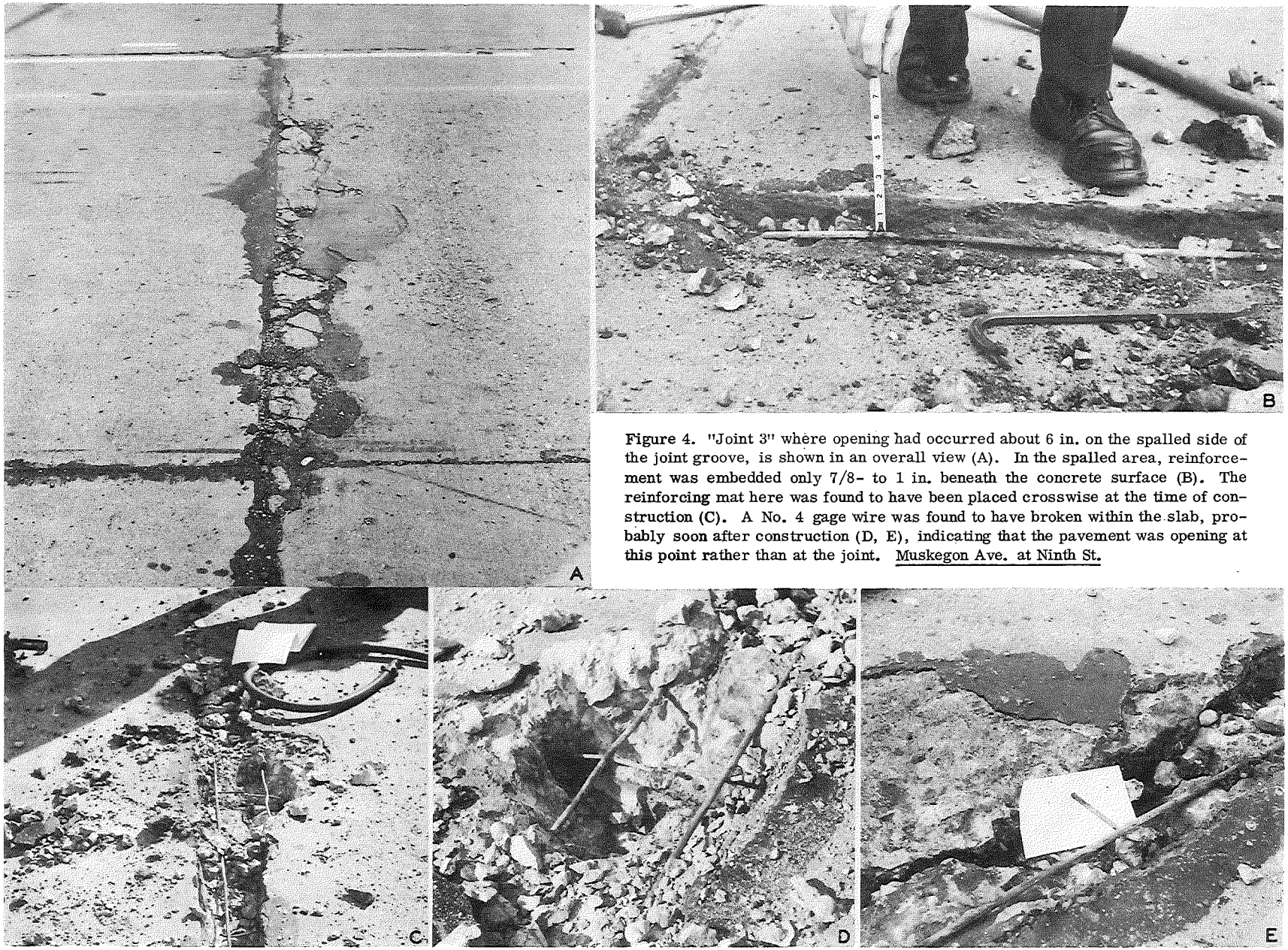

Figure 4. "Joint 3" where opening had occurred about 6 in. on the spalled side of the joint groove, is shown in an overall view (A). In the spalled area, reinforcement was embedded only 7/8- to 1 in. beneath the concrete surface (B). The reinforcing mat here was found to have been placed crosswise at the time of construction (C). A No. 4 gage wire was found to have broken within the slab, probably soon after construction (D, E), indicating that the pavement was opening at this point rather than at the joint. Muskegon Ave. at Ninth St.

Spalling at Other Joints

As noted previously, only the three joints which exhibited the worst spalling on this project were investigated to determine the cause of the trouble. However, in Table 1 joint spalling on the project has been tabulated regardless of the size of the spalled area to demonstrate the distribution of spalls throughout the project. The spalling is subdivided between spalls at joints at intersections and at joints between intersections. It should be noted that most of the spalling--89 percent--occurred at spring line or centerline joints of intersections, rather than at joints between intersections. Forty-three of the one hundred joints on this project had one or more spalls.

Conclusion

In all three joints examined, spalling could be directly associated with irregularity in construction practice. As has been noted in previous reports, construction or night joints experience a relatively disproportionate share of poor performance. On this project, two of the three joints examined were night joints.

TABLE 1
TABULATION OF JOINT SPALLING
Survey of August 23, 1960

	Location	No. of Joints	Spalls at Intersection		Spalls Between Intersections
			At Spring Line	At Center Line	
MUSKEGON AVENUE	At First Street	2	1	0	–
		3	–	–	1
	At Second Street	3	8	0	–
		3.5[a]	–	–	0
	At Third Street	3	4	0	–
		3	–	–	0
	At Fourth Street	3	3	2	–
		3	–	–	0
	At Fifth Street	3	3	2	–
		3	–	–	2
	At Sixth Street	3	7	2	–
		3	–	–	1
	At Seventh Street	3	3	3	–
		3	–	–	0
	At Eighth Street	3	1	0	–
		3	–	–	0
	At Ninth Street	3	4	0	–
	TOTALS	50.5[b]	34	9	4
WEBSTER AVENUE	At First Street	2	3	0	–
		3	–	–	3
	At Second Street	3	3	5	–
		2	–	–	2
	At Third Street	3	2	6	–
		3	–	–	1
	At Fourth Street	3	0	2	–
		3	–	–	1
	At Fifth Street	3	5	4	–
		3	–	–	0
	At Sixth Street	3	2	3	–
		3	–	–	0
	At Seventh Street	3	3	3	–
		3	–	–	0
	At Eighth Street	3	3	5	–
		3.5[a]	–	–	0
	At Ninth Street	3	0	0	–
	TOTALS	49.5[c]	21	28	7

[a] Three 4-lane joints and one 2-lane joint.
[b] Of these 50.5 joints, 23 have one or more spalls.
[c] Of these 49.5 joints, 20 have one or more spalls.