OFFICE MEMORANDUM

MICHIGAN
DEPARTMENT OF STATE HIGHWAYS

August 4, 1971

To: L. T. Oehler
Engineer of Research

From: H. L. Patterson

Subject: Epoxy Mortar Surfacing on the Crietz Rd Bridge over I 496, Lansing (S05 of 23081A): A Report on the First and Second Annual Field Inspections. Research Project 67 G-157. Research Report No. R-778.

INTRODUCTION

This report is part of the performance evaluation outlined by G. R. Cudney in a letter of December 8, 1967 to John Risch. It is primarily concerned with evaluating the epoxy mortar wearing surface on the subject bridge. The bridge was erected on an experimental basis to determine whether the orthotropic design and epoxy wearing surface were practical in this climate. The structure is described in a Design Division report compiled by John Risch ("Final Report of Experimental Orthotropic Bridge," January 1970).

The steel deck and concrete curbs of the bridge were placed in the winter and summer of 1969, respectively, and the epoxy mortar surfacing was applied in September and October of that year. The deck was divided such that the south half and north half contained different epoxy mortars applied at a minimum thickness of 5/8 in. On the south half, the epoxy binder used was "Guardkote 250," an oil-modified epoxy produced by the Shell Oil Co. On the north half, the epoxy binder consisted of compatible components from two sources: "Epon 815," a modified epoxy resin from Shell Oil Co. and "Versamid 140," a modified polyamide curing agent from the Chemical Division of General Mills and carrying their designation "Genepoxy E15." To the best of our knowledge, this application of the latter epoxy was its first use on Michigan highways.

BRIDGE DECK INSPECTION TECHNIQUES

A system of surveillance was established to detect any faults or failures which might occur in the epoxy mortar wearing course. It consisted of a semi-annual series of oblique photographs taken longitudinally down both sides of the bridge, accompanied annually by a closely detailed inspection. All deterioration features were photographed and recorded on a scale drawing of the deck plan. To aid in cross-referencing between the oblique photographs and the scale drawing, the curbs were measured and marked off in 10-ft intervals from north to south. Six-inch stenciled numbers denoting the distance were painted near the marks such that they would be visible in the photographs.

The oblique photographs were taken from an elevation of 10 ft and showed a 35-ft longitudinal distance down the deck; each subsequent photograph in the series overlapped its predecessor by 10 ft to aid in continuity. All photographs taken during the detailed inspection consisted of two pictures of each feature; a general area picture to show the relative location, and a close-up to show the detail.

To supplement the photographs and mapping of deterioration features, tests were run in the spring and fall of each year with the Department's skid testing vehicle. As an additional check on the slipperiness of the deck, weekly inspections were performed during the first operational winter to determine the deck surface icing characteristics. Table 1 gives a summary of the skid tests. Additional discussion of these results are presented at the end of the report.

OBSERVATIONS OF DECK PERFORMANCE

Figure 1 shows the overall view of the deck looking south at the time the initial set of oblique photographs were taken; approximately one month after the bridge was opened to traffic.

Weekly inspections of icing conditions on the deck throughout the winter revealed that this deck was typical of most, in that it became very slippery if snow were allowed to accumulate; however, liberal amounts of deicing salts had been applied in all cases of significant snow accumulation and the deck surface afforded good traction. Icing, resulting from overnight frost conditions, did not seem to produce a slippery surface on the deck.

Inspection After the First Winter

In the latter part of April 1970, the deck was closely inspected and all types of deterioration were shown and noted on a scaled plan drawing. Figure 2 is a diagram of the deck which shows the signs of deterioration found at the time of this inspection.

On the west strip of the north half, where some screeding difficulties were encountered with cold E15-V140 epoxy mortar, several badly pitted areas were observed. This problem was later solved by heating the epoxy. We believe that an excessive amount of air had been trapped during mixing by the cold, higher viscosity binder in these areas. Traffic soon removed the thin cover over the voids, and in their exposed condition they resembled pitting instead of air bubbles.

On the south half of the bridge, the weather was warmer when the Guardkote 250 mortar was placed, and this binder had a lower viscosity so excessive trapped air did not become a problem. However, it appeared that the mortar wearing surface was developing a pattern of craze cracking. Reference to Figure 2 shows that the present pattern was not random but seemed to be developing under the outside wheel track of both the northbound and southbound traffic lanes. Many of these craze crack areas appeared to coincide with live-load negative moment areas over the transverse floor beams.

Inspection After the Second Winter

In mid-May 1971, the deck was again closely inspected and all types of deterioration were noted and recorded as before. Figure 3 is a diagram of the deck which shows the deterioration features found at the time of this inspection.

On the north half of the bridge, where the E15-V140 epoxy mortar was placed, the condition of the mortar surface had changed very little. Some light traffic abrasion had occurred and the west side "pitted" area, located about 35 ft from the north abutment, had enlarged about 50 percent. This pitting, as previously explained, is merely the exposure of large (1/16 to 1/8 in.) air bubbles that were trapped by the cold viscous epoxy binder. Although this is a distinct feature, it appears to be superficial (Fig. 4).

On the south half of the bridge, where the Guardkote 250 mortar was placed, the condition of the mortar surface has continued to deteriorate. Many of the areas that were observed to have obscure craze cracking in 1970 have now become distinct, thus expanding the total area now exhibiting craze cracking. On the east side of the bridge around the 170-ft mark, and on the west side near the 160-ft mark, clusters of craze cracked spots have developed. At first it appeared that this cracking had gone full-depth through the epoxy mortar, because dark "rusty" spots were apparent; however, further investigation established these "rust streaks" to be embedded asphalt. Figure 5 is a view of these clusters around the 170-ft mark on the east side of the deck.

On the west side of the deck near the 150-ft mark, a longitudinal crack pattern is developing about 7 ft from the curb line; presently it consists of three parallel cracks which apparently are the result of flexure in the steel deck. These cracks are located directly above the east edge of the second rib from the west girder. This crack pattern is shown on the diagram in Figure 3 and a close-up view of it appears in Figure 6.

REMARKS

During the time that this bridge was being constructed, several hydraulic patching mortars were being evaluated in the Research Laboratory. A Guardkote 250 epoxy mortar was included in the series as a control material and the subsequent evaluation disclosed that it sustained excessive shrinkage. It was theorized in the report[1] that the shrinkage was caused by a volatilization of the oil with which the epoxy was extended. It would appear from the development of craze cracked areas on this bridge that the Guardkote 250 epoxy mortar surfacing is undergoing the same shrinkage as was observed in the laboratory, but it appears to be a surface feature and does not go full depth.

The parallel longitudinal cracks which were previously described, are probably the result of a combination of stresses. One of the contributing stresses, since the cracks occurred midway between two floor beams, was probably tension caused by differential flexure of the longitudinal ribs as live loads moved across the bridge. Other contributing stresses were caused by shrinkage and thermal contraction.

The light traffic abrasion shown in the diagram in Figure 3 is probably responsible for the loss of traction that is apparent in Table 1. There also appears to be a greater accumulation of road oils and dirt in the surface of the south half. It is believed that the coefficients of friction as measured on June 3, 1971 should be about the minimum that will be reached; additional tests will confirm if any further polishing should develop. Another winter's exposure may require some remedial measures for the fine cracking in the south half, but no recommendations are being made at this time.

TESTING AND RESEARCH DIVISION

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TABLE 1
DECK SURFACE SKID TEST SUMMARY
(Wet sliding tests at 40 mph)

Mortar Type and Location	Coefficient of Friction* and Dates Tested			
	12-2-69 (initial)	5-4-70	10-14-70	6-3-71
North Half (E15 - V140)				
Northbound Lane	0.67	0.52	0.57	0.41
Southbound Lane	0.66	0.53	0.55	0.38
Average	0.67	0.53	0.56	0.40
South Half (Guardkote 250)				
Northbound Lane	0.75	0.48	0.56	0.40
Southbound Lane	0.69	0.46	0.51	0.31
Average	0.72	0.47	0.54	0.36

* Each test value is the average of 3 individual tests in each direction.

(1) "Evaluation of Five Commercial Fast-Setting Hydraulic Patching Mortars," MDSH Research Report No. R-715, October 1969.

Figure 1. View looking south over Crietz Rd Bridge, December 1969.

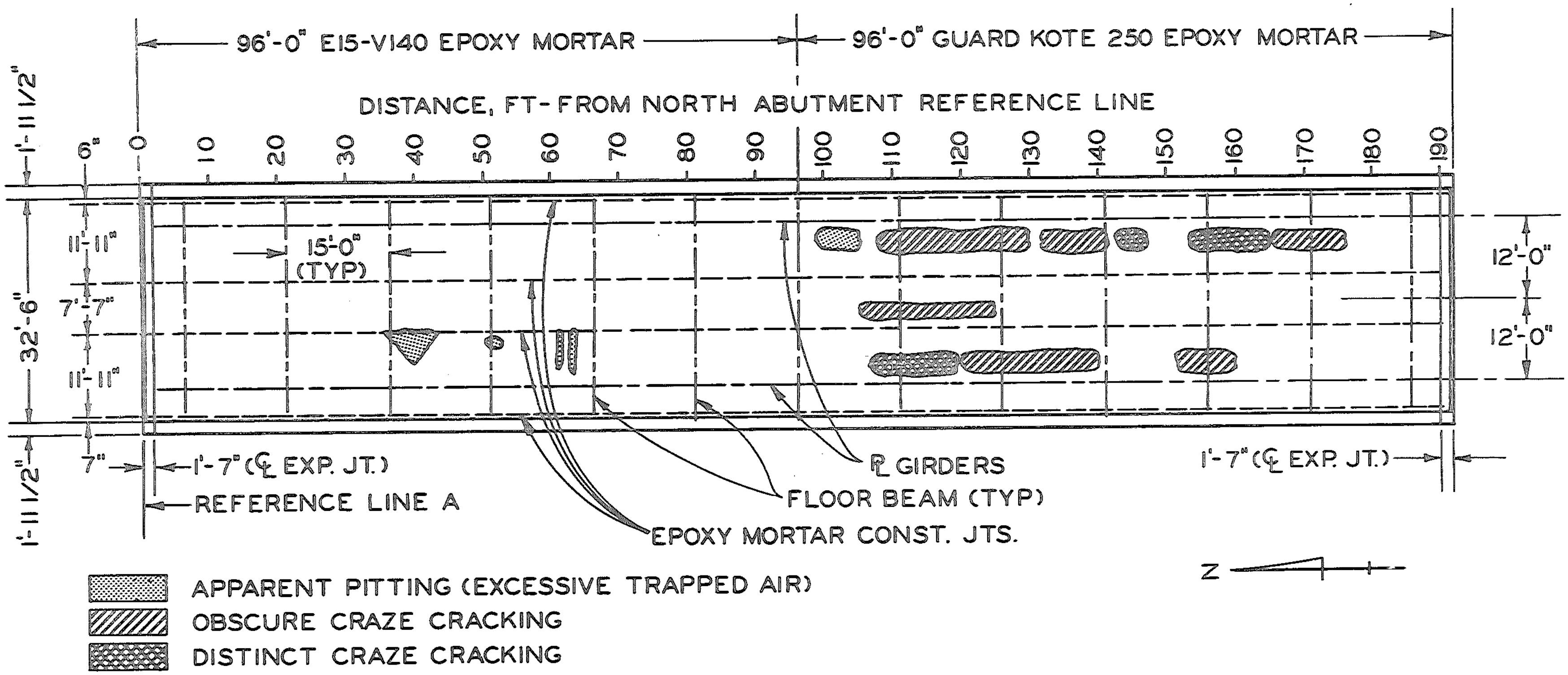


Figure 2. Deterioration features in the epoxy mortar wearing surface as observed on April 29, 1970.

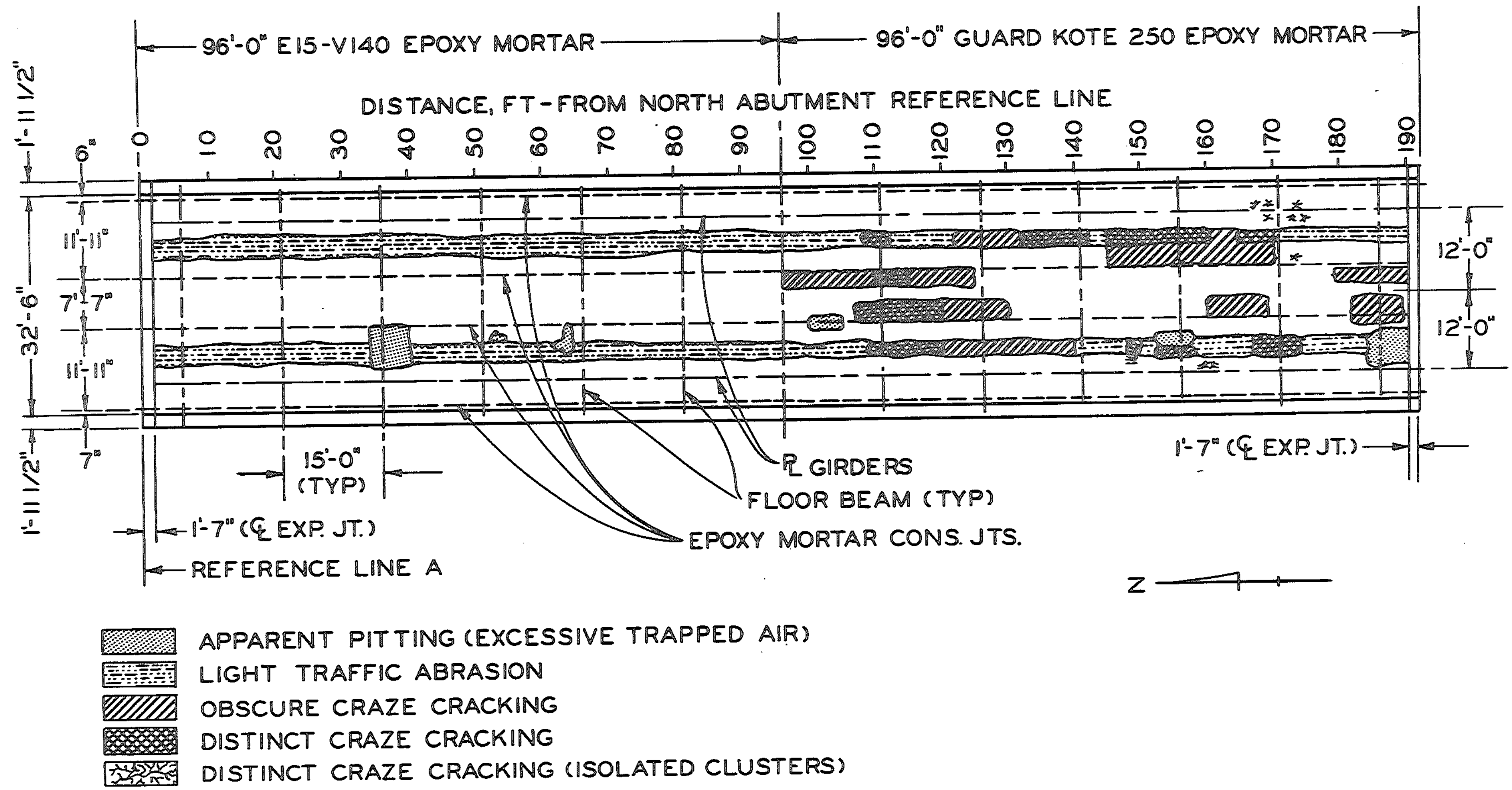


Figure 3. Deterioration features in the epoxy mortar wearing surface as observed on May 6, 1971.

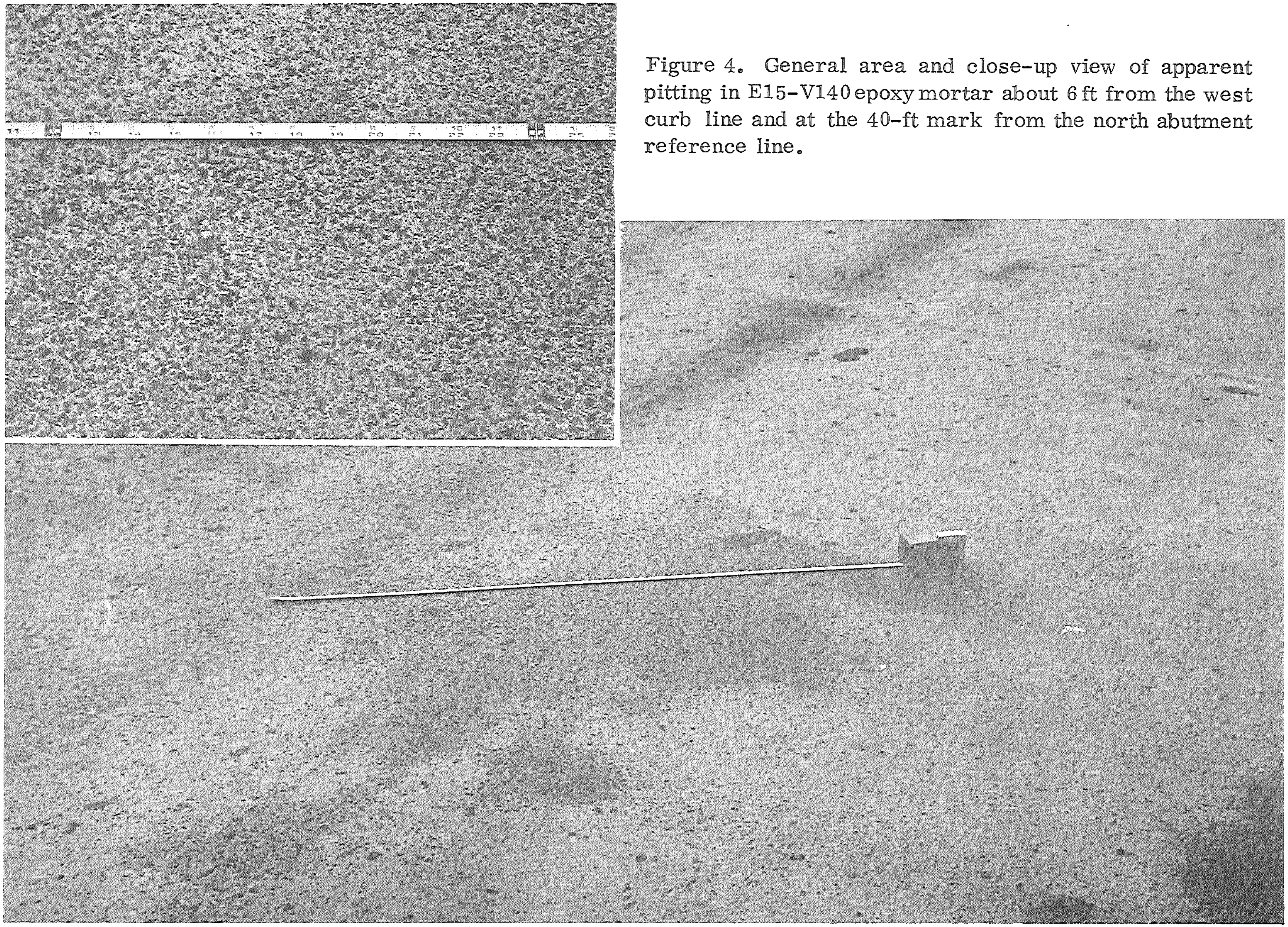
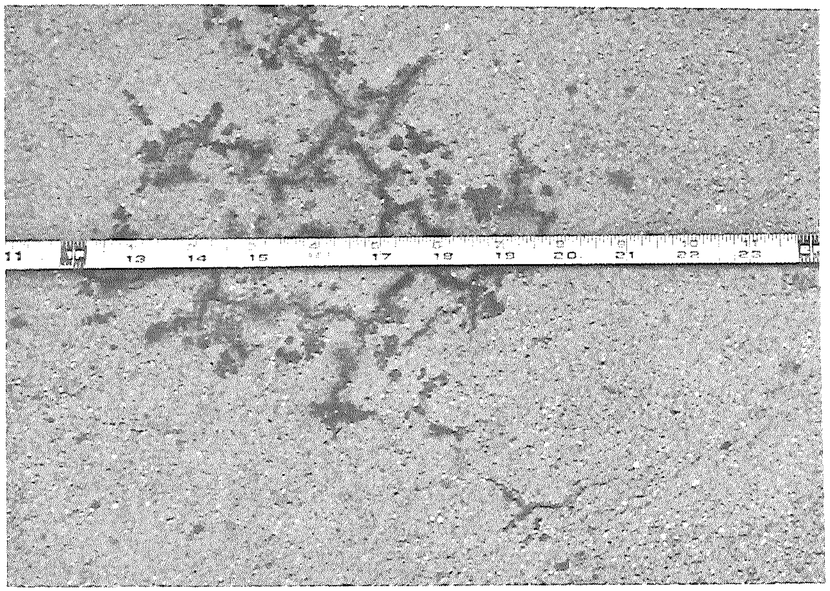


Figure 4. General area and close-up view of apparent pitting in E15-V140 epoxy mortar about 6 ft from the west curb line and at the 40-ft mark from the north abutment reference line.



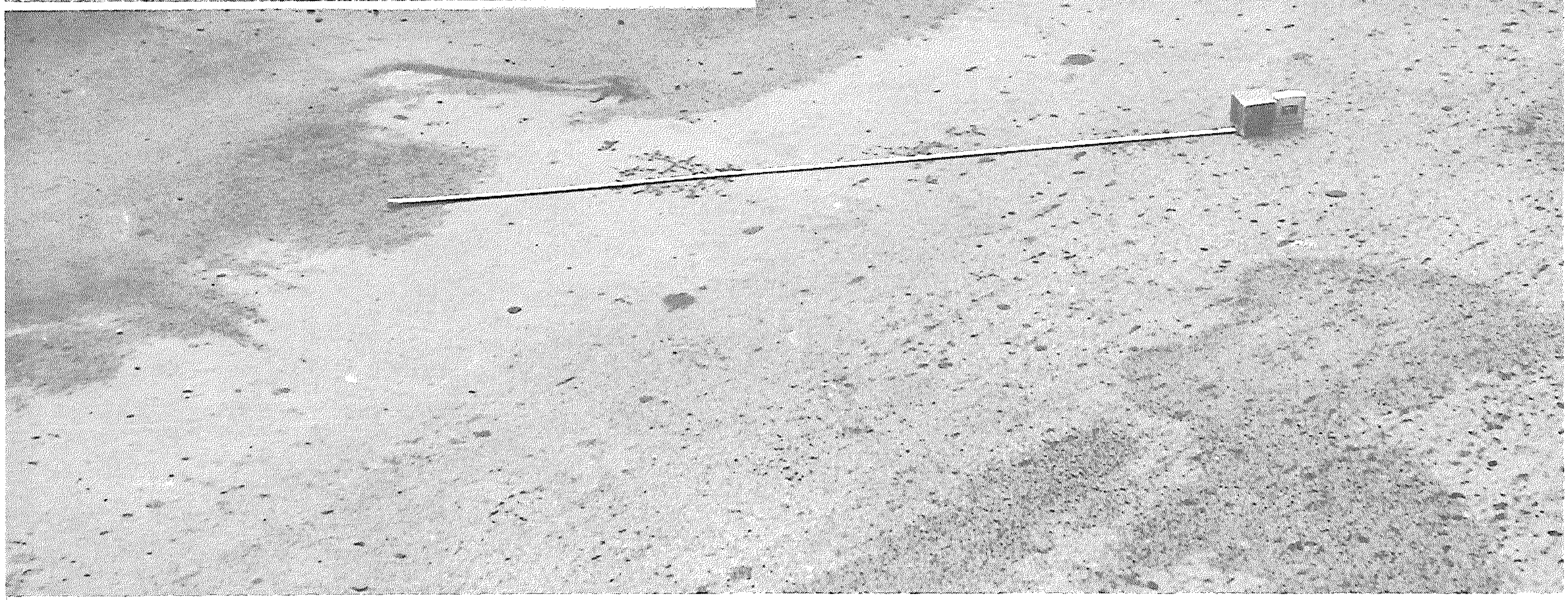


Figure 5. General area and close-up view of isolated distinct craze cracking in the Guardkote 250 epoxy mortar surfacing located 5 ft from the east curb line and at 172 ft from the north abutment reference line. The black streaks originally thought to be rust are actually embedded asphalt probably from approach paving operations.

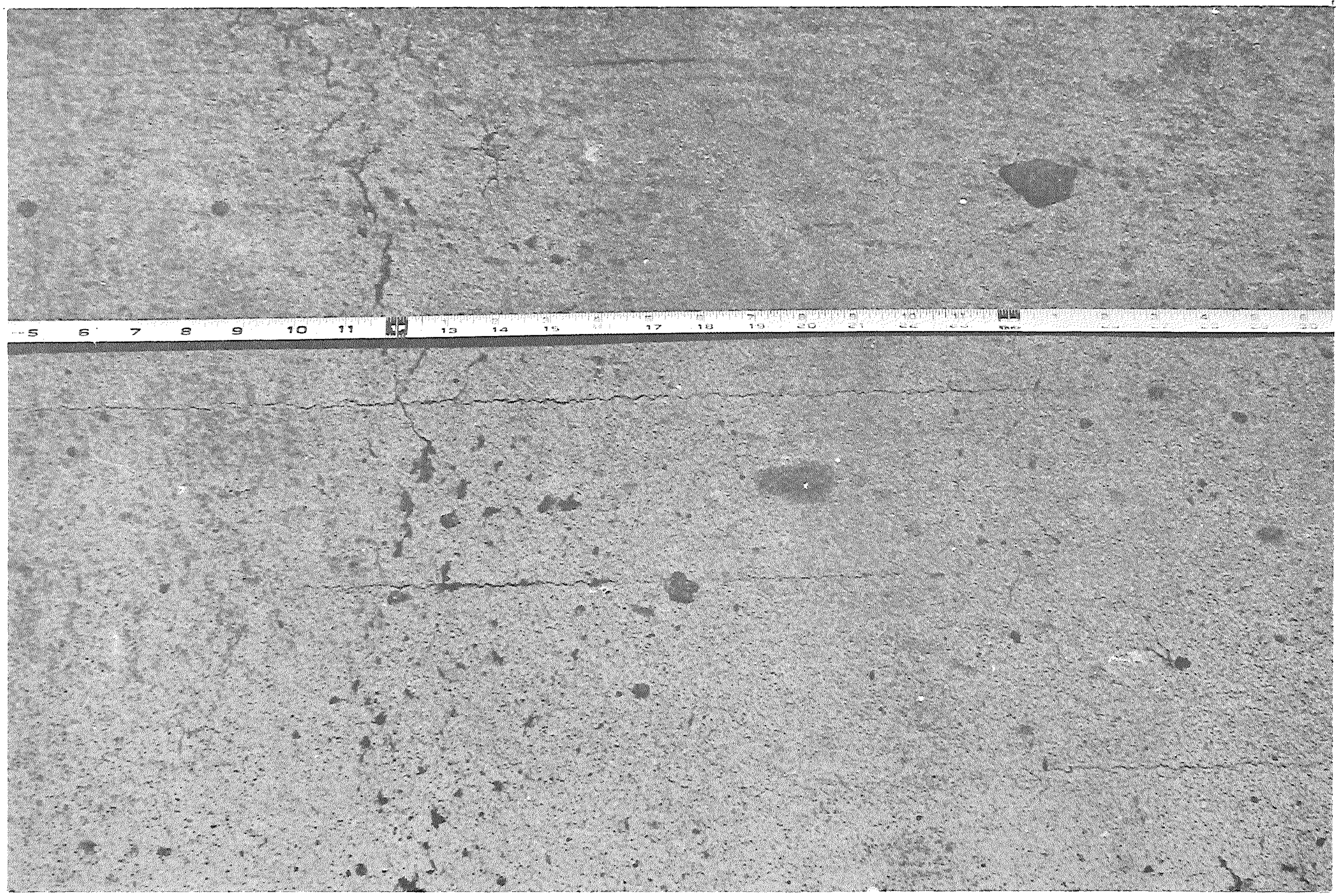


Figure 6. Close-up view of parallel longitudinal cracks which are developing along with a distinct craze crack pattern in the Guardkote 250 epoxy mortar surfacing about 7 ft from the west curb line and at the 150-ft mark from the north abutment reference line.