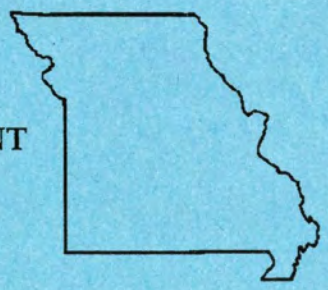
MISSOURI COOPERATIVE HIGHWAY RESEARCH PROGRAM

REPORT 92-5

PERFORMANCE OF POLYMER CONCRETE WEARING SURFACE SYSTEM ON THE POPLAR STREET BRIDGE INSPECTION REPORT II

MISSOURI HIGHWAY AND TRANSPORTATION DEPARTMENT
UNIVERSITY OF MISSOURI, COLUMBIA
FEDERAL HIGHWAY ADMINISTRATION



PERFORMANCE OF POLYMER CONCRETE WEARING SURFACE SYSTEM ON THE POPLAR STREET BRIDGE

Inspection Report II
Tests conducted on the Poplar Street Bridge during June 25-27, 1993

Prepared for

Missouri Highway and Transportation Department

by

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The opinions, findings, conclusions and recommendations expressed in this report are those of the authors and are not necessarily those of the Federal Highway Administration, the Missouri Highway and Transportation Department or the University of Missouri-Columbia.

INTRODUCTION

The inspection project jointly sponsored by the Missouri Highway and Transportation Department (MHTD) and the Federal Highway Administration (FHA) is being conducted by the Department of Civil Engineering, University of Missouri-Columbia (MU). Dr. Vellore S. Gopalaratnam and Dr. James W. Baldwin, Jr., are the Principal Investigators. Mr. Bryan A. Hartnagel, MU Graduate Research Assistant and Mr. Michael Holder, MU Undergraduate Student Assistant assisted the principal investigators with the tests, results of which are reported and discussed here.

This first inspection was conducted during September 18-19, 1992 approximately one month after the polymer concrete wearing surface was placed on the Poplar Street Bridge. This second inspection originally planned for March 1993 could not be conducted until June 25-27, 1993 due to scheduling problems.

TEST SECTIONS

The test sections used during the second inspection were identical to those used earlier during Inspection I [1]. These are listed here again for completeness of this report.

Test Section A:	Right eastbound lane (Lane 4) from Station 21+00 to Station 23+00
Test Section B:	Right middle eastbound lane (Lane 3) from Station 35+00 to Station 37+00
Test Section C:	Left westbound lane (Lane 1) from Station 37+00 to Station 35+00
Test Section D:	Right middle westbound lane (Lane 3) from Station 27+00 to Station 25+00

TEST PROGRAM AND PROCEDURES

The test program during each inspection comprises: (i) pull-out tests to record the adhesion strength in tension of the wearing surface system to the deck-plate, (ii) resistivity tests to monitor cracking in the wearing surface, (iii) chain drag/sounding tests to monitor delaminations of the wearing surface from the deck-plate, (iv) miscellaneous observations to record wearing surface thickness, aggregate loss, visible cracks and cracking patterns. The typical layout used for the pull-out and resistivity tests for Inspection II is illustrated in Fig. 1. It should be noted that the resistivity test locations used for this inspection are identical to those used during Inspection I.

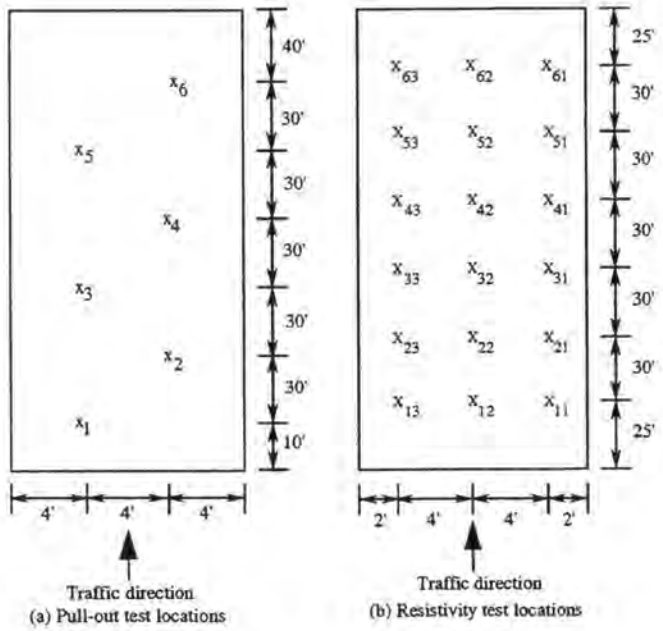


Fig. 1 Typical layout of a test section (not to scale).

Details of the procedures have been included in the report on Inspection I [1] and will not be duplicated here. Results from this inspection are summarized in the following section.

SUMMARY OF RESULTS

A summary of core pull-out test results is presented in Table 1. The average peak pull-out stress recorded was 419 psi. Individual test values for the peak pull-out stress ranged from 258 to 753 psi. Cohesive failure in the wearing surface was observed only in two instances (B10 and B12). Even in these instances, the failure was due to pull-out of the top layer of aggregates rather than a failure in the epoxy material itself. Since the majority of failures were in the glue material (failure types 1, 2 or 3, see Fig. 2), as stated earlier in Inspection Report I [1], little can be said of the tensile adhesion strength of the wearing surface other than that it is larger than 419 psi (on the average). Results from pull-out tests conducted during this inspection show a systematic pattern of temperature sensitivity much like that observed during the last inspection. Adhesive failure at the pipe cap was the most predominant type of failure observed. The lower value for the average peak

pull-out stress recorded during this inspection (419 psi) compared to Inspection I (507 psi) can be attributed in large part to the differences in average ambient temperature at the time of testing (66°F in Inspection I as opposed to 78°F in Inspection II).

Summaries of results from the resistivity tests are reported in Tables 2-5 for Test Sections A-D respectively. Although resistivity values recorded were far lower than those recorded in Inspection I for the same locations, these values are still in excess of the 700,000 Ω generally used to identify acceptable behavior of polymer concrete membranes. Resistivity values recorded ranged from 3 MΩ to 200 MΩ. Given the limited data set, it is not possible at the present time to provide conclusive reasoning for this drop in resistivity. Two likely reasons are: (i) traffic related wear of the sealant coating of methyl methacrylate, and (ii) differences in humidity and moisture conditions. Whether these or other alternate reasons are responsible for the lower resistivity may become clearer with additional data from future inspections. For resistance values below 30 MΩ a higher resolution ohm meter was used in this inspection to corroborate values recorded with the previously used ohm meter.

Like in the previous inspection, the chain drag test did not indicate any delamination of the wearing surface in the four test sections. However the reliability of this test on flexible steel deck is questionable given the fact that no discernible difference was detected in the acoustic signals in the vicinity cracks located near the expansion devices (Fig. 3).

No noticeable aggregate loss was detected on the test sections or on other sections of the bridge. The average thickness recorded in conjunction with the pull-out tests was 0.613 in. The range of thickness recorded was 0.445 in. - 0.801 in. These values are consistent with those recorded earlier.

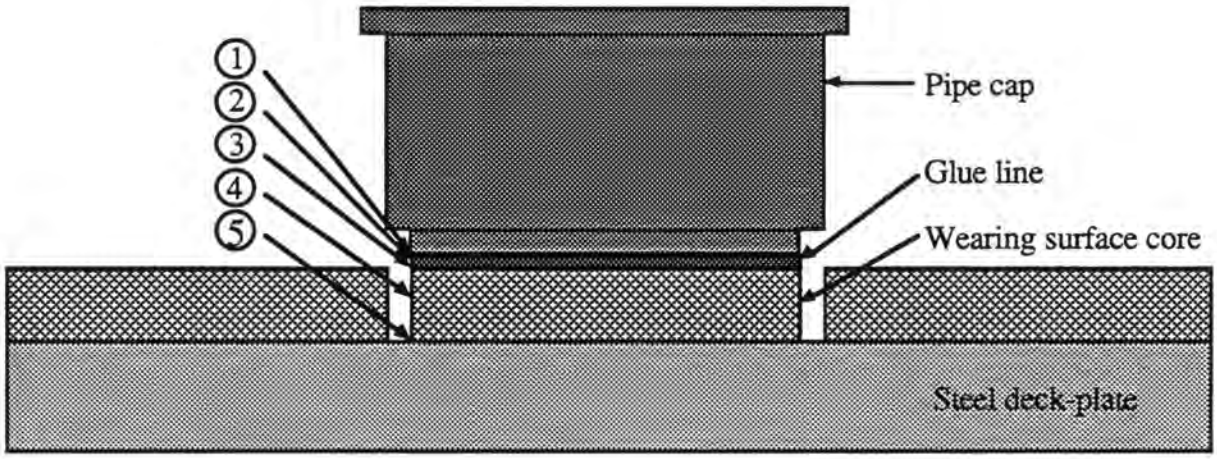
Profiles of two visible cracks first reported by personnel from Illinois Department of Transportation in mid-June were recorded (Fig. 3). These are located at the two ends of the right eastbound lane (Lane E4). Resistivity tests conducted on the cracks and the immediate vicinity suggested that these cracks in the transition zone were possibly through thickness cracks. Resistivity tests performed at different locations over the crack typically yielded resistivity values in

Table 1 : Summary of results from core pull-out tests - Inspection II

(Tests conducted on the Poplar Street Bridge during June 25-27, 1993)

Core[1]	Depth (in.)	Diameter (in.)	Time glued	Air temp. (at glueing) (°F)	Time tested	Air temp. (at testing) (°F)	Peak load (lbs)	Peak stress (psi)	Failure type[2]
A1	0.445	1.9375	23:15	74	1:25	69	1370	465	1 - 10%, 3 - 90%
A2	0.616	1.9375	23:10	74	1:20	69	1100	373	1 - 85%, 3 - 15%
A3	0.608	1.9375	23:05	74	1:10	69	1390	472	1 - 30%, 3 - 70%
A4	0.680	1.9375	23:00	74	1:00	69	1510	512	1 - 33%, 3 - 67%
A5	0.690	1.9375	22:55	74	0:55	69	1330	451	1 - 30%, 3 - 70%
A6	0.670	1.9375	22:50	74	0:45	69	2220	753	1 - 50%, 3 - 50%
B7	0.748	1.9375	12:45	86	14:10	90	810	275	1 - 100%
B8	0.520	1.9375	12:40	86	14:05	90	1000	339	1 - 100%
B9	0.579	1.9375	12:35	86	13:55	90	760	258	1 - 100%
B10	0.595	1.9375	12:25	86	13:45	90	980	332	3 - 50%, 4 - 50%
B11	0.605	1.9375	12:15	86	13:40	*3	*3	*3	*3
B12	0.569	1.9375	12:10	86	13:35	90	940	319	4 - 100%
C13	0.747	1.9375	22:55	76	0:15	74	1460	495	1 - 100%
C14	0.683	1.9375	22:45	77	0:10	74	700	237	1 - 100%
C15	0.585	1.9375	22:35	76	24:00	74	1810	614	1 - 100%
C16	0.603	1.9375	22:25	76	23:55	74	1330	451	1 - 100%
C17	0.616	1.9375	22:10	77	23:45	74	1260	427	1 - 100%
C18	0.801	1.9375	22:00	77	23:40	74	2020	685	1 - 100%
D19	0.547	1.9375	17:55	82	20:10	82	1030	349	1 - 100%
D20	0.599	1.9375	17:45	83	20:05	82	1630	553	1 - 100%
D21	0.632	1.9375	17:35	84	19:57	82	870	295	1 - 100%
D22	0.481	1.9375	17:25	84	19:10	82	820	278	1 - 100%
D23	0.635	1.9375	17:15	85	19:05	82	1230	417	1 - 100%
D24	0.479	1.9375	17:08	86	19:00	82	860	292	1 - 100%

Note:
1. *All pipe caps were glued to the core using Transpo T-371 MMA.*
2. *See Fig. 2 for legend to failure types. Percentages besides failure type notations indicate approximate areas of the failure of each type as observed from the pulled-out pipe caps.*
3. *Glued pipe cap was accidentally displaced prematurely and could not be tested.*



① Adhesive failure at the pipe cap
② Cohesive failure in the glue
③ Adhesive failure at the wearing surface
④ Cohesive failure in the wearing surface
⑤ Adhesive failure at the deck plate

Fig. 2 Schematic defining legends used for pull-out failure description.

Table 2 : Results from the resistivity tests - Inspection II
(Tests conducted on the Poplar Street Bridge during June 25-27, 1993)

Test Section: A *(Eastbound Lane 4, Stations 21+00 to 23+00)*

Initial wetting at: 21:50 First reading R_1 at: 22:20
Second reading R_2 at: 22:35 Third reading R_3 at: 22:50

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
A11	100	100	100
A12	100	90	100
A13	150	150	150
A21	160	125	70
A22	80	80	80
A23	90	80	50

Initial wetting at: 22:50 First reading R_1 at: 23:10
Second reading R_2 at: 23:25 Third reading R_3 at: 23:50

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
A31	150	100	70
A32	50	75	75
A33	100	120	100
A41	80	50	60
A42	100	100	100
A43	90	90	70

Initial wetting at: 23:55 First reading R_1 at: 0:20
Second reading R_2 at: 0:30 Third reading R_3 at: 1:00

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
A51	3.5	3.5	3.7
A52	3.0	3.2	3.3
A53	3.4	3.6	3.8
A61	20	19	18
A62	20	17	14
A63	20	18	16

Table 3 : Results from the resistivity tests - Inspection II
(Tests conducted on the Poplar Street Bridge during June 25-27, 1993)

Test Section: B *(Eastbound Lane 3, Stations 35+00 to 37+00)*

Initial wetting at: 12:10 First reading R_1 at: 12:30
Second reading R_2 at: 12:45 Third reading R_3 at: 13:15

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
B11	17.5	16.2	13
B12	26	23	18.5
B13	21	22	20
B21	15	14.2	11.7
B22	20.5	19	17
B23	18	17	17

Initial wetting at: 13:15 First reading R_1 at: 13:30
Second reading R_2 at: 13:45 Third reading R_3 at: 14:15

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
B31	11.5	12	11
B32	18	19	21
B33	14.5	12.5	10.5
B41	11	10.5	11
B42	18	20	20
B43	14	13	11

Initial wetting at: 14:15 First reading R_1 at: 14:30
Second reading R_2 at: 14:45 Third reading R_3 at: 15:15

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
B51	15	9.2	12.6
B52	14.5	12.5	15
B53	15.5	13.5	14.4
B61	13	14	13.5
B62	14	14.5	12.3
B63	18	14.5	13.7

Table 4 : Results from the resistivity tests - Inspection II
(Tests conducted on the Poplar Street Bridge during June 25-27, 1993)

Test Section: C *(Westbound Lane 1, Stations 37+00 to 35+00)*

Initial wetting at: 22:00 First reading R_1 at: 22:20
Second reading R_2 at: 22:40 Third reading R_3 at: 23:10

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
C11	100	100	100
C12	150	150	125
C13	150	150	90
C21	200	200	150
C22	150	150	100
C23	150	100	60

Initial wetting at: 23:05 First reading R_1 at: 23:20
Second reading R_2 at: 23:40 Third reading R_3 at: 0:10

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
C31	30	35	30
C32	30	35	35
C33	30	45	40
C41	60	60	60
C42	50	60	45
C43	70	80	45

Initial wetting at: 0:15 First reading R_1 at: 0:25
Second reading R_2 at: 0:45 Third reading R_3 at: 1:10

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
C51	40	40	30
C52	22.5	20	22.5
C53	22.5	20	20
C61	30	25	19
C62	27.5	25	20
C63	22.5	30	19

Table 5 : Results from the resistivity tests - Inspection II
(Tests conducted on the Poplar Street Bridge during June 25-27, 1993)

Test Section: D *(Westbound Lane 3, Stations 27+00 to 25+00)*

Initial wetting at: 17:15 First reading R_1 at: 17:30
Second reading R_2 at: 17:50 Third reading R_3 at: 18:15

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
D11	35	27.5	27.5
D12	30	26.5	27
D13	30	18	23
D21	40	23	40
D22	50	35	35
D23	40	35	32.5

Initial wetting at: 18:20 First reading R_1 at: 18:40
Second reading R_2 at: 18:55 Third reading R_3 at: 19:20

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
D31	60	40	40
D32	45	40	35
D33	45	35	35
D41	60	45	45
D42	50	45	45
D43	30	26.5	26

Initial wetting at: 19:25 First reading R_1 at: 19:40
Second reading R_2 at: 20:00 Third reading R_3 at: 20:30

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
D51	80	50	50
D52	70	55	55
D53	70	50	50
D61	80	60	40
D62	60	70	40
D63	60	70	70

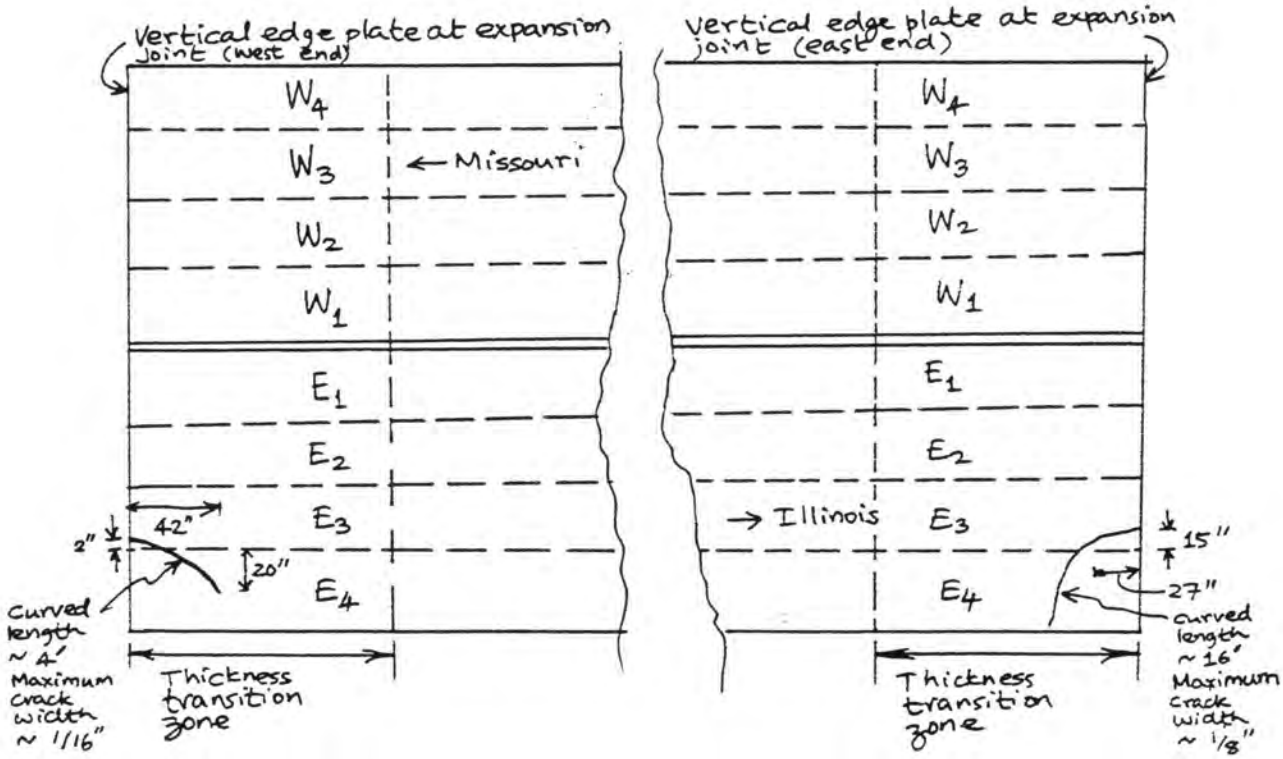


Fig. 3 Schematic of the cracks observed in the transition zones at the two ends of right eastbound lane (Lane E4)

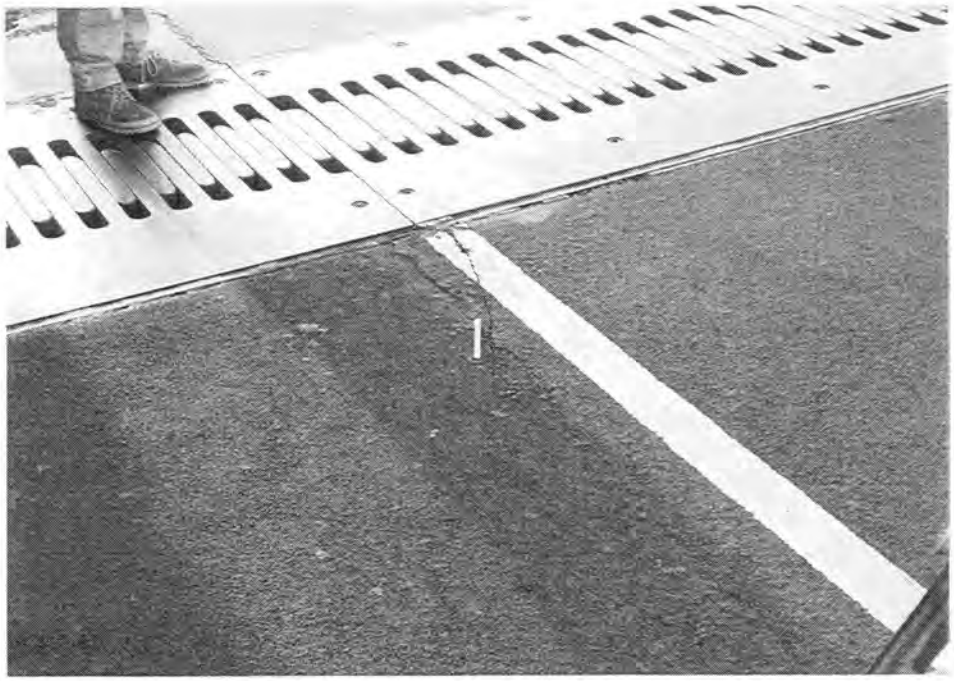


Fig. 4 Photograph of the crack at the west end of Lane E4

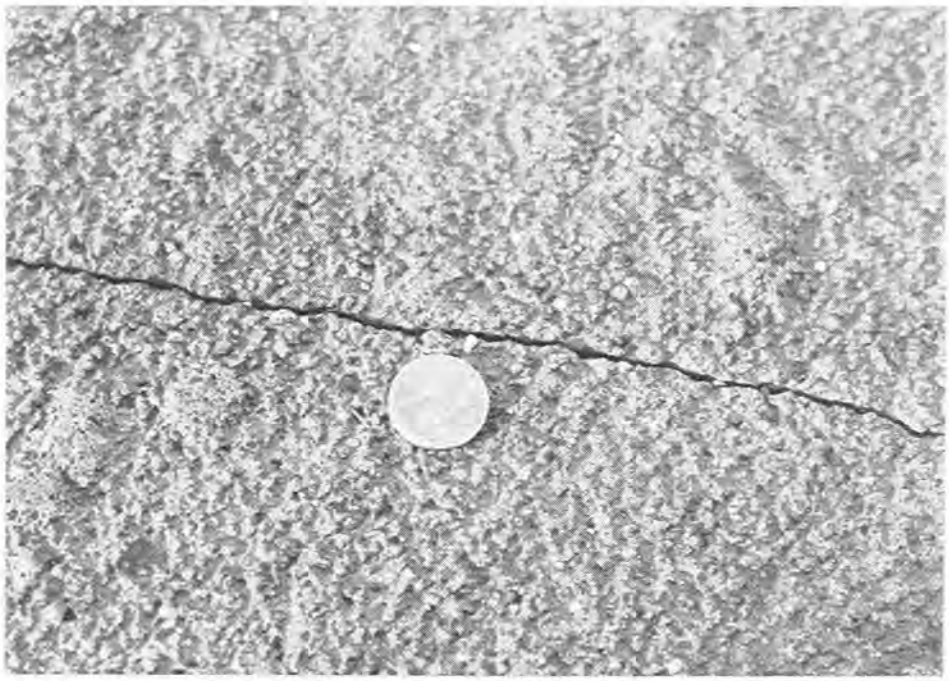


Fig. 5 Photograph of the crack at the east end of Lane E4.

the 100,000 Ω- 300,000 Ω range. Readings in the immediate vicinity (not directly over the crack) were in the 200-300 MΩ range. Water percolated through both cracks quite readily. The crack at the west end was smaller of the two (Figs. 3-5). Extensive rust stains were observed near the crack at the east end. This observation offers additional evidence that the crack may possibly be a through-thickness crack. The deck-plate at these two locations was examined from below (at the box girder level). No cracking in the deck-plate was visible. The cause for the presence of these cracks in the thickness transition zones of the wearing surface is unclear at the present time. Further inspection of these cracks is scheduled for July 24, 1993.

REFERENCE

1. Gopalaratnam, V.S., Baldwin, J.W., Hartnagel, B.A., and Krull, T., "Performance of Polymer Concrete Wearing Surface System on The Poplar Street Bridge - Inspection Report I,", Test Conducted during September 1992, Report prepared for the Missouri Highway and Transportation Department by the Department of Civil Engineering, University of Missouri-Columbia.