MISSOURI COOPERATIVE HIGHWAY RESEARCH PROGRAM

REPORT 92-5

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

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 I

Tests conducted on the Poplar Street Bridge during September 18-19, 1992

Prepared for

Missouri Highway and Transportation Department

by

Vellore S. Gopalaratnam
James W. Baldwin, Jr.
Bryan A. Hartnagel
and
Theodore R. Krull

Department of Civil Engineering
University of Missouri-Columbia

in cooperation with

Federal Highway Administration

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. Theodore R. Krull, 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. In addition to providing useful data on the in-service performance of the wearing surface system, results from this first inspection will also serve as a benchmark for planned future inspections. In all seven inspections are planned during the five year project duration. The second inspection is scheduled to be conducted approximately six-months after the first inspection. Yearly inspections will follow during the remainder of the project duration. Since the mid-August completion of the placement of the polymer concrete wearing surface, the bridge has been open to normal traffic for nearly one month prior to this inspection.

TEST SECTIONS

The MHTD in conjunction with the principal investigators identified the following test sections on the Poplar Street Bridge. These sections were selected on the basis of logistics of traffic control and appropriateness for the test program requirements.

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 25+00 to Station 23+00

* *Due to a miscommunication between the investigators and the MHTD traffic control personnel, Test Section D was blocked off from Station 27+00 to Station 25+00 instead of the originally designated stations. Since this change did not affect the scope or objectives of the test program, the investigators decided to go ahead with the scheduled tests in this*

section. For comparisons with results from the subsequent inspections, it was decided to use the new Test Section D for all subsequent inspections as well.

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.

Pull-Out Tests

Pull-Out tests were performed generally following the guidelines described in ACI 503R (Appendix A). Six locations within each test section were identified for the pull-out tests. These locations are shown in Fig. 1. Based on prior experience with pull-out failures of glue while testing similar composite systems, it was decided that two different types of glues be used for the preliminary tests (on two of the four test sections). Accordingly three pull-out tests were conducted using each type of glue for the first two test sections (Test Sections A and C). The glues used were Devcon 5-Minute epoxy and Transpo T-71 methyl methacrylate (MMA). After the performance of these two glues was observed based on tests in Test Sections A and C, it was decided that Transpo T-71 MMA be used on all the subsequent pull-out tests.

Cores were drilled using a 2-in. (nominal inside diameter of the core drill) at the desired locations, Fig. 2. Average wearing surface thickness at each core location was measured (Fig. 3) after the core was cleaned for gluing the pipe cap (Fig. 4). After adequate curing of the glue (typically between 1 1/2 and 2 hours), the cores were subjected to pull-out loads using a loading frame specially designed to be in compliance with ACI 503R. A manually controlled loading rate of approximately 20 lb./s was used as recommended in ACI 503R. The loading frame was equipped with a strain-gage based load cell. The load cell was connected to a conditioner which provided

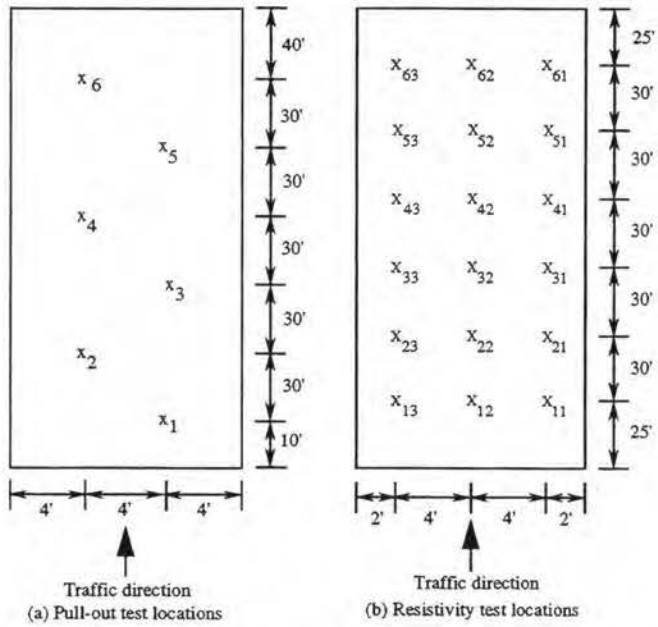


Fig. 1 Typical layout of a test section (not to scale).

Fig. 2 Drilling the wearing surface in preparation for the pull-out test.

Fig. 3 Making core depth and core diameter measurements.

Fig. 4 Gluing the pipe cap to the core.

power for the strain gage bridges, balancing and calibration features. This conditioner also allowed automatic recording of the peak pull-out load, Fig. 5.

Resistivity Tests

Resistivity tests were performed in accordance with ASTM D 3633-88 at 18 locations on each of the four test sections. A 30 ft x 4 ft grid (2 ft from the lane boundaries) was laid out for the resistivity tests. The 18 locations comprised 6 rows along the length of the test section. Each row had three locations transverse to the traffic (Figs. 1 and 6). Typical notations used to identify resistivity test locations are illustrated in Fig. 1. Six resistivity tests were performed simultaneously to save time, Fig. 7. Each set of tests took approximately 1 - 1 1/2 hours to complete. The test location was wet initially with a spray of soap water and before each of three readings was taken. This was necessary to allow enough time for the soap water to penetrate potential cracks in the wearing surface. Resistivity tests during the subsequent inspections will be performed at the same locations each time so that changes in resistivity can be readily compared. Fig. 8 shows resistivity measurements being made using an ohm-meter.

Delamination Survey

The test sections were subjected to chain drag tests conducted in accordance with ASTM D 4580-86. Two chain drag devices were specially fabricated for the project using copper tubes and steel chains.

Miscellaneous Observations

Detailed visual observations of the test sections in particular and the entire deck in general were carried out during the inspection. Special attention was given to inspecting the construction joints along the lane boundaries.

Fig. 5 Pull-out test showing loading frame and instrumentation used.

Fig. 6 Locations of the resistivity test are being marked.

Fig. 7 Test section showing six resistivity tests in progress.

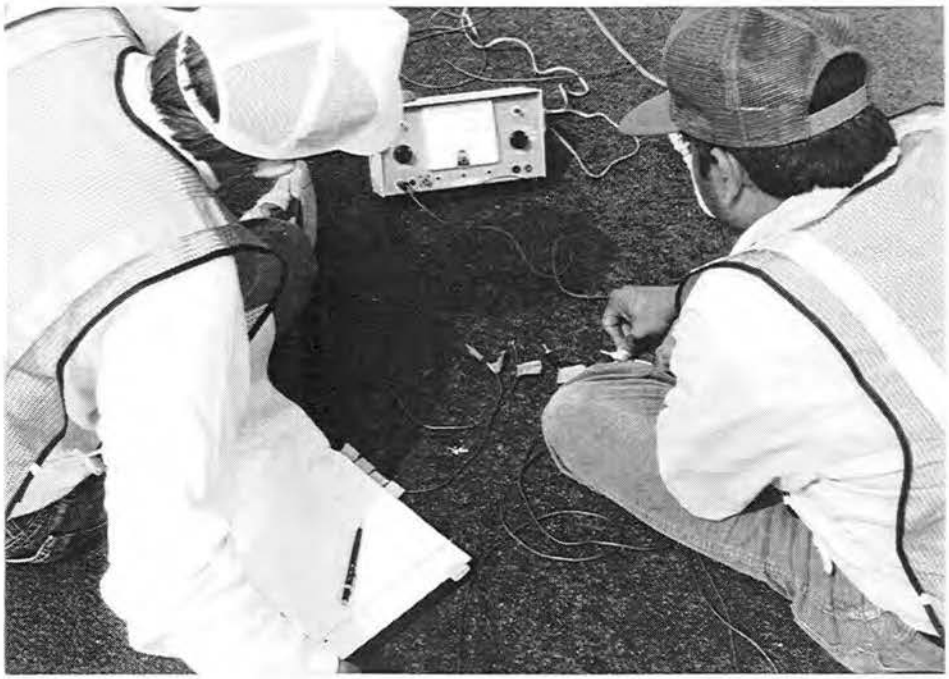


Fig. 8 Resistivity measurements being recorded.

SUMMARY OF RESULTS

A summary of the test results from the core pull-out test is presented in Table 1. The average peak pull-out stress recorded (excluding tests where Devcon epoxy was used to glue pipe caps) was 546 psi. The associated range of pull-out stress values obtained was 301 - 818 psi. If results from all the pull-out tests are included, the average peak pull-out stress equals 507 psi. It should be noted that these peak stress values may not have direct correlation with the tensile adhesion strength of the wearing surface to the steel deck-plate because in all but two instances (D22 and D23) the pull-out failure was due to the failure of the glue and not the wearing surface (failure types 1, 2 or 3). Even in those two instances, only the top layer of aggregates were pulled off with the pipe cap. Although not always consistent, it was observed that the peak stress recorded was marginally higher at the colder test temperatures. It is expected that larger variations in the test temperature will produce more scatter in the results from the pull-out test since both the glue and the wearing surface material are temperature sensitive.

Summaries from the resistivity tests are presented in Tables 2-5 for Test Sections A-D respectively. Resistivity values recorded were far in excess of the 700,000 Ω generally used to identify acceptable behavior of polymer concrete protective membranes. The resistivity values recorded ranged from 35-1000 MΩ. It was observed that at these large values of resistivity it was difficult to record small differences in resistivity from location to location or at one location as a function of time. Based on previous laboratory experience with similar composite systems, the resistivity values consistently decreased with time as the soap solution was allowed to penetrate into the wearing surface (at a rate which reduced with time). While this was generally true in these field tests, the values were not always consistent. Drying of the soap water at the test location during the time between readings may have been in part responsible for this. Since the resistance values are significantly larger than the generally accepted limit of 700,000 Ω, the large scatter in the test results should not cause concern.

The chain drag test did not indicate any delaminations of the wearing surface. It should however be noted that the investigators were not happy with the effectiveness of this test for use on

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

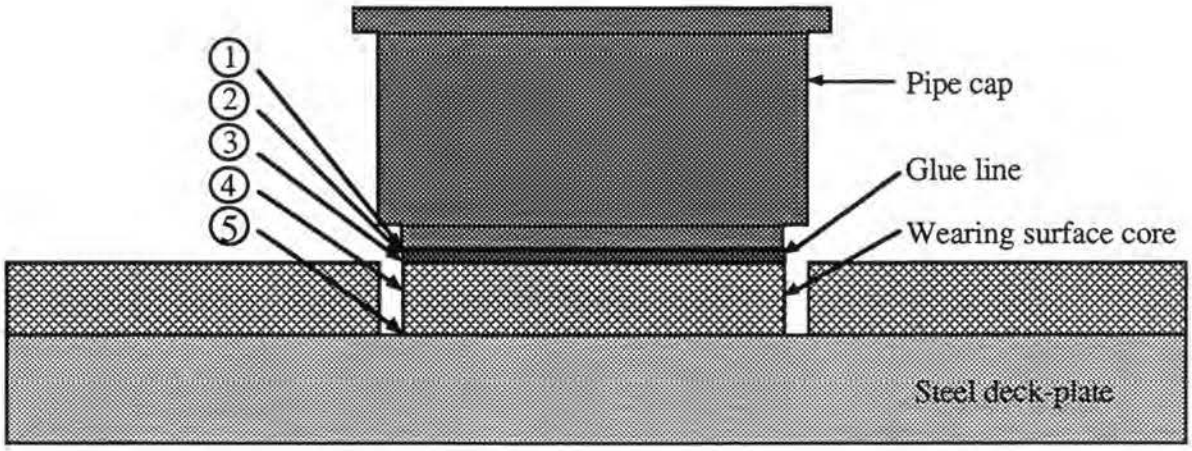
(Tests conducted on the Poplar Street Bridge during September 18-19, 1992)

Core	Depth (in.)	Diameter (in.)	Time glued	Air temp. (at glueing) (^oF)	Time tested	Air temp. (at testing) (^oF)	Peak load (lbs)	Peak stress (psi)	Failure type[2]
A1	0.653	1.9688	23:20	64	3:50	58	1505	494	1 - 33%, 2 - 33%, 3 - 34%
A2[1]	0.585	1.9688	23:15	64	3:45	58	1328	436	2 - 100%
A3	0.645	1.9688	23:10	64	3:35	58	1905	626	1 - 100%
A4[1]	0.762	1.9688	23:05	64	3:30	58	1288	423	2 - 100%
A5	0.633	1.9688	23:00	64	3:20	58	2340	769	3 - 100%
A6[1]	0.775	1.9688	21:45	65	3:15	58	470	155	2 - 100%
B7	0.600	1.9688	16:00	73	18:00	70	1425	468	1 - 100%
B8	0.697	1.9688	16:05	73	18:05	70	1509	496	1 - 100%
B9	0.584	1.9688	16:10	73	18:15	70	1275	419	2 - 25%, 3 - 75%
B10	0.646	1.9688	16:15	73	18:20	70	1729	568	1 - 100%
B11	0.605	1.9688	16:20	73	18:30	70	1788	587	3 - 100%
B12	0.720	1.9688	16:25	73	18:35	70	1442	474	1 - 100%
C13[1]	0.573	1.9688	2:15	60	6:20	62	1430	470	2 - 100%
C14	0.685	1.9688	2:20	60	6:30	62	1788	587	2 - 25%, 3 - 75%
C15[1]	0.646	1.9688	2:25	60	7:10	63	1102	362	2 - 100%
C16	0.400	1.9688	2:30	60	7:20	63	2490	818	1 - 50%, 3 - 50%
C17[1]	0.650	1.9688	2:35	60	*[3]	*[3]	*[3]	*[3]	*[3]
C18	0.865	1.9688	2:40	60	7:30	63	2400	788	3 - 100%
D19	0.536	1.9688	11:20	69	13:10	71	916	301	3 - 100%
D20	0.739	1.9688	11:15	69	13:15	71	1462	480	1 - 100%
D21	0.680	1.9688	11:10	69	13:20	71	1271	418	1 - 100%
D22	0.600	1.9688	11:05	69	13:40	71	1681	552	3 - 25%, 4 - 75%
D23	0.799	1.9688	11:00	69	13:50	71	1515	498	3 - 25%, 4 - 75%
D24	0.601	1.9688	10:55	69	14:00	71	1465	481	1 - 100%

Note: 1. *Devcon 5-Minute epoxy was used to glue these pipe caps to the core. All other pipe caps were glued to the core using Transpo T-371 MMA.*

2. *See Fig. 9 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. 9 Schematic defining legends used for pull-out failure description.

Table 2 : Results from the resistivity tests - Inspection I
(Tests conducted on the Poplar Street Bridge during September 18-19, 1992)

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

Initial wetting at: 21:45
Second reading R_2 at: 23:30
First reading R_1 at: 22:55
Third reading R_3 at: 24:00

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
A11	500	500	500
A12	750	700	750
A13	500	500	500
A21	500	500	500
A22	350	300	300
A23	350	400	500

Initial wetting at: 23:30
Second reading R_2 at: 0:30
First reading R_1 at: 24:00
Third reading R_3 at: 3:00

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
A31	500	400	250
A32	600	500	400
A33	1000	700	500
A41	750	500	400
A42	1000	600	500
A43	400	450	500

Initial wetting at: 2:30
Second reading R_2 at: 3:40
First reading R_1 at: 3:05
Third reading R_3 at: 4:00

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
A51	600	300	200
A52	1000	1000	250
A53	1000	750	200
A61	600	400	100
A62	1000	1000	300
A63	700	750	200

Table 3 : Results from the resistivity tests - Inspection I
(Tests conducted on the Poplar Street Bridge during September 18-19, 1992)

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

Initial wetting at: 15:45 First reading R_1 at: 16:00
Second reading R_2 at: 16:30 Third reading R_3 at: 17:00

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
B11	150	150	150
B12	100	100	150
B13	85	85	90
B21	150	150	150
B22	100	100	85
B23	80	80	85

Initial wetting at: 16:55 First reading R_1 at: 17:10
Second reading R_2 at: 17:25 Third reading R_3 at: 17:55

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
B31	250	250	400
B32	250	250	350
B33	200	200	300
B41	200	200	350
B42	300	300	400
B43	200	200	350

Initial wetting at: 17:30 First reading R_1 at: 18:00
Second reading R_2 at: 18:30 Third reading R_3 at: 18:55

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
B51	400	500	500
B52	300	400	350
B53	200	400	300
B61	300	500	300
B62	500	400	400
B63	750	500	500

Table 4 : Results from the resistivity tests - Inspection I
(Tests conducted on the Poplar Street Bridge during September 18-19, 1992)

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

Initial wetting at: 5:25
Second reading R_2 at: 6:15
First reading R_1 at: 5:40
Third reading R_3 at: 6:35

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
C11	1000	1000	1000
C12	1000	1000	1000
C13	1000	1000	1000
C21	>1000	1000	1000
C22	1000	750	1000
C23	1000	750	1000

Initial wetting at: 6:10
Second reading R_2 at: 7:30
First reading R_1 at: 7:00
Third reading R_3 at: 8:00

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
C31	1000	1000	1000
C32	1000	1000	1000
C33	1000	1000	1000
C41	1000	1000	1000
C42	1000	1000	1000
C43	1000	1000	1000

Initial wetting at: 7:30
Second reading R_2 at: 8:30
First reading R_1 at: 8:05
Third reading R_3 at: 9:00

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
C51	1000	1000	1000
C52	1000	1000	1000
C53	1000	1000	1000
C61	1000	1000	1000
C62	1000	1000	1000
C63	1000	1000	1000

Table 5 : Results from the resistivity tests - Inspection I
(Tests conducted on the Poplar Street Bridge during September 18-19, 1992)

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

Initial wetting at: 10:30 First reading R_1 at: 11:15
Second reading R_2 at: 11:45 Third reading R_3 at: 12:30

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
D11	50	45	50
D12	50	40	45
D13	60	45	40
D21	90	45	50
D22	60	60	50
D23	60	60	50

Initial wetting at: 12:00 First reading R_1 at: 12:30
Second reading R_2 at: 13:00 Third reading R_3 at: 13:30

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
D31	60	60	55
D32	40	40	45
D33	35	35	40
D41	50	45	45
D42	45	40	35
D43	35	45	35

Initial wetting at: 13:15 First reading R_1 at: 13:45
Second reading R_2 at: 14:05 Third reading R_3 at: 14:25

Location	Resistance R_1 (MΩ)	Resistance R_2 (MΩ)	Resistance R_3 (MΩ)
D51	200	200	250
D52	200	150	250
D53	200	200	200
D61	250	200	200
D62	250	200	200
D63	200	175	200

a bridge deck of this type, particularly given the noise level on the deck. The noise level on the very flexible steel deck was significant enough to mask potential differences in audible acoustic signals from the device expected due to localized delaminations.

No noticeable aggregate loss was detected on the test sections or on the other sections of the bridge deck. The average thickness of the wearing surface recorded in conjunction with the pull-out tests was 0.653 in. Variations in wearing surface thickness ranged from 0.4 in. to 0.865 in. The unevenness of the steel deck plate and the procedures used to place the wearing surface are likely reasons for this large variation in the wearing surface thickness. There is some concern about this variation because strains in the wearing surface are likely to vary as a function of the wearing surface thickness.

No visible cracks were detected anywhere in the test section or in the rest of the bridge. The construction joints examined in the test sections by visual observation also appeared to be crack-free.