

INTERNALLY-SEALED CONCRETE FOR BRIDGE DECK PROTECTION

Interim Report
Period Covered: July 1979 — September 1981

by

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Research Scientist

(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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ABSTRACT

The experimental deck exhibited a significant amount of cracks in the survey done at 29 months after heat treatment. These were attributed mainly to the heating and the cooling process, as only a few cracks were observed on the control deck. Delaminations totaling about 3% of the total deck surface were found on the experimental structure at 39 months and none were found on the control deck. Measurable but low chloride contents compared to the corrosion threshold value were determined at 42 months in the experimental deck but no significant value was obtained on the control. The electrical potential values at 47 months on the experimental deck indicate the possibility of corrosion taking place, whereas for the control the values show that at a 90% probability level no corrosion activity is occurring.

The report includes recommendations on the future use of this protective system and for frequent evaluations of the experimental deck.

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BACKGROUND

The initial report on this study was submitted in July 1978, and a progress report covering the period July 1978 — June 1979 was issued in August 1979. In June 1981 the principal researcher, S. S. Tyson, resigned and the present writer assumed responsibility for the project.

The recommendations presented in the two reports by Tyson related to the cracks associated with the heat treatments on the internally-sealed concrete deck.

DECK EVALUATIONS

This report presents results of evaluations of the experimental and control structures as noted in Table 1. These are discussed under the following subheads.

Table 1

Schedule of Evaluations

<u>Date</u>	<u>Feature</u>	<u>Months After Heat Treatment</u>
March 1980	Cracks	29
January 1981	Delaminations	39
April 1981	Chloride contents	42
September 1981	Electrical potentials	47

Survey of Cracks

Cracks observed during and after the heat treatment were attributed mainly to the heating and cooling processes and are referred to as thermal cracks.

Photographs of the internally-sealed concrete deck made with close-range terrestrial photogrammetry at 29 months were used to determine the total length of the cracks. The cracks were classified into two groups: those smaller than 1 mm width and those larger than 1 mm. Based on this general classification, the length of the narrow (<1 mm) cracks on the three experimental spans totaled 112 ft. (34 m), as measured from the plan views, and the length of the wider cracks (>1 mm) totaled 219 ft. (67 m).

The control deck exhibited a few cracks attributed to plastic and drying shrinkage. Thus cracking was not as extensive as on the experimental deck and no photogrammetric evaluation was made.

Figure 1 shows the internally-sealed concrete deck surface at 47 months.

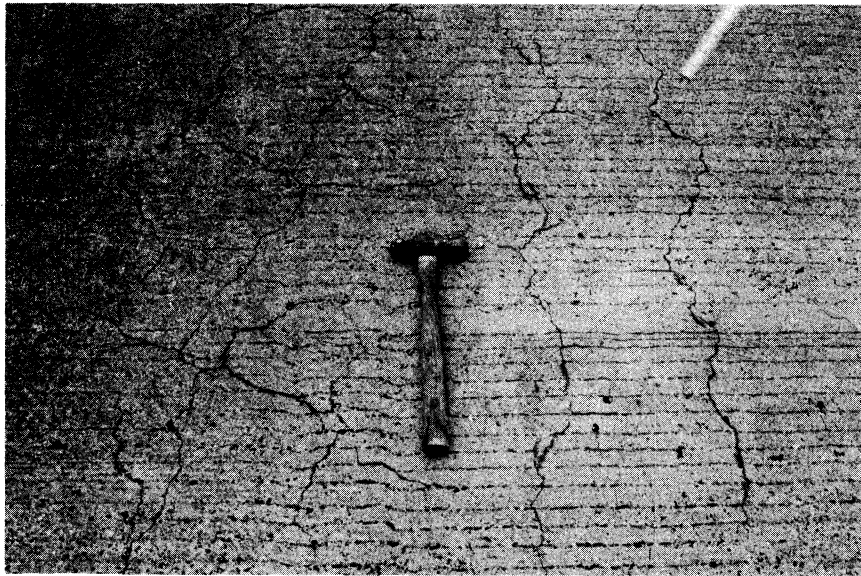


Figure 1. Cracks on internally-sealed concrete deck surface.

Delaminations

In the 18-month survey, hammer and chain drag soundings over the three experimental and three control spans revealed delamination at only one small area about 6 in. (150 mm) in diameter in the center span of the experimental deck. In the 39-month survey the experimental deck exhibited 145 ft.² (13.5 m²) of delaminated areas, which is about 3% of the total deck surface. An inspection of the control spans did not reveal any delaminated areas.

Chloride Contents

At 42 months cores were drilled from two locations in each span, one in the traffic lane and the other in the passing lane, of the experimental and control decks. The chloride contents were determined at two levels; D1 extending from a depth of 0.5 in. (13 mm) to 1 in. (25 mm) and D2 from 1.5 in. (38 mm) to 2 in. (51 mm). The calculated chloride contents were corrected for background chloride values of 0.45 and 0.68 lb./yd.³ (0.27 and 0.40 kg/m³) for the internally-sealed and control concretes, respectively. The results, summarized in Table 2, indicate that no significant chloride content was found in the control spans. All of the values for the control samples were recorded as 0 except one value, 0.03, which is not considered significant.

Table 2

Chloride Contents in lb./yd.³

<u>Type</u>	<u>Span</u>		<u>Traffic Lane</u>		<u>Passing Lane</u>	
	<u>No.</u>	<u>Location</u>	<u>D1*</u>	<u>D2</u>	<u>D1</u>	<u>D2</u>
Control	1	East	0.00	0.00	0.00	0.00
	2	West	0.00	0.00	0.00	0.00
	3	Center	0.00	0.00	0.03	0.00
Internally Sealed	1	West	0.35	0.05	0.10	0.00
	2	Center	0.18	0.12	0.14	0.00
	3	East	0.35	0.25	0.22	0.00

$$1 \text{ lb.yd.}^3 = 0.59 \text{ kg/m}^3$$

*D1 - 0.5 in. - 1 in. (13 mm - 25 mm)

D2 - 1.5 in. - 2 in. (38 mm - 51 mm)

Measurable chloride contents were found in the traffic and passing lanes of the experimental deck, but these are small values relative to the total chloride corrosion threshold value of 1.3 lb./yd.³ (0.77 kg/m³) of concrete, and corrosion of the reinforcing bars would not be expected at this time from such low amounts. It appears significant, however, that measurable quantities of chloride were found in the experimental spans but not in the controls.

Electrical Potentials

Electrical potential values were obtained at 47 months. Table 3 summarizes the percentages of the electrical potential values in three standard ranges obtained on each of the spans based on a 5-ft. (1.5-m) grid. These are shown for the initial 5-month reading, the 18-month reading, and the 47-month reading. Column A indicates the percentage of the spans with readings below -20 volt CSE, the level established by ASTM C876 as indicating a 90% probability that no corrosion of reinforcing steel is taking place. Column B indicates the proportion of the span with readings between -0.20 and -0.35 volt CSE, where corrosion activity of the reinforcing steel is uncertain. Column C indicates the proportion of the span with readings above -0.35 volt CSE, considered by ASTM C876 as indicating a greater than 90% probability that corrosion is occurring.

Table 3

Distribution of Electrical Potential Readings

Span			Percentage of Readings at Different Levels*								
Type	No.	Location	5 Months			18 Months			47 Months		
			A	B	C	A	B	C	A	B	C
Control	1	East	100	0	0	100	0	0	100	0	0
	2	West	100	0	0	100	0	0	100	0	0
	3	Center	100	0	0	100	0	0	100	0	0
Internally Sealed	1	West	87	13	0	100	0	0	80	19	1
	2	Center	69	31	0	100	0	0	94	6	0
	3	East	82	18	0	100	0	0	100	0	0

*Ranges for Measurement:

- A Below - 0.20 volt CSE
- B -0.20 to - 0.35 volt CSE
- C Above -0.35 volt CSE

As shown in Table 3, the initial 5-month readings indicated some uncertainty concerning the probability of corrosion in the internally-sealed areas. At 18 months all readings were in the range indicating a very low probability of corrosion; however, at 47 months small proportions of two internally-sealed spans were again in the uncertain range and 1% of the area of one span had values above -0.35 volt CSE. It is significant to observe that all the readings at each inspection of the control span indicated no corrosion.

DISCUSSION

Numerous thermal cracks that developed during the heat treatment of experimental internally-sealed decks have been shown by this and other studies to be the major deterrent to the use of the internally-sealed system of protecting bridge decks against the damaging effects of deicing salts. General recognition of the problem is indicated by the publication in a Transportation Research Circular dated April 1981 of a research problem statement on heat treatments for both internally-sealed and polymer-impregnated concretes. The results of this study indicate that problems with durability may be encountered at earlier than expected ages in the experimental deck. The control deck appears to be performing satisfactorily.

RECOMMENDATION

Because of indications that the performance of the experimental deck is being adversely affected by the presence of thermal cracks, heat-treated, internally-sealed concrete should not be used until improved heating procedures can be developed or reduced melting temperatures for the wax can be established so that significant thermal cracks and delaminated areas will not occur.

The study decks should be evaluated at least annually to provide assurance that there is no accelerated corrosion of the reinforcing steel in the internally-sealed spans.

