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RESEARCH UPDATE

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PERFORMANCE OF WATERPROOFING MEMBRANES ON CHLORIDE CONTAMINATED BRIDGE DECKS

REFERENCE

Work Plan 86-R-10, Bridge Deck Performance Following Rehabilitation, Update No. U87-4, Update No. U87-8.

SUBJECT

This update reviews the progress of research on the performance of waterproofing membranes in retarding or stopping corrosion activity on reinforcing steel in chloride (Cl-) contaminated bridge decks.

HISTORY

Update U87-4 reported an 85%± reduction in corrosion activity on Rte. 100 BR #178, which had been sealed with a marginal waterproofing system without the benefit of deck repair. Update U87-8 reported a reduction in corrosion activity from 34% of the readings to a single active location (at the end of the deck) on Rte. 14 BR #131, despite the fact that the concrete contained an average of 2.9 lbs. of Cl- at the rebar level. The area under evaluation had been waterproofed with a preformed sheet membrane 11 years earlier.

STATUS

Based on the results obtained on bridges #178 & #131, several bridges under contract for deck repair in 1986 were monitored closely for corrosion activity and the extent of concrete repair. The surveillance included copper-copper sulfate half-cell readings at a one foot grid interval before repair and again after patching prior to the application of a preformed sheet membrane waterproofing system. The investigation also included Interstate 91 BR #8N, the repair of which had also been documented in detail in 1983.

The followup testing was carried out at locations where Cl- contaminated concrete was not removed and active corrosion values had been recorded prior to waterproofing. In many cases, the retests were taken at locations immediately adjacent to areas which had been repaired due to the presence of concrete delamination at such areas. The testing on BR #8N was within areas which had active corrosion and were not repaired but the initial specific corrosion values had not been recorded.

Due to the presence of the dielectric membrane which prevented completion of the circuit, it was necessary to modify the standard method of obtaining the half-cell potentials of the reinforcing steel. The procedure was accomplished by boring a 3/4" hole through the bituminous pavement and membrane to the concrete deck. A plastic pipe nipple with sponge insert was utilized to provide the necessary electrical circuit without saturating the sample hole with water. After testing, the holes were blown dry and sealed with an approved self leveling, one part polyurethane sealant.

The results of the retesting on areas where corrosion activity was recorded just prior to waterproofing can be seen in Table 1. The test period noted is the length of time between the membrane application and the retest date.

Table 1

ROUTE BRIDGE # TOWN	TEST PERIOD (MONTHS)	NUMBER OF TESTS	PERCENTAGE OF TESTS NO LONGER ACTIVE	AVERAGE VOLTAGE REDUCTION
I-91 BR 8N Brattleboro	49	38	100%	0.186±
VT 16 BR 1 Hardwick	15	34	88%	0.102
US 2 BR 75 Plainfield	13	42	98%	0.093
VT 14 BR 131 Coventry	2½	47	53%	0.057

The retest results on the four decks appear very promising since all corrosion readings had dropped with most now below the -0.35 volt corrosion threshold. Although the results of the earlier studies on bridges #178 and #131 had suggested corrosion activity could be retarded, the rapid decrease in corrosion values such as that noted on BR #131 in only 2½ months was surprising.

The average potential reading dropped in ratio to the length of time the deck was sealed from the penetration of moisture. Readings on BR #8N averaged -0.214 volts after being sealed for 49 months.

The theory that corrosion activity would accelerate in areas adjacent to new concrete patches due to the difference in Cl- content between the new and old concrete appears not to be true where the deck is sealed with a waterproofing membrane.

In addition to the testing described earlier, retesting was also carried out at locations which had been repaired but still retained corrosion values of -0.35 volts or greater. The repair generally consisted of Preparation of Concrete Surface, Class II which includes removal of all concrete down to a point 3/4" beneath the bottom bar in the top mat of reinforcing steel. In some cases, only Class I repair was completed which entailed removal of concrete above the top mat of steel only.

In the case of the areas repaired with Class I removal, the continuation of active corrosion reading prior to waterproofing was not at all surprising since Cl- contaminated concrete remained around the reinforcing steel. Corrosion activity also continued in some areas where Class II repairs were completed. Since Cl- contaminated concrete has been removed and the rebars had been sand blasted it is assumed that the continuation of active readings was due to spot areas of contamination on the hard to reach bottom of the bars or due to corrosion activity on the bottom mat of steel. The bottom mat corrosion can occur in a relatively short span of exposure when corrosion of the top mat creates fracture planes and spalls which trap and concentrate Cl- solutions which seep down through cracks in the bituminous overlay or flow along the partially sealed concrete deck surface.

The results of the retesting on the active areas which had been repaired can be seen in Table 2.

Table 2

ROUTE BRIDGE # TOWN	TEST PERIOD (MONTHS)	NUMBER OF TESTS	PERCENTAGE OF TESTS NO LONGER ACTIVE	AVERAGE VOLTAGE REDUCTION
VT 16 BR 1 Hardwick	15	84	79%	0.099
VT 14 BR 131 Coventry	2½	19	21%	0.031

The retest results show a reduction in corrosion activity in repaired areas following waterproofing, although the percentage of reduction is less than that experienced in areas which had never been repaired. It is assumed that the reduced success in repaired areas is the result of bottom mat corrosion which is being identified with the half cell. Further or complete reductions in corrosion activity may not be attainable unless the waterproofing is able to dry out and reduce the available oxygen supply in the area of the bottom mat.

The field test results obtained and discussed in this report support the following conclusions:

1. A satisfactory deck rehabilitation program does not require the removal of Cl- contaminated concrete or the repair of areas with active corrosion of the reinforcing steel if the final treatment includes the application of a satisfactory waterproofing membrane system.

2. Corrosion activity will not accelerate in areas of the deck adjacent to new concrete patches due to the difference in Cl- content between the old and new concrete if the deck is sealed with an effective waterproofing membrane system.

FOLLOWUP

Additional testing is planned as follows:

1. A portion of the test locations will be retested to determine if corrosion readings continue to decrease.
2. Tests will be taken at additional locations on decks currently in the study.
3. Additional decks will be included in the study to further evaluate the findings reported here.
4. Followup testing will be done on bridge decks where corrosion is occurring on the bottom mat of reinforcing steel in an attempt to determine if a waterproofing membrane can reduce the bottom mat corrosion.

Distribution: A, B, C, D and E