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BRIDGE DECK
REPAIR AND PROTECTIVE SYSTEMS
LATEX MODIFIED CONCRETE TOPPING

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16. Abstract

Measures to reduce or eliminate bridge deck deterioration by the use of various protective systems have been the subject of a series or reports begun in 1976. This report presents current observations of latex modified deck topping concrete protective systems. Latex modified concrete topping has not provided long-term protection for the ten structures under evaluation in Colorado. Cost comparison are made between repair with latex modified concrete and deck replacement. Over a 40-year period, replacement costs are slightly less than rehabilitation costs. Greater control of the curing of deck topping materials may reduce shrinkage cracking. Nightime paving, cooler calmer weather and higher himidity would increase the probability of success on latex modified concrete to rehabilitation projects. Asphalt membrane and asphalt overlay are also suggested to increase the probability of success.

Implementation

Latex modified concrete is not recommended as a rehabilitation option in Colorado at this time. Further evaluation of two structures using latex modified concrete under night paving and tight control of curing methods is currently underway on I-25 North of Longmont.

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INTRODUCTION

Several reports concerning bridge deck deterioration and various protective systems have been published over the last nine years. The most recent CDOH report Evaluation of Bridge Deck Repair and Protective Systems CDOH-DTP-R-80-15 dealt with latex modified concrete and Colorado low slump class DT concrete. That report discussed construction and bridge deck repair procedures and included specifications in the appendices. This report is a follow up on that 1983 report and concludes the evaluations of the latex modified deck topping. The acceptance, publication and distribution of this report will therefore conclude the evaluation of the current decks topped with latex modified concrete from this research study.

TABLE A

Decks Surfaced with Latex Modified Concrete Deck Topping

No.	Structure No. and Location	Construction Date/ Repair Date	ADT/Avg. Daily Heavy Trucks	Lbs. Salt Applied/Yd^2/Year
1	E-17-KT I 76 Over 96th	1976 (New)	25,400 2,670	7.6
2	E-17-DQ I 76 WB Over SH 85	1957 1976	8,100 1,230	10.0
3	E-17-IT (Top Deck) I 225 SB Over I 70	1965 1976	2,100 660	6.7
4	E-17-IU (2nd Deck) I 70 EB Over I 225	1965 1976	9,200 1,360	10.2
5	F-16-HJ I 70 EB Over 20th	1968 1977	1,470 1,120	9.2
6	F-16-HK I 70 WB Over 20th	1968 1977	14,700 1,120	9.2
7	E-16-HF I 70 WB Over 32nd	1968 1977	12,400 860	9.2
8	F-16-HE I 70 EB Over 32nd	1968 1977	12,400 860	9.9
9	E-17-IA I 76 WB Over I 270	1967 1977	14,200 1,790	11.4
10	E-17-IB I 76 EB	1967 1977	11,600 1,600	11.4 Over I 270

LATEX MODIFIED CONCRETE DECK TOPPING

The first latex modified concrete topping in Colorado was placed on I-225 over Sand Creek in 1973. Shrinkage cracking occurred immediately after construction, and patches were placed over much of the surface. This repair job failed by 1980. This deck was then removed from the experimental evaluation category and from this research project. CDOH engineers still considered latex modified concrete to be a promising protective system. They expected and hoped for an additional twenty and perhaps thirty or more years of service from properly applied protective systems.

Ten more decks were constructed or repaired with latex modified concrete during 1976 and 1977 while implementing more rigid construction controls, especially curing agents and covering the surface to prevent shrinkage cracking. The construction included removal of all unsound concrete, sand blasting of exposed steel, and placing latex modified concrete to at least 2 inches above the steel. Construction details were discussed in detail in previous reports. The construction repair and curing of these ten decks (Table A) was completed in a satisfactory manner and CDOH engineers were generally pleased with the projects. Follow up evaluations were disappointing as cracking progressed and finally delamination, popouts, patching and complete overlays were observed. The results of physical tests, which included half cell and chloride analysis, were not conclusive. Six chloride samples were taken from each structure for each evaluation period. The results are so scattered that no trends can be determined. A larger number of samples, from each structure at each test period are apparently necessary to

produce good statistical results. The half cell results are also widely scattered and unusable. It is speculated that the irregular surface of old concrete covered by variable thicknesses of new latex modified concrete could produce different results if the half cell probe is not placed on the exact same spots each year. Also different amounts of moisture in the deck from year to year could produce variability in localized half cell activity. Sounding of delaminated concrete by the hammer method and visual observations are dependable tools of evaluation but show deterioration only in the late stages. The following pages are chronologically arranged photographs and evaluation notes on each of these ten structures.

EVALUATIONS

E-17-KT I-76 Over 96th

New 1976 Latex Modified Topping

Photo #1

This structure was built new and topped with latex modified concrete. Hairline cracks showed up on both the surface and the underside within the first year. Surface cracks present in the spring of 1977 increased in number, length and width by December 1977.

Photo #2

Cracks through the deck show salt evaporates to the underside. December 1977. Although this cracking was disappointing it was hoped that salt contamination and subsequent deterioration would be limited to the narrow vertical cracks.

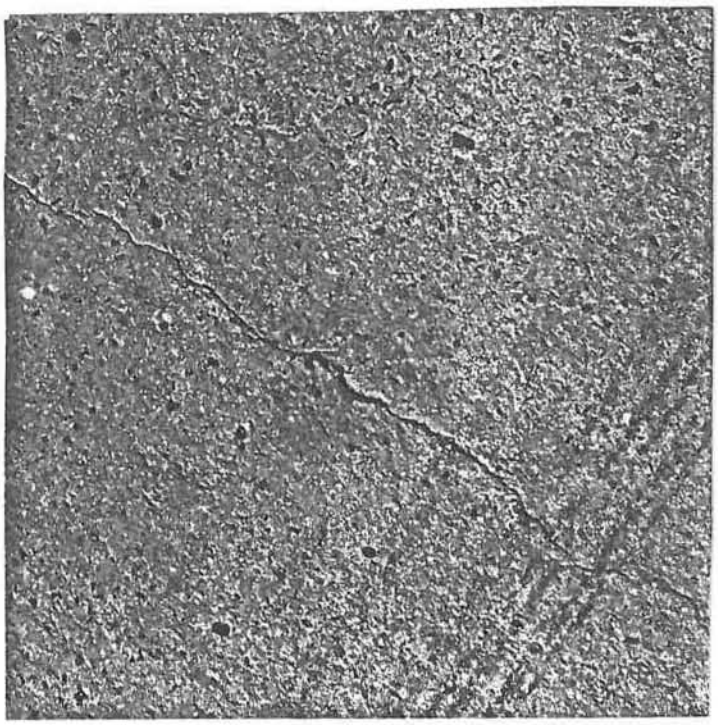
Cracking had increased on the surface of the deck in 1980.

Photo #3

More salt stains were present on the underside of the deck in 1980.

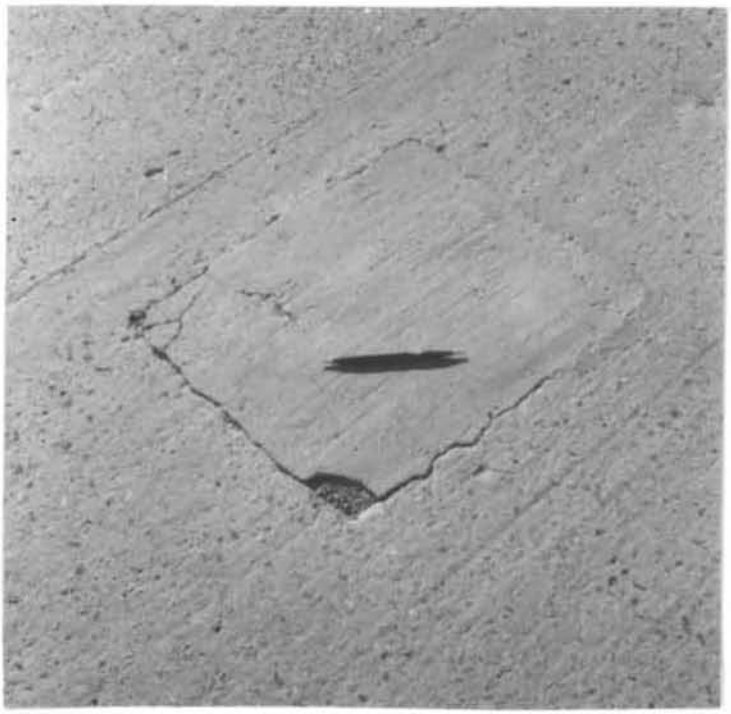
Photo #4

E-17-KT I-76 Over 96th



Surface cracks are visably larger Feb. 84

Photo #5



Seven one foot square duracal patches have been placed by maintenance forces. These are surface patches generally less than 2" deep. Feb. 84

Photo #6

E-17-DQ I-76 WB Over SH 85

Const. 1965 Repair 1976-Latex Modified

Sept. 1980
Close-up of
typical cracks.

Photo 7

Structure E-17-DQ is I 76 west bound over state highway 85. The surface showed many hairline cracks within two years after it was repaired. These cracks covered approximately 30% of the surface by 1982 (6 years after repair). By 1984 the surface was cracked to about 80% of the area and a pothole has developed near the west end which has been patched with asphalt.

E-17-IT (Top Deck) I-225 SB over I-70

Const. 1965 Repair 1976-Latex Modified

Surface cracks started to appear in the latex modified surface as early as December of 1977.

Photo # 8

Cracking and salt precipitates were visible on the bottom of the deck, however most of this salt was here before the repair took place. Dec. 1977.

Photo # 9

Cracking increased during the next several years. Most of this cracking was transverse, parallel and over reinforcing steel.

Several pop outs had occurred in the south span by 1982.

Photo # 10

Delamination and popouts became quite extensive by 1984.

Photo # 11

E-17-IT (Top Deck) I-225 SB over I-70

There was much more salt precipitates on the underside of this deck in 1984 than there was just after the repair in 1977.

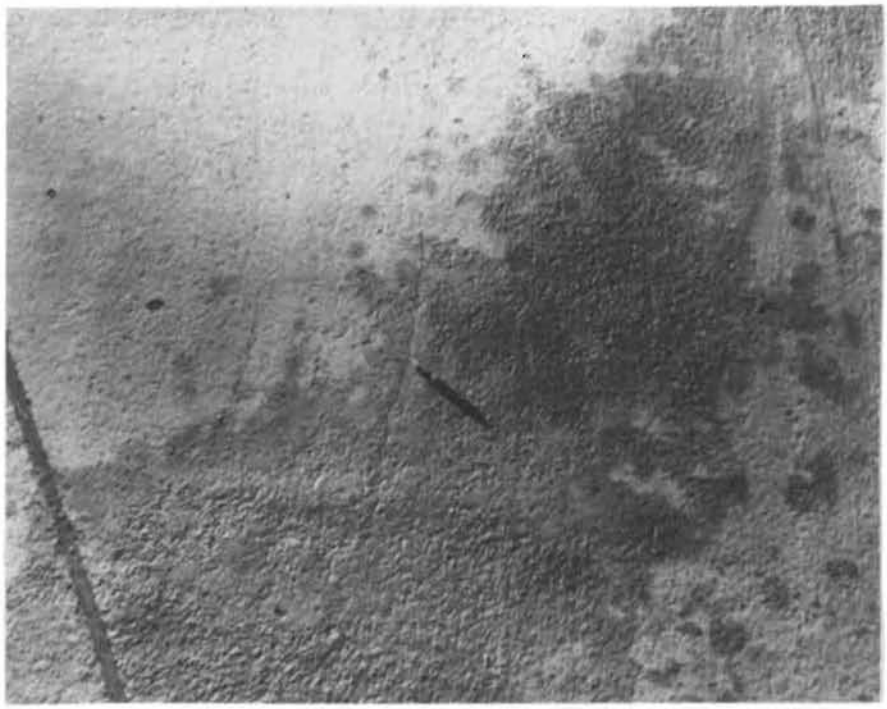
Photo #12

Delaminated concrete is broken out and scattered by traffic causing hazards of the potholes and debris on the highway.

Photo #12a

E-17-IU (2nd Deck) I-70 EB over I-225

Const. 1965 Repair 1976-Latex Modified



A few cracks appeared in the Latex Modified Surface by December of 1977.

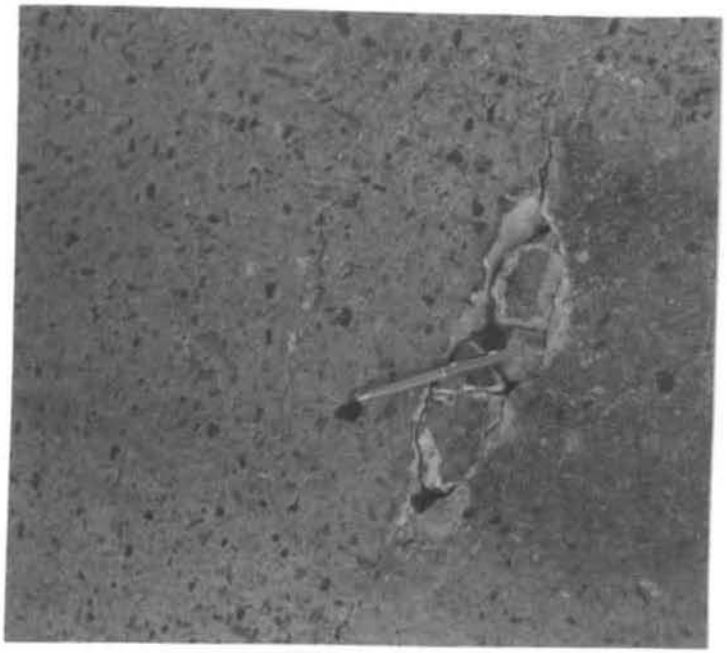
Photo #13

The underside was in relatively good condition in 1977.

Photo # 14

E-17-IU (2nd Deck) I-70 EB Over I-225

Const. 1965 Repair 1976



A new spall appeared in 1982 on a former crack over a rebar. The deck surface for several inches after the trailing edge of this spall is iron stained as if rusty water had been excreted from the crack under traffic in a similar manner to that of roadway pumping on saturated subgrade.

Photo # 15

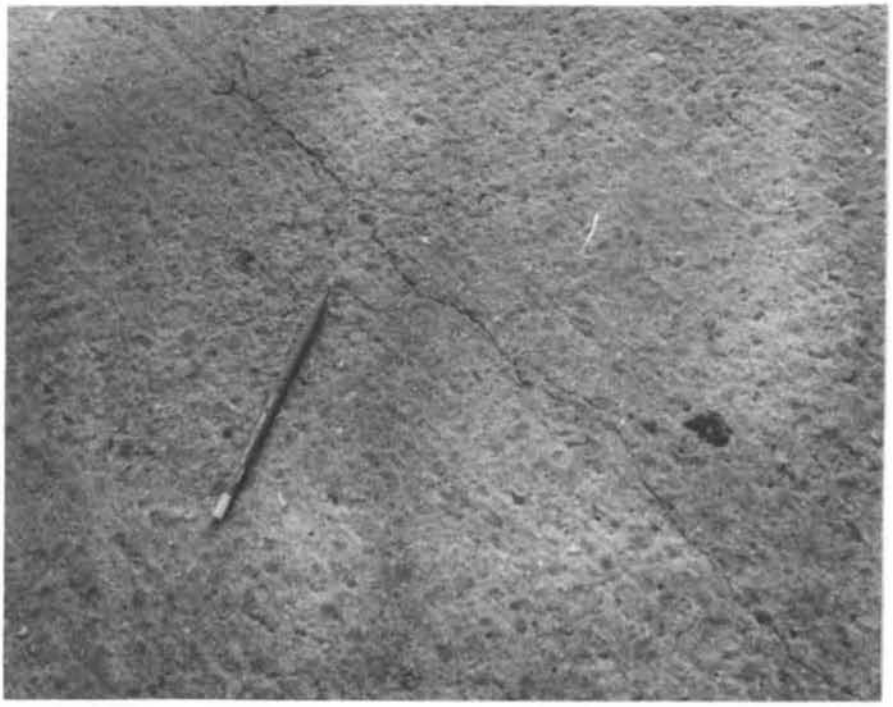
In the fall of 1983 the entire deck was delaminated. "D" cracking had progressed to the point where 4" square blocks were thrown out causing hazards to vehicles. Maintenance patched and overlaid the structure.

In February of 1984 the asphalt overlay is showing reflective cracking and potholing.

Photo # 16

F-16-HJ & F-16-HK I-70 Over 20th

Const. 1968 Repair 1977



Cracks developed in the new Latex Modified deck after only three months. December 1977

Photo # 17

Salt stains on the underside are probably from the old salt contaminated concrete. 1977

Photo # 18

Photo # 19

By May of 1980 there was considerable cracking over the reinforcing steel. It was estimated that over 50% of the surface was cracked.

During the late summer and early fall of 1983 most of these decks were delaminated as tested by the hammer method. Many 4" blocks had come out causing a traffic hazard. Maintenance forces patched the holes and overlaid the structures.

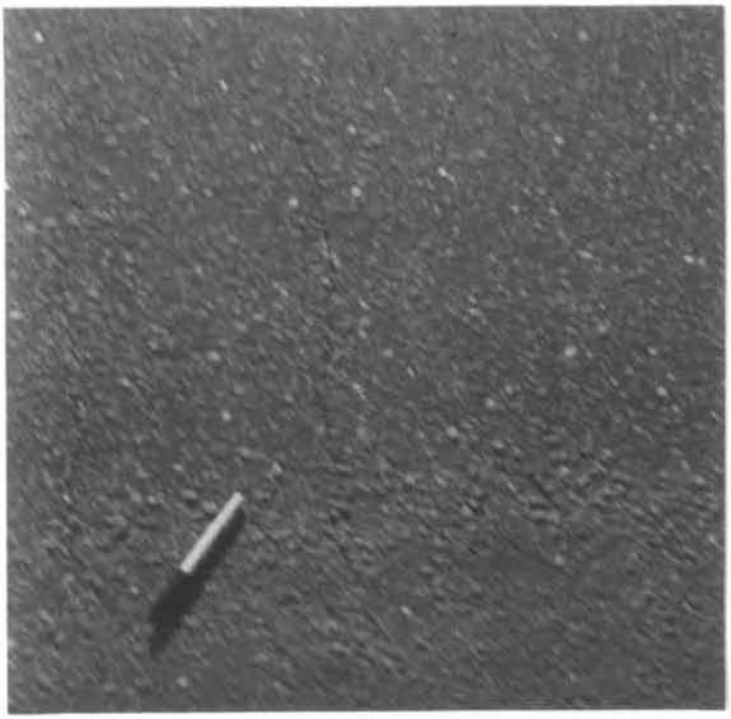


Photo # 20

This February 1984 photo shows reflective cracking in the asphalt overlay from a popout in the concrete.

E-16-HF and E-16-HE I-70 Over 32nd.

Const. 1968 Repair 1977 - Latex Modified

Cracks developed in the new Latex Modified deck after only three months. December 1977

Photo # 21

Eight to ten cracks per span showed salt precipitation under the bridge

Most of this was residual salt from the before 1977 repairs.

Photo # 22

E-16-HF and E-16-HE I-70 Over 32nd

Surface cracks were observed on over 50% of reinforcing steel by 1982. There were no additional salt stains apparent on the underside of the deck.

Photo # 23

In June of 1983 the surface cracks were wider and quite extensive. Maintenance had to apply crack sealer to the passing lane.

During the late summer and fall of 1983 most of these decks were delaminated as tested by the hammer method. Many 4" blocks had come out causing a traffic hazard. Maintenance forces patched the holes and overlaid the structures.

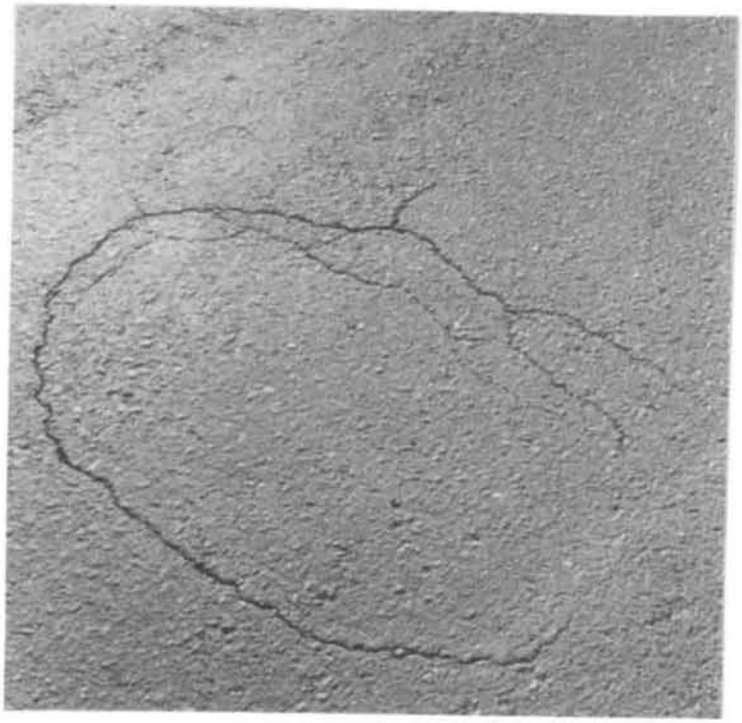


Photo # 24

This photo shows reflection cracking over a concrete pop out. Several others are just starting to reflect through. February 1984.

E-17-IA I-76 WB Over I-270

Const. 1967 Repair 1977-Latex Modified

A concrete pop out appeared near the end of the deck in September of 1980.

Photo # 25

Chicken wire cracking and salt are prominent over a 10 Ft. square area on the underside of the deck near the west end center. 1984.

The surface of the deck has many hair line cracks over and parallel to the reinforcing steel. 1984

Photo # 26

Feb. 1984 The popout at the end of the deck is growing.

Photo # 27

A second popout has appeared near the center of the deck.

Several other areas are now showing "D" cracking and will be popouts within a few months. 1984.

Photo #28

COST ANALYSIS

A detailed cost analysis was performed on four of the ten structures which were repaired with latex modified concrete. From Table A they are E-17-IT I-225 SB over I-70, E-17-DQ I-76 WB over S.H. 85, E-16-HF I-70 WB over 32nd and F-16-HJ I-70 EB over 20th.

Table B shows the results of this cost analysis. The costs for items calculated were from the 1976 and 1977 cost estimate report and from the bid tabulations from the repair projects on the above structures. The analysis for replacement included concrete, steel, waterproofing asphalt, curbs, guardrail and removal of present deck. Asphalt concrete removal, partial deck removal and or deck scarifying and latex modified concrete were included in rehabilitation costs. Traffic control, mobilization and other miscellaneous items were not included in either replacement or rehabilitation since such items would be the same or similar in either of the alternatives.

The present worth costs for rehabilitation were calculated assuming that five additional rehabilitations would be required to keep these structures in service for the equivalent 40 year period. These figures can be compared to the one time deck replacement costs.

The figures in the bottom part of table B are annual costs for a 40 year period for each alternative. These figures are very subjective because of the assumed 40 year life of a new deck. Various engineers, designers and planners have different ideas about the longevity of a new structure. This cost analysis and table are intended to point out possible savings in replacement over repair of decks and the reader or user is encouraged to develop his own figures and consider all alternatives when a structure is severely distressed.

TABLE B

Cost Analysis of Four Structures

Alternatives (Rehabilitation vs. Replacement)

	STRUCTURE			
QUANTITIES	E-17-IT	E-17-DQ	E-16-HF	F-16-HJ
Approx. Deck AREA ($YD.^2$)	616	869	926	856
SLAB THICKNESS	7"	7 1/4"	7.5"	7.5"
COST: DECK REHABILITATION Latex. Modified	$20,550	$ 19,570	$ 58,430	$ 66,590
COST: DECK REPLACEMENT	$82,850	$114,255	$121,000	$115,060
COMMENTS			ADDED COSTS TO REHAB. DUE TO ASPHALT REMOVAL & REMOVAL OF PORTION OF STRUCTURE	ADDED COSTS TO REHAB. DUE TO ASPHALT REMOVAL & REMOVAL OF PORTIONS OF STRUCTURE
Total Present worth costs of Rehabilitation for a 40 year period.	$95,370	$133,470	$142,100	$131,550
Annual cost of Rehabilitation	$ 4,816	$ 6,740	$ 7,167	$ 6,643
Annual cost of Deck Replacement 40 year longevity.	$ 4,185	$ 5,770	$ 6,110	$ 5,810

DISCUSSION

It is appropriate at this point to discuss some possible causes of the failures evidenced in the previous section. Some shrinkage cracks developed in most of these ten structures even though special precautions were taken to apply curing compound and cover the concrete immediately after placement of the concrete. Colorados semiarid climate combined with hot weather and mild winds are factors which promote shrinkage cracking. Water penetrates the latex modified concrete as observed by resistivity testing on newly completed decks, therefore latex modified concrete is permiable to water. The old concrete is salt contaminated from conditions which existed prior to the repair jobs. Some corrosion of the steel probably continues to occur in the presence of this residual chloride and any residual or new water in the system. This subsequent corrosion could also cause new hairline cracks above the rebars. Many hairline cracks were observed parallel to and above the steel within a short time after the repair jobs.

It is also speculated that electrical potentials (corrosion cells) are created when the new deck topping is placed in contact with the older salt contaminated concrete. In the presence of water, corrosion would certainly continue; cracks would develop opening new avenues of entry for more water and salt.

Companion decks repaired in 1978 and 1979 with DT mix and protected by membranes and asphalt overlays have not shown servere deterioration at this time. Since they were completed one or two years and after the latex modified decks, are protected by a membrane these structures are not expected to show distress yet and a direct comparison should not be made.

CONCLUSIONS

It is obvious from the photographs and field observations that the latex modified concrete topping has not provided long term protection for these ten structures. After seven years the decks are in as bad or worse condition than they were before the repair. These decks are currently in need of another repair or replacement.

RECOMMENDATIONS

Greater control on the curing of deck topping materials would hopefully reduce shrinkage cracking. CDOH Engineers are currently considering nighttime paving in which cooler, calmer weather with slightly higher humidity would decrease the potential for shrinkage cracking. A permanent membrane and overlay may be required to eliminate or reduce entry of water and new chlorides into the bridge deck.