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Project Summary Report 0-4069-S
Project 0-4069: Mitigation Techniques for In-Service Structures with Premature Concrete Deterioration

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PROJECT SUMMARY REPORT

Mitigation Techniques for In-Service Structures with Premature Concrete Deterioration: A Summary

Introduction

Recent investigations of concrete bridge structures throughout Texas have shown an increasing number that are deteriorating prematurely. This Premature Concrete Deterioration is caused by two expansive distress mechanisms: Alkali-Silica Reaction (ASR) and Delayed Ettringite Formation (DEF). While chemically different, both mechanisms need moisture.

The effects of this deterioration on structural performance were studied in Project 0-1857: "Structural Assessment of In-Service Bridges with Premature Concrete Deterioration." Results from that project let engineers determine if a deteriorating member has enough structural capacity to remain in service. If a deteriorating member can remain in service, it is necessary to apply a mitigating technique to control further expansion from ASR or DEF, separately or in combination.

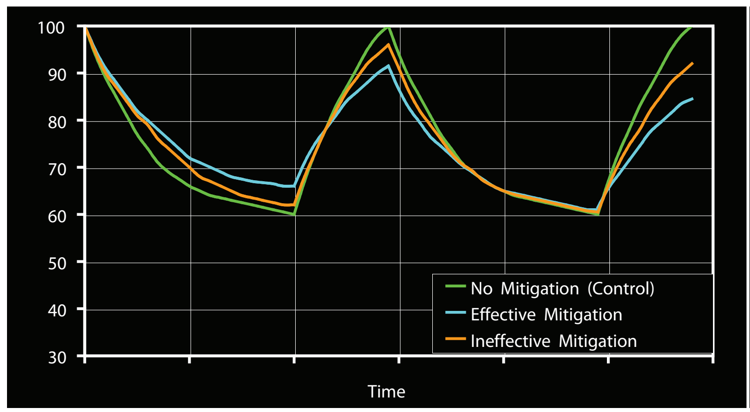

Figure 1 Proposed Test Method

Table 1 Mitigation Treatments

	Mitigation Treatment
M1	TxDOT Surface Treatment—Silane, plus TxDOT Appearance Coat Paint
M2	TxDOT Surface Treatment—Silane
M3	TxDOT Surface Treatment—Silane, plus Class B Type II Latex Paint
M4	TxDOT Surface Treatment—Silane, plus Opaque Concrete Sealer
M5	Lithium Nitrate, followed by TxDOT Surface Treatment—Silane
M6	Penetrating Epoxy
M7	Control; no mitigation treatment

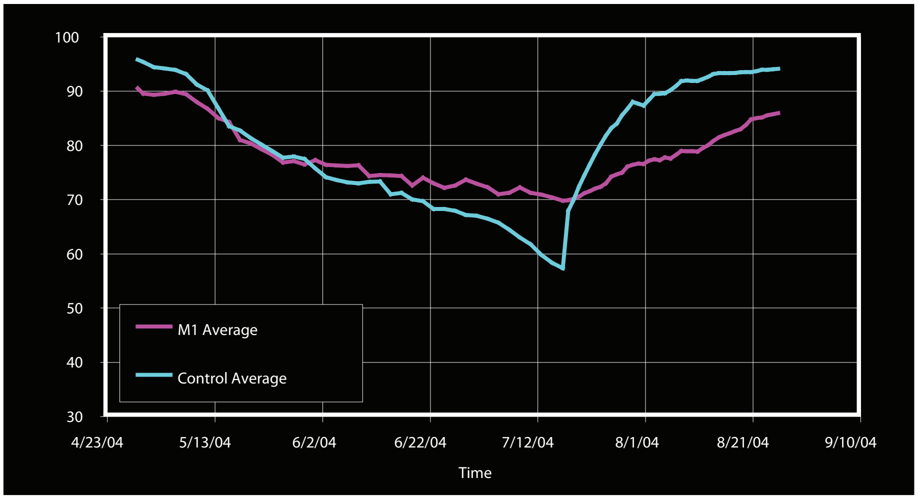

Figure 2 Example of Changes in Internal RH in Treated Versus Untreated Specimens

What We Did...

Finding effective mitigation techniques was the objective of TxDOT Project 0-4069. Because no standard nor modified ASTM tests could tell the difference between effective and ineffective mitigation treatments, a new test method was developed and was used for further evaluation of possible mitigation treatments. The proposed test method involves subjecting a concrete test specimen to cycles of drying and wetting (Figure 1).

Each specimen is subjected to controlled cycles of wetting and drying. The internal relative humidity of treated specimens is compared with that of control specimens. Each proposed mitigation treatment is evaluated by how well it controls the internal relative humidity of the specimen. Since premature concrete deterioration requires an internal RH of at least 80%, effective mitigation techniques would allow RH to decrease rapidly below 80% during drying stages, but keep RH from increasing above 80% during wetting stages.

In developing the proposed test method, the high relative humidity (RH) was set at 100%, a natural upper limit). The low RH was set at 60%, because NOAA weather records indicate that this is a typical lower value for areas of Texas with observed premature concrete deterioration. Six mitigation treatments were used (Table 1).

Examples of relative humidity in specimens with Treatment M1 versus no treatment are shown in Figure 2.

The proposed test method was evaluated by comparing the time that treated (T_M) and control (T_C) specimens spend above 80% RH. This was expressed

Table 2 Exposure-Time Ratios for each Mitigation Treatment

Mitigation Treatment	Exposure-Time Ratio
M1	0.64
M2	1.0
M3	0.87
M4	0.81
M5	0.92
M6	1.09

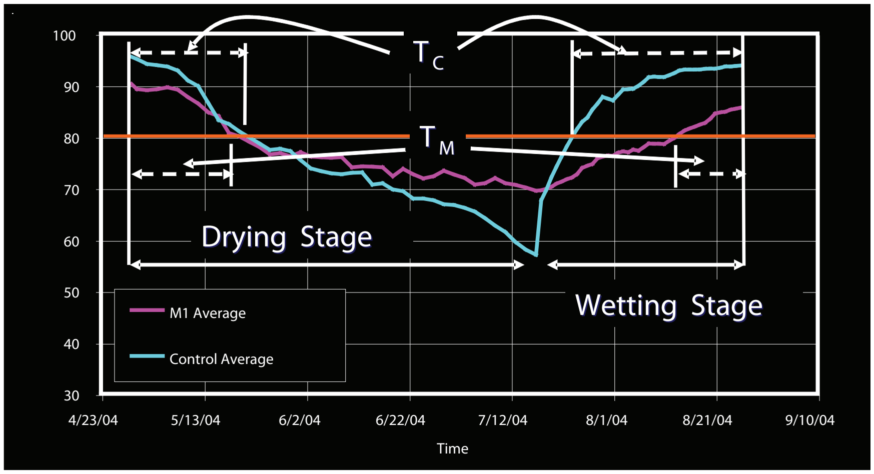

Figure 3 Calculation of Exposure-Time Ratio for Treatment M1

in terms of an "exposure-time ratio":

$$Exposure - Time\ Ratio = \frac{T_M}{T_C}$$

Exposure-time ratios less than 1.0 represent effective treatments; ratios greater than or equal to 1.0 represent ineffective treatments. Examples of the calculation of an exposure-time ratio are shown in Figure 3. Exposure-time ratios for each mitigation treatment at 1/2-in. depth are shown in Table 2.

Because premature concrete damage increases about linearly with time above an internal RH of 80%, mitigation treatment extends a structure's life by a factor about equal to the inverse of the exposure-time ratio:

$$Extended\ Life \approx \frac{Untreated\ Life}{Exposure - time\ ratio}$$

What We Found...

Mitigation Treatment M1 (the current TxDOT recommendation) is the most effective mitigation treatment. Based on laboratory testing performed in Project 0-4069, it extends the life of treated structures by a factor of 1.3 to 1.5.

The Researchers Recommend...

- Use the current TxDOT treatment (M1) to mitigate or prevent premature concrete deterioration. The treatment must include gray appearance paint; Silane alone (Treatment M2) is not sufficient.
- Continue to evaluate proposed laboratory test method with more concretes and further cycles.
- Continue to monitor field performance.
- Standardize the proposed test method through ASTM.

For More Details...

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The research is documented in the following reports:

Report 4069-1, *Mitigation Techniques for In-Service Structures with Premature Concrete Deterioration*.

Report 4069-2, *Mitigation Techniques for In-Service Structures with Premature Concrete Deterioration: A Literature Review.*

Report 4069-3, *Mitigation Techniques for In-Service Structures with Premature Concrete Deterioration*.

To obtain copies of a report: CTR Library, Center for Transportation Research, (512) 232-3126, email: ctrlib@uts.cc.utexas.edu

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