

## TECHNICAL REPORT TITLE PAGE

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**2. REPORT DATE**

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**3. TITLE AND SUBTITLE**

Reduction of Concrete Deterioration by Ettringite  
Using Crystal Growth Inhibition Techniques:  
Part II Field Evaluation of Inhibitor Effectiveness

**4. TYPE OF REPORT & PERIOD COVERED**

Final Report type, March 2002 to May 2004

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**8. ABSTRACT**

The effects of diethylenetriaminopenta (methylenephosphonic acid) (DTPMP) a phosphonate inhibitor, on the growth of delayed ettringite have been evaluated using concrete in highway US 20 near Williams, Iowa, and the cores of six highways subject to moderate (built in 1992) or minor (built in 1997) deterioration. Application of 0.01 and 0.1 vol. % DTPMP to cores was made on a weekly or monthly basis for one year under controlled laboratory-based freeze-thaw and wet-dry conditions over a temperature range of -15 to 58°C to mimic extremes in Iowa roadway conditions. The same concentrations of phosphonate were also applied to cores left outside (roof of Science I at Iowa State University) over the same period of time. Nineteen applications of 0.1 vol % DTPMP with added deicing salt solution (~ 23 weight % NaCl) were made to US 20 during the winters of 2003 and 2004. In untreated samples, air voids, pores, and occasional cracks are lined with acicular ettringite crystals (up to 50 µm in length) whereas air voids, pores, and cracks in concrete from the westbound lane of US 20 are devoid of ettringite up to a depth of ~0.5 mm from the surface of the concrete. Ettringite is also absent in zones up to 6 mm from the surface of concrete slabs placed on the roof of Science I and cores subject to laboratory-based freeze-thaw experiments. In these zones, the relatively high concentration of DTPMP caused it to behave as a chelator. Stunted ettringite crystals 5 to 25 µm in length, occasionally coated with portlandite, form on the margins of these zones indicating that in these areas DTPMP behaved as an inhibitor due to a reduction in the concentration of phosphonate. Analyses of mixes of ettringite and DTPMP using electrospray mass spectrometry suggests that the stunting of ettringite growth is caused by the adsorption of a Ca<sup>2+</sup> ion and a water molecule to deprotonated DTPMP on the surface of the {0001} face of ettringite. It is anticipated that by using a DTPMP concentration of between 0.001 and 0.01 vol % for the extended life of a highway (i.e. >20 years), deterioration caused by the expansive growth of ettringite will be markedly reduced.

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**9. KEY WORDS**

PCC, Portland cement concrete, pavement,  
deterioration, ettringite, crystal inhibitor

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