

ABSTRACT

Yang, Zhifu, Ph.D., Purdue University, May 2004. Assessing Cumulative Damage in Concrete and Quantifying Its Influence on Life Cycle Performance Modeling

It is becoming increasingly popular to utilize numerical simulation models to predict the long-term performance of concrete structures. The majority of these models have been developed using laboratory test data that consider concrete in an uncracked state. While uncracked concrete exists as the best case scenario, frequent cracking occurs in real structures that could have a profound impact on life cycle performance. Cracks from several sources may accumulate and interact accelerating the deterioration of concrete. For example, microcracks due to mechanical loading may permit the ingress of excessive water, thereby increasing the susceptibility to freeze/thaw damage and an increase in freeze/thaw damage may reduce the load carrying capacity of concrete. To accurately simulate the performance of actual concrete facilities, the role of cracking and its cumulative effect on the changes of material properties should be accounted for in any of these models.

The main goal of this investigation is to assess the cumulative damage in concrete and quantify its influence on the life-cycle performance modeling. Samples were taken from five concrete pavement sections based on age, traffic, and overall performance to assess existing damage and to identify possible sources responsible for inducing the damage. These results were used as a baseline to assess the types of damage that merited laboratory investigation. After the field assessment, laboratory investigations were conducted to simulate the damage that may be expected in the field. After various levels of damage were introduced in laboratory specimens, durability tests (freezing and thawing and water absorption) and direct tensile test were performed to develop an understanding of how the pre-existing damage accelerated the deterioration process. Specifically, it was determined that cracks dramatically increase the rate and amount of water absorption and reduce the direct tensile strength and modulus of elasticity of concrete.