Application of Synchrotron Radiation to *In Situ* Measurement of Delayed Ettringite Formation

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Introduction

A potentially significant cause of concrete deterioration is cracking associated with the presence of the calcium aluminate sulfate mineral, ettringite [$3CaO\bullet Al_2O\bullet 3CaSO_4\bullet 32H_2O$]. This phase starts to form a few years after the concrete is cast. The specific mechanism causing its delayed formation remains controversial. To develop a better understanding of this process, the Turner-Fairbanks Highway Research Center of the Federal Highway Administration, in collaboration with the University of Maryland, is performing a series of experiments in the laboratory on concrete specimens under controlled conditions. The primary damage data are obtained by using a standard expansion measurement method (ASTM C490-86) at specific time intervals. To correlate this damage with delayed ettringite formation, it is necessary to have time-resolved data on the mineralogy of the specimen. However, conventional methods (SEM-EDAX, powder diffraction XRD, or thermal analysis) require destructive sampling of the specimen. Also, these methods use very small sample sizes ~1 mg, which may not be representative of the heterogeneous concrete specimen. Energy dispersive diffraction using a synchrotron radiation source offers the possibility of a non-destructive method that can scan the mineralogy of a significant volume of concrete.[1]

Materials and Methods

The specimen consisted of a 2 × 8 × 8 cm slab sawn from a concrete prism that had shown expansion on the order of 1% after 200 days.[2] A white light beam ($20 < E < 120$ keV) was used to illuminate the specimen. The energy dispersive diffraction spectra were taken in transmission mode using a CZT detector mounted at a 2θ of 10º. Typical voxel size was on the order of 1 mm^3. A rectangular region 20 × 5 × 2 mm through the specimen was scanned at a rate of 1 voxel each 10 s.

Results

A total of 252 spectra were obtained over a period of 6 h. However, because of calibration problems, it was not possible to associate the observed diffraction peaks with known concrete mineral phases.

Discussion

The feasibility of using synchrotron radiation to perform non-destructive energy dispersive diffraction on concrete specimens has been demonstrated. Future studies will investigate ettringite distribution in concrete specimens as a function of time. Methods development will focus on scanning software that will minimize the amount of beamtime used to scan aggregates within the specimen.

References

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