# DEPTH PROFILING AND PHASE DISCRIMINATION IN DETERIORATED CONCRTE UTILIZING SCANNING ELECTRON MICROSCOPY WITH AUTOMATED POINT COUNT ANALYSIS

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## ABSTRACT

Automated point count analysis utilizing scanning electron microscopy (SEM) associated with energy dispersive spectroscopy (EDS) allows for the discrimination of various phases by chemical composition. Phases are discriminated by energy dispersive spectroscopy with "rule" files developed for all phases of interest. Automatic control of the SEM stage and recording of coordinates also allows for the mapping of individual phases by location within a polished concrete section. In this manner, relative quantities of each phase (i.e. ettringite, monosulfate, CSH) may be plotted with respect to depth of the concrete from the surface. Automation of the analysis is achieved by fixing an array of points over selected "standard" magnified paste images. The computer then obtains EDS data from each point within a given image. Images and EDS point data can be electronically stored for subsequent review. Therefore, the frequency with which a given phase coincides within the regular grid system of points allows variations in paste composition to be observed. Comparisons of automated to manual SEM analysis are presented.

## INTRODUCTION

The cement paste portion of ordinary concrete consists primarily of calcium silicate hydrate (C-S-H), calcium hydroxide (CH), ettringite/monsulfate (AFt/AFm), and unhydrated cement grains. Their distribution across the cement paste is fairly uniform. The paste constituents are severely altered when a concrete is exposed to a sulfate and chloride containing environment (1-3). These changes follow a systematic pattern across the concrete from the exposed surface to the chemical environment (3).

Scanning electron microscopy associated with EDS has become a valuable tool for the examination of concrete microstructure. EDS data collected by computer-controlled scanning electron microscopy (CCSEM) can be used for depth profiling, in conjunction with, or similar to elemental information data collected using microprobe techniques with x-ray wavelength dispersive spectroscopy (WDS). The major advantage of automated SEM is that phase identification is possible by classifying EDS spectra collected from each point. The collection of EDS spectra is possible manually by an operator. However, this is a time consuming process. A large number of EDS spectra with images can be acquired automatically and stored in a computer limiting operator bias. The stored spectral information can be retrieved and summarized by assigning a set of rules (4). This paper describes a similar procedure to analyze a deteriorated concrete by using SEM with automated point count analysis.