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Evaluation of accelerated degradation test methods for cementitious composites subject to sulfuric acid attack; application to conventional and alkali-activated concretes

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Abstract:

The degradation of cementitious composite materials under chemical sulfuric acid attack has been widely investigated. The agglomeration of a global database of test results is complicated by the differing test methodologies employed in each study. As a result it is difficult to isolate the influence of individual test parameters and hence directly compare the relative performance of different cementitious material. In this study the existing accelerated test methodologies including: brushing, wetting and drying cycling, and increased concentration of sulfuric acid are investigated such that the influence of test methodology on degradation rate and microstructural performance can be identified. This approach is taken with the view of developing a common methodology for indicating the susceptibility of a given cementitious material in an aggressive environment. Rather than comparing the performance of individual materials this work aims to compare the influence of test methodology when applied to different materials.

Keywords: Conventional concrete; Alkali-activated concrete; concrete degradation; sulfuric acid corrosion; accelerated testing

1. Introduction

Cementitious materials are required for applications that are subject to chemically and biologically aggressive environments. The demands for durable materials are expected to increase with time as both the amount of infrastructure and the aggressiveness of the external environment, to which components are subject to, increases [1].

Particularly demanding environments for cementitious products occurs when the material is exposed to biological processes, for example those encountered in waste water systems. Biogenic degradation commonly occurs in sewage collection systems, dramatically reducing the infrastructure service life and leading to significant economic losses. For example, in the United States alone, it has been estimated that $390 billion will be needed to repair existing wastewater infrastructure over the period from 2002 to 2022 [2]. Biogenic sulfuric acid corrosion occurs in environments with high hydrogen sulfide (H_2S) concentration, moisture, and atmospheric oxygen, and is one of the most rapid causes of concrete degradation [3].

Biogenic degradation of concrete can be directly studied by in-situ testing or the use of a biogenic simulation chamber [1, 3]. The biogenic activity gradually reduces the pH of environment until it stabilises at a pH 1-2 [4]. In a normal sewage collection system, this process takes several years, making in-situ testing an unfeasible option for rapidly developing a new material [5]. In a biogenic simulation chamber, bacterial process can be accelerated by a complex control system, reducing test periods to approximately 5 months [6, 7]. While capturing the mechanism of biogenic corrosion, the use of a biogenic chamber is largely infeasible in most civil engineering labs which do not have the ability to purchase, operate, or maintain complex biogenic chambers.

As an alternative to the long time periods and complexity of in-situ and simulation chamber tests, standard chemical tests (i.e. ASTM C 267 [8]) are easily conducted. Standard tests usually use realistic concentrations of sulfuric acid (i.e. sulfuric acid of pH 1) and subject the specimens to continuous sulfuric acid immersion.

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