

A CASE STUDY OF ETTRINGITE INDUCED MICRO-CRACKING OF CONCRETE AT A WASTE WATER TREATMENT PLANT

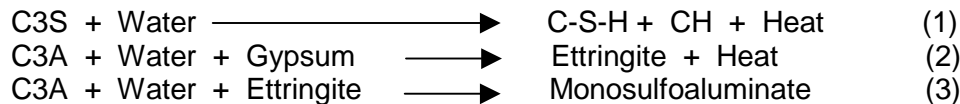
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Summary. Saudi Aramco engineers observed micro-cracks at walls and slabs of Industrial Waste Water Treatment Plant after cementing jobs had been completed. These micro-cracks were also found to propagate as a function of time, thus indicating that the reactions causing the failure are also time dependent. Surface analyses instruments at R&D Center were used to determine the causes of concrete deterioration, and it was observed that ettringite, which is a hydrated calcium sulfoaluminate, formed after the cement was cured and caused the concrete to expand and crack. This delayed ettringite formation (DEF) results from high ambient temperature and high salinity water used during cementing and adversely affects cement/concrete strength, durability and integrity.

This paper discusses the nature of DEF in cement paste and at the aggregate /paste interfaces as observed by scanning electron microscopy (SEM) and computed X-ray tomography (CT Scan). Based on these observations, recommendations are made to minimize DEF induced micro-cracking of cement and concrete.

Introduction

Cement hydration is a function of C_3S , C_2S , C_4A , and C_4AF reactions with water, usually in the presence of gypsum and other property enhancing additives. The products of reactions are primarily calcium silicate hydrate, calcium hydroxide and ettringite according to the following equations:



Where C_3S is tricalcium silicate, C_2S is dicalcium silicate, C_4A is tetracalcium aluminate, C_4AF is tetracalcium aluminium ferrite, $C-S-H$ is Calcium silicate hydrate, and CH is Calcium hydroxide.

Each of the cement constituents participates in hydration reactions in the presence of water, but the rate of reaction can differ for each constituent. For example, C_3A and gypsum would hydrate first and react with each other to produce ettringite. The formation of ettringite in cement pastes and concrete, is associated with volume increase and expansion of the matrix. However, the expansion usually does not cause distress during early stages of cement hydration since it is accommodated by the plastic and porous nature of the cement paste (1,6).

Concrete is not an inert material, it interacts with its surrounding environment and undergoes chemical changes. These chemical changes cause degradation of concrete, the severity of which depends on the environment and the exposure conditions. The most common causes of concrete deterioration are (a) reinforcement corrosion, (b) salt weathering, (c) alkali silica reaction and (d) sulfate attack. Among these factors, sulfate attack, is responsible for delayed