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How to deal with Structures affected by Delayed Ettringite Formation

Bruno Godart

Paris-Est University, IFSTTAR, Champs sur Marne, France

Contact: bruno.godart@ifsttar.fr

Abstract

The expansive sulphate internal reaction of concrete due to Delayed Ettringite Formation (DEF) can damage concrete structures severely. DEF is defined as the formation of ettringite in a concrete after setting, and without any external sulphate supply, but with water supply. This phenomenon occurs in concretes exposed to frequent humidity or contact to water, and subjected to a relatively high thermal treatment (> 65°C) or having reached high temperatures during casting. This reaction may cause large structural disorders due to unexpected deformations and additional stresses in concrete and reinforcement, and the problem is therefore to know how to deal with such structures affected by DEF. The prediction of future deterioration, the appraisal methodology and the assessment of the efficiency of remedial operations are crucial points for existing affected structures whose serviceability and structural safety may constitute a serious concern.

Keywords: Structure, concrete, delayed ettringite formation, disorder, appraisal, treatment.

1 Introduction and presentation of the reaction

The expansive internal sulphate reaction due to Delayed Ettringite Formation (DEF) can damage concrete structures severely. In healthy concretes, the primary ettringite (a hydrous calcium trisulphoaluminate) is a normal reaction product formed from the reaction of C_3A and C_4AF with gypsum during the plastic stage of the hydration of Portland cement. But, when peak temperatures in concrete are over 65°C, the sulphates may be incorporated in other cement phases and released a long time after concrete hardening, resulting in a slow formation of secondary ettringite (or delayed ettringite). The swelling property of ettringite can then lead to potentially disruptive expansion.

Therefore, DEF is defined as the formation of ettringite in a concrete after setting, and without any external sulphate supply. Generally, it necessitates a water supply, but in the case of some massive structures the internal humidity may be sufficient to trigger the reaction. It is admitted now that DEF may occur in concrete with an internal relative humidity of about at least 95 % [1]. Of course, DEF is developing much easier in concretes exposed to frequent humidity or contact to water, and subjected to a relatively high thermal treatment (> 65°C) or having reached equivalent temperatures for other reasons (massive cast-in-place concrete, concrete casting during summer, etc).

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