Modelling of Deterioration of Reinforced Concrete

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Introduction

There is continuing debate about the main reasons for premature deterioration of concrete structures and about their relative importance. Problems are variously attributed to inadequate specification, poor design detailing and inferior workmanship. Corrosion of steel in concrete, however, represents the most common and serious form of degradation of reinforced concrete structures worldwide and the economic loss and damage caused by this process makes it one of the largest infrastructure problems facing industrialised countries. The factors that are generally associated with high rates of corrosion of steel in concrete are the presence of excessive chloride contamination in the material and/or carbonation of the concrete cover, producing effects of the sort illustrated in the examples shown in the following figure:

(a)

(b)

(c)

Figure: Cracking, spalling and rust staining of concrete caused by: (a) Ingress of chloride from sea water, (b) Ingress of chloride from de-icing salt, (c) Carbonation-induced corrosion

For purposes of modelling, corrosion of steel in concrete has often been described simply as a two-stage process consisting of an initiation period, t_i, during which carbonation or chloride ingress into the element occurs, followed by a propagation period, t_p, from the onset of corrosion to the assumed condition corresponding to a limit state (Tuutti, 1982). The design service life, t_d , is given by:

$$t_d = t_i + t_p$$

The relative lengths of the initiation and propagation periods depend on the exposure conditions, cover and characteristics of the concrete.

In recent years, there have been numerous efforts to develop service-life models for reinforced concrete structures exposed to the corrosive effects of different environments. These have highlighted several of the difficulties inherent in the development of performance-based codes and standards for new structures. They have also focused attention on some of the problems that need consideration in developing new approaches to manage the performance of existing structures (RILEM, 2007).

Research Summary

In the early stages of this project, a critical review is being undertaken of modelling methodologies and performance tests that have been proposed to deal with some of the more significant forms of degradation to which reinforced concrete is susceptible, in particular those involving reinforcement corrosion associated with the individual actions of chloride ingress and carbonation-induced corrosion. The quality of the related software will be assessed in cases where this is publicly available and sensitivity to assumed values of critical input variables will be examined for specific cases. The adequacy of existing performance tests will be assessed in relation to estimation of these critical input variables.

Having identified some of the significant gaps in our current knowledge, efforts will be made to simulate the conjoint actions of coupled degradative agencies (such as carbonation and chloride contamination) in cases that have not yet been seriously addressed from a modelling perspective.

References

Tuutti, K. (1982), Corrosion of steel in concrete, Swedish Cement and Concrete Institute, Stockholm, Report F0 4.

RILEM (2007), Proceedings International RILEM Workshop on Integral Service Life Modelling of Concrete Structures, eds. R.M. Ferreira, J. Gulikers and C. Andrade, Guimaraes, Portugal, November 2007.