ESTIMATION OF CONCRETE SERVICE LIFE

The Theoretical Background

by

Vagelis G. Papadakis

Chemical Engineer, PhD

Patras, Greece, 2005

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V.G. Papadakis & Associates
Building Technology & Durability
Patras Science Park S.A.
Stadiou Str., Platani, GR-26504, Patras, Greece
Tel.: +30 2610 911571 & +30 6932 327323
Fax: +30 2610 911570 e-mail: vgp@psp.org.gr

Foreword

Concrete is the most widely used building material. Despite of the significant advances made in concrete technology in recent years, the problems of unsatisfactory durability of structures are in a dramatic increase. Deterioration of concrete in service may be the result of a variety of mechanical, physical, chemical or biological processes. *Corrosion of steel reinforcement* is the most serious durability problem of reinforced concrete structures. It impairs not only the appearance of the structure, but also its strength and safety, due to the reduction in the cross-sectional area of the reinforcement and to the deterioration of bond with the surrounding concrete.

Over the past 50 years, an enormous amount of energy has been expended in laboratory and field studies on *concrete durability*. The results of this research are still either widely scattered in the journal literature or mentioned briefly in the standard textbooks. Moreover, the theoretical approaches of deterioration mechanisms with a predictive character are limited to some complicated mathematical models not widely applicable in practice. A significant step forward could be the development of appropriate *software for computer estimation*, including the reliable mathematical models and strengthened by adequate experimental data. Within this framework, the present work is the *theoretical background* where such software is based, as well as the *permanent reference* to explain any inquires and check further the reliability of the results.

In the present work, a *mix design strategy* to fulfil any requirements on strength and service life is presented. The *chemical and volumetric characteristics* of concrete are first estimated and the *service life of the concrete structure* is then predicted, based on fundamental models developed earlier mostly by the present author. The prediction is focused on the basic deterioration phenomena of the reinforced concrete, *carbonation and chloride penetration.* Aspects on *concrete strength* and *production cost* are also considered. The proposed models enable mixture proportions to be accurately specified and concrete performance reliably predicted. This work is the *source book* for the development of the software for estimation of concrete service life, EUCON®. In general, this work concerns *Construction Engineers* and *Building Material Manufacturers* towards fundamental comprehension of materials behavior. Basic principles of Chemical Engineering are applied to simulate the physicochemical processes, yielding simple and accurate mathematical models for *design* and *prediction.* The work structure presented herein is in full compliance with the new *European Standards for cement: EN 197 and concrete: EN 206.*

The experimental research and mathematical modeling has been carried out by the present author as a part of various national and European Union research programs in Greece and Denmark, during the last 20 years. The *General Secretariat for Research and Technology, Ministry of Development, Greece,* provided financial support for the present work through the PRAXE Programme (02-PRAXE-86).

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Vagelis G. Papadakis
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Dr. *Vagelis G. Papadakis* holds a diploma in Chemical Engineering (1986) from the University of Patras, Greece, and a Ph.D. on the subject of carbonation and durability of concrete from the same institution (1990). He has a 20-year experience on scientific and demonstration projects on durability and technology of concrete, authored many papers and awarded by the American Concrete Institute (Wason Medal for Materials Research- 1993). He worked as a Researcher at the Danish Technological Institute, Building Technology Division, Concrete Centre (1997-1999) on supplementary cementing materials in concrete, holding an EU-fellowship (Marie Curie Grant). He was head of Concrete Technology Laboratory of TITAN Cement company S.A., Greece (1999-2000). At the present, he is head of "V.G. Papadakis & Associates – Building Technology and Durability" an innovative firm placed in "Patras Science Park S.A." and he is also teaching the courses of "Construction

Materials" and "Plant Design and Economics" in the University of Patras and University of Ioannina.

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