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Autor: Bobo, Corneliu
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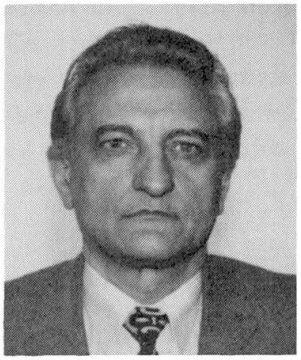
Deterioration of Reinforced Concrete Structures under Normal Conditions

Corneliu BOB
Prof. of RC Structures
INCERC
Timisoara, Romania



Corneliu Bob, born 1939, received his civil engineering degree from University "Politehnica" of Timisoara in 1961 and PhD in 1970. He is currently professor of Reinforced Concrete Structures and head of the National Research Institute INCERC- Timisoara branch. He published many papers and some books on various aspects of civil engineering.

Summary

The theoretical model, established by the author, as well as the experimental determinations were used assessing the stage of reinforcement corrosion in existing structures. A useful model which does not need experimental determinations is offered in this paper. A satisfactory agreement was obtained concerning the depth of carbonation and chloride penetration between the theoretical model and experimental results. The corrosion process period is analyzed, too. The minimum concrete covers, specified in different norms as well as in accordance with author's model, are also presented.

1. Introduction

In order to make quantified statements as to the service life of a member or a structure it is necessary to know the factors that affect the service life. The durability aspect is to be examined with reference to the failure or deterioration mechanisms, which are: reinforcement corrosion, chemical attacks, freeze-thaw bursting, alkali-aggregate reactions, fatigue, erosion. From these only reinforcement corrosion, freeze-thaw bursting and alkali-aggregate reactions are really important for reinforced concrete structures under normal conditions. The durability of concrete structures depends both on the resistance of the concrete against physical and chemical attack and on its ability to protect embed steel reinforcement against corrosion. In a climatic region the most common damage is the corrosion of the reinforcement adjacent to the exposed surface. The concrete structures examined in Romania by the author have had some deterioration of the component parts due to of reinforcement corrosion as main factor.

2. A quantitative model of reinforcement corrosion

In a reinforced or prestressed concrete element a so-called passivation layer is formed on the surface of reinforcing bars. This passivation layer may ,however, be attached by the surrounding concrete environment, so that electrical potential differences may develop along the bars: electrochemical corrosion will then take place. The progression of deterioration of an element

with time is described by initial period and corrosion process period. A numerical calculation method for both initial period (time until deterioration start) and corrosion process period (time of deterioration) is presented. The author of this paper has suggested a formula for the average value of the depth of carbonation and for the chloride ion penetration as factors of initial period. The corrosion process rate of the reinforcement is also presented.

The proposed formula takes into account: the binding capacity of the cement type, environmental conditions, surface concentration and permeation properties by concrete compressive strength. The use of this parameter was suggested because of: the concrete compressive strength is a conventional quantity and its value depends on a multitude of factors, among them, the quality and content of the cement, the water-cement ratio, the aggregate characteristics, the casting conditions etc.; the concrete compressive strength is the major criterion when assessing the quality of a concrete class for the design of a new concrete structure as well as for judging of a concrete structure which has to be renovated.

3. Experimental determinations

Some concrete structures with different duration of service life and deterioration of component parts have been examined and proposed for rehabilitation. The stage of carbonation and/or chloride penetration in reinforced and prestressed concrete elements were theoretical and experimental assessed. For experimental assessment the concrete was extracted from the structure elements with an electric drill from different depth and was stored in small and air-tight boxes till laboratory analysis. The analysis were performed by phenolphthalein test and pH methods.

Theoretical assessment is based on the formula and data presented. Such quantitative model is very useful for engineers in judging the concrete structures which have to be obsolete and are then radically renovated or demolished as the bridge of 80 years old. The compressive strengths, used in formula for average depth of carbonation or chloride penetration, was established with nondestructive methods. On the other hand, the strength values were also used for the structural analysis of the buildings.

Data presented points out the importance of two parameters for the durability of the reinforced concrete structures under normal conditions: the concrete cover and concrete strength. The minimum cover to reinforcement, in mm and concrete quality for durability are presented.

4. Conclusions

A quantitative model of reinforcement corrosion for both time until deterioration starts (initial period) and time of deterioration (corrosion process period) is presented in the work. The model suggested is an analytical tool for the diagnostic guide and control of the concrete structures; only a few parameters easily to be obtained are necessary. On the other hand, experimental determinations were made on several and various elements of the concrete structures. A satisfactory agreement was obtained between the quantitative model and the experimental data. As a result of the authors studies an important conclusion for design is pointed: the importance of the strength and depth of the concrete cover for the durability of the reinforced concrete structures under normal conditions