

Chapter 60

Reliability-Based Criteria for the Decision of the Compensation of Corroded Flexural Reinforcement

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ABSTRACT

Corrosion of reinforcement is considered as the major cause of most deteriorated concrete structures. As reinforcement corrodes, the load carrying capacity is affected and hence, the probability of failure increases. At the time of inspection of deteriorated structures, engineers are faced with the problem whether the available steel is enough to secure the safety of the structural member. This chapter addresses this problem based on reliability-based approach to evaluate the safety of the deteriorated members due to uniform corrosion under bending. A methodology is proposed to facilitate the determination of the member reliability index based on basic material properties and current loading. A step-by-step procedure is proposed based on charts developed in this study according to the Egyptian code provisions.

INTRODUCTION

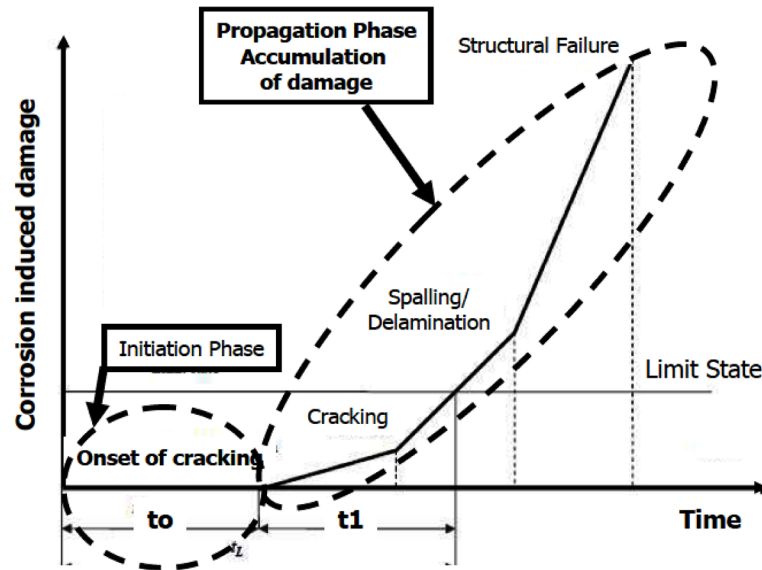
Rehabilitation of existing reinforced concrete (RC) structures represents a burden on any nation economy due to its prohibitive expresses. Thus, it necessitates the development of a methodology that allows for an accurate prediction and evaluation of the load-carrying capacity of deteriorated RC members.

The degradation of the load-carrying capacity of RC members over time is associated with different parameters such as environmental effects,

overloading, and material degradation due to fatigue. However, corrosion of reinforcing steel bars, as an environmental factor, represents the most severe factor (Kilaeski 1980).

Typically, embedded steel reinforcement in concrete is protected by the passivation layer of a thin film of iron oxide (Kilaeski 1980). The high pH level provided by the hydrated cement is usually sufficient to retard corrosion. However, with the diffusion of external ingress such as chloride ions, the pH level is lowered and corrosion initiates as the chloride content reaches a certain threshold

Figure 1. Schematic representation of corrosion phases with time



value (West and Hime, 1985). This stage is called the corrosion initiation period, in which, no sign of deterioration appears. Afterwards, the corrosion advances leading to cracking, spalling, or delamination according to the time of inspection and it is called the propagation period (Marsh and Frangopol, 2008). Schematic representation of corrosion phases with time is shown in Figure 1.

Generally, corrosion of reinforcing bars can be classified into two groups; the uniform corrosion, and the pitting corrosion (Fontana, 1987). In the first, the corrosion is characterized by a uniform reduction in the cross sectional area, while in the second, the bar might appear intact at most parts, while there is a pit or pits along its length. In this chapter only uniform corrosion is considered.

By the time of inspection, particularly in the propagation period, the engineers are faced with the problem of steel bar cross sectional area reduction. A decision is usually required whether to just clean the bars and coat it with a scarifying material (such as zinc) or compensate for the reduction in the reinforcement area. This decision is usually experience-dependent and in some cases is referred to the project's specifications. One of

the common practices experienced in the repair market is that compensation of corroded steel is mandatory if the reduction in the steel area reaches a certain percentage (e.g, 15%) of the original reinforcing bars. This condition is rather vague as it does not consider all issues affecting the load carrying capacity of the member; such as original design, current loads, reinforcement ratio, and many other factors.

In this chapter, the reliability-based technique is utilized to establish the criteria required for the decision of compensation for the corroded reinforcement. The developed method is limited to sections subjected to flexural and suffers a uniform corrosion. The Egyptian code of practice (ECP-203, 2007) has been used throughout the study; however, any other code of practice could be applied.

The concept of structural reliability, as developed over the last few decades, has become an acceptable and rational tool for evaluating the safety of structures⁶. It allows for the consideration of the uncertainty in both loading and resistance of the members leading to a better evaluation of its failure probability.

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