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Review of Intricacies Corrosion of Reinforcement in Concrete

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Abstract

The process of corrosion of steel reinforcement in concrete considered to be world wide problem that results in serious structural failures. The material loss has a direct impact on national economy. Enormous efforts made to combat corrosion. Since the problem is large, complicated and versatile. Understanding the phenomena, mechanism and preventive measures to minimize the problem still need study in depth.

Introduction

Corrosion is the process of destruction of metal surface by the interaction of environment. The process is well understood electrochemical phenomenon. The severity of the problem can be realized when steel undergo corrosion in reinforce concrete which results in premature failure of life span reduction of RC member . The dimension of the problem is increasing day to day in all spheres of constructions continue to challenge the mankind. Over the years various mechanisms are proposed, number of methods have been developed. The literature on corrosion is enormous and vast. Even then also thr problem persist. This prompted us to undertake this study and review the intricacies of the mechanism, various reactions in situ, quantum of the damage, effective methods developed to of minimize the damage.

Corrosion of Steel in Concrete

Concrete as a material of construction even for the structures situated in severe environment has been accepted for a long time. Concrete structures are generally designed for a minimum life span of 50-75 years without any problem. There are number of cases within that severe damage and failure occur. This is attributed to deterioration of concrete due to corrosion of steel.

Corrosion of steel is considered to be well understood electrochemical phenomena, Steel in concrete is generally known to be highly resistant to corrosion because of its surface film ferric

oxide. Inorder that corrosion to initiate, this film has to be depassivated or broken. This situation will come into picture when concrete loses alkalinity drastically.

The mechanism of corrosion of steel in concrete in its simplified form can be represented in the following steps.

$Fe = Fe^{++}+2e^{-}$ (Oxidation at Anode) --------(1)

$O_2+2H_2O+4e^{-} = 4OH^{-}$ (At Cathode) =- ------(2)

OH ions act like barriers of electric current through electrolytes present in the pores of concrete. Thus

$Fe^{++}+ 2OH^{-} = Fe(OH)_2$ (Neutralisation at Anode) ------(3)

Net Reaction: Combination of (1) and (2)

$2Fe + 2H_2O + O_2 = Fe(OH)_2$ (Black dust)

$4Fe(OH)_2 + H_2O + O_2 = 4Fe(OH)_3$ (Red Dust)

The reactions within the interface are not only complicated but also not completely understood. It is the Red dust that is responsible for the cracking of concrete because its volume is four times as large and black rust has volume twice than the parent one.

Corrosion of Reinforcing Bars before and after Embedment

i) Reinforcing bars can corrode when stored in atmosphere or during life of an RC member.

The first stage of corrosion of bars is exhibited in the formation of brown dust followed by the formation of scales & pitting. These bars can be used for construction by removing scales, but it leads to compensation of reduction in diameter of the bar. However, pitted bars are harmful due to their associated brittleness.

ii) If concrete is dense and adequate protection given to the bars chances of corrosion is remote. But with low standards of concreting the bars get exposed to atmospheric oxygen and moisture. In addition honey combed concrete , inadequate mixing, industrial atmosphere marshy areas and carbonation aid the process further.

Accelerators of Corrosion

Even though Oxygen and moisture - the two main agents to trigger corrosion there are some agents accelerates the process. The important among these agents are:

- Chlorides & Sulphates
- Chlorine

- H_2S, SO_2, methane and other gases etc.
- Uric, Nitric, Sulphuric Acids
- Electrical Charges

The aggressiveness of the atmosphere depends on the presence of any one or combination of these.

It is chlorides and sulphates in coastal belts cause severe damage, chlorine in treatment plants, H_2S, SO_2, methane and other chemical gases in sanitary structures makes vulnerable.

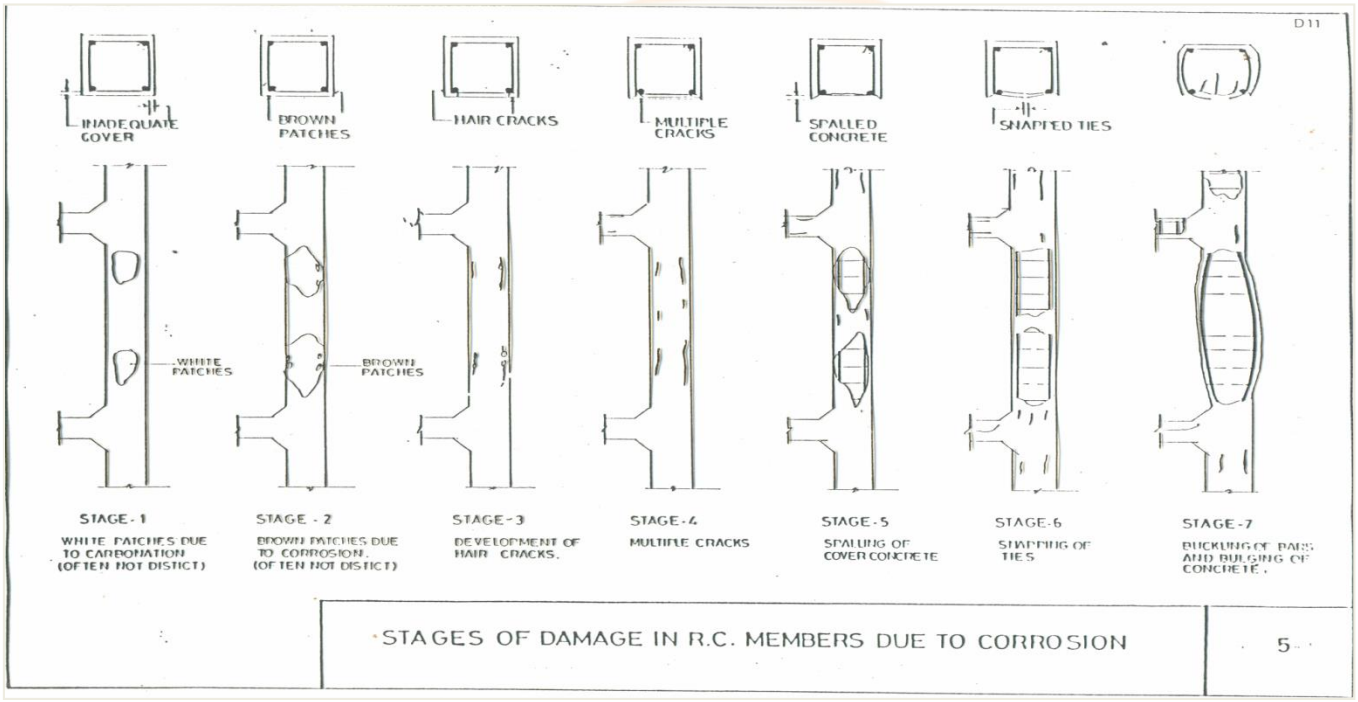
Damage Stages

The first symptom of corrosion is the formation of hair cracks along the bar. The very next stage enhancement of the process lead to multiple cracks, as a result bars freely exposed to atmosphere. Further widening of cracks and spalling of cover concrete exposing bars totally. In due course the ties and stirrups reduce drastically in their size leading to snapping and buckling of main bars and bulging of core concrete leading to ultimate collapse of the member.

From the first stage to the last, there are seven distinct stages of corrosion.. One redeeming future, the damage can be stopped at any stage up to snapping of ties and stirrups.

Generally it takes about 4-5 years for the formation of hair cracks. Another 5 years are sufficient to make the structure unserviceable. These corresponding figures in coastal belts are 1-2 years and 4-5 years respectively.

FIG. 2: STAGES OF CORROSION



Protective/Preventive Measures to Minimise Corrosion:

There are several options available to minimize the damage process. The important being:

1)Use of stainless steel/corrosion resistant special bars in place of conventional bars.

2) Use of coated bars.

3) Use of corrosion inhibitors in concrete.

4) Provision of surface coatings on members

5) Provision of cathodic protection on permanent basis.

These options are in addition to rigorous control on concrete quality at sites.

Stainless steel is the answer in highly sensitive off-shore defense & nuclear structures. Certain alloy based special steel bars were also probed. For example,

Cu-W or Ni bearing steels can also be used.

The main limitation for the usage of these is the High Cost Factor.

Few coatings on bars were also tried. This category include zinc rich mortar application, phosphatisation, galvanization etc. Even application of inhibitors such as organic reactive groups like triazoles, benzoates, polymeric coats, silicones, silicates epoxy etc were also tried successfully.

Restoration Measures for Affected Members:

At any stage up to snapping of ties and/or stirrups corrosion of bars can be arrested or controlled. The basic principle behind any technique is to insulate the affected r.c member from getting in contact with moisture & oxygen any further.However, the damage already occurred is a permanent one

Conclusions:

Corrosion of reinforcing bars in r.c members poses serious structural hazards' This makes the life of corrosion affected members get drastically reduced. Apart from serious efforts still the pictures appears to be grim. The problem, however, be effectively tackled by good construction practices coupled with use of foolproof sealing techniques or other techniques outlined.

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