Corrosion Studies on High-Performance Hybrid Fibre Reinforced Concrete

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Abstract - ***Today concrete has developed as an unavoidable material in the construction industry. One of the major problems associated with the reinforced concrete is the corrosion of the steel rebars. This occurs in the form of rusting. As the corrosion develops, the rebar loses its strength and eventually reduces the life of the member. This action is predominant in the seashores and coastal areas owing to the presence of salts in the air. This paper concentrates on improvising the effect of such conditions in the concrete and the rebar by incorporating hybrid fibres into the concrete along with silica fume. The specimens taken for the study are made up the conventional mix along with 10 % silica fume and steel and glass fibres of varying proportions of 0.25%, 0.50%, 0.75% by volume of the concrete. The rebars are corroded at a high rate by immersing them in a salt water bath and passing electricity. The corrosion is measured on the basis of half-cell potential based on ASTM – C876, a non-destructive testing method adopted to check the rate of corrosion.***

Key Words: **Corrosion, Half-Cell Potential, Accelerated Corrosion, Hybrid Fibre Concrete, Non-Destructive Testing**

1. INTRODUCTION

It is well known that under certain conditions in the reinforced steel structures or certain structural elements the reinforcement steel, corrosion may commence. Corrosion of reinforcement has been established as the predominant factor causing widespread premature deterioration of concrete construction worldwide, particularly road infrastructure facilities and certain industrial facilities. The most important causes of corrosion initiation of reinforcing steel are the ingress of chloride ions and carbon dioxide to the steel surface. After initiation of the corrosion process, the corrosion products (iron oxides and hydroxides) are usually deposited in the restricted space in the concrete around the steel. The formation of rust causes expansive stresses, which crack and spall the concrete cover. This, in turn, results in progressive deterioration of the concrete. As a result, the repair costs nowadays constitute a major part of the current spending on infrastructure. Quality control, maintenance and planning for the restoration of these structures need non-destructive inspections and monitoring techniques that detect the corrosion at an early stage.

Corrosion causes an increase in the expenditure by going for either reconstruction or restoration measures. There have been a lot of research studies on the problems faced due to deterioration of concrete followed by corrosion of steel rebar. Periodical monitoring of the structures for such corrosion activity is necessary to reduce the maintenance costs. The repair and restoration operations are quite complex and require special treatments of the cracked zone. But even after such treatments, the life expectancy of such repairs are restricted. Such monitoring provides periodical information about the activity either chemical or physical going on inside the concrete. Most of the structures show such distresses within a short duration. It is a common practice to go for restoration or remedial measures only after the condition worsens to rusting of steel rebar, cracking and spalling of concrete by way to heavy rusting of steel reinforcements followed by cracking and spalling on concrete. Since the time period for such deterioration is unpredictable it becomes necessary to go for periodical corrosion measurements.

Although corrosion is an internal activity which can be directly measured by taking the rebar out of the concrete and checking for the weight loss of steel, many indirect measures like electrochemical and non-destructive testing methods are available to determine the rate of corrosion happening in the rebar. In this paper, one such method is used to analyse the impact of hybrid fibres on the corrosion of steel rebar in concrete. The rate of corrosion is compared after the addition of the fibres in the concrete along with silica fume with the help of open circuit potential [5][6]. The half-cell used for this method is saturated Calomel half-cell electrode with a standard potential of +0.240V versus Hydrogen electrode.

2. HALF-CELL POTENTIAL METHOD

The cylindrical specimen 150mm x 300mm is cast with a steel rebar of 300 mm with 1/3rd of its length protruding outside the cylinder. The specimen is cured in a saltwater bath containing 3% of *NaCl* and corrosion is accelerated with the help of applied current for 120 hours [6]. The specimen is then taken out and coated with a wetting agent to prevent patches and achieve a uniform surface. The half cell is connected to the ground terminal of the multimeter and the positive terminal is attached to the steel rebar. The procedure is repeated for several locations and the maximum value is considered. The readings are tabulated and are compared with the chart for determining the corrosion activity.

Table - 1: Half-Cell Potential Reference Values

Potential vs SCE	Activity of corrosion
> 280 mV	High
130 mV to 280mV	Moderate
< 130 mV	Low

The points of observation should not be very close as there won't be any significance as it will record more or less same readings. There are no predetermined criteria for this spacing.

3. RESULTS

The half-cell potential values obtained are compared with the standard potential values and the rate of corrosion activity is observed.

Table - 2: Half-Cell Potential of Specimens

Mix	Potential value in mV	Rate of corrosion activity
Control mix	290	High
Silica fume 10%	225	Moderate
Fume 10% + 0.125% glass fibre + 0.125% steel fibre	170	Moderate
Fume 10% + 0.25% glass fibre + 0.25% steel fibre	132	Moderate
Fume 10% + 0.375% glass fibre + 0.375% steel fibre	117	Low

4. DISCUSSION

It is observed that upon the addition of silica fume admixture the rate of corrosion is reduced to some extent which may be accounted to the chemically inert nature of the admixture. Upon the addition of hybrid fibre (0.125% of glass fibre and 0.125% of steel fibre), the potential value decreases further which is due to the fact that the voids are blocked by the glass fibres and the sacrificial anodic process of the steel fibres. Hence impregnation of the components that are the major factors contributing for corrosion are prevented with the addition of fibres. As the percentage of fibre increases, the potential decreases due to the increased impact of these two factors.

5. CONCLUSION

The addition of chemical admixture and hybrid fibres is found to enhance the steel rebar corrosion and prevent it from losing its strength due to corrosion. The addition of fume is found to increase the amount of water consumption beyond 10%. However, as the percentage of fibre increases, it becomes tedious to mix the concrete and hence up to 0.375% of glass fibre and steel fibre each can be utilised in regions of the severe environment in order to reduce the corrosion activity of steel bars.

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