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EXPERIMENTAL STUDY OF THE REDUCTION IN FLEXURAL STRENGTH OF CORRODED REINFORCED BEAMS

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Abstract: Reinforced concrete is one of the most common materials used by the construction industry worldwide. The raw materials for its construction are widely available and the structures constructed are generally durable. Due to the wide variety of applications, strong concrete structures are vulnerable to a range of threat conditions, including marine, industrial or other critical environments. In fact, the need for high durability is not always achieved in practice due to which the corrosion of reinforcement in concrete occurs which is one of the main causes of deterioration in the RC structure. Corrosion of Reinforcement has been widely reported and is one of the main causes of durability threat in R C structures.

In the present study an experimental investigation was carried out on flexural strength of M 20 grade corroded reinforced concrete beams at three different corrosion levels (5 %, 10% and 15%) and results obtained are compared with a non-corroded reinforced beam of similar configuration. It is found that initially (on 5% corrosion) the rate of reduction of ultimate flexural strength is more as compared to more corroded beams (10 % and 15 %).

***Key words* - Reinforced Concrete beam, chloride induced corrosion, flexural strength, two-point loading.**

I. INTRODUCTION

Of all the problems of concrete durability, the corrosion of rebars were recognized as the main source of deterioration of concrete structures. The increase mass loss of corroded rebar is mainly due to two reasons. The first reason is the carbonization of the concrete cover, due to this the alkalinity of the concrete is eliminated. The second reason is the presence of chloride ions in the adequate amount of on the surface of the rebar.

Corrosion of steel rebar in RC beam Reduces cross-sectional steel area and creates local dislocation of the steel surface. The tensile capacity of steel is reduced is directly proportional to loss of steel mass.

In addition, the loss of steel surface causes a loss of bond between steel surrounded concrete. All these actions play a major role in the loss of rigidity and ductility of the R C beams and thus, reduce the ultimate strength of RC beams.

It should be noted that the rebar provided in reinforced concrete to counter tensile forces and to create controlled cracking within tensile zone. However, corrosion not only disrupts the steel bar and its function of transferring tensile pressure, but also damages the concrete by spalling the cover. The mechanism of rebar corrosion is the corrosion of steel included in concrete is an electrochemical process. The decayed steel surface acts as a composite electrode that is a mixture of anode and cathode that is electrically connected through the steel body, on which coupled anodic and cathodic reactions occur.

II. Experimental study

For conducting the experimental study, a series of processes are done. In this study first of all materials are collected. Locally available fine aggregate and coarse aggregate is used and was colleted from a local vendor. Cement used is pozzolana Portland cement.

On the basis of the properties of material trial mixes are prepared and tested. Out of those trial mixes the mix having desirable result is chosen for furthers study. In this study used grade of concrete is M25.

Table 1 Design Mix Ratio for M-25 Grade Concrete

Cement	Fine Aggregate	Coarse Aggregate	w/c
1	1.76	2.9	0.5

After obtaining the mix of appropriate strength, the 28 days cured specimens were fully immersed in a 5% NaCl solution in plastic tank and the corrosion is induced by flowing of current.

2.1 Set up for Accelerated Corrosion Regime

A constant electrical current was provided between the anode (steel reinforcing bars in the concrete beams) and the outside cathode, by a D.C. power device. The reinforced beams under corrosion process were observed once for each day. The beams were allocated into four groups based on the required level of steel corrosion (0 % corrosion, 5% corrosion, 10 % corrosion, and 15% corrosion). The level of corrosion indicates to the percentage of loss mass of steel reinforcement in affected beams. The required time for exposing the accelerating steel process for each group was theoretically calculated by Faraday's law, ((Many former researchers have effectually employed the Faraday's law to theoretically calculation of steel mass loss or estimation the essential time for attaining a definite level of corrosion in the reinforced concrete samples.

2.2 Formula for Calculation of Corrosion Time:

The time for different level of corrosion is calculated by the following equation (based on Faraday's law), which is given below:

$$t = (\Delta m\ F.Z.)/\ (M.i.)$$

Where:

(t) is the time required for corrosion in seconds. (F) is the Faraday's constant which is equal to 96500 A/s. (Δm) is mass loss of rebars caused by the accelerated corrosion. (M) is the molar mass of rebars which is about 56 g, (i) is the current induced in accelerated corrosion regime in Ampere. (Z) is the ionic charge of iron equal to 2.

For achieving the required level of corrosion 1 Ampere current is induced in the corrosion regime, based on above parameters the time required for desired level of corrosions are tabulated below.

Table 2 Time required for desired level of corrosions.

S. No.	Percentage of corrosion	Current impressed (A)	Average Mass of Reinforcement used (gm)	Time required (hours)
1	5	1	3200	153
2	10	1	3250	311
3	15	1	3224	463

Fig 1. Set up of accelerated corrosion regime.

Fig 2. Arrangement for testing of specimen

III. RESULTS AND DISCUSSION

After putting the beam specimen in corrosion regime for the required period the specimens were tested in flexure under two-point loading.

The ultimate load that the beam can carry under flexure is recorded and from the equation of simple bending the flexure strength of beam specimens were calculated.

Table 3 Two-point Loading test Results

S. No	Corrosion Condition	Ultimate Flexural load (kN)	Ultimate Flexural Stress (Mpa)	Average
1	Non-Corroded (0% Corrosion)	83.59	14.86	14.17
		79.20	14.08	
		76.34	13.57	
2	5 % Corrosion	61.63	10.95	11.22
		62.50	11.11	
		65.26	11.60	
3	10 % Corrosion	59.08	10.50	10.26
		57 .55	10.23	
		56.64	10.06	
4	15 % Corrosion	54.63	9.71	9.35
		50.56	8.98	
		52.59	9.35	

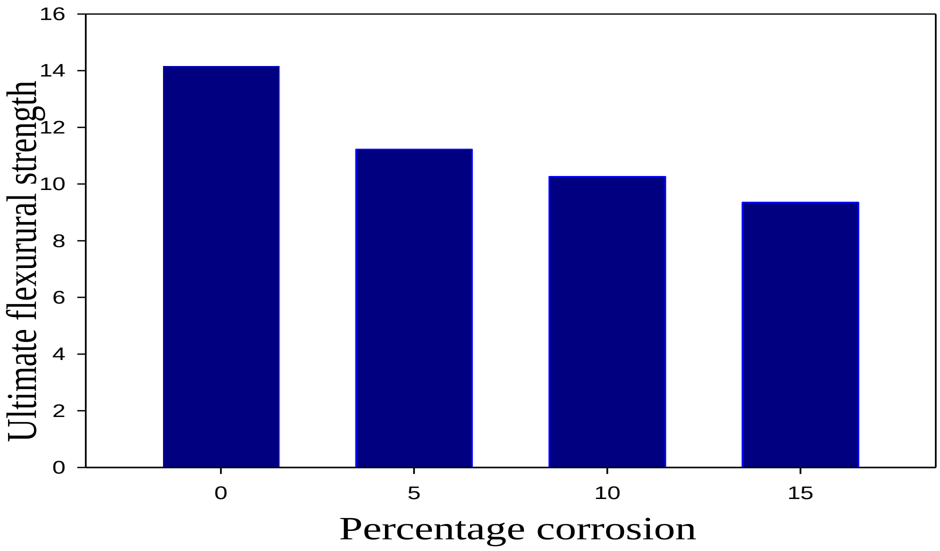

Fig 3 Histogram chart showing decrease in flexural strength on different corrosion level

From the above data and graph it is clearly observed that the rate of decrease in flexural strength is more on 5 % corrosion it is approximately 20%. On further increase in corrosion i.e. 10 % and 15 % the rate of decrease in flexural strength is slower as compared to 5 % corrosion. This may be due to initially the surface of steel loses its bond strength rapidly because of surface corrosion. When the corrosion level is increased, the rusted steel is going to bulk but the volume to accommodate this rusted steel is confined, may be due to this the rate of decrease in bond strength is low resulting the rate of decrease in flexural strength is also low.

IV. CONCLUSIONS

Based on the results of this experimental study, the following conclusions can be drawn.

Despite the test period and the exposure condition, no cracking due to corrosion, was detected on the surface of steel reinforced concrete beams. However, the colour of specimen surface ranged from light orange to dark brown.

The overall behaviour of the beam specimens tested conforms that, reductions in the ultimate capacity and deflection capacity as increasing corrosion.

The crack width due to corrosion increases with the level of corrosion of the embedded steel.

From results obtained by experimental investigation it is observed that ultimate load carrying capacity of beam specimens is decreased by 20.1 % for 5% corrosion, by 27.5 % for 10 % corrosion and by 34.17% for 15 % corrosion compared to controlled beam (i.e. 0% corrosion.)

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