[ICESTM-2018]
ISSN 2348 – 8034
Impact Factor- 5.070

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

A STUDY ON CRACKING TIME OF RCC BEAMS WITH TWO DIFFERENT COATINGS OVER STEEL AND SUBJECTED TO ACCELERATED CORROSION

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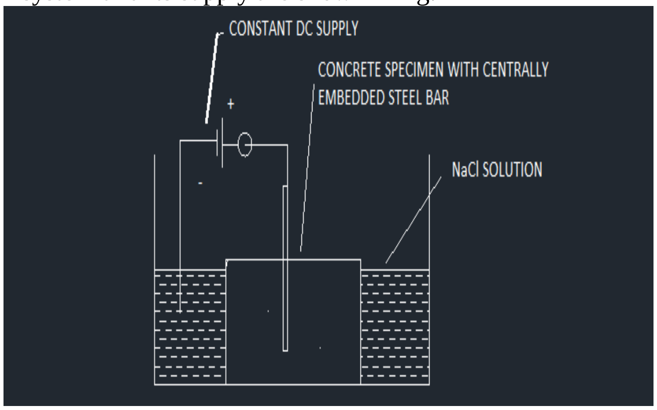
ABSTRACT

In the aggressive environments, the concrete is deteriorated due to the presence of chlorides in the environments. Ehen the chloride reaches the steel, corrosion will takes place and the final result is early failure of RCC members or structure. So in this paper, the work is divided in to two phase.
In the first phase of work, the concrete was strengthen additionally by replacing the OPC with the silica fume in six various percentages 0, 5, 10, 15, 20, 25. The mechanical properties of silica fume concrete were studied and optimized.
In the second phase of work, four beams were casted with normal, epoxy coated, zinc coated reinforcement and tested by accelerated corrosion technique. The time required to observe crack due to corrosion of reinforcement was compared with normal.

Keywords: *mechanical properties, silica fume, epoxy, accelerated corrosion.*

I. INTRODUCTION

Corrosion in construction industry is defined as an electro chemical process of deterioration of reinforcement steel in RCC in the presence of chlorides and oxygen. It will take several years to form corrosion in natural conditions. Accelerated corrosion is a technique used to reduce the time requirement by accelerating the chloride induced corrosion by imparting the DC supply to the system when the member is immersed in sodium chloride solution. The chlorides penetrate the concrete and deterioration is initiated. When the chloride reaches the reinforced steel in the presence of oxygen, the corrosion starts. That's why, in this project, the corrosion was controlled by strengthening both the concrete and steel. The concrete is strengthen by replacing partially with optimized percentage content of Silica fume and the steel with the protective coating such as epoxy resin and with sacrificial coating such as Zinc. In the process of accelerated corrosion, the anode and cathode are electrically connected with each other and are immersed in a common electrolyte. In this study, steel is acted as an anode and the sodium chloride solution is used as an electrolyte. The corrosion system and its supply are shown in fig.



Sample Accelerated corrosion system

The free electrons are released at the cathode, travels to the anode through the electrolyte and deposit at the anode. The electrolyte solution is deionized into sodium, oxygen and hydrogen molecules, which produce the corrosion to the steel. The reactions behind the corrosion are shown in bellow. A source of direct current is connected to a pair of inert electrodes immersed in molten sodium chloride. Because the salt has been heated until it melts, the Na^+ ions flow toward the negative electrode and the Cl^- ions flow toward the positive electrode. When Na^+ ions collide with the negative electrode, the battery carries a large enough potential to force these ions to pick up electrons to form sodium metal.

Negative electrode : $Na^+ + e^- \rightarrow Na$

Cl^- ions that collide with the positive electrode are oxidized to Cl_2 gas, which bubbles off at this electrode.

Positive electrode (anode): $2\,Cl^- \rightarrow Cl_2 + 2\,e^-$

The net effect of passing an electric current through the molten salt in this cell is to decompose sodium chloride into its elements, sodium metal and chlorine gas.

Cathode (-): $Na^+ + e^- \rightarrow Na$

Anode (+): $2\,Cl^- \rightarrow Cl_2 + 2\,e^-$

The central reaction in the corrosion process of steel is over-simplified.

$$Fe^0 = Fe^{++} + 2e^-$$

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II. Materials Used

The following materials are used.

- Ordinary Portland cement (53 grade)
- Fine aggregate (zone-II)
- Coarse aggregate
- Silica fume
- Water
- HYSD rebar
- Epoxy coated steel
- Zinc coated steel

III. EXPERIMENTAL PROGRAMME

In the first phase of work, the cubes, cylinders, prisms with standard sizes 10X10X10 cm, 150 dia X300 long, 10X10X50 cm respectively are casted with the concrete having silica fume as a partial replacement of cement in six various percentages 0, 5, 10, 15, 20, 25 by weight. They were tested after the 28 days curing. Based on the mechanical properties of the concrete, the optimum content of silica fume was found.

In the second phase of work, totally 4 beams are casted with 4 different combinations and different designations.

B-2: Nominal concrete beam reinforced with normal steel
B-4: Silica fume concrete beam reinforced with normal steel
B-6: Silica fume concrete beam reinforced with epoxy coated steel
B-8: Silica fume concrete beam reinforced with zinc coated steel

The beams are tested under accelerated corrosion by immersing in the sodium chloride solution with 10V direct potential supply. For the work feasibility daily 10 hours, 10V DC current is supplied to the beams, time required to observe the first crack due to corrosion are noted in days.

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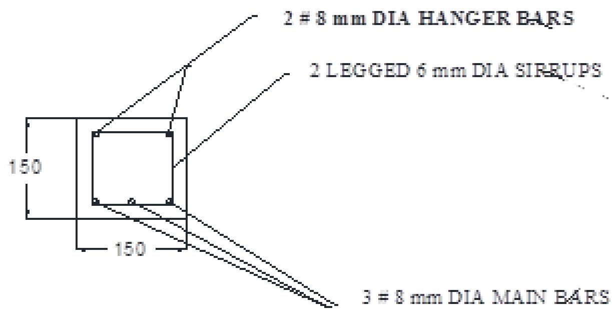
IV. MIX DESIGN

As per IS: 10262 and IS: 456:2000, the mix was designed as 1:1.75:2.96 by weight with water cement ratio 0.45 and 390 Kg cement used for cubic metre of concrete.

V. BEAM DESIGN

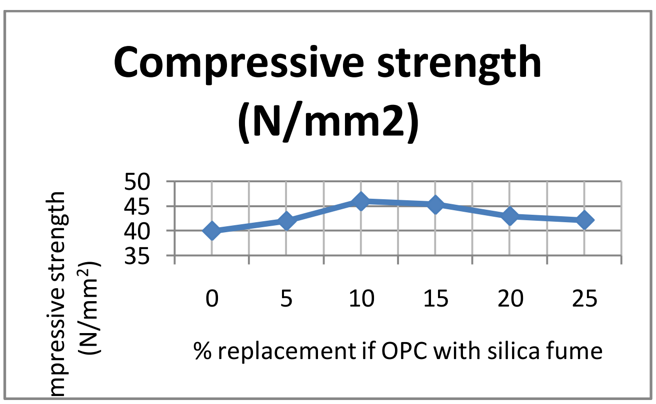
According to IS:456:2000 guide lines, the beam is designed as 150mm X 150mm overall deep with 25mm cover,1000mm long with 3 bars of 8mm as tension zone reinforcement and 2legged 6mm dia stirrups at 100mm c/c spacing throughout the span as shear reinforcement. Two bars of 8 mm dia are used as hanger bars.



VI. TEST RESULTS

- phase:I

% replacement if OPC with silica fume	Compressive strength (N/mm^2)	Split tensile strength (N/mm^2)	Flexural strength (N/mm^2)
0	40	2.74	4.33
5	42	2.92	4.41
10	**46**	**3.16**	**4.9**
15	45.3	2.95	4.2
20	43	2.92	4.1
25	42.2	2.71	3.9



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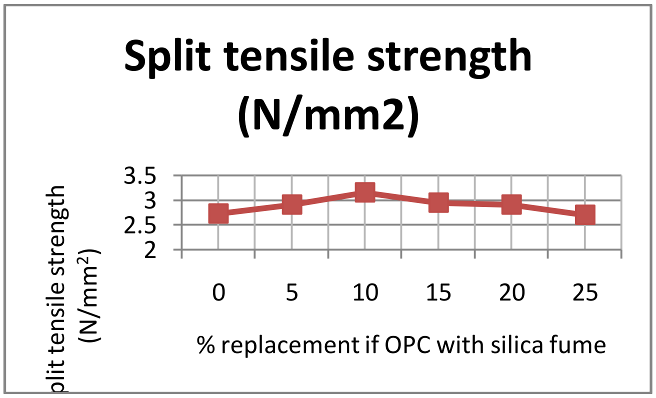

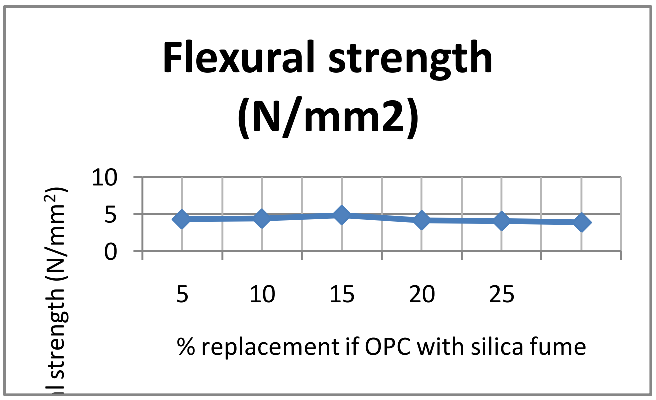

- phase: II

	Time required to observe first crack due to corrosion (days)
Nominal concrete beam reinforced with normal steel	6 days
Silica fume concrete beam reinforced with normal steel	14 days
Silica fume concrete beam reinforced with epoxy coated steel	20 days
Silica fume concrete beam reinforced with zinc coated steel	40 days

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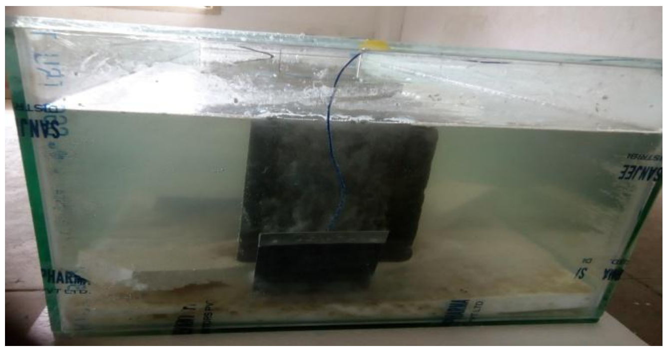

Beam specimen after accelerated corrosion

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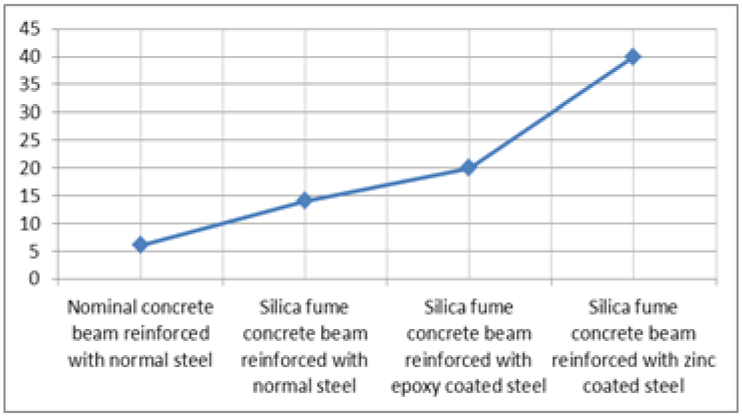

VII. CONCLUSIONS

Based on the experimental investigation on the mechanical properties of the silica fume based cement concrete such as compressive strength, split tensile strength and flexural strength, the following conclusions were made.

- The cement replacement with the silica fume up to 10%, fresh and harden properties of the concrete are improved. Further increasing of replacement of cement with silica fume was result in decreasing the strength characteristics of concrete.
- At the 10% of cement replaced with silica fume, the compressive strength was increased by 15% as compared with the nominal concrete at the age of 28 days. The split tensile and flexural; strengths are increased by 25.39% and 63.3% respectively.

The scientific justification for accelerating corrosion using an impressed current is strong, dramatically reducing the initiation period required for depassivation from years to days and fixing the desired rate of corrosion without compromising the reality of the corrosion products formed. Based on the accelerated corrosion test results, the following conclusions were drawn.

- The time required to observe first crack is increased by 2.33 times for silica fume concrete (SFC) as compared to normal RCC beam subjected to corrosion.
- The time required to observe the first crack is 3.33 times increased by providing epoxy coating over the reinforcement as compared with normal reinforcement in SFC beam subjected to corrosion.
- The zinc metallic coating provide sacrificial anodic condition & improves the time required to observe first crack by 6.66 times in aggressive environments as compared with normal RCC beam.

Finally I reckon that, the cold galvanized zinc metallic coating over the reinforcement bars along with the silica fume concrete is preferable for constructing structural members in chloride contaminated environmental conditions

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