



Corrosion Prevention on Coated Rebars and Fiber in R.C Slabs

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Abstract

Concrete structures prevail primarily due to prior attrition of steel due to preterm failure of rebars. The major cause of deterioration is the corrosion of the steel reinforcement, that can lead to structural problems. By utilizing our knowledge on corrosion of steel reinforcement, concrete structures could be made more durable. The research work is intend at arrestcorrosion in RC slabs by glazing silicon tombac to the steel rods. Nylon fiber is induced in concrete to attain strength for the concrete. A study report carried the effects of coating material between the conventional and fibers in concrete was compared with that of uncoated material between the conventional and fiber in concrete rebar's. A continuous corrosion process is accelerated by inducing direct current to rebars. Process used to prompt corrosion is Accelerated corrosion test and Half-cell measurement.

Keywords: Corrosion test, Nylon fiber, R.C Slab, Silicon tombac coating.

1. Introduction

The reinforcement bars used to strengthen concrete structures are prevented from corrosion by applying coating to the reinforcement bars. Various steels are used in buildings in many different ways and that's the problem creates the corrosion in buildings. The designers are puts an effort to reduce the huge economic loss caused by corrosion. For specific information of corrosion problems is directed to various corrosion committees of the ASTM and of the British Iron and Steel Research Association. These specialists are advised to give various methods to be used to prevent the corrosion.

Concrete is a backbone to the infrastructure of a nation. Various researches have established new construction materials and techniques used in structures. The corrosion protection of reinforcement can be done by epoxy coating technique and to increase the strength of the concrete polypropylene fiber is used. Weight loss of coated reinforcement concrete is less than conventional reinforcement concrete by 3% "Yazeed and Anju (2016)[1]".

This improves corrosiveness and increases the durability of the structure. Layer coats enhance steel substrates from corrosion in competitive environment. The rate of corrosion was monitored by using Half-Cell potentiometer. Re-bars using nitro zinc primer coating in Ordinary Portland Cement(OPC) + 5% Silica fume. Specimens are subjected to corrosion process by impressing an external Direct Current (Galvanostatic Method) under stressed and unstressed conditions. For an unstressed and stressed condition, the uncoated specimen shows 47% and 61.4% more reduction in weight than that of coated specimens "S.M. Sivasankar and S.Venkatesh (2017) [2]."

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mechanism of steel reinforcement and its influence on the structural behavior of concrete beams will be subjected to corrosion using chemical as well as electrochemical techniques "Kamas hware B et al., (2010) [3]".

Concrete system could lead to reduced chances of corrosion of steel in reinforced concrete structures and to increase durability by the replacement of granite rock powder and it is more resistant to sulfate attack. Reinforcement corrosion was measured by corrosion potential and linear polarization resistance (LPR) of the concrete specimen "Abaho. G and M. R. Prenesh (2016) [4]".

The weight loss of steel due to corrosion of Tiscon CRS, ordinary Fe 415 and coated Fe 415 conducts the loss in weight for coated rebar is about 30% less than that for uncoated rods and about 20% less than for CRS. The time enquired for CRS and coated Fe415 is 30 to 40% more than that for uncoated Fe415 rods "Sukumar P. (2000) [5]".

The cement polymer anticorrosive protective coating improves the bond strength of 30-35% due to excellent compatibility at the steel concrete interface, satisfies the codal requirements of Indian Standards "Ms.B.Saritha[6]".

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"R.K.Dhir.et.al, [7]". The Paper describes a study undertaken to determine the effect of PFA on reinforcement corrosion due to chlorides in concrete. The results indicate that the time to corrosion initiation when PFA is included is greatly increased, but that the quantity of chlorides causing this does not differ significantly between PFA and OPC concretes. After a given period of exposure,



the concentration of chlorides at the surface of the reinforcement and the resulting corrosion intensity were lower in PFA concrete. A relationship between corrosion rate, water-soluble chloride content and coefficient of chloride diffusion has been developed, suggesting that the ability of the binder system to limit chloride migration is an important factor influencing the corrosion process. From this a means is proposed of evaluating corrosion risk in concrete under chloride attack.

“Sunil J. Kulkarni [8]” have investigated the reinforcement bars used to strengthen concrete structures are prevented from corrosion by applying coating to the reinforcement bars. Various steels are used in buildings in many different ways and that’s the problem creates the corrosion in buildings. The designers are puts an effort to reduce the huge economic loss caused by corrosion.

2. Materials & Methods

2.1 Specimens

M25 grade concrete was used in casting all the specimens. The cube of size 150 mm x150mm x150 mm and the cylinder of size 150mm x 300mm were cast to establish the compressive strength and split tensile strength for 28 days as per the standard IS procedures for the optimal strength of nylon fiber. Similarly, the slab specimens of size 500 mm x500 mm x 60 mm have been cast and tested to find corrosion. The insulated copper wires are joined to the main reinforcement of the slabs at the equivalent points.

2.2. Materials Used

Ordinary Portland Cement (OPC) of 53 Grade has been used. Nearby available river sand passing through 4.75mm IS sieve is used as fine aggregate conforming to the requirements of IS 383–1970. The river sand is free from dust particles and to eliminate waste materials and oversized particles. Coarse aggregate used is locally available crushed angular aggregate, sieve size passing through 20mm. Portable water has been used for concrete and curing purposes.

2.3. Silicon Tombac Coating

Silicon tombac is an alloy made of copper (80%), zinc(16%) and silicon (4%). It has high corrosion resistance, high strength and ductility. It is the construction material with the highest strength that can be economically used. This alloy is very suitable for thin-walled and heavy-duty structural parts. It is shown in fig.1.



Fig 1: Silicon tombac coating

2.4. Nylon Fiber

Nylon fiber is used in concrete. It is a synthetic polymer fiber and it gives good specific strength. It has high resistance to fungi and acts

as an anti-bacterial element. It acquires additional tensile strength due to high viscous flow. Nylon fiber is shown in Fig.2.



Fig 2: Nylon Fiber

2.5. Physical Properties of Materials

The test results of specific gravity and water absorption of fine aggregate, coarse aggregate and nylon fiber used in this study are given in Table 1.

Table 1: Physical properties of materials

Properties	Fine Aggregate	Coarse Aggregate	Cement	Fiber
Specific gravity	2.66	2.68	3.14	1.13
Water absorption (%)	2.4	1.15	-	-

2.6. Methods Used to Induce the Corrosion

The method used to induce corrosion is Galvan static method (accelerated corrosion method) and half-cell measurement.

2.7. Accelerated Corrosion Test

In this method slabs were casted for M25 grade of concrete. Rebars of the slab are connected with insulated copper wires while casting and the slabs were immersed in 3% of sodium chloride solution. Providing direct current, the slabs were treated to corrosion. Positive terminal of the DC power supply is attached to the main reinforcement of the slabs and negative terminal is attached to the steel plate, which also kept immersed in the salt water.

The stainless steel plate was 1.5mm thick. The density of current is around 1.8 to 2.0 mA/cm² of the surface area of the rod was induced corrosion. The slabs placed in the tank were subjected to a current density of 1.8 mA/cm² from external DC source. The plate acts as cathode was placed below the slab. The chart of this test set-up is shown in fig.3



Fig 3: Experimental setup of slab

2.8. Half-Cell Measurement

This method is used to find the corrosion potential measurements. To measure the voltages that are present over the rebar in concrete. This rebar's were coated and uncoated to find the values. The half-cell is a hollow tube contains in a copper electrode and immersed in copper sulphate solution. The base of the tube is porous and covers in a sponge material. The copper sulphate permeates this sponge that can then be placed on a concrete surface allowing an electrical potential (V) to be measured. The aim of the method is to be measure the voltage difference between the rebar and the concrete over the rebar. Large negative voltage (-350mV) indicate that corrosion may be taking place. Voltage smaller than about -250mV generally mean corrosion is not taking place. The schematic diagram of this test set-up is shown in fig 4.



Fig 4: Experimental setup of Half-cell readings

3. Results & Discussion

3.1. Compression Strength of Cube

The compression strength is the capability of a material or structure to survive loads tending to reduce size. It can be calculated by plotting applied force against deformation in a testing machine. The specimen used were normal cubes of size 150x150x150mm. The load was applied and the results have been tabulated as in table 1

Table 2: Compressive strength for conventional and fiber concrete

Specimen details	Compressive Strength in 7 days (N/mm2)	Compressive Strength in 14 days (N/mm2)	Compressive Strength in 28 days (N/mm2)
Conventional	23.55	25.77	27.11
With Fibre	31.11	33.77	37.11

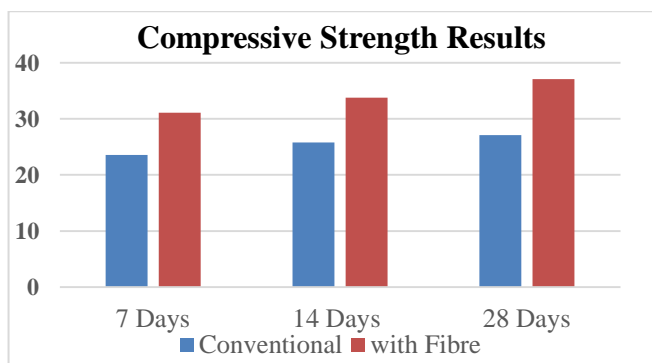


Fig 5: Comparing the compressive strength of concrete

From the table 1 and fig 5 it can be seen that nylon fiber gives the best compressive strength than conventional for the 7,14 and 28 days.

3.2. Split Tensile Strength

This test is carried out by placing the normal cylinder specimen of diameter 150mm and height 300mm horizontally between the loading surface of the compression testing machine and the loading was applied until the failure of the cylinder. Table 2 shows the test result for split tensile strength concrete for M25 concrete.

Table 3: Split tensile test on cylinder

Specimen details	Split tensile for 7 days (N/mm2)	Split tensile for 14 days (N/mm2)	Split tensile for 28 days (N/mm2)
Conventional	1.83	2.05	2.26
With Fibre	2.4	2.75	3.04

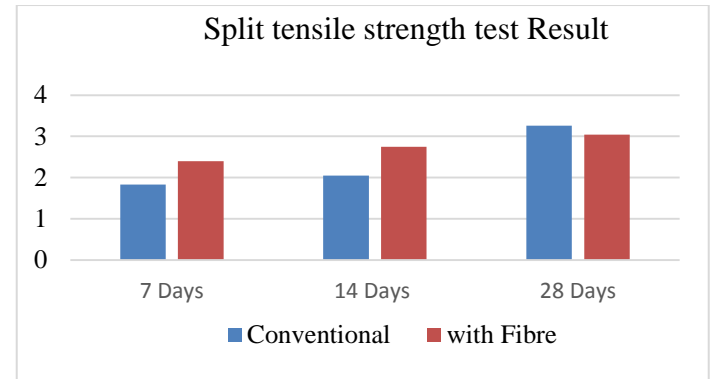


Fig 6: Split tensile strength

From the table 3 and fig 6 it can be seen that nylon fiber gives the best tensile strength than conventional for the 7,14 and 28 days.

3.3. Weight Loss

Weight loss of steel reinforcement was determined in the slab of size 500x500x60mm. The coated and uncoated specimens were immersed in a 3% of NaCl solution after the curing period the rebar's are allowed to weight. The reduction or increase in weight of the steel reinforcement was evaluated and recorded. The formula to calculate the weight loss %

$$WL (\%) = \frac{W_i - W_t}{W_i} \times 100$$

Where W_i = initial weight of rebar's (g);

W_t = weight of rebar's after the curing period (g).

3.4. Uncoated Specimens:

The rebar's are uncoated in both conventional and with fibre specimen. The initial weight is measured and the reduction in weight of the steel is measured as final weight. Then the weight loss % is calculated. From the table 3 it shows the weight loss % with fiber is more than that of conventional. Hence the steel loss % gets higher in uncoated specimen.

Table 4: Results for uncoated specimen

S.no	Details of specimen	Initial wt (gms)	Final wt (gms)	% weight Loss
1	Conventional	165	154	6.66
2	With Fibre	168	156	7.14

3.5. Coated Specimens:

The rebar's are coated in both conventional and with fibre specimen. The initial weight is measured and the reduction in weight of the steel is measured as final weight. Then the weight loss % is calculated. From the table 4 it shows the weight loss % with fiber is

less than that of conventional. Hence the steel loss % gets lower in coated specimen.

Table5 : Results for coated specimen

Sl.No	Details of Specimen	Initial wt (gms)	Final wt (gms)	% weight Loss
1	Conventional	178	172	3.37
2	With Fibre	176	171	2.84

3.6. Half-Cell Readings

Check the electrical continuity of the cell between copper rod and terminal of the wire, which is attached at the copper rod. Clean the copper rod using emery sheet to get the red colour surface of the copper rod free from sulphate coating. Prepare saturated copper sulphate solution using copper sulphate crystals with glass beakers and glass stick. Remove the half-cell cover and fill with copper sulphate solution in the half-cell tube and close cover tightly. Keep the cell unit vertically for about 5 to 10 minutes so that the copper sulphate solution should permeate through sponge bottom of the cell. The readings are taken for coated and uncoated specimen.

Table6: Half cell readings for uncoated conventional reinforcement

Time Intervals (Hrs)	Potential value
0	-
25	74
50	127
75	129
100	165
125	185
150	216

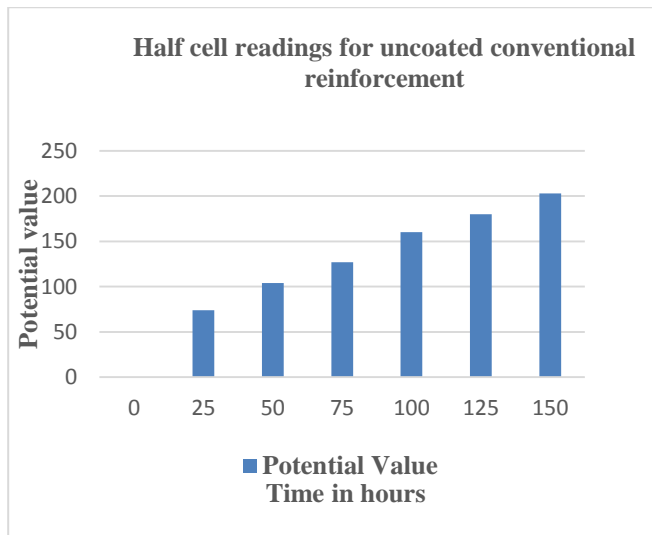


Fig 7: Half-cell reading for uncoated conventional Reinforcement

From the table 6 and fig 7 the half-cell readings for uncoated usual reinforcement shows the potential values at the specific time in hours. Here the corrosion attains at the lower rate.

Table7: Half-cell readings for uncoated fiber reinforcement

Time intervals (hrs)	Sample I
0	-
25	206
50	227
75	299
100	314
125	370
150	390

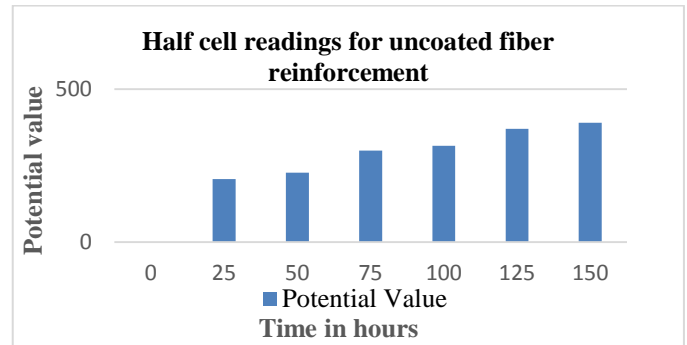


Fig 8: Half cell reading for uncoated fibre reinforcement

From the table 7 and fig 8 the half-cell readings for uncoated fiber reinforcement shows the potential values at the specific time in hours. Here the corrosion attains greater than the uncoated conventional reinforcement.

Table 8: Half-cell readings for coated conventional reinforcement

Time Intervals (Hrs)	Potential value
0	-
25	234
50	262
75	267
100	290
125	320
150	330

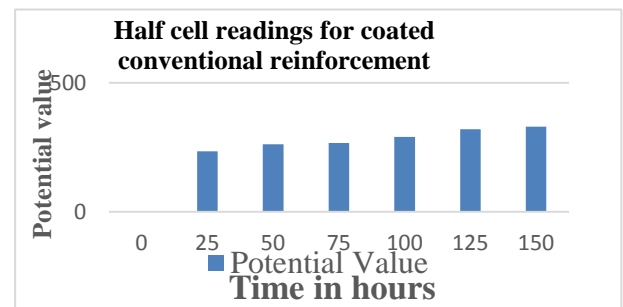


Fig 9: Half-cell reading for coated conventional reinforcement

From the table 8 and fig 9 the half-cell readings for coated conventional reinforcement shows the potential values at the specific time in hours. Here the corrosion attains greater than the uncoated fiber reinforcement.

Table 9: Half-cell readings for coated fiber reinforcement

Time Intervals (Hrs)	Potential value
0	-
25	28
50	46
75	74
100	105
125	121
150	157

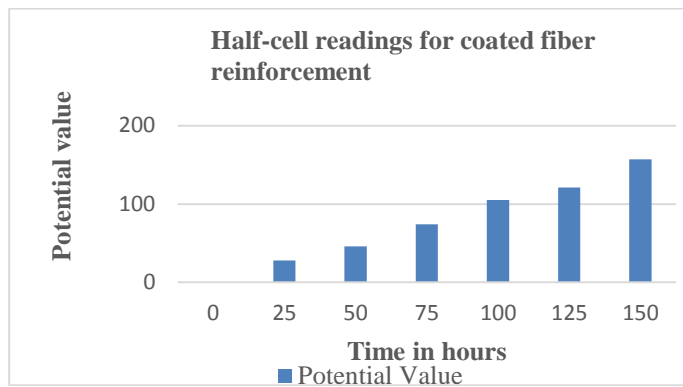


Fig .10: Half-cell reading for coated fibre reinforcement

From the table 9 and fig 10 the half-cell readings for coated usual reinforcement shows the potential values at the specific time in hours. Here the corrosion reduces than other corrosion values.

4. Conclusion

The experimental study on steel reinforcement corrosion is protected on rebar's using coating material on both conventional and fiber induced in concrete. The efficiency of the coating material was compared with that of the uncoated rebar. M25 grade of concrete is used on both coated and uncoated material. Experimental result analysis for compressive strength, split tensile strength, weight loss and half-cell readings are the basis for conclusion enclosed. The fiber induced in concrete gives 40% better strength than control concrete. Therefore, corrosion of steel reinforcement is protected by coating the rebar's could be reduced the corrosion.

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