Corrosion resistance studies on the concrete made with basalt fibres and basalt fibre reinforced rebars

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Abstract. In the present work, assessment of corrosion resistance for M30 grade concrete made with basalt fibres in terms of Resistivity, Potentials and Chloride ion diffusion is made to understand the corrosion resistance studies of concrete specimen made with basalt fibre and BFRP bars. The time of total charge passing till full crack failure for different effective covers considered is more for M30 grade concrete beams made with basalt fibres and BFRP rebars. The time of total charge passing at failure in M30 grade concrete beams made with basalt fibres and BFRP rebars is more because beam specimens did not develop any fissures or micro cracks. Measured electrical resistivity values of M30 grade concrete beams made with basalt fibres have shown high electrical resistance indicating their superior corrosion inhibition ability. M30 grade concrete beams made with basalt fibres and BFRP rebars used for the study exhibited very less probability (less than 5% probability) for corrosion at 28 days.

1 Introduction

Corrosion is major issue in reinforced concrete structure made with steel rebars. So there are various mechanisms using which the corrosion in reinforced concrete structures can be prevented. Basalt fibre are obtained from basalt rock so no corrosion can occur in basalt fibres. Basalt fibre reinforced polymer bars are made from the basalt fibres and glued into the form of bars using polymer as glue. So, in this current study, concrete specimens are prepared with basalt fibres and basalt bar embedded at the centre and various corrosion presence studies are carried out.

2 Methodology

For this study, basalt fibre length of 36mm and dosage of 0.4% fibre volume of the concrete is considered as optimum based on previous studies and is used for further studies. M30 grade concrete samples are made with basalt fibres and basalt fibre reinforced polymer (BFRP) bars. The mix proportion is mentioned below.

Table 1. Quantities per m^3 of concrete for M30 grade concrete

Concrete grade	Cement (kg/m^3)	Water (ltrs)	Aggregates	
			Fine (kg/m^3)	Coarse (kg/m^3)
M30	373	184	697.6	1149

Ratio of ingredients of concrete for M30 grade concrete is 1: 1.86: 3.07

In this study, assessment of corrosion resistance for M30 grade concrete made with basalt fibres in terms of Resistivity, Potentials and Chloride ion diffusion is made to understand the corrosion resistance studies of concrete specimen made with basalt fibre and BFRP bars.

3 Corrosion Studies

3.1 Modified method of constant voltage technique

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After 28 days of typical curing, four beams were cast and evaluated. All four corners of each beam are reinforced with 10 mm diameter HYSD bar with varied effective covers ranging from 10 mm to 40 mm. Beams measuring 150 x 150 x 500 mm are cast and cured in fresh water for 28 days. The findings of a modified constant voltage methodology appropriate for accelerated cracking investigations in beams with 10 mm diameter HYSD bar reinforcement at varied effective covers ranging from 10 mm to 40 mm at all four corners of each beam are presented in this study. The specimens to be analysed are stored in a glass tub that measures 750 mm X 300 mm X 300 mm and is filled with real sea water. All of the extended reinforcements have been cleaned, sleeved, and are ready for the power supply units to be connected. The power supply is linked in parallel to all four bars, and anodic current is impressed at a constant voltage of 20 V. The potentials for all the bars are recorded every 12 hours with reference to a freely corroding zinc electrode before and after an hour, and immediately before the test is closed for the day. The crack's length is measured and the work is terminated when it reaches 500 mm.

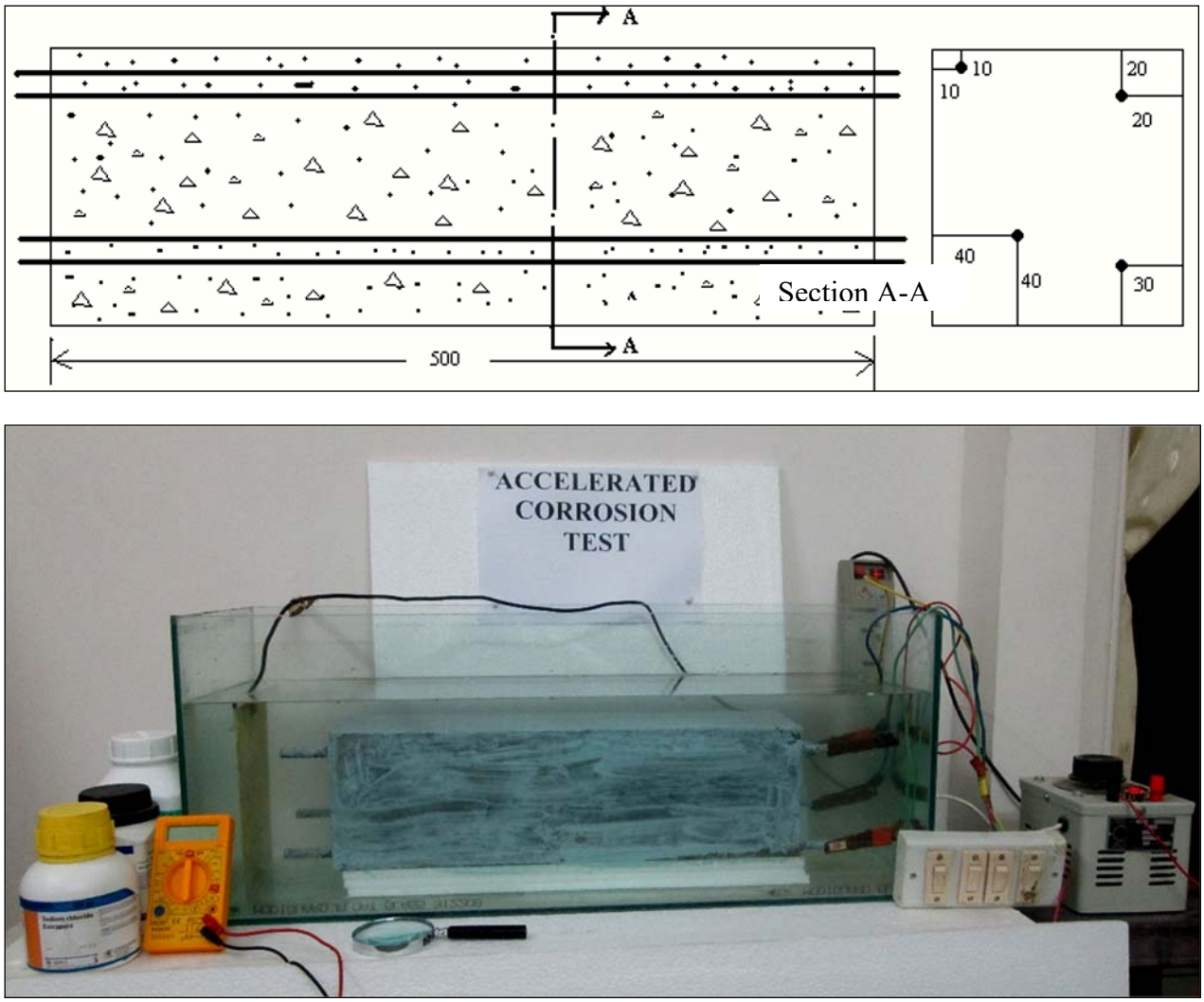

Fig.2. Accelerated corrosion of concrete set up

Fig.3. Test Specimen and Mould

The investigation is carried out to study the corrosion resistance for M30 grade concrete made with basalt fibres and BFRP bars. Beam Designations are shown below:

Beam- Type 1 = M30 grade concrete made with No fibres and steel rebars
Beam- Type 2 = M30 grade concrete made with basalt fibres and steel rebars
Beam- Type 3 = M30 grade concrete made with No fibres and BFRP rebars
Beam- Type 4 = M30 grade concrete made with basalt fibres and BFRP rebars

Table 2. Charge applied on each Beam (until full crack occur longitudinally)

Beam Designation	Time of total charge passed for full crack to occur longitudinally (in Hours)			
	10 mm	20 mm	30 mm	40 mm
Beam – Type 1	49	117	212	456
Beam – Type 2	31	81	160	342
Beam – Type 3	28	68	139	299
Beam – Type 4	36	94	188	389

3.2 Electrical resistivity studies

The electrical resistivity technique is a nondestructive testing (NDT) method that determines the capacity of a medium to conduct electric current based on the presence of electrolyte, water, and salts in the concrete's pore solution.

The electrical resistance of the cube's saturated surface is measured. Resistivity (Ωcm), $\rho = (R * A)/L$

Where
R= Resistance measured in kilo ohms
A = Surface area of the cube = 100 cm^2
L= Distance between two electrodes= 10 cm

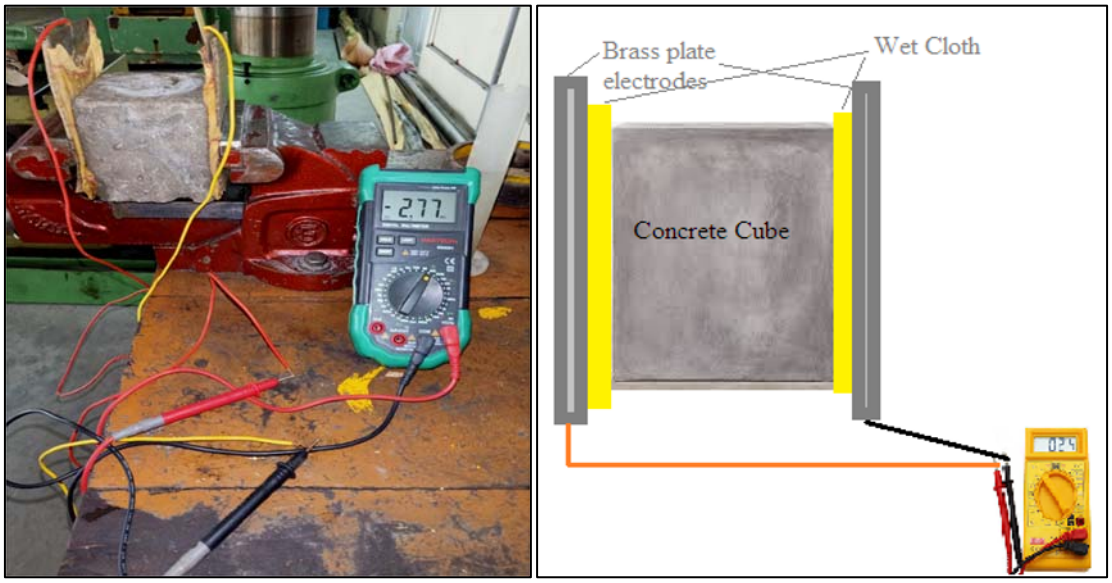

Fig.4. Experimental setup for measuring the electrical resistivity

Table 3. Electrical Resistivity of M30 grade concrete made with basalt fibres

	Resistivity ρ (Ω.cm)			
	3 days	7 days	14 days	28 days
Type 1	6800	16900	31650	58900
Type 2	14200	24500	36000	69500
Type 3	14300	25000	54900	85300`
Type 4	11300	21800	54700	79500

3.3 Half-cell potentiometer Test

Measuring half-cell potentials in M30 grade concrete with basalt fibres and BFRP rebars to predict the likely rate of corrosion.

ASTM C 876 suggests a criteria for evaluating the probability of corrosion based on potentials (SCE, mV). According to it, if the potentials is more than -120, the probability of corrosion is as low as 5%, if the potentials is between -120 and -270, the probability of corrosion is nearly 50%, and if the potentials is less than -270, the probability of corrosion is as high as 95%. Half-cell potentials of M30 grade concrete produced with basalt fibres and BFRP rebars are shown in the tables.

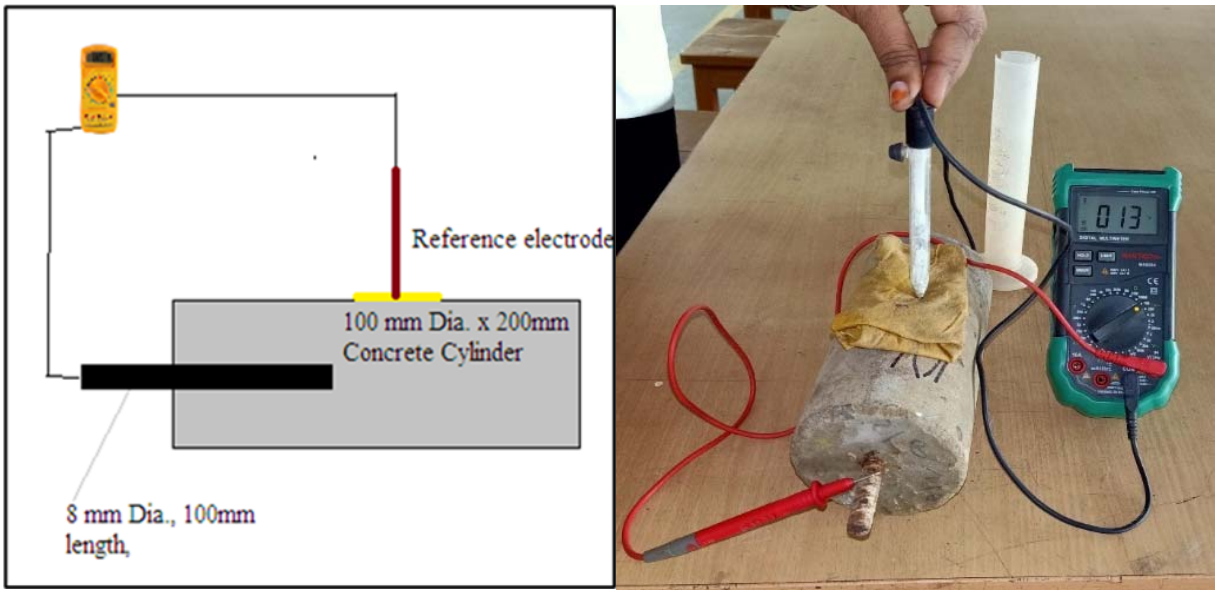

Fig.5. Half-cell potentiometer Test setup

Table 4. Potentials of M30 grade concrete made with basalt fibres and BFRP rebars

	Potential (-mV)			
	3 days	7 days	14 days	28 days
Type 1	No Reading	176	98	47
Type 2	No Reading	142	94	45
Type 3	No Reading	134	54	33
Type 4	No Reading	126	45	17

If half-cell potentials are high (more negative value, i.e. > -270 mV), the likelihood of corrosion is considerable; otherwise, if half-cell potentials are low (less negative value, i.e. -120 mV), the likelihood of corrosion is extremely low. Corrosion is more likely to start in M30 grade concrete beams containing basalt fibres and BFRP rebars.

4 Conclusions

1. For M30 grade concrete beams constructed with basalt fibres and BFRP rebars, the time from entire charge passage to full crack failure is longer for different effective coverings evaluated.
2. Because the beam specimens did not develop any fissures or micro fractures, the period of complete charge passage at failure in M30 grade concrete beams constructed with basalt fibres and BFRP rebars is longer.
3. Electrical resistivity values of M30 grade concrete beams constructed with basalt fibres were found to be high, indicating that they had better corrosion prevention capacity.
4. The M30 grade concrete beams with basalt fibres and BFRP rebars employed in the study had a very low chance of corrosion (less than 5% probability) after 28 days.

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