EXPERIMENTAL STUDY ON CORROSION RESISTANCE OF BASALT BARS WITH STEEL BARS

Sabareesh .S.V
Dept. of Civil Engineering
Saintgits College of Engineering
Kottayam, Kerala, India

Sanju Mary Sobichen
Dept. of Civil Engineering
Saintgits College of Engineering
Kottayam, Kerala, India

Reshma Kassim
Dept. of Civil Engineering
Saintgits College of Engineering
Kottayam, Kerala, India

***Abstract*— Concrete is relatively strong in compression and weak in tension. Also cracks start to form as soon is concrete is placed and before it has properly hardened. Cracks are major cause of weakness in concrete leading to subsequent fracture, failure and lack of durability. Weakness in tension can be overcome by use of conventional rod reinforcement. Composite reinforcement is an interesting and attractive alternative to conventional steel bars reinforcement since it significantly increases the structure durability due to its high corrosion resistance. Basalt fibre is the material of choice presently and is an inorganic fiber with extremely high strength, improved strain to failure, high temperature resistance, excellent stability, good chemical resistance, and natural, eco-friendly and inexpensive. This project studies corrosion resistance behavior of basalt rebars in comparison with steel bars. Study reveals that basalt bar perform better corrosion resistance than steel bars. Self-sensing concrete has the capability to sense the conditions itself such as crack, damage, strain, deformation etc. through incorporating functional fillers or sensing component. It is also known as self-monitoring or self-diagnosing concrete. Here conductive fillers are going to be incorporated as additives to concrete. The conductive fillers using in this study are nanomaterials such as multi-walled carbon nanotube, carbon black, carbon fibre powder and graphene. The preliminary test of cement and aggregates were done. Mix is fixed based on the workability tests and compressive strength tests as per IS 10262:2009. Electrical resistivity of trial concrete cube specimens with and without carbon black were measured. The cube specimens with carbon black showed good change in electrical resistivity response than specimens without carbon black, under the application of load. Electrical resistivity, change in electrical resistivity due to the application of load and mechanical properties of specimens incorporated with different conductive fillers are to be evaluated.**

***Keywords*— Basalt Rebars , Corrosion**

I. INTRODUCTION

Structural concrete is usually reinforced with conventional steel bars, which can last for decades without exhibiting any deterioration if it is properly protected from corrosion attack. However, this is not possible in so many cases, such as structures that are exposed to extreme environments such as deicing salts in bridge, marine structures, parking structures, etc. The combination of moisture contaminated with chlorides and temperature will accelerate the corrosion of steel reinforcement and lead to the deterioration of the structure and eventual loss of serviceability. A recent increase in the use of eco-friendly, natural fibers as reinforcement for the fabrication of lightweight, low cost polymer composites can be seen globally. One such material of interest currently being extensively used is basalt fiber, which is cost-effective and offers exceptional properties over glass fibers. So, compared to other fiber reinforced polymers now basalt stands at top as carbon composites are having high cost. Basalt bars can be used as a replacement for steel but it has its limitations. In this project we are investigating corrosion behaviour of basalt bars in comparison with steel bars.

II. MATERIALS USED

A. Basalt

Made from volcanic rock basalt rebar is tough, stronger than steel and has a higher tensile strength. Much lighter than steel, 89% percent in fact! Basalt rebar is naturally resistant to alkali, rust and acids. Moisture penetration from concrete does not spall. Needs no special coating like fiberglass rods.

Basalt rebar has the same thermal coefficient expansion as concrete. Allowing thinner, lighter panels and decks, basalt rebar reduces the thickness and spacing between the rods and the concrete and surface. Much more flexible design. Smaller rods allow for more critical spacing and designs. Basalt rebar is easily cut to length with regular tools. Basalt rebar does not conduct electricity or induce fields when exposed to RF energy, great for MRI or data buildings. Basalt rebar is perfect for Marine environments and Chemical plants where corrosion is a continuous concern. Data sheet of basalt bar is shown in figure 1

Specifications for Basalt Re-bars Nominal Diameter (mm)		Nominal Cross Section Area	Maximum Tensile Strength	Safe Tensile Strength	Modulus	Elongation at Break (mini value)	Weight Per Meter (g/m)	Mtr/Kg
Outside diameter mm	Inside diameter	Mm2	Mpa	Mpa	Gpa	%		
4							25	40
6		28.27					56	17.86
8	7.7	50.27	1100	1000	50	2.5	100	10
10	9.6	78.54	1000	950	50	2.5	158	6.41
12	11.5	113.1	950	900	50	2.5	227	4.41
16	15.4	201.1	900	850	50	2.5	405	2.47
20	18.5	295.50	850	800	50	2.5	592	1.69
22	21.6	382.73	800	750	50	2.5	768	1.3
25	24.5	537.90	760	700	50	2.5	1076	0.93
28	28.4	645.90	700	650	50	2.5	1292	0.77
32	31.6	807.34	700	650	50	2.5	1615	0.62

Fig. 1: Data sheet of basalt bar

III EXPERIMENTAL INVESTIGATION

This experiment was executed using the accelerated corrosion test a modified corrosion test , which consists of a partial immersion of the concrete specimen, containing Fe 500 steel bars and basalt bars with a diameter of 10 mm and a length of 80 mm, in a saline solution containing 35 grams of NaCl per liter of water[15]. A potential difference occurred between the steel bars in each specimen and a power supply, which provided a constant voltage. The cathode was generated in the steel bars, which promoted the migration of chloride ions from the solution to the area adjacent to the metal, where accelerated oxidation reactions happened by electron loss. In this experiment, it was shown that a constant 16.5 V over a period of 40 hours was enough to allow evaluation of weight and thickness loss in the metal bars. After 40 hours, the specimen was cured in 20 days. After the curing process, the block was weighed, and then broken to analyze the metal bars. The specimen was cleaned using a solution of 23% sulfuric acid and then was ground, to determine how much material thickness was lost.

$$\text{Mm per year} = 13.56 \times \Delta m/(S \times t \times \rho) \text{ [17]}$$

$$T = \Delta m \times 365/ (At \times \rho)$$

Fig.2: Basalt Reinforced Flexural Beam

Fig. 3: Steel Reinforced Flexural Beam

Fig. 4: Device used for supply of constant voltage of 16.5V

The materials used to make device used for supply of constant voltage of 16.5V are a step-down transformer,4 resistors, Capacitor. They produce a constant voltage of 16.5V. After giving this constant voltage continuously for 40hrs the specimens are cured for 20 days.

Fig. 5: Steel specimen

Fig. 6: Basalt specimen

V. RESULTS AND DISCUSSIONS

Specimens were given 20hours of constant voltage in partially immersed saline solution. Steel specimen showed corrosion after 40 hours and basalt specimen doesn't show any signs of corrosion.

Fig. 7: Steel specimen after 40 hours

Fig. 8: CB Specimen load v/s resistance graph

Rate of corrosivity is determined as per

Mm per year = 13.56 × Δm/(S×t×ρ)

Where
Δm = loss in mass(mg)
S = area of material exposed in inches
$S = \pi * r * ((2 * h) + r)$
t = time of exposure in hours
ρ = density of material
Steel bars showed a rate of corrosivity of 0.0103 mm/year. Rate of corrosivity is determined as per NACE rp0075 as shown table 1.

Table 1 :Rate of corrosivity is as per NACE rp0075

Uniform corrosion rate (mm/year)	Corrosivity
< 0.025	Low
0.025 a 0.12	Moderate
0.13 a 0.25	High
>0.25	Severe

VI CONCLUSIONS

In this project we investigated the corrosion behavior of basalt bars in comparison with that of steel bars. Basalt rebar is perfect for Marine environments and Chemical plants where corrosion is a continuous concern.Basalt bars are brittle in nature. Basalt bars shown no sign of corrosion. As per NACE rp0075, steel bars shows a corrosivity of 0.0103 which indicates low corrosion.

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