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EXPERIMENTAL INVESTIGATION ON SELF HEALING CONCRETE BEAMS USING BACTERIA

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Abstract: A new technique in rectifying cracks in concrete by utilizing microbiologically induced calcite precipitation is discussed. Bacillus Subtilis, a common soil bacterium can induce the calcite precipitation. In this research, Bacterial concrete is prepared under grade of M20. The design of mix proportion is carried under IS code provision. Beams in size 1500x100x150 mm are cast and tested after 28 days of curing. Flexural strength of bacterial concrete are to be found and it compared with conventional concrete. In concrete self-healing property is successfully achieved due to addition of bacteria.

Keywords: Bacterial concrete, Bio-Mineralization, Strength, Self-Healing.

I. INTRODUCTION

Concrete is one of the main materials used in the construction industry. Most of the concrete structures are liable to cracking when subjected to tension. Tiny cracks on the surface of the concrete make the whole structure vulnerable because water seeps in, to degrade the concrete and corrode the steel reinforcement, greatly reducing the lifespan of structure. The best way to heal cracks by triggering a healing mechanism without human intervention upon appearance of the crack, inspecting and monitoring are consequently needed no longer. Bacterial activities simply trigger a change in solution chemistry that leads to over saturation and mineral precipitation. Use of these bio mineralogy concepts in concrete leads to potential invention of new material called **Bacterial concrete**.

II. BACTERIAL CONCRETE AND METABOLISM

Self healing concrete is a product that will biologically produce insoluble limestone to heal crack which appears on the surface of concrete. Bacteria can lie dormant within the concrete up to 200years. Bacteria from genus Bacillus species **"Bacillus Subtilis"** is rod shaped, form a tough protective endospore, allowing it to tolerate extreme environmental conditions. When a concrete structure is damaged, water start to seep through the cracks and the spores of the bacteria start to grow on contact with water and nutrients. This process starts to feed on calcium lactate and converts them in to insoluble limestone. Then, the insoluble limestone coagulates on the cracked surface, thereby sealing it up.

III. PREPARATION OF BACTERIA

- Nutrient broth is a basic media composed of 2grams of simple peptone and 2grams of beef extract.
- Potassium chloride – 1 gram
- Magnesium sulphate – 1 gram
- Manganese chloride – 1 gram
- Distilled water – 1000 ml

The above chemical ingredients are mixed together and autoclave at 121°C. The boiled water is reddish in colour due to the presence nutrients. Then, bacteria is added and inoculated the culture medium overnight at 37°C for growth of cells until it turns into yellow colour. Dilute the medium by adding 0.5ml of calcium chloride and 1ml of ferrous sulphate. Incubate the medium for an hour at room temperature.

IV. MATERIALS AND TESTS

- Cement - Ordinary Portland cement grade of 53 with normal consistency which satisfies IS 12269 – 1987.

- Fine aggregate – zone II with specific gravity of 2.6, fineness modulus of 3.3 are satisfied as per IS 383– 1970.
- Coarse aggregate – 20mm of size with specific gravity of 2.7 and fineness modulus is 3.78 are satisfied as per IS 383 – 1970.

V. REINFORCEMENT DETAIL

About 4 beams of size 1500 x 100 x 150 mm were cast.

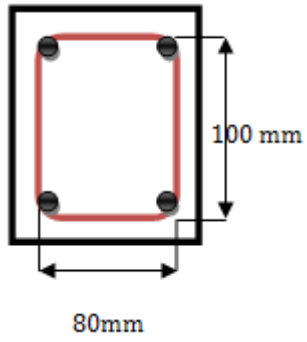

Figure 1

- At top - 10mm ϕ bars
- At bottom – 12mm ϕ bars
- Stirrups – 8mm ϕ bars

VI. DESIGN OF MIX PROPORTION

For 4 beams:

- Volume of cement: 35kgs
- Volume of sand: 50kgs
- Volume of aggregate: 100kgs
- Volume of water: 18 litres

For 1 conventional concrete beam:

- Volume of water: 4.5 litres

For 1 bacterial concrete beam:

- Volume of water: 4.4 litres + 100ml of bacteria.

VII. TEST RESULT AND DISCUSSION

Table 1

Specimen	Flexural strength N/mm²
Conventional concrete [CC]	7.2
Bacterial concrete [BC 1]	7.7
Bacterial concrete [BC 2]	8.5
Bacterial concrete [BC 3]	8.1

The beams are tested after 28 days. Table 1 shows the flexural strength of the conventional and bacterial concrete beams. The flexural strength of bacterial concrete is high when compared to conventional concrete. This is due to the presence of bacteria in concrete which heals the crack.

VIII. CONCLUSION

- A bacterium along with nutrients induces calcite precipitation in concrete which heals the crack by itself. This is known as self healing.
- In M20 grade of concrete, the percentage of bacterial concrete[BC 1, BC 2, BC 3] are increased in the order of 10.69%, 11.80% and 11.25% when compared to conventional concrete.

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