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# Bacillus Concrete

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***Abstract:*** **Concrete is one of the widely used material in the field of civil engineering constructions. The concrete structures undergo several issues which affect the durability of concrete. In all those several effects cracking is one which affects the mechanical strength of concrete. The main aim of the present study is to repair the cracks in the concrete using the biological repair technique. This technique involves the use of ureolytic bacteria for the purpose of healing of cracks which is known as Bio-cementation (or) microbiologically induced calcite precipitate (MICP). The Bacillus subtilis is the bacteria used in the study as solution replacing 30% of the water during the concrete mix. A comparison of strength is made between conventional concrete and bacterial concrete in which results came out to be in favor of bacterial concrete. The study result showed that there was a noticeable increase in the strength of bacterial concrete.**

**Keywords: Bacillus subtilis, bacterial concrete, bio-calcification, compressive strength and Split tensile strength.**

## I. INTRODUCTION

Concrete is a composite material which is mixture of cement, fine aggregate, coarse aggregate and water bonded together which gets hard as time passes. Has the concrete is high in compressive strength and weak tensile strength, the steel reinforcements are induced into concrete which is good in tensile strength. Since the concrete structures develops crack due the heavy load and atmospheric actions, the water content or the moisture particles find way to enter into the concrete structure and it will affect the tension member by causing corrosion of the steel which leads to the deterioration of structure. To reduce formation cracks and to increase the durability various methods has been adopted like injecting fluid into cracks or providing additional steel while construction so that the cracks maybe minimized. Constant research has been going on for elimination this disadvantage, leading to the development of the new techniques, considering various parameters such as the speed of construction, the strength of concrete, the durability of concrete and the environmental friendliness. This study deals with the application of bacteria (Bacillus Subtilis) in filling up the cracks, as the durability of concrete is generally believed to be related to the characteristics of its pore structure and thus the porous media permeability has to be modified. This bacteria precipitate calcite and thus helps to fill the cracks and the pores present in the concrete. This technique is economical compared to all other repair techniques at present situation. This self-healing techniques can also be adopted in the field of construction as it increases the durability and economical in all aspects.

## II. MATERIALS

### A. Cement

Cement is a binder material, a substance used for construction that sets, hardens and adheres to other materials, binding them together. Cements used in construction are usually inorganic, often lime or calcium silicate based. There are many varieties of cements introduced to construction industry according to the requirements. In this study, an ordinary Portland cement of 53grade has been used confirming to the code provision IS 12269-1987.

### B. Coarse aggregate

The most common size of aggregate used in construction is 20mm. The physical attributes are tried according to IS 383:1970 procurements. Here we have used 20mm and below sized aggregates for our experimental work.

### C. Fine aggregate

The fine aggregate used in the process of execution of this study is M-sand. Manufactured sand (M-sand) is a substitute of river sand for concrete construction. M-sand is produced from hard granite stone by crushing. The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. The size of M-sand is less than 4.75mm.

### D. Water

Water fit for drinking is generally considered fit for making concrete. Water should be free from acids, oils, alkalis, vegetables or other organic Impurities. Soft waters also produce weaker concrete. Water utilized for the mixing and curing of concrete is suitable and convenient, insisting according to IS 456-2000.

### E. Bacteria

Bacteria are relatively simple, single celled organisms. The bacteria used is Bacillus subtilis. B. subtilis is a

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Gram-positive, catalase-positive bacterium, found in soil and the gastrointestinal tract of ruminants and humans. A member of the genus Bacillus, B. subtilis is rod-shaped, and can form a tough, protective endospore, allowing it to tolerate extreme environmental conditions. It is a bacterium with the ability to precipitate calcium carbonate in the presence of any carbonate source. The bacterium is used in this project for the same and for the improvement in the strengths of the concrete test specimens were observed. The microbes are a bacillus species and are completely not harmful to human beings. They precipitate inorganic crystals hence the healing of the cracks takes place in the concrete. This bacteria is used in the form of solution as a replacement of water of 30%.

**F. Bio-calcification**

Bacterial concrete, as the name suggest is an improvisation provided to cement using living microbes which are capable of doing so. Using microbes such as Bacillus subtilis which as properties of bio calcification can secrete calcium carbonate as an extracellular product thus filling the pores and the cracks internally making the structure more compact and resistive to seepage. As the texture becomes more compact the compressive and split tensile strength is also considerably increased. Thus, this process can reduce the seepage considerably permanently [1].

## III. METHODOLOGY

The steps involved in preparation of bacterial solution for a self-healing concrete are as follows:

**A. Preparation of bacteria solution**

1. a) Primarily 25g [25ml] of Nutrient broth (Luria Bertani) is added to a 500ml conical flask containing 500ml distilled water.

b) It is then covered with a thick cotton plug and is made air tight with paper and rubber band.

c) It is then sterilized using a cooker for about 10-20 minutes. Now the solution is free from any contaminants and the solution is clear orange in color before the addition of the bacteria.

d) Later the flasks are opened up and an exactly 1ml of the bacterium is added to the sterilized flask and is kept in a rotatory shaker at a speed of 150-200 rpm overnight.

e) After 24 hours the bacterial solution was found to be whitish yellow turbid solution.

2. Based on properties of concrete ingredients M-25 grade of concrete (As per IS: 10262- 2009) will be prepared with usual aggregates without the addition of bacterial solution.

3. A new batch of samples which prepared with replacement of water by 30% (i.e. 4,500ml) of bacterial solution.

4. Concrete mixture is poured into the moulds of cube (150x150x150mm) and cylinder (150mm in dia and 300mm height) in three layers by giving each layer 25 blows using tamping rod.

5. Then the moulds are placed on the vibrator machine for further compacting & also to reduce the air voids present in it.

6. It is demoulded after 24 hours and immersed in water for curing purpose. The curing is done for 7, 14 and 28 days. The water absorption test is also carried out.

8. Finally the sample will be tested in compressive testing machine to determine the strength characteristics (compressive and split tensile strength).


***Fig 1: Bacterial solution***

## IV. RESULTS AND DISCUSSION

The test results showed that there was increase in strength of bacterial concrete specimens compared to conventional concrete specimens. The main aim of this project is to heal the cracks by itself and the results shows the healing of cracks. The test results, figures and graphs are given below.

Water Absorption Test

***Table 1: Water absorption test result***

| Concrete Mix | Curing Period | | |
|---|---|---|---|
| | 7days | 14days | 28days |
| Conventional Concrete | 20.65MPa | 22.21 MPa | 27.32 MPa |
| Bacterial Concrete | 28.50 MPa | 30.58 MPa | 41.54 MPa |

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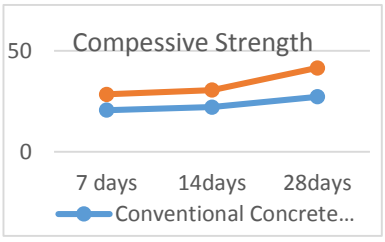


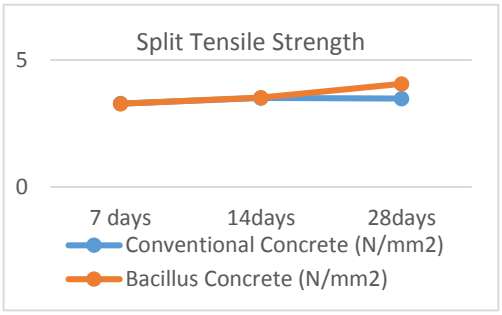


***Graph 1: Water absorption***

***Graph 3: Split tensile strength***


***Fig 2: Compressive Strength testing***

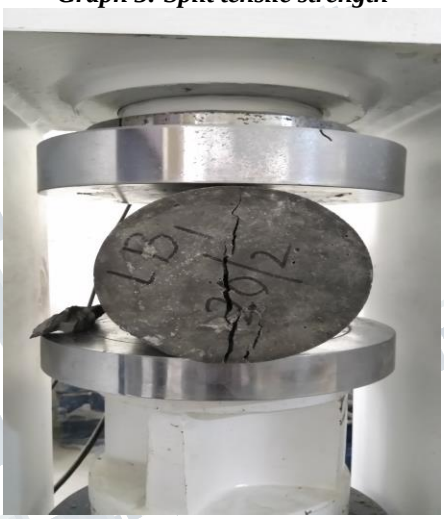

***Fig 3: Split tensile strength testing***

The test results showed that the water absorption of bacterial concrete was less than conventional concrete.

Compressive Strength Test

The result shows that there was no increase in strength at early stages but as the curing period increased the strength also increased upto 16.67% at 28th day of curing when compared to conventional concrete.

***Split Tensile Strength***

***Table 3: Split tensile strength test result***

| Concrete Mix | Curing Period | | |
|---|---|---|---|
| | 7days | 14days | 28days |
| Conventional Concrete | 3.29 MPa | 3.51 MPa | 3.48 MPa |
| Bacterial Concrete | 3.28 MPa | 3.52 MPa | 4.06 MPa |

**Cracks Healed**

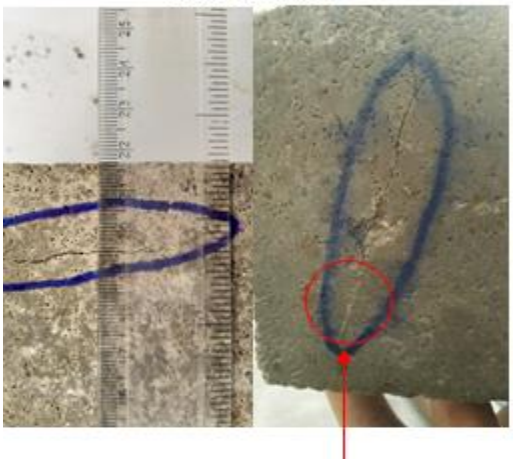

***Fig 4: Cracks formed and Healed***

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*Magnified image of cracks healed*

## V. CONCLUSION

The bacterial concrete will have higher life span when compared to that of conventional concrete because calcite precipitate crystals impermeable the concrete specimen and resists the harmful solutions entering the concrete specimen there by reducing the deleterious effect which they may cause. This concrete can be used to prevent cracks and hence saving the structure from corrosion of steel. Due to bacteria there is increased smoothness and surface texture of the bacterial concrete specimen. The main advantage of using bacteria in concrete is that it can withstand higher pH and temperature. Bacterial concrete has lower heat of hydration and less thermal cracks. There was not much improvement in the tensile strength. As the bacterial solution is added there was increase in compressive and tensile strength and less water absorption for Bacterial concrete.

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