Effect of Bacillus Aerophilus on Concrete

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ABSTRACT— ***Concrete is widely used in construction. Some of major drawbacks are Cracking and Seepage .Cracks form an open pathway to the reinforcement and can lead to durability problems like corrosion of the steel bars. These cracks should be repaired because they can reduce the service life of the structure. As synthetic polymers, currently used for concrete repair, may be harmful to the environment, the use of a biological repair technique is investigated in this study. Bacterial concrete, as the name indicates is an improvisation provided to cement using living microbes which are capable of doing so. Ureolytic bacteria such as Bacillus Aerophilus are able to precipitate $CaCO_3$ in their micro-environment by conversion of urea into ammonium and carbonate. The bacterial degradation of urea locally increases the pH and promotes the microbial deposition of carbonate as calcium carbonate in a calcium rich environment. These bacteria have properties of bio calcification can secrete calcium carbonate as an extra cellular product thus filling the pores and the cracks internally making the structure more compact and resistance to seepages. As the texture becomes more compact the compressive strength, flexural strength &split tensile strength is considerably increased.***

The laboratory tests are conducted on 43 grade ordinary Portland cement (OPC). The physical tests of the ingredient materials are conducted according to IS specifications .For laboratory tests M30 concrete is adopted. On hardened concrete the strength related test such as Compression, Split tensile and flexural tests on cubes, cylinder and beams are conducted as per IS specifications.

Keywords— Bacillus Aerophilus, Compression Test, Split Tension test, Bio calcification

1. INTRODUCTION

Concrete is the most widely used construction material in the world. Despite its different qualities in construction, it is known to have several limitations. It is weak in tension and has limited ductility and less resistance to cracking. Since the beginning there has been continuous research carried out around the world, various modifications has been made over the years to overcome the insufficiency in cement concrete. The continuing research in the field of concrete technology has led to the development of special type of concrete considering various parameters such as the speed of construction, the strength of concrete, the durability of concrete and the environmental friendliness

Cement concrete in terms of weight it stands second only to water. In terms of cost, generally it accounts for about 25 to 30 % of the national budget. Concrete is the main material used for the infrastructure development in every country around the world. As far as India is concerned, our infrastructure development as just started. In the upcoming years there will be a sudden advancement in the production and use of cement and concrete. Cement is a binder; a substance that sets and hardens independently, and can bind other materials as well. Cements are generally graded according to a few set of specifications defined (Refer - IS 269(2013) [7], IS-8112(2013) [8], IS 12269(1987) [9]) which differentiate the various grades of cements.

Cement is one of the most important ingredient materials of concrete; generally the Ordinary Portland Cement (OPC).

1.1 Objective

It is found that metabolic activities of favourable microorganisms led to the mineral precipitation in concrete and improved the overall behaviour of concrete. This process occurs inside or outside the microbial cell and within the concrete. Often bacterial activities simply trigger a change in chemistry that leads to the mineral precipitation. Use of these mineralogy concepts in concrete as lead to potential invention of new material called "Bacterial Concrete".

1.2 Bacillus Aerophilus

Bacillus Aerophilus is a species of bacteria first isolated from cryogenic tubes used for collecting air samples from high altitudes, hence its name. Colonies on nutrient agar are white, irregular, raised and 5–8 mm in diameter . Growth occurs at 8°–37° C, but not at 40° C. Growth occurs between pH 6 and pH 10, but not at pH 5 or pH 11. The strain is resistant to ultra-violet radiation. Produces acid from a number of substrates and utilizes a number of sugars, amino acids and other carbon compounds as sole carbon sources.

2. PROCEDURE

2.1 Preparation of Bacterial Solution

Primarily 12.5g [5] of Nutrient broth (media) is added to a 500ml conical flask containing distilled water. It is then covered with a thick cotton plug and is made air tight with paper and rubber band. 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 colour before the addition of the bacteria. Later the flasks are opened up and an exactly 1ml of the bacterium is added to the sterilized flask and is kept in a shaker at a speed of 150-200 rpm overnight. After 24 hours the bacterial solution was found to be whitish yellow turbid solution.

Figure 1: Bacterial solution

2.2 Preparation of M30 Concrete

OPC Cement is used with nominal size of aggregate as 20mm. Specific gravity of cement is 3.15 and that of Coarse aggregates and Fine Aggregates are 2.65 and 2.56 respectively. Water Absorption of Coarse Aggregates is 0.5 and Fine Aggregates is 1%.The target mean Strength was taken as 38.25 N/mm^2.Water Cement Ratio was found to be 0.45.Finally we ended up with Mix of **1:1.51:2.45** as per IS:10262-2009. Bacterial concrete mix is made by adding 50ml of 10^5cells/ml concentration solution of prepared bacterial culture per specimen to be casted.

Figure 2: Casted Moulds

3. TESTS ON CONCRETE

3.1 Compression test

The cubical moulds of size 150mm x 150mm x 150mm were used and tested as per IS 516:1959[11]. The required quantities of cement, along with fine aggregate and coarse for the M-30 mix are weighed accurately for concreting .The wet concrete is now poured into the moulds and for every one third layers the mix in the moulds and is compacted with vibrator. Three Cubes of 3, 7, 28 and 56 days age were tested in a compressive strength testing machine.

Table 1: Compressive strength test results for 3, 7, 28 & 56 days.

Sl.No	Days	Normal concrete (N/mm^2)	Bacterial concrete (N/mm^2)
1.	3	16.27	21.433
2.	7	22.4	30.05
3.	28	37.4	50.2
4.	56	43.4	56.53

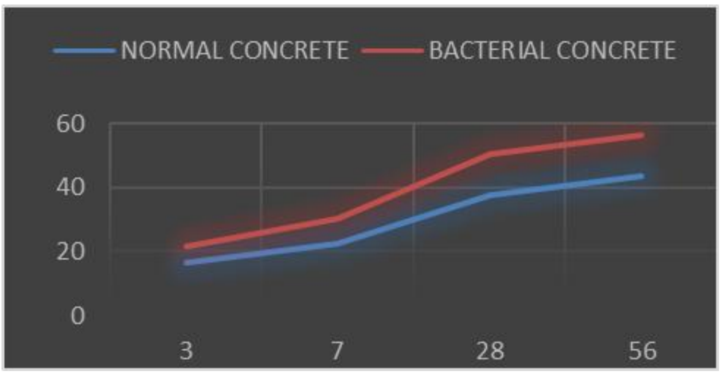

Figure 3: Plot of compressive strength vs Age (days)

3.2 Flexural test

Moulds of 10cm x 10cm x 50cm is used and the Moulds are tested as per IS: 516-(1959) [11]. The required quantities of cement, fine aggregate and corresponding coarse aggregate for the particular mix are weighed accurately for concreting. After the concreting operations, the upper surface is leveled and finished with a mason's trowel. The corresponding identification marks were labeled over the finished surface and 3 beams were tested for 28 day strength.

Table 2: Flexural strength test results for 28 days

Sl.No	Days	Normal Concrete(N/mm^2)	Bacterial Concrete(N/mm^2)
1	28	4.88	6.41

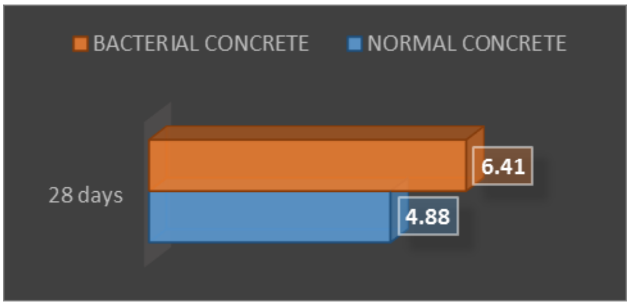

Figure 4: Plot of age (days) vs. flexural strength

3.3 Split tension test

The cylindrical moulds of diameter 150 mm and height 300 mm are casted and tested as per IS:5816-(1999)[10]. The corresponding identification marks were labeled over the finished surface and 3 cylinders were tested for 28 day strength.

Table 3: Split tension test results for 28 days

Sl.No	Days	Normal Concrete(N/mm^2)	Bacterial Concrete(N/mm$^{2)}$
1	28	2.6	2.85

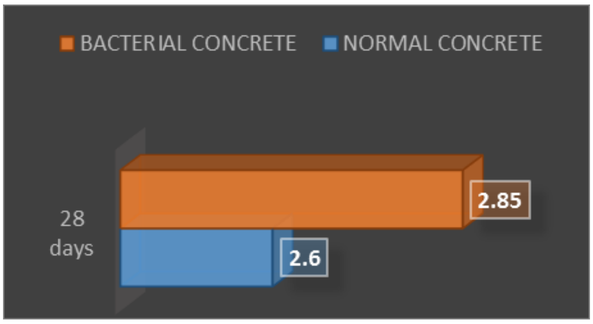

Figure 5: Plot of split tension strength vs age (days)

4. CONCLUSION

The Bacterial concrete has given good results compared to normal concrete. There was significant improvement of compressive strength by 35% in concrete with bacteria. The Split Tensile Strength is increased by more than 9%and Flexural Strength has increased by more than 30% for bacterial concrete. This concrete can be used to prevent cracks and hence saving the structure from corrosion of steel.

5. SCOPE FOR FUTUR STUDIES

The different species of the bacteria can be tried with different grades of concrete. Concrete can also be tested with different proportion of fly ash and GGBS.

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