Effect of Depth of Crack on the Improvement of Compressive Strength of Concrete By Bacillus Pasteruii

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***Abstract* - Cracks are one of the naturally weaknesses of concrete and they are irreversible. Bacillus Sphaericus, a common soil bacterium induce the precipitation of calcite exhibited its positive potential in selectively consolidating simulated fractures in the consolidation of sand. A compression strength tested on mortar cubes treated with bacteria were studied. The effect of different depth of crack on the compression and flexural of concrete was studied. It was found that all the increase in depth of crack reduce the strength of cubes and beams improved by Bacillus Pasteruii.**

***Index Terms*—Bacterial Concrete, Bacillus Pasteruii, Crack Repair, Self Healing Concrete**

I. INTRODUCTION

In concrete, cracking is a common phenomenon due to the relatively low tensile strength. High tensile stresses can result from external loads, imposed deformations (due to temperature gradients, confined shrinkage, and differential settlement), plastic shrinkage, plastic settlement, and expansive reactions (e.g. due to reinforcement corrosion, alkali silica reaction, sulphate attack). Without immediate and proper treatment, cracks tend to expand further and eventually require costly repair. Durability of concrete is also impaired by these cracks, since they provide an easy path for the transport of liquids and gasses that potentially contain harmful substances. If micro-cracks grow and reach the reinforcement, not only the concrete itself may be attacked, but also the reinforcement will be corroded when it is exposed to water and oxygen, and possibly carbon dioxide and chlorides. Micro-cracks are therefore precursors to structural failure [1].

Fig 1 Bacillus Pasteruii and Food – P-Urathine

Fig 2 Failed Specimen

In 1995, Gollapudi et al. ([2] as quoted by [3]), were the first to introduce this novel technique in fixing cracks with environmentally friendly biological processes. Bacterially induced calcium carbonate precipitation has been proposed as an

alternative and environmental friendly crack repair technique. Bacillus Sphaericus produces urease, which catalyzes urea to produce CO2 and ammonia, resulting in an increase of pH in the surroundings where ions Ca2+ and CO32- precipitate as CaCO3. The first three factors are provided by the metabolism of the bacteria while the cell wall of the bacteria will act as a nucleation site [4].Possible biochemical reactions in medium to precipitate CaCO3 at the cell surface that provides a nucleation site can be summarized as follows.[5]

$$Ca^{2+} + Cell \rightarrow Cell\text{-}Ca^{2+}$$
$$Cl^{-} + HCO_3^{-} + NH3 \rightarrow NH_4Cl + CO_3^{2-}$$
$$Cell\text{-}Ca^{2+} + CO_3^{2-} \rightarrow Cell\text{-}CaCO_3\downarrow$$

Fig. 3 creating artificial crack by marble cutter

II. EXPERIMENTAL PROGRAM

A soil bacterium, Bacillus Pasteruii was used. Bacterial strain was obtained from national chemical laboratory. It forms irregular dry white colonies on nutrient agar. The culture is introduced into nutrient broth of 25 ml in 100 ml conical flask and the growth condition are maintained at 37^{o}C temperature and placed in 125 rpm orbital shaker for 24 hours. The concentration of cells (10^9 cells/ml) of water was maintained.

A. Compressive strength study

Mortar samples were made by using ordinary Portland cement. The composition of the mortar mix is Cement and Ennore sand ratio is used as 1:3 (by weight). Moulds with dimensions of 70.6 mm× 70.6 mm× 70.6 mm. After casting, all moulds were placed in a normal temperature of room with a relative humidity of more than 90% for a period of 24h. After de-moulding, the specimens were placed for the curing for 28 days. At 28th day artificial cracks depth of 15 mm, 20 mm and 25 mm were developed by marble cutter on the upper surface as shown in figure-3. In that cracks paste of Bacillus Pasteruii mixed with Ennore sand inserted as shown in figure-4.. After that bacteria's (Bacillus Pasteruii) were feed P-Urathine (food – Urea based) at every 6 hours interval for 28th days as shown in figure - 5. And After it Compression test carried out as shown in figure - 6 at 7th, 28th and 56th day.

Fig. 4 – Inserting paste of Bacillus Pasteruii mixed with Ennore sand in cracked portion

Fig. 4 Applying food to Bacillus Pasteruii with pipette

III. TEST RESULTS

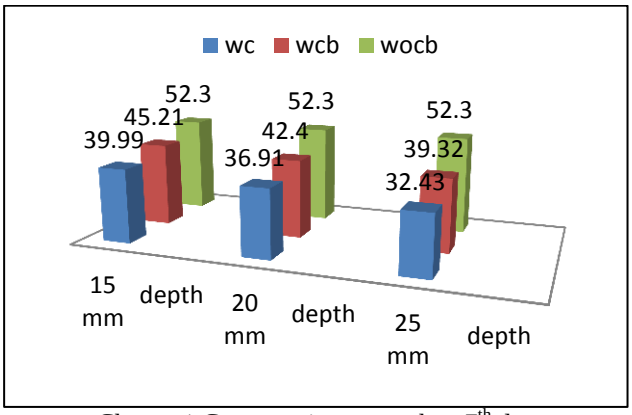

Chart – 1 Compression strength at 7th day

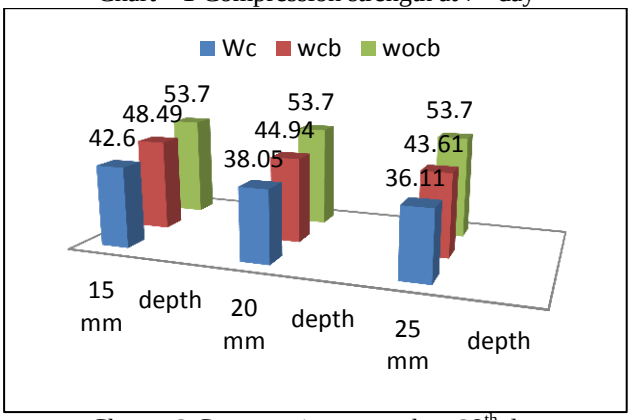

Chart – 2 Compression strength at 28th day

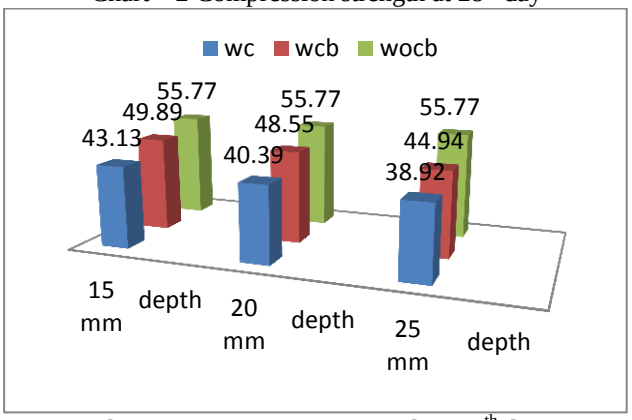

Chart – 3 Compression strength at 56th day

IV. DISCUSSION

The improvement in strength of concrete depending upon following factors.

- Depth of crack
- Number of days from inserting bacteria in cracked portion.

All the test results were compared with that of the uncracked and cracked concrete specimens. It was found that all the specimens effectively healed which had less depth of crack. The lesser the depth of crack improvement in compressive strength is more.

V. Conclusion

From the experimental program improvement of the Compressive strength as well as flexural strength reduces with the increase in the depth of crack. It might be because of at the greater depth bacteria might not be proper contact with air. The use of this biological repair technique is highly desirable because the mineral precipitation induced as a result of microbial activities is pollution free and natural.

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