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COMPARITIVE STUDY ON IMPROVEMENT ON THE CONCRETE CRACKS BY USING BACILLUS SPHAERICUS, BACILLUS PASTUERII AND BACILLUS COHNI WITH

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Abstract: Cracks are one of the naturally weaknesses of concrete and they are irreversible. Bacillus, 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 was 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 different Bacillus.

Keywords: Cracks, Bacillus Sphaericus, Bacillus Pastuerii, Bacillus Cohni

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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 instantaneous and proper treatment, cracks tend to expand further and finally 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 damaging 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].

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 CO_2 and ammonia, resulting in an increase of pH in the surroundings where ions Ca^{2+} and CO_3^{2-} precipitate as $CaCO_3$. 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 $CaCO_3$ at the cell surface that provides a nucleation site can be summarized as follows. [5]

$Ca^{2+} + Cell \rightarrow Cell\text{-}Ca^{2+}$

$Cal^{-} + HCO^{3-} + NH_3 \rightarrow NH_4Cl + CO_3^{2-}$

$Cell\text{-}Ca^{2+} + CO_3^{2-} \rightarrow Cell\text{-}CaCO_3\downarrow$

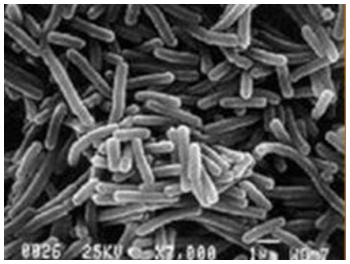

Fig 1 Bacillus Pastuerii, Bacillus Sphearicus

- **II. EXPERIMENTAL** PROGRAM

A. Compressive strength study

Fig 2 compression test

Mortar cubes were made by using ordinary Portland cement. 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 in normal water at ambient temperature. After that for 28 days different bacteria (Bacillus Pastuerii, Bacillus Cohni and bacillus Sphearicus) inserted in crack mixed with standard sand and after that bacteria's were feed at every 6 hours interval for 28 days. And After it Compression test carried out at 7^{th}, 28^{th} and 56^{th} day.

B. Flexural strength study

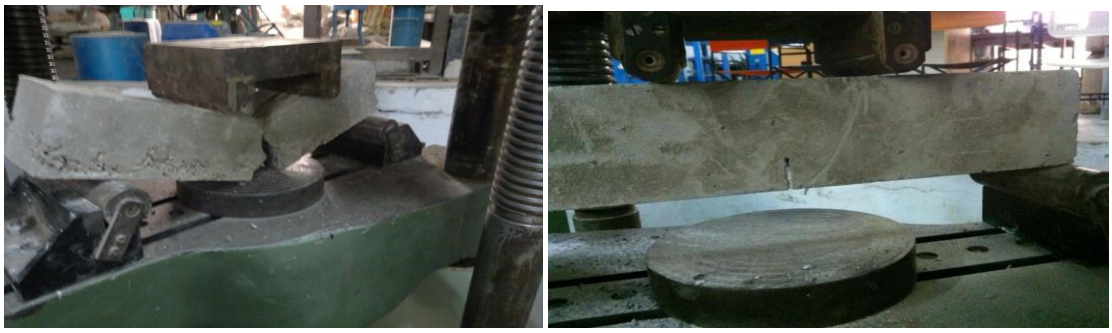

Fig 3. Flexural test

Concrete Beams grade M20 were made by using ordinary Portland cement. Moulds with dimensions of 500 mm× 100 mm× 100 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. After that for 28 days different bacteria (Bacillus Pastuerii, Bacillus Cohni and bacillus Sphearicus) inserted in crack mixed with standard sand and after that bacteria's were feed at every 6 hours interval for 28 days. And After it Flexural test carried out at 28th and 56th day.

C. Durability study

After 28 days of casting, each cube is tested for weight an accelerated experimental test program is conducted on ordinary Portland cement concrete. The specimens are arranged in such a way that the clearance around and above the specimen is not less than 30 mm. The solution has been changed for an interval of every 15 days .Before testing; each specimen is removed from the tubs, and brushed with a soft nylon brush and rinsed in tap water. This process removes loose surface material from the specimens. The percentage weight loss, percentage compressive strength loss is taken for a set of cubes at 56 days.

III. TEST RESULTS

Table 1 Compressive test results at 56th days

crack	Wocb (N/mm^2)	Wc (N/mm^2)	Wcb (Bacillus Pastuerii) (N/mm^2)	Wcb (Bacillus Sphericus) (N/mm^2)	Wcb (Bacillus Cohni) (N/mm^2)
15 mm depth	55.77	43.13	49.89	45.2	47.56
20 mm depth	55.77	40.39	48.55	41.35	43.87
25 mm depth	55.77	38.92	44.94	38.13	39.34

Table 2 Flexural test results at 56th days

crack	Wocb (N/mm^2)	Wc (N/mm^2)	Wcb (Bacillus Pastuerii) (N/mm^2)	Wcb (Bacillus Sphericus) (N/mm^2)	Wcb (Bacillus Cohni) (N/mm^2)
15 mm depth	6.79	4.93	5.33	5.13	5.13
25 mm depth	6.79	3.99	4.26	4.13	4.26

IV. DISCUSSION

The effects of the following parameters on the compression, flexural and durability of concrete were investigated:

- Depth of crack
- Number of days from healing of crack
- Types of Bacteria

The experimental study on concrete beams shows that not much considerable improvement in flexural strength because of following reason:

- Bond between calcite and concrete is not developed in 56 days. It might take more than 6 month to create good bond between them.

All the test results were compared with that of the uncracked and cracked concrete and mortar. It was found that all the specimens effectively healed which had less depth of crack.

V. CONCLUSIONS

- Cracked repaired by Bacillus pastuerii gives more strength in compressive, flexural and durability test than repaired by Bacillus Sphaericus and Bacillus Cohni.
- Strength of repaired cubes decrease with the increase in depth of crack. It might be because of at the greater depth bacteria might not be proper contact with air due to less voids.

- 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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