Improvement of the Concrete Cracks by Using Bacillus Sphaericus

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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, flexural and durability tested on mortar cubes and concrete beams treated with bacteria were studied. The effect of different depth of crack on the compression, flexural and durability of concrete was studied. It was found that all the increase in depth of crack reduce the strength of cubes and beams.**

***Index Terms*—Self Healing Concrete, Bacterial Concrete, Bacillus Sphaericus** *(key words)*

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 sphaericus
(Image courtesy :AMBERGENE CORPORATION)

Fig 2 compression test

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]

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

II. EXPERIMENTAL PROGRAM

A. Compressive strength study

Mortar samples were made by using ordinary Portland cement. The composition of the mortar mix is shown in Table 1. Cement and 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

Fig 3. Flexural test on concrete beam

Fig. 5 Cultured Bacteria and food

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 bacteria's were feed at every 6 hours interval. And After it Compression test carried out at 7^{th}, 28^{th} and 56^{th} day.

B. Flexural Strength

The investigation is carried to study the flexural behavior of concrete. 36 simply supported beams consisting of balanced section are cast and tested. Concrete samples were made by using ordinary Portland cement. Moulds used had 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 bacteria's were feed at every 6 hours interval. And After it Compression test carried out at 28^{th}days.

C. Durability Test

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^{th} days.

Fig. 4 – Cube After 28 day immersed in $MgSo_4$ Solution

III. 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

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.

IV. Conclusion

- The addition of Bacillus Sphaericus in cracks improves the compressive strength. Improvement in strength is around 16.4% at 7th day, 17.3% at 28th day and 17.6% at 56th day.
- The experimental study on concrete beams shows that not much considerable improvement in flexural strength because of following reason :

Fig. 5 Paste of bacteria mixed with fine sand and Insertion of bacteria paste in crack surface

- At time of developing cracks due to continuous vibration of machine micro cracks has been developed in beams and just because of that reason at time of testing it

may not have shown much improvement in flexural strength results.

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

- The percentage weight loss respectively in WOCB, WC-15, WCB-15, WC-25 and WCB-25 are 1.31%, 1.95%, 0.65%, 1.67% and 0.59%. It shows that weight loss percentage in WCB is less compared to WOCB and WC
- The percentage strength loss respectively in WOCB, WC-15, WCB-15, WC-25 and WCB-25 are 3.07%, 4.31%, 3.22%, 5.29% and 3.79%. It shows that strength loss percentage in WCB is less compared to WC but larger than WOCB.

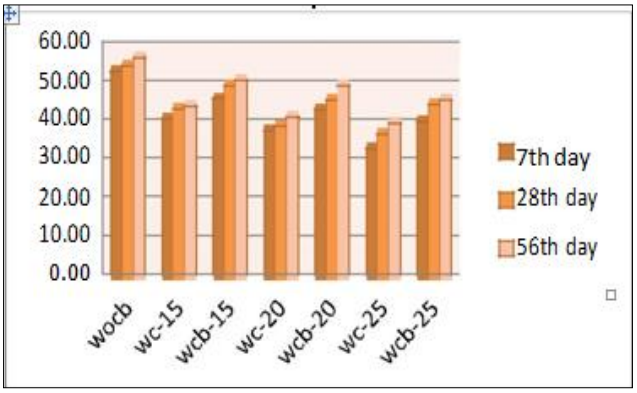

Chart 1 : Compression test result

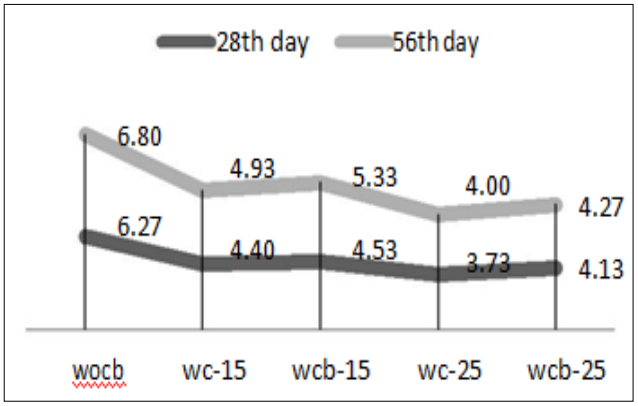

Chart 2 – Flexural Test Results

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