Comparitive study on Improvement on the Concrete Cracks by using Bacillus Pastuerii and Bacillus Sphaericus

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Abstract—Cracks are one of the naturally weaknesses of concrete and they are irreversible. Bacillus Sphaericus and Bacillus Pastuerii are common soil bacterium induce the precipitation of calcite exhibited its positive potential in selectively consolidating simulated fractures in the consolidation of sand. A comparative study on effect of crack repair by different bacteria on compression, flexural and durability tested on mortar cubes and concrete beams. 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.

Key words: Self-Healing Concrete, Bacterial Concrete, Bacillus Sphaericus, Bacillus Pastuerii

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].

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]

$$Ca2+ + Cell \rightarrow Cell\text{-}Ca2+$$

$$Cl- + HCO3- + NH3 \rightarrow NH4Cl + CO32-$$

$$Cell\text{-}Ca2+ + CO32- \rightarrow Cell\text{-}CaCO3\downarrow$$

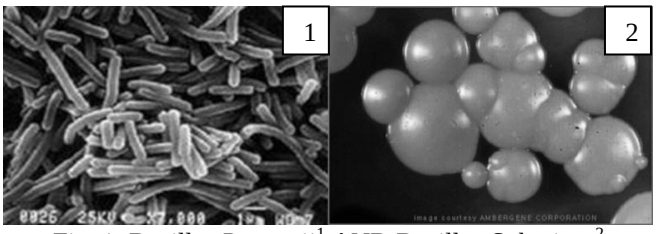

Fig. 1: Bacillus Pastuerii[1] AND Bacillus Sphericus[2]
1 - Image courtesy: www.ufrgs.br and
2 - Image courtesy: AMBERGENE CORPORATION)

II. EXPERIMENTAL PROGRAM

A. *Compressive strength study*

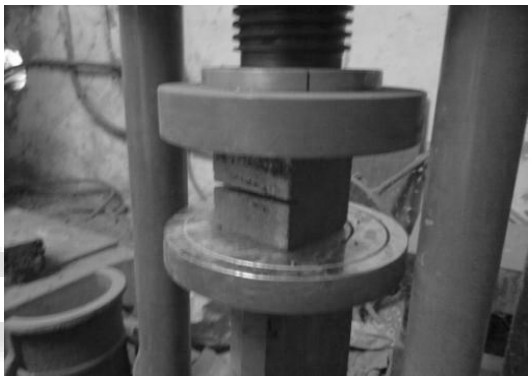

Fig. 2: Compression Test

Mortar cubes 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 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 inserted in crack mixed with standard sand and after that bacteria's were feed at every 6 hours interval. And After it Compression test carried out at 7th, 28th and 56th 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 inserted in crack mixed with standard sand and after that bacteria's were feed at every 6 hours interval. 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.

Fig. 4: Durability Test

III. TEST RESULTS

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

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)
15 mm depth	6.79	4.93	5.33	5.13
20 mm depth	6.79	3.99	4.26	4.13
25 mm depth				

Table. 2: Flexural test results at 56th days

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

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.

	wt. at 1 day (gm)	wt. at 56 day (gm)	Change in Weight %	ref. comp. Strength N/mm^2	comp. Strength N/mm^2	Change in Strength
Wocb	782	769	1.6	52.1	50.75	2.59
10 wc	767	759	1.1	33.91	32.45	4.31
10 WCB (Pastuerii)	752	739	1.7	42.2	40.25	4.62
10 WCB (Sphericus)	774	766	1.1	40.77	38.66	5.18
10 wc	772	765	0.9	28.69	27.87	3.76
20 WCB (Pastuerii)	771	762	1.1	36.52	34.98	4.22
20 WCB (Sphericus)	768	759	1.1	34.62	32.92	4.91
10 wc	761	751	1.2	20.66	19.98	3.29
30 WCB (Pastuerii)	765	754	1.4	31.77	30.13	5.16
30 WCB (Sphericus)	768	758	1.2	30.02	28.77	4.16

Table. 3: Results of experiment

V. CONCLUSION

Cracked repaired by Bacillus Pastuerii gives more strength in compressive, flexural and durability test than repaired by Bacillus Sphericus.

Fig. 4: Inserting Bacteria

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