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CRITICAL STUDY OF BACTERIAL CONCRETE OVER NORMAL CONCRETE

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Abstract

Concrete is a construction material that is used world- wide because of its first rate properties. When we said concrete in the building trade, we actually mean reinforced concrete that is RCC. As we know concrete is very strong in compression but weak in tension. However, the disadvantage of this material is that it simply cracks due to its low tensile strength. It is a well known fact that concrete structure are very vulnerable to cracking which allows chemicals and water to enter and disgrace the concrete, reducing the performance of the structure and also requires limited preservation in the form of repairs. The main reason behind the structural failure is the microcracks. Recently, A narrative technique is used to remediating microcracks called Biomineralization. It is a process by which living organisms form inorganic solids. It is done by the addition of bacterial strains namely Bacillus Sphaericus and Sporosarcina Pastuerii. When microcracks growth reaches the reinforcement due to exposure to water and oxygen and possibly CO_2, chlorides too. So, self healing concrete can be done by application of MICP (Microorganism used for calcium carbonate precipitation in concrete). The maximum crack width healed in the specimens of the bacteria series was 970micrometre, about 4 times that of non bacterial series. The applicability of specifically calcite mineral precipitating bacteria for concrete revamp and plugging of pores and cracks in concrete has been recently investigated and studies on the possibility of using specific bacteria as a sustainable and concrete -embedded self-healing agent was studied and results from current studies are discussed.

***Keywords**: RCC concrete, chemicals, MICP, microcracks, bacterial concrete etc.*

1. INTRODUCTIONMICP is a technique that comes under the broader category of science called “biomineralization”. This concept was given by “Ramakrishana”. It minics the process by which bone fractures in the human body are naturally healed by osteoblast cells that mineralize to reform the bone. In such a way that bacterial concrete heals the cracks in concrete.The self healing agent can lie dormant within the concrete for upto 200 yrs.This technique can be used to improve the compressive strength and stiffness of cracks in concrete specimens.

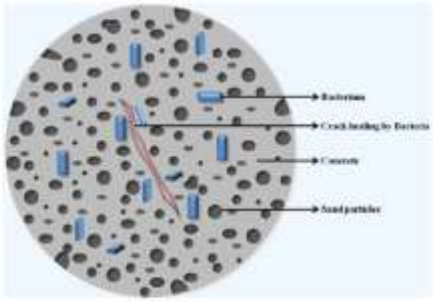

Fig. 1: Calcifying bacteria and their applications

2. LITERATURE REVIEW

1. Different types of bacteria, as well as abiotic factors (salinity and composition of the medium) seem to contribute in a variety of ways to calcium carbonate precipitation in a wide range of different environments (Knorre & Krumbein, 2000; Rivadeneyra et al., 2004).
2. The selection of bacteria is done on the basis of its high resistance against pH, temperature and lack of water content. So, due to this reason Ghosh, mandal (2006) and other researchers used thermophilic bacteria other than mesophilic bacteria 37.

3. OBJECTIVES

The objectives of the investigation were:

a. To study the effects of different concentrations of the bacteria on the durability of the concrete.

b. To study the efficiency of bacteria when suspended in different media (water, phosphate-buffer and urea-CaCl2) on the durability of the concrete.

4. VARIOUS TYPES OF BACTERIA USED IN CONCRETE

There are various types of bacteria were used in bacterial concrete construction are:

1. Bacillus pasteurizing
2. Bacillus sphaericus
3. Escherichia coli
4. Bacillus subtilis
5. Bacillus cohnii
6. Bacillus balodurans
7. Bacillus pseudofirmus

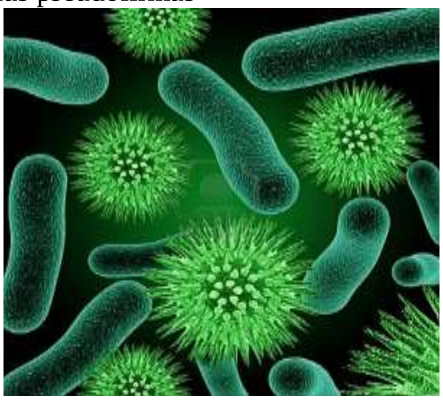

Figure 2: Bacteria – based self- healing concrete

5. MECHANISM OF CHEMICAL PROCESS

Self healing concrete is a result of biological reaction of non reacted lime stone and a calcium based nutrient with the bacteria to heal the cracks appeared on the building. Special types of bacteria's known as Bacillus are used along with the calcium nutrient known as Calcium Lactate. While preparation of concrete, this products are added in wet concrete when the mixing is done.

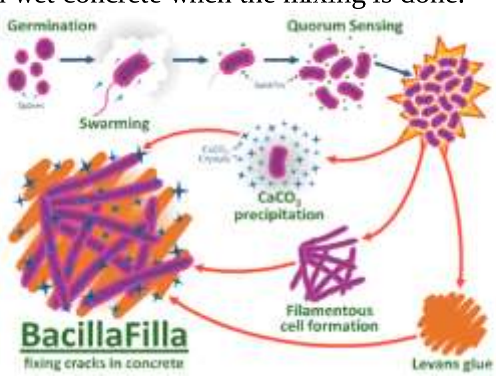

Figure 3: BacillaFilla fixing cracks in concrete

When the cracks appear in the concrete, the water seeps in the cracks. The spores of the bacteria grow and starts feeding on the calcium lactate overwhelming oxygen. The soluble calcium lactate is converted to insoluble limestone. The insoluble limestone starts to harden. Thus filling the crack, automatically without any external aide.

When the water comes in contact with the unhydrated calcium in the concrete, calcium hydroxide is produced by the help of bacteria, which acts as a catalyst. This calcium hydroxide reacts with atmospheric carbon dioxide and forms limestone and water . This extra water molecule keeps the reaction going. The limestone then hardens itself and seals the cracks in the concrete.

The bacteria used in this research produce urease which catalyzes the hydrolysis of urea ($CO(NH_2)_2$) into ammonium (NH_4^+) and carbonate (CO_3^{2-}), First, 1mol of urea is hydrolyzed intracellular to 1mol of carbonate and 1mol of ammonia (Eq. (1)). Carbonate impulsively hydrolyses to form additionally 1mol of ammonia and carbonic acid (Eq. (2)). These products subsequently form 1mol of bicarbonate and 2mol of ammonium and hydroxide ions (Eqs. (3) and (4)). The last 2 reactions give rise to a pH increase, which in turn shifts the bicarbonate equilibrium, resulting in the formation of carbonate ions (Eq. (5)).

$$CO(NH_2)_2 + H_2O \Rightarrow NH_2COOH + NH_3 \quad (1)$$

$$NH_2COOH + H_2O \Rightarrow NH_3 + H_2CO_3 \quad (2)$$

$$H_2CO_3 \Leftrightarrow HCO_3^- + H^+ \quad (3)$$

$$2NH_3 + 2H_2O \Leftrightarrow 2NH_4^+ + 2OH^- \quad (4)$$

$$HCO_3^- + H^+ + 2NH_4^+ + 2OH^- \Leftrightarrow CO_3^{2-} + 2NH_4 + 2H_2O \quad (5)$$

Since the cell wall of the bacteria is negatively charged, the bacteria draw cat ions from the environment, including Ca^{2+}, to deposit on their cell surface. The Ca^{2+} ions subsequently react with the CO_3^{2-} ions, leading to the precipitation of $CaCO_3$ at the cell surface that serves as a nucleation site (Eqs. (6) and (7)).

$$Ca^{2+} + Cell \rightarrow Cell\text{-}Ca^{2+} \quad (6)$$

$$Cell\text{-}Ca^{2+} + CO_3^{2-} \rightarrow Cell\text{–}CaCO_3\downarrow \quad (7)$$

Several bacteria have the ability to precipitate calcium carbonate. These bacteria can be found in soil, sand, natural minerals. This strain showed a high urease activity, a continuous configuration of dense calcium carbonate crystals and a very negative zeta-potential . Self-healing concrete is a product that will biologically produce limestone to heal cracks that appear on the surface of concrete structures. Specially selected types of the bacteria genus Bacillus, along with a calcium-based nutrient known as calcium lactate, and nitrogen and phosphorus, are added to the ingredients of the concrete when it is being mixed. These self-healing agents can lie latent within the concrete for up to 200 years.

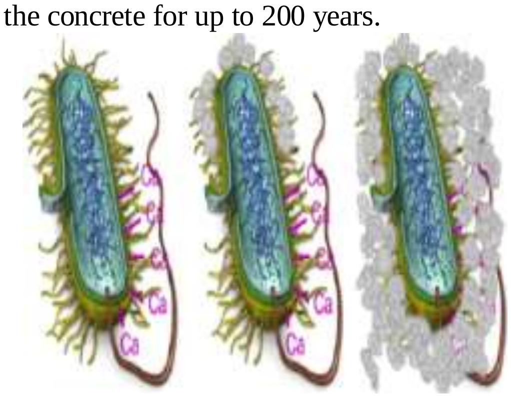

Figure 4: Calcite precipitation by bacterial concrete

6. APPLICATION OF BACTERIAL CONCRETE

The use of microbial concrete in Bio Geo Civil Engineering has become increasingly popular.

From improvement in toughness of cementitius materials to improvement in sand properties, from repair of limestone monuments, sealing of concrete cracks to extremely tough bricks, microbial concrete has been pleasing in one and all. Application of various bacteria in construction area by various author and other application of bacteria in construction area.

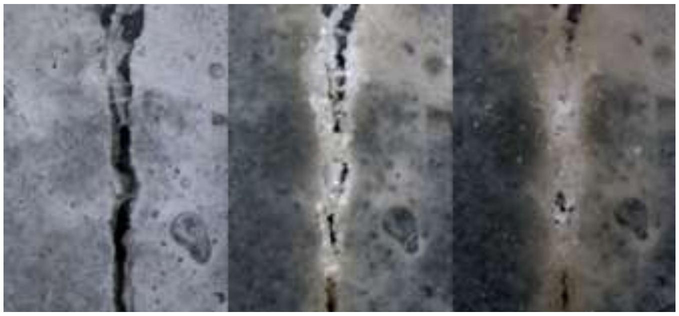

Figure 5: Stages of healing the concrete

7. ADVANTAGES OF BACTERIAL CONCRETE

1. Self repairing of cracks without any external adviser.
2. Important increase in compressive strength and flexure strength when compare to normal concrete
3. Resistance towards freeze- thaw attacks
4. Reduction in permeability of concrete
5. Reduces the corrosion of steel due to the cracks configuration and improves the durability of steel reinforced concrete

8. DISADVANTAGES OF BACTERIAL CONCRETE

1. Cost of bacterial concrete is double than conventional concrete
2. Growth of bacteria is not good in any atmosphere and media
3. Design of mix concrete with bacteria here is not available any IS code or other code
4. Study of calcite precipitate is costly

9. RESULT AND DISCUSSION

Table 1: Compressive Strength Test result for 7 and 28 days of Bacterial Concrete

Sr. No.	Days	Normal Concrete (N/mm^2)	Bacterial Concrete(N/mm^2)
1.	7	20.85	27.10
2.	28	30.00	38.95

Table 2: Flexural Strength Test result for 7 and 28 days of Bacterial Concrete

Sr. No.	Days	Normal Concrete (N/mm^2)	Bacterial Concrete (N/mm^2)
1.	7	3.90	4.6
2.	28	7.05	7.80

From the above table we have discussed that the compressive strength test result for 7 and 28 days of bacterial concrete. In 7 days the compressive strength of normal concrete is 20.85N/mm^2 as compared to bacterial concrete is 27.10N/mm^2. In 28 days the compressive strength of normal concrete is 30N/mm^2 as compared to bacterial concrete is 38.95N/mm^2 .

Then we have discussed about the flexural strength test result for 7 and 28 days. In 7 days the flexural strength of normal concrete is 3.90N/mm^2 as compared to bacterial concrete is 4.6N/mm^2 . In 28 days the flexural strength of normal concrete is 7.05N/mm^2as compared to bacterial concrete is 7.85N/mm^2.

10. CONCLUSIONS

a. From the results we can seen that both the compression strength and the flexural strength of the bacterial concrete is greater than that of normal concrete.

b. Limitations of biotechnological applications on building materials could be clearly understood from the past text studies.

c. Many cementitious and stone materials are capable of exhibiting improved compressive strength and reduction in permeability, water absorption, decay of reinforcement etc.

d. Cementation by bacteria is very easy and convenient for usage. This will soon give the basis for high quality structures that will be cost efficient and environmentally safe, but more work is required to advance the possibility of this technology from both inexpensive and practical point of views.

e. Increase in compressive strength is mainly due to the consolidation of the pores inside the cement mortar with microbiologically induced calcite precipitation.

f. When bacterial concentration increases, the Calcium Carbonate ($CaCO_3$) precipitation increases.

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