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SELF HEALING CONCRETE

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Abstract-- Concrete is no good when cracked as it defeats the very purpose of its use. Cracks in concrete can be seen in almost every structure around the world. Though small cracks in buildings does not imply that buildings or structures are not in good shape, but it surely says that the structure is deteriorating. So what does self healing in concrete does? It actually heals small cracks in concrete which eventually allows t increase the service life of a structure. When cracks appear in a concrete structure, the reinforcement comes in contact with CO_2 , water and other chemicalspresent in the atmosphere. The process of repairing cracks when they form is termed as self healing concrete. Self healing concrete is formed by using bacteria , therefore also called as bacterial concrete. Some types of bacteria used are Bacillus Sphaericus, Bacillus Subtilis,etc.

Keywords:Bacillus Subtilis, cracks, concrete, self healing.

I. Introduction

Self healing concrete as the name suggests is a type of concrete which can heal its cracks that are formed once the concrete comes in hardened state or when full strength of concrete is achieved. In the process of healing of cracks, no extra cost is required therefore in long term it becomes economical.
Self healing concrete is a relatively new concept and was developed by Dutch scientist HendrikJonkers. In self healing concrete one more important thing of importance is that the bacteria which is used consumes the oxygen available to it, thereby preventing the internal corrosion of the steel or reinforcement present in the concrete.
Bacterial concrete or self healing concrete fills up the cracks developed in structures by the help of bacterial reaction in the concrete after hardening. The process of self-healing of cracks or self-filling up of cracks by the help of bacterial reaction in the concrete after hardening is known as Self-Healing Concrete.[3]
Concrete constructions are currently designed according to set norms that allow cracks to form up to 0.2 mm wide. Such micro cracks are generally considered acceptable, as these do not directly impair the safety and strength of a construction.[6]
Moreover, micro cracks sometimes heal themselves as many types of concrete feature a certain crack-healing capacity.
Researchers call the material "bioconcrete" that can "self-heal." In order to keep the bacteria dormant until it is needed, it is placed in small, biodegradable capsules containing the nutrient. When the concrete cracks, and water enters the gaps, it comes into contact with the bacteria and the food source, setting the healing process off. The bacteria then feed on the calcium lactate, joining the calcium with carbonate to form limestone, fixing the crack.[4]
There are various types of bacteria were used in bacterial concrete construction are:

- Bacillus pasteurizing
- Bacillus sphaericus
- Escherichia coli
- Bacillus subtilis

II. Mechanism of Bacteria concrete[2]

Self-healing concrete is a result of biological reaction of non-reacted limestone and a calcium based nutrient with the help of bacteria to heal the cracks appeared on the building.
Special type of bacteria's known as Bacillus are used along with calcium nutrient known as Calcium Lactate. While preparation of concrete, this products are added in the wet concrete when the mixing is done. This bacteria's can be in dormant stage for around 200 years.

When the cracks appear in the concrete, the water seeps in the cracks. The spores of the bacteria germinate and starts feeding on the calcium lactate consuming 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.

The other advantage of this process is, as the oxygen is consumed by the bacteria to convert calcium into limestone, it helps in the prevention of corrosion of steel due to cracks. This improves the durability of steel reinforced concrete construction.

III. Preparation of Bacteria concrete

Bacterial concrete can be prepared in two ways -

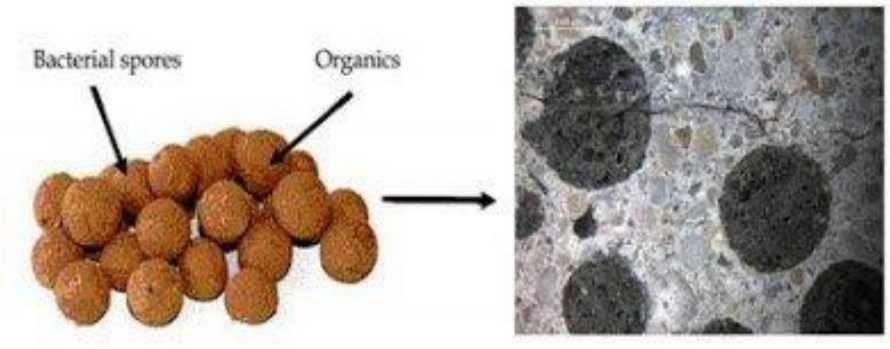
- By direct application
- By encapsulation in lightweight concrete

In the direct application method, bacterial spores and calcium lactate is added into concrete directly when mixing of concrete is done. The use of this bacteria and calcium lactate doesn't change the normal properties of concrete. When cracks are occurred in the structure due to obvious reasons.

The bacteria are exposed to climatic changes. When water comes in contact with this bacteria, they germinate and feed on calcium lactate and produces limestone. Thus sealing the cracks.[1]

By encapsulation method the bacteria and its food i.e. calcium lactate, are placed inside treated clay pellets and concrete is prepared. About 6% of the clay pellets are added for making bacterial concrete.[3]

When concrete structures are made with bacterial concrete, when the crack occurs in the structure and clay pellets are broken and the bacteria germinate and eat down the calcium lactate and produce limestone, which hardens and thus sealing the crack. Minor cracks about 0.5mm width can be treated by using bacterial concrete.



Process of Bacterial Concrete [7]

Among these two methods encapsulation method is commonly used, even though it's costlier than direct application.

IV. Chemical Process of Self-Healing or Bacterial Concrete

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.

$$CaO + H_2O \rightarrow Ca(OH)_2$$

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

The limestone then hardens itself and seals the cracks in the concrete.

Results on bacterial concrete and normal concrete [7]

Table 1 - Compressive Strength Test Result for 7 and 28 days for Bacterial Concrete

Sr. No.	Days	Normal Concrete (N/mm^2)	Bacterial Concrete (N/mm^2)
1	7	20.5	26.9
2	14	26.8	34.0
3	21	28.7	35.9
4	28	29.7	38.5

V. Conclusion

In this paper it is shown that the concrete which can crack due to various reasons such as excessive load, weathering of concrete,etc., can be healed by applying specific bacteria during the process of mixing, in encapsulated form. The bioconcrete formed as a result of above process can heal minor cracks. Also the compressive strength of the concrete is enhanced by almost 30% which is a very significant amount. So even though the cost of bioconcrete is a bit high but this is overshadowed by its enhanced properties.

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