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Self Healing Concrete

Sakshi Bhalerao[1], Nikhil Gaikwad[2]

[1]Sakshi Bhalerao, Dept. of Civil Engineering, MITWPU, India
[2]Nikhil Gaikwad, Dept. of Civil Engineering, MITWPU, India

Abstract – *In today's world, selection of appropriate materials plays vital role in construction. Concrete is the prevalent construction material. Sustainability of concrete is very important. Concrete is susceptible to climatic changes therefore cracks occur in the material. To reduce crack formation and achieve sustainable concrete, environmental friendly and effective methods can be adopted. Self healing concrete reduces maintenance cost and damage detection cost. However, it is not currently used on an industrial scale. Bacterial concrete can be an effective response to the sustainability of concrete. So, in this paper we have explained self healing concrete technique to get better sustainability.*

Key Words: **Self healing, Concrete, Sustainable, Cracks, Bacteria**

1. INTRODUCTION

Concrete is the most important material in construction. There are various methods available to attain strong, durable and sustainable concrete but due to some errors like temperature variation, improper handling, application of heavy loads, corrosion of reinforcement steel, etc. cracks occur in structure. Crack formation is very common yet inevitable problem.

Dutch scientist Hendrik Jonker invented a Self healing concrete technique. In this technique various bacteria are used to heal cracks occurred in concrete structure. Self healing concrete fills up the crack developed in structure with the help of bacterial reaction. The process of Self healing cracks by the bacterial reaction in the concrete after its hardening is known as Self-healing concrete. In this method, concrete is the product which produce limestone biologically and helps to heal cracks that appear on concrete structure. These Self healing agents can lie dormant in concrete up to 200 years.[1]

Repairs of concrete structure involves application of mortar on damaged surface which helps to bond the surface. Sometimes, metal pins are used to ensure it does not fall away. Repairs can be time consuming as well as expensive. It can be very difficult to get access to damaged parts especially when they are underground or at great height. So, to overcome these difficulties Self healing concrete can be used.

2. SELF HEALING

When cracks are formed in the structure, water seeps through it and spores of the bacteria germinate when comes in a contact with the water and feed on calcium lactate and produces limestone. Limestone solidifies on cracks developed and leads to sealing of cracks.

In this process, consumption of oxygen is involved. Oxygen is an essential element in the process of corrosion of steel and because of this bacterial activity, oxygen gets consumed which leads to increasing the durability of steel reinforced concrete structure. Testing has shown that when water seeps into structure through cracks, bacteria germinate and gets multiply quickly. They convert nutrients into limestone within seven days. However, it may take longer outside in lower temperature. This type of bacterial concrete can be prepared in three ways:

1. By direct application.
2. By encapsulation in light weight concrete.
3. By vascular method

2.1 BY DIRECT APPLICATION

In this type, bacterial spores and calcium lactate is added directly into concrete at the time of mixing of concrete. Even if addition of bacterial spores and calcium lactate is done, it does not change any normal properties of concrete. Due to the formation of cracks, bacteria are exposed to the climatic changes. When water comes in a contact with bacteria, they germinate and feed on calcium lactate and produce limestone. Thus it seals crack. [2]

2.2 BY ENCAPSULATION IN LIGHT WEIGHT CONCRETE

In this type, bacteria and their food i,e. calcium lactate placed inside the treated clay pellet and concrete is prepared. About 6% of clay pellets are added for making bacterial concrete. When cracks occur in a structure, clay pellet gets broken and bacteria germinate, eat their food and then produces limestone which hardens and seals the crack.

2.3 BY VASCULAR METHOD

In this method a network of vascular tube is built in structure by implanting smooth glass tube bars into the concrete and then removing it later, which leaves space in the structure in which bacterial pores can be injected or pumped. In this process the healing bacteria can be applied for longer period giving a higher healing rate and better efficiency of healing process.[4]

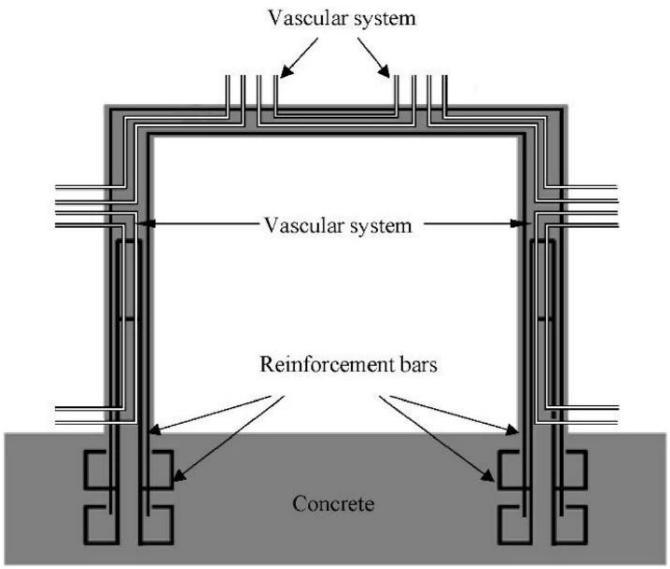

Figure 1: Vascular system of Self healing concrete [3]

3. VARIOUS BACTERIA

Following are the various bacteria which can be used in bacterial concrete construction:

- Bacillus pasteurizing
- Bacillus sphaericus
- Escherichia coli
- Bacillus subtilis
- Bacillus cohnii
- Bacillus balodurans
- Bacillus pseudofirmus

4. CHEMICAL PROCEDURE

When the bacteria are mixed with concrete, the bacteria are in an inactive state .When water comes in a contact with un-hydrated calcium in concrete, calcium hydroxide is produced by the help of bacteria which acts as a catalyst. Calcium hydroxide reacts with atmospheric carbon dioxide and forms limestone and water. This extra molecule of water keeps the reaction going. Chemical reactions accrued in this process are expressed through the equations below.[7]

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

$$Ca(C_3H_5O_2)\ 2 + 7O_2 \rightarrow CaCO_3 + 5CO_2 + 5H_2O$$

Figure 2: Chemical reaction [5]

5. EFFECT ON CONCRETE PROPERTIES

Following are the effects on Concrete Properties:

5.1 SETTING TIME

The addition of bacteria gives mix result in setting time. Depending on nutrient or bacteria added the setting time is accelerated or retarded, like calcium lactate delays setting time where as calcium nitrate quickens setting time

5.2 COMPRESSIVE STRENGTH

The compressive strength either may increase od decrease depending on the spice of bacteria used and the percent of cement and aggregate replaced.[6]

5.3 PERMEABILITY

As compared to normal concrete bacterial concrete has reduced permeability as the pores are filled with calcium carbonate. Bacteria's reduce water absorption and porosity of concrete which increases durability.

6. ADVANTAGES

- It increases durability of steel reinforced concrete structures.
- Self-repairing of cracks without any external aid.
- Significant increase in compressive strength and flexural strength compared to normal concrete.
- Resistance towards freeze-thaw attacks.
- Reduction in permeability of concrete
- Bacillus bacteria are harmless to human life and hence can be used effectively.

7. DISADVANTAGES

- Bacterial concrete is costly than conventional concrete.
- Volume of concrete increases by holding clay pellets. [8]
- Design of mix concrete with bacteria is not available in any IS code or other code.
- Investigation of calcite precipitate is costly.

8. CONCLUSION

In the above paper it is explained how Self Healing Technology assures to be a durable solution for current problems faced in concrete structures. This method does not provide any harm to human health, and therefore we have also explained how it can be used effectively in upcoming years. It is also expected that such materials and structures can survive for at least 50 years.

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