

A Study on Self Healing Mortar Cubes Adding Different Proportion of Bacteria

Bhagyashree B. Parmar¹, Rahulkumar B. Shah², Nirav C. Vaghasia³

^{1,2,3}Dept of CIVIL ENGINEERING

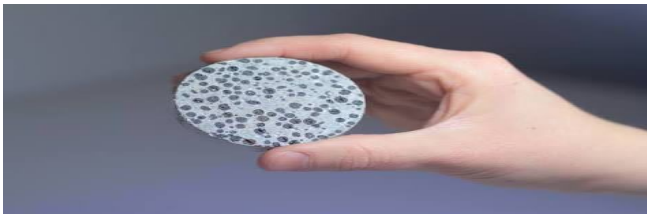
^{1,2,3}Alpha College Of Engineering And Technology

Abstract- The most commonly observed failure in the case of concrete is crack. Due to addition of excess of water during mixing of concrete or may be due to shrinkage and creep, crack may be developed. If any treatment and precaution are not taken, then crack will expand further more and require expensive repair. This project discusses about the filling of voids in fresh concrete and healing of artificially cracked cement mortar using *Bacillus Sphaericus* (for surface treatment) and *Bacillus Pasteurii* (crack healer) bacteria's. The mechanism of crack healing in self healing concrete presumably occurs through metabolic conversion of calcium lactate to calcium carbonate which results in crack healing. The effect on the compressive strength, flexural strength due to the mixing of bacteria along with effect of water absorption and sorpivity on concrete cubes is shown in our project. also perform SEM test for analysis of creak healing in concrete.

Keywords- crack, *Bacillus Sphaericus*, *Bacillus Pasteurii*, crack healer, SEM test

I. INTRODUCTION

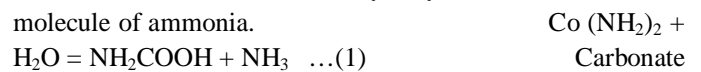
Defination - Henk Jonker and his microbiology researches group invented a special type of concrete . Other names of self healing concrete are:-1.Bio concrete 2.Bacterial concrete. Lifespan and durability of concrete structure can also be increased by using the self healing concrete in the structure.



Purpose- Nowadays, cracking is common phenomenon due to low tensile strength if the proper treatment is not applied on the structure than it tends to expand further and eventually require costly repair. **Solution-**Self Healing concrete is a special type of concrete it has the ability to repair itself autonomously one other advantage of bacteria in concrete also helps in enhancing the properties of concrete in both natural and laboratory conditions. As per the self healing property and

enhancement in other aspects of concrete like durability, it is clear that addition of this kind of agent in concrete would save environment and money. Because the other pre-defined materials for enhancement in strength and durability were not more costly than bacterial concrete and they also require regular maintenance which reduces the economy of structure.

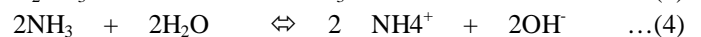
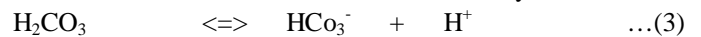
Process of self healing mortar-The bacteria used in this research produce urease which catalyzes the hydrolysis of urea ($\text{Co}(\text{NH}_2)_2$) into ammonium (NH_4^+) and carbonate (Co_3^{2-}). First, 1 molecule of urea is hydrolyzed intracellular to 1 molecule of ammonia.



Carbonate spontaneously hydrolyses to form additionally 1 molecule of ammonia and carbonic acid



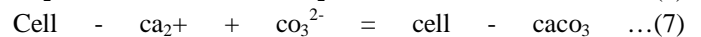
These products subsequently from 1 molecule of bicarbonate and 2 molecules of ammonium and hydroxide ions.



The last 2 reactions give rise to a pH increase, which in turn shifts the bicarbonate equilibrium, resulting in the formation of carbonate ions.



Since the cell wall of the bacteria is negatively charged, the bacteria draw Ca^+ 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



Several bacteria have the ability to precipitate calcium carbonate. These bacteria can be found in soil, sand, natural minerals.

II. METHODOLOGY

Selection of bacteria-There are various types of Bacterias that can be used in the concrete of bacillus group such as *B. Subtilis*, *B. Pasteurii*, *B. Sphaericus* etc. We have selected ***Bacillus Sphaericus*** (for surface treatment) and ***Bacillus Pasteurii*** (crack healer) since these bacteria produces Calcium Carbonate and due to ease of availability from the

nearest laboratory, we have used it for our future investigation. It is also formally known as Hay bacillus or grass bacillus is a Gram-positive, catalase-positive bacterium, found in soil and many more places the gastrointestinal tract of ruminants and humans.



Safety measures for the Bacterial solution-Bacteria are harmful for the health and it may lead to diseases like (diarrhea and headache), therefore precautions must be taken. It is compulsory to use gloves and cover your mouth while dealing with the bacterial solution. The flask must be slightly heated before pouring the bacterial solution. The whole procedure must be done between the two candles so that the bacterium doesn't get contaminated and polluted by the interference of the other bacteria's present in the environment.

Method of mixing-There are different methods of mixing the solution in the concrete which are viz. 1. Direct Mixing 2. Indirect Mixing 3. Injection Method. In our study we have adopted the direct method in which, firstly the measuring jars were sterilized in oven for a temperature of about 100°C to 105°C for 5 minutes. After 5 min. once it gets slightly cooled, the bacterial solution is poured from the flask in the measuring jar. The flask is firstly heated under the candle before pouring it into the jar, so that the bacterium doesn't get contaminated or polluted by the other bacteria's present in the environment. Once the bacterial solution is mixed in the water, the water is properly stirred and then it is used for immersion in the mortar or concrete.

Preparation of mortar-From the above proportion of material 30 mortar cubes are casted shown below. IS code used IS-1541 specification for same for plastering.

Sand size = 10mm

W = 16%

C/S = 1:4

Mould capacity = 800 gm

No. of mould = 36

For 1 mould

Cement = 160 gm

Sand = 640 gm

Total = 800 gm



Healing:-3 mortar cubes of different proportion for healing purpose after 7 days curing.

Compressive test:-3 mortar cubes of all types for 7, 14 and 28 days for compressive strength test.

Healing test of self-healing concrete-
 1. Crack formation
 2. Sprinkling of water
 3. Measuring of crack

Crack formation:-All mortar cubes of 5ml, 10ml, 15ml, 20ml, 25ml are test on compressive testing machine after 7 days of curing. Gradually the load is applied in all the mortar cubes. There are 3 cubes of different proportion of bacteria so we have to take the average of that 3 cubes for healing purpose. Minimum load is applied on the mortar cube at which the crack is formed on the cubes.



Sprinkling of water-After the crack is generated in all the mortar cubes, the mortar cubes needs the water for formation of calcium carbonate (CaCO₃).

Measuring of crack-Scanning Electron Microscope (SEM):-The Morphology and mineralogical composition of the deposited calcium carbonate crystals were investigated using scanning electron microscope (SEM). SEM micrographs were obtained using a jeol JSM5600 LV model Philips XL 30 attached with EDX unit, with accelerating voltage 30K.V., magnification 10x upto 400000x and resolution for W.(3.5 nm). Samples surface were first coated with carbon then with gold.

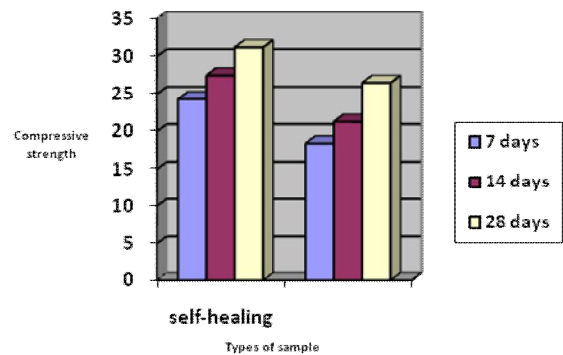


Scanning Electron Microscope Machine

III. EXPERIMENTAL RESULTS AND DISCUSSION

Experiment and results are important to perform so that the characteristics of concrete cube are know properly and also for justify them.

Compressive Strength:-As we perform the compressive strength test on the mortar cubes on different days to know the strength taking capacity of cubes. As the self healing concrete is casted by knowing the optimum dosage of bacteria in the mortar cubes. So, we also have to know that the percentage of bacteria will also increases the compressive strength of concrete or not.



Healing result-

No.	Types of concrete	Healing measurement (5mm crack)
1	Conventional concrete	No healing
2	5 ml	97 % of total healing
3	10 ml	75 % of total healing
4	15 ml	50 % of total healing
5	20 ml	40 % of total healing
6	25 ml	35 % of total healing

From this results, it clearly shown that we are getting better results in 5ml proportion of bacteria in mortar cubes. So main aim of our project is to compare self-healing concrete and conventional concrete, so for that we need the proportion of bacteria for self healing concrete. According to cement content from self healing mortar to self healing concrete the proportion of bacteria in self healing concrete is found by,

Self healing mortar

160 gm = 5 ml

Self healing concrete

1480 gm = (?)

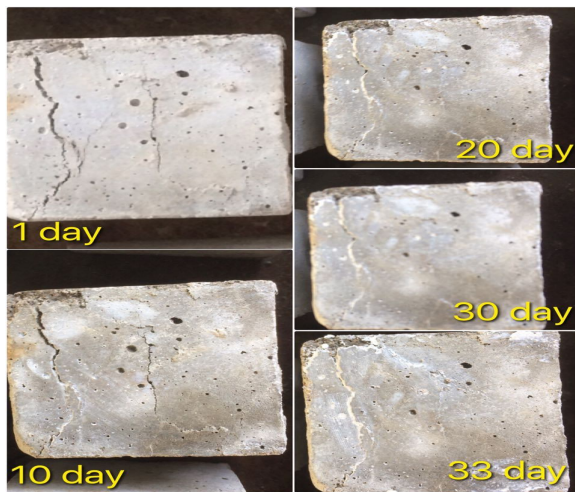
From interpolation

160 = 5 ml

1480 = (?) (46.25 ml)

So for self healing concrete we used 46.25 ml of bacteria in 1 mould of concrete Cubes.

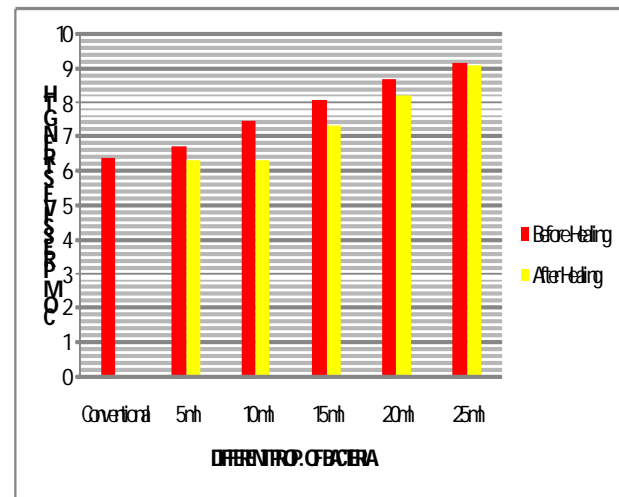
Healing result of mortar cubes-



Mortar: - Compressive strength (After healing)-

1. Crack formation
2. Sprinkling of water
3. Measuring of crack

As the self healing mortar heals its crack after 33 days, so we provided sufficient atmosphere for our bacteria to convert calcium lactate into calcium carbonate. After 33 days it is clearly visible that the crack in the mortar are fully heal. So it can also gain its strength. After 33 days we provided 7 more days for self healing mortar to gain its strength. The result signify that after healing the capacity of mortar gaining the compressive strength is somewhat less than before healing of self healing mortar.



IV. CONCLUSION

1. As the Self-healing concrete is eco-friendly in nature, as it increases the durability of many building materials, the self-healing concrete is found that is more advantages than conventional concrete.
2. Reduction in permeability.
3. As the bacterial concentration increases, the formation or precipitation of calcium carbonate is also increases.
4. Reduction in reinforcement corrosion.
5. The increases of strength showing in our investigation by adding more bacteria out there is optimum dosage for getting the maximum healing of concrete.
6. As the presence of concentration of *B. pasterii* increases the compressive strength of Portland cement mortar cubes.
7. Increases in compressive strength is mainly due to consolidation of cracks Inside that there are small pores which will fill by microbiologically induced calcium precipitation.

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