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# Experimental Study on Behaviour of Self-Healing Concrete Using Ceramic Tiles Powder by the Replacement of Fine Aggregate

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**ABSTRACT:** One of the most common problems developed in concrete is about cracks. Cracks are unavoidable in concrete and make the concrete elements weak. Cracks allow water and other salts to seep through them and make the concrete weak and reduce the life of concrete. Corrosion of steel due to salts weakens the reinforced concrete in tension as well. So there is need to develop the methods for curing the cracks and regaining the strength of concrete structures. Currently synthetic polymers can be used to repair the cracks which are harmful to environment which lead to develop biological treatment techniques. In this study, a biological repair technique was used in which bacteria of 105 cells/ml were mixed with concrete to heal the cracks. The experiments were carried out to evaluate the effect of *Bacillus cohnii* on the compressive strength, Tensile strength, and Flexural test for, 7 and 28 days. In addition to above technique ceramic powder was partially added in the place of fine aggregate. The ceramic powder (5, 10, 15 and 20 %) was added by weight of fine aggregate in concrete mix and experiments were carried out. The experimental results show that 10 % ceramic powder replaced concrete with and without bacteria has more strength when compared to the conventional concrete.

**KEYWORDS:** Bacterial Concrete, ceramic powder, Eco-friendly, *Bacillus Subtilis*.

## I. INTRODUCTION

Concrete must be relatively impervious to withstand the service conditions for which it has been designed, without serious deterioration over the lifespan of the structure. The loss of concrete durability may be caused by the severity of the environment to which it is exposed or by internal changes within the matured concrete itself. The external causes may be physical, chemical or mechanical and may be due to attack by natural or industrial aggressive liquids and gases. The impact of durability-related problems, particularly, cracking of the surface layer of concrete reduces material durability as ingress water and detrimental chemicals cause a range of matrix degradation processes as well as corrosion of the embedded steel reinforcement. One of the recent methods to improve the durability and strength of concrete is by the addition of bacteria into the concrete which protects the concrete by natural calcite deposition.

Self-Healing Concrete means that repairs its own cracks. Self-healing is the tightening of cracks, probably due to the precipitation of calcium carbonate and the clogging of particles. When self-healing is considered, a crack has healed when it is liquid tight again. When cracks heal in this way, the strength recovery is limited. Self-healing can only occur for cracks smaller than 0.2 mm. Another healing mechanism is the tightening of cracks by the use of microorganisms. So we can use the non-pathogenic bacteria's such as *Bacillus Subtilise*, *Pseudomonas Fluoresces* and *Escherichia Coli*. And they are non-host based bacteria which are capable of multiplying and recharged to be refilled within the concrete. Thus crack can be refilled by these bacteria. When cracks appears in a concrete structure and water starts to seep in through the spores of the bacteria starts microbial activities on contact with the water and oxygen. A peptone based nutrient supplied along with bacteria to growth the biologically induced concrete has exhibited better durability and crack repairing performance compared to normal concrete.

### Objectives

- To minimize cost of self-healing concrete.
- To utilize the wastage material.
- To reduce landfill disposal. Redirect recyclable recovered resource back to the manufacturing process.
- To determine compressive strength .

## II. LITERATURE REVIEW

**H.M.Jonkers (2011)** In this paper the author discussed about the mechanisms of self-healing concrete. The study shows that the crack healing of self-healing concrete based on expanded porous clay minerals loaded with bacteria and calcium lactate is more efficient than of concrete of the same composition with empty expanded clay particles. Therefore, the conclusion of the work is that the two-component bio-chemical healing agent is a more promising bio-based and thus a sustainable alternative for the healing process of cracks in the concrete.

**Soundarya et al (2014)** In this paper the author reviewed that the effect of the calcite precipitating bacteria and its self-healing mechanism. The bio mineralization process is carried out to study on the calcite precipitating bacteria. The different kinds of bacteria and its properties are explained. The chemical process and its healing capacity is determined at the course of the paper. The application of the bacterial concrete, its advantages and disadvantages are briefly explained in the paper.

**Salmabanu Lehar et al (2015)** The paper reviewed about the research done by different authors. According to the study in the paper it is shown that the cracks healed by autogenously mechanism in various sizes such as 0.5 mm to 0.87 mm. The condition of microorganism and its growth were studied on different kinds of bacteria. It was determined that the bacteria feeds on the nutrient source provided to it which in turn produces the calcium carbonate in the form of limestone and heals the cracks.

**Museet Genet Mehari et al (2017)** this paper explained the factors affecting the self-healing efficiency of cracked concrete structures. The factors affecting are size of the crack, age of concrete and its crack, temperature, pressure, healing time, presence of water and air, dosage, size and dispersion of capsules, healing agents and its viscosity, concrete material composition, expansive agents and mineral admixtures and most importantly the  $Ca^{2+}$  ions concentration. It is concluded from the paper that in order to realize self-healing efficiency and reliability, it is very essential to take care in opting a healing agent.

**Kusuma K et al (2018)** In this paper the most important aspects of self-healing concrete were discussed. The bacteria used for the experiment was *Bacillus Manutergium*. The bacteria were isolated and the bio-concrete mechanism were explained in detail. All the basic tests for cement, fine aggregate and coarse aggregate were conducted and the results were tabulated. The study on the self- healing concrete showed that there was an enhancement of compressive strength of concrete. It also showed that the water absorption and the water permeability of the concrete had a positive effect. The paper concluded that the use of bio concrete can be a competent alternative and high-quality concrete sealant which is an ecofriendly and a cost -effective way when compared to conventional concrete.

III. METHODOLOGY

RAW MATERIAL

Cement

Cement is a binder, a substance that sets and hardens independently, and binds other materials together. Many types of cements are accessible in the market. The frequently used cement is Ordinary Portland cement. Ordinary Portland cement of 53 grade was used for the analysis. The specific gravity of Ordinary Portland cement was 3.15 g/cm<sup>3</sup>.

Coarse aggregate

The coarse aggregate is the huge component of concrete. It is chemically a steady material. Existence of coarse aggregate reduces the drying shrinkage and other dimensional changes occurring on account of movement of moisture. Hard broken granite stones were used as coarse aggregate in concrete. Size of coarse aggregate used in the inspection was 10mm. The specific gravity of the coarse aggregate was found to be 2.68

Fine aggregate

The main function of the aggregate is to assist in producing fine aggregate also help the cement paste to hold the coarse aggregate particle in suspension. This action promotes plasticity in the mixture and prohibit the possible segregation of paste and coarse aggregate. It should be reliable, clean and be free from organic matters. It should not contain any definite amount of clay balls and harmful impurities such as alkalis, salt, coal, decayed vegetation etc. Streams and has been used as fine aggregate. The specific gravity of sand was initiated to be 2.56. Natural sand confirming to zone II with a specific gravity of 2.43 was used. The test was done as per IS: 383-1970 reaffirmed in 1997.

Chemical composition of fine aggregate.

constituents	% by mass
alumina	13.86
silica	79.98
Potassium and sodium	1.67
Calcium	0.87
titanium	0.15
iron	1.89
manganese	1.44
LOI	0.31

MIX PROPORTIONS

Proportioning of concrete mixtures consist of determination of respective ingredients necessary to produce concrete having adequate workability, strength and durability for the particular strength and for various exposure conditions. Here cement content with 360 kg/m<sup>3</sup> mix was designed for the study. The mix was designed by keeping a constant density of 2400 kg/m<sup>3</sup> and W/C ratio of 0.4. The mix proportions for the controlled concrete mix of 360 kg/m<sup>3</sup>, grade is found to be 1: 2.1: 3.16: 0.40. This mix was used throughout the study. The details of different mix proportions for 360 Kg/m<sup>3</sup>.



Mix Properties

Grade mix without rice husk and bacteria, and with rice husk are given in Table 2. Various mixes are denoted starting from M1 to M4 that are given in Table 2.



Table 2 Mix Design for 360kg/ m<sup>3</sup> of cement content with bacteria and Ceramic Tiles Powder

Item	M 1	M 2	M 3	M 4
Cement ( %)	100	100	100	100
Cement (kg/m <sup>3</sup> )	360	360	360	360
Coarse aggregate (kg/m <sup>3</sup> )	1138	1138	1138	1138
Sand (kg/m <sup>3</sup> )	720	682	644	606
Ceramic tile powder (%)	5	10	15	20
Ceramic tile powder (kg/m <sup>3</sup> )	38	76	114	152
Water (L/m <sup>3</sup> )	144	144	44	44
Bacteria (L/m <sup>3</sup> )	100	100	100	100

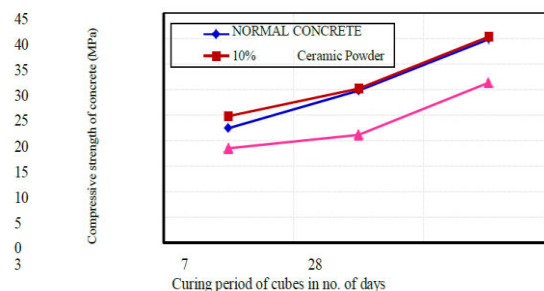
IV. EXPERIMENTAL RESULTS

Compressive Strength for Cubes

Compressive strength values of cubes for 7 days and 28 days with various replacement levels are shown in Table 4. It is observed that the 7 days compressive strength has been increased by addition of Bacillus cohnii by 10%. And the 28 days compressive strength has been increased by addition of Bacillus cohnii by 12%. It is observed that 7 days compressive strength of concrete by replacement of fine aggregate with 5% of ceramic powder has been increased by addition of Bacillus cohnii by 23%. And the 28 days compressive strength of concrete by replacement of fine aggregate with 5% of ceramic powder has been increased by addition of Bacillus cohnii by 26%. From these results the addition of bacteria is increasing the compressive strength of concrete and this increase is more in microbial concrete when ceramic tile is used as 5% replacement to the fine aggregate.

Table 4 Compressive Strength of Cubes

Mix	Ceramic powder (%)	Bacteria (L/m <sup>3</sup> )	7 days (N/mm <sup>2</sup> )	28 days (N/mm <sup>2</sup> )
M-1	0	0	34.55	44.2
M-2	5	0	9.45	18.1
M-3	0	100	38	49.55
M-4	5	100	11.7	22.7



Split Tensile Strength for Cylinders

Split Tensile strength values of cylinders for 28 days with various replacement levels are shown in Table 5. It is observed that the 28 days Split Tensile Strength has been increased by the addition of the bacteria Bacillus cohnii by 12%. When the fine aggregate is replaced with 5% of ceramic powder it has been observed that an increase of 14% in the split tensile strength of the concrete.

Mix	Split Tensile Strength (N/mm <sup>2</sup> )
M-1	2.99
M-2	2.41
M-3	3.34
M-4	2.73

## V. CONCLUSION

- Compressive strength at 7 days has been increased by addition of *Bacillus cohnii* by 10%. And the 28 days compressive strength has been increased by addition of *Bacillus cohnii* by 12%. Compressive strength of concrete at 7 days by replacement of fine aggregate with 5% of ceramic powder has been increased by addition of *Bacillus cohnii* by 23%. And the 28 days compressive strength of concrete by replacement of fine aggregate with 5% of ceramic powder has been increased by addition of *Bacillus cohnii* by 26%. From the above
- Bacterial concrete is advantageous than conventional concrete due to its self-healing capacity and eco-friendly nature.
- Concrete with 10% ceramic powder showed increase in strength and 30% ceramic powder showed decrease in strength when compared to normal concrete.
- Calcite precipitate of bacteria indirectly increases the strength of concrete by filling the voids. The cost of Bacterial concrete is more. So, it is profitable when we go for higher RC structures. By using bacterial concrete the rehabilitation cost can be reduced.

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