The Asian Review of Civil Engineering
ISSN: 2249-6203 (P) Vol.7 No.2, 2018, pp.16-19

DOI: https://doi.org/10.51983/tarce-2018.7.2.2265

An Experimental Study on Self Healing Concrete Using Bacteria

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Abstract - **Concrete will prolong to be the important material for building construction, but this concrete structure are subjected to cracking .These cracks on the surface of the concrete make whole structure obnoxious because of the water that ooze into the concrete. These cracks can be rehabilitated by self-healing concrete which will biologically produce limestone. There are two self-healing agent parts they are the bacterial spores and the calcium lactate. These agents are introduced to the concrete during the cement-mixing process. Therefore the bacteria that satisfy the above norms are Bacillus pasteurii and its optimum temperature is 35º- 45º. It is an environmentally, friendly, biotic process and it is also a self-remediating process. These self-healing concrete is potential of lengthening in service life of public buildings. The aim of our project is to develop a new type of concrete in which bacteria promote self-healing of cracks. Various tests such as compressive strength test, split tensile strength test and flexural strength test will be carried out. The grade of concrete used in our project is M20.**
Keywords: **Bacillus Megaterium, Steam Curing, Bacterial Preparation**

I. INTRODUCTION

Concrete shows relatively high compression strength and lower tensile strength. The elasticity of concrete does not vary at low stress levels but starts reducing at higher stress levels as crack develop. All concrete structures would crack at some point, due to shrinkage and tension. Concrete when subjected to continuous forces are prone to creeping.

II. BACTERIA IN CONCRETE

Concrete is highly alkaline building material, so bacteria used should be able to survive in this high alkaline environment for long durations and be able to form spores, withstanding the mechanical forces during concrete mixing. These are rod shaped bacteria which can create a tough protective endospore and also these can survive under extreme environmental conditions.

Fig. 1 Cultured Bacteria and its Microscopic View

A bacterial concrete mix is prepared by using alkali-resistant soil Bacillus Megaterium, along with nutrients from which the bacteria could potentially produce calcium based bio materials. Such bacteria are Gram-Positive Bacteria and have enormously thick outer cell membrane that makes them to retain viable until a suitable circumstances is available to grow. The only aspect need to be checked is the result of nutrients media on the setting time of the cement.

Bacteria induced precipitate has been proposed as an alternative and environmental friendly crack remediation. It is greatly advantageous because the bacterial precipitation brought as a result of microbial activates in pollution free and natural.

Fig. 2 Encapsulation of Bacteria and its Nutrients

III. STEAM CURING

Steam curing at atmospheric pressure is one of the methods for obtaining high early strengths in concrete especially in precast concrete production. This technique enables early removal of shuttering and facilities early vacating of the pre-stressing bed in precast industry providing a major economic advantage as well. It also aids in faster and safer construction as sufficient strength is attained in short period and maintained without any other form of curing. The strength enhancement depends on steam curing cycle. The parameters involved in an steam curing period followed by gradual cooling.

Steam curing is adopted to attain early strength in concrete, where additional heat is required to accomplish hydration. Steam curing is the process by which concrete is cured at high temperatures at atmospheric pressure in steam. At the same time, moulds can be removed earlier and less curing storage is required which gives an economic advantage. Here, we have adopted Steam curing for Bacterial Concrete samples at optimum temperature needed to attain the strength.

Fig. 3 Steam Curing

IV. MATERIALS

A. Cement

The cement used is Chettinad Cement with a specific gravity of 3.15.

B. Fine Aggregate

River sand was used throughout the Experimental Study as it has required gradation of fines, physical properties such as shape, smooth surface textures and consistency. They provide greater strength to the concrete by reducing bleeding, segregation, honeycombing, voids and capillary.

C. Coarse Aggregate

20mm size course aggregate was used as the particle shape of the aggregate contributes to the effectiveness of producing a high performance concrete.

D. Bacterial Capsule

The bacteria was cultured and inserted to the capsules made out of clay with its nutrients Calcium Lactate. Each capsule is dipped to the cement slurry. To form a coat over the capsule, 15% of bacterial capsule is added to the concrete mix.

Fig. 4 Bacterial Capsules

V. METHODOLOGY

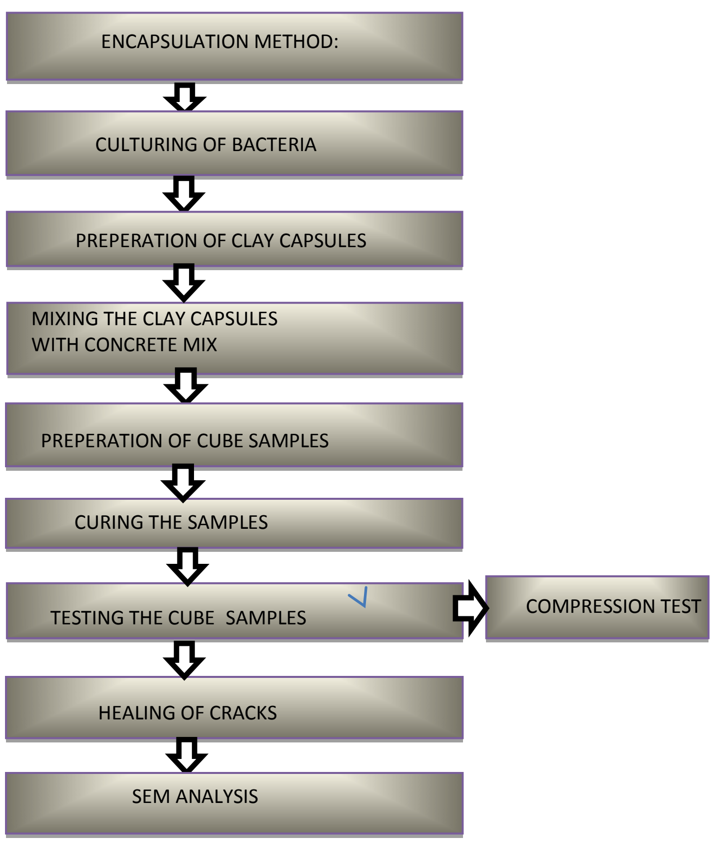

Fig. 5 Methodology

VI. TEST ON CEMENT

A. Fineness of Cement

Determination of fineness of the given sample. Finer cement deteriorates more quickly when exposed to air and is likely to cause more shrinkage, but less prone to bleeding.

1. Result
Fineness of cement=0.78%
2. Discussion
For Ordinary Portland Cement fineness should not be more than 10% of original weight as per IS CODE[269-1975]90% of cement should pass through IS-90 microns. Hence this sample can be used.

B. Test for Fine Aggregate

1. Specific Gravity of Fine Aggregate
Specific gravity of the given sample was determined.
2. Result
Specific Gravity of fine aggregate = 2.52

C. Test on Coarse Aggregate

1. Water Absorption
This test helps to determine the water absorption of coarse aggregate. For this test a sample not less than 2000g should be tested.

TABLE I WATER ABSORPTION OF COARSE AGGREGATE

S. No.	Weight Of Oven Dried Specimen (w1g)	Weight of Saturated Dried Specimen (w2g)	Weight of Water Absorbed (w2g-w1g)	Percentage of Water Absorption = (w2-w1)/w1x100
1.	220	220	0	0
2.	220	220	0	0

D. Test on Fresh Concrete-Workability

1. Workability
Workability test is carried to check the consistency of freshly made Bio concrete. Concrete is said to be workable when it is easily placed and compacted homogenously.

E. Slump Cone Test

TABLE II SLUMP TEST

Water Cement Ratio	Slump (mm)
0.50	75

1. Casting of Bioconcrete
Materials of the concrete composition were taken and ensure for its properties. M20 grade mix is casted by adding 15% clay pellets filled with Bacillus Megaterium and Calcium Lactate into the mix.

Fig. 5 Capsule mixed cubes

2. Steam Curing Of Bioconcrete
Steam curing for 7-8 hours at pressure of 45^0 Celsius was expected to achieve maximum early strength.

F. Test on Hardened Concrete

1. The Compression Test
Determine the compressive strength of hardened Bio concrete. The compression test was carried out to find the strength of the concrete that can be obtained in the perfect conditions. Testing should also be carried out precisely. It is expressed in Megapascals (MPa).

TABLE III RESULT ON COMPRESSIVE STENGTH FOR 450C OF STEAM CURING

S. No.	Mix Ratio	Compressive Stength N/mm^2
1.	M_{20}	21.99
2.	M_{20}	21.45
3.	M_{20}	21.96

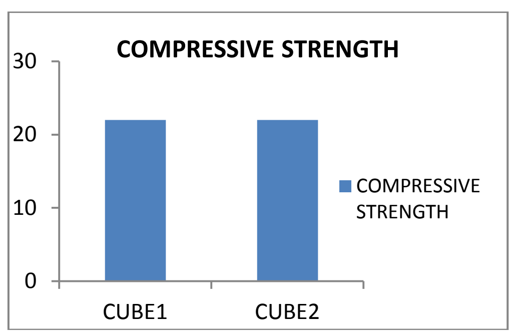

Fig. 6 Compressive Strength

VII. CONCLUSION AND DISSCUSSION

The bacteria can survive only at the optimum temperature of 35^0-55^0 Celsius. Lime formation can be found over the crack. Thus, the crack on the sample was healed using the bacteria (Bacillus Megaterium). Steam Curing helps in time consumption and helps in attaining strength earlier. Strength of the concrete improves without adding any Aritifical chemical admixtures.The results showed that the bacteria showed excellent repairing ability to small cracks and the self-healing agent can be applied for self-healing of early age cracks in cement-based material. However, the self-healing capacity depended on many factors. The cracks of early age with small width could be almost fully filled after steam curing.

The bacteria which are known to be alkali-resistant, i.e. they grow in natural environments characterized by a relatively high pH (10-11). In addition, these strains can produce spores which are resting cells with sturdy cell walls that protect them against extreme environmental mechanical and chemical stresses. Therefore these specific bacteria may have the potential to resist the high internal concrete pH values and remind viable for long time as well as spore viability for up to 200 years is documented. We hypothesized the concrete immobilized spores of such bacteria may be able to seal cracks by bio mineral formation after being revived by water and growth nutrients entering freshly formed cracks. Although the exact nature of the produced minerals still needs to be clarified, they appear morphologically related calcium precipitates.

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