Experimental Investigation of a Self-Healing Concrete Considering Bacillus Megaterium Bacteri and Fibers

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Article Info
Volume 5, Issue 1
Page Number: 33-38
Publication Issue :
January-February-2021

Article History
Accepted : 06 Jan 2021
Published : 16 Jan 2021

ABSTRACT

It is strong enough to resist compressive load but prone to cracking due to weak in tension which ultimately reduce the life of structure. Hence, any effort to improve the life span of structure will indirectly improve the sustainability of the environment. Cracks in concrete lead to ingress of chemicals in to concrete structure resulting in lower strength and durability.

To increase the durability of the structure either cracks are repaired which is expensive or provide extra reinforcement to ensure the cracks width stays within certain limit. Only for durability reason, this extra steel is not desirable. One way to increase the durability of structure and reduce such extra cost is to use self-healing concrete. Self- healing of concrete is any process by the material itself involving the recovery and hence improvement of performance after an earlier action that had reduce the performance of material.

In this study we are mixing Bacillus Megaterium bacteria with fibers in concrete with the motive to enhance its self healing properties with strengthening.

Here it is concluded that with bacteria concrete become more resisting to weathering effect and have capability to self heal with addition of fibers become comparatively more durable and load bearing.

Keywords: Bacteria, Concrete, Fibers, Strength, Self Healing, Material, Admixtures.

I. INTRODUCTION

The word concrete comes from the Latin expression “concretus” which means compounded. It was used by the ancient Romans in construction of walls and roofs, and it is a heterogeneous composite material with the following constituents: cement, coarse aggregate, fine aggregate, and water. There are two types of concrete used in the world: ordinary plain concrete which is made by mixing cement, fine aggregate and coarse aggregate with water; when steel reinforcement is added to plain concrete, it is called reinforced concrete. Concrete is the most commonly used building material in the world. It is durable, available everywhere and strong and is the cheapest man-made construction material to produce and recycle. Unfortunately, concrete is susceptible to many different types of damage which result in cracks. These cracks can be broadly classified as (i) structural cracks which come from design defects, construction and supervision problems; and (ii) non-structural cracks caused by ambient conditions e.g. (temperature, humidity) and/or quality of materials. Ambient conditions cause damage to concrete by freeze/thaw cycles, chemical attacks, corrosion, extreme loads and other environmental factors. Consequently, maintenance of concrete structures is recurrent and costly. Many countries in the world have spent billions of dollars every year on maintaining infrastructure such as buildings and bridges.

Self Healing 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. Types of bacteria, its mechanism and preparation of bacterial concrete was presented. In modern days, the use of technology has taken the standards of construction to a new high level. Different types of procedures, methods and materials are used to attain a very good, sustainable and economic concrete construction.

This common problem of cracking in building has many remedies before and after the crack. One of the remedial process is Bacterial Concrete or Self-Healing Concrete.

Various Types of Bacteria Used in Concrete

There are various types of bacteria were used in bacterial concrete construction are:

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

Objectives

The primary objectives of this study are as follows:

1. To heal the crack by bacterial precipitation.
2. To investigate the effect of bacterial species in achieving strength in contrast to conventional concrete.
3. To improve durability and compressive strength of concrete.
4. Use of silica gel as moisture absorbing agent to rapid the self healing activity
5. Use of Bacillus Megaterium for the preparation of self healing concrete.

II. Literature review:

Lagazo, Magil A et. al. (2019) the research paper introduced the use of microorganisms-Bacillus Subtlis as its very profitable for building up an intense system and set forth a concentrated exertion retouching concrete as a technique for brake control to overhaul organization life in a strong structure. The framework Microbiologically Induced Calcite Precipitation (MICP) was grasped. It was the usage of Bacillus Subtilis close by its supplements which are the Sodium Bicarbonate (NaHCo3), Ammonium Carbonate (NH4Cl), Calcium Chloride Dehydrate (CaCl2), and supplement stock. The blending extent utilized was 1:2 ½: 5:0.45 alongside 30 ml fluid type of Bacillus Subtilis with the cell convergence of 105 cells/ml. The strength of solid blend was assessed by directing a test on 150mm x 150mm x 150mm 3D shape for compressive strength test, 6in x 12in the round and hollow form for split elasticity test, 21in x 6in x 6in rectangular pillars for flexural strength text and 3in x 6in for water assimilation test, 3 examples each test. All example used for recovering is 4in x 2in x 2in which was purposely broken. The examination exhibits that there was a critical augmentation in the nature of concrete added with microbes or bacterial cement diverged from ordinary concrete and thusly calcium carbonate precipitation is clear after 3 a month in limited scope parts.

The outcomes reasoned that the development of minute life forms that the expansion of bacterial arrangement Bacillus Subtilis in cement introduced upgrades in various properties of concrete the extent that a compressive quality test, split rigidity test, water ingestion test, and flexural quality test. As the microorganisms can convey in the examination community, it very well may be wound up being particularly secured and does‟t give a treat to human wellbeing. The assessment accomplished use of minute creatures in concrete upgraded its solidarity and solidness henceforth utilizing this kind of microscopic organisms for the self-mending instrument in cement can deliver financially economical solid or tough structures.

Abubakar Magaji et. al. (2019) the exploration paper researched on self-mending of breaks in concrete based substances and black-top cement. The break arrangement was a fundamental well known to marvel in a solid structure that empowers the water and different kind of synthetic substances into the solid into the breaks and diminishes their solidness, strength and which assaults the fortification in the event that it interacts with water, CO2 in addition to different synthetic substances. Self-mending cement could resolve the snag of solid structures deteriorating impressively before the finish of their life expectancy. Presenting the microbes inside the solid performs it incredibly valuable it improves the characteristic of the solid, which is higher than the customary cement. Microorganisms fix the breaks in cement by giving the calcium carbonate gem that hinders the breaks and fixes them. Numerous scientists have taken care of their work on oneself mending kind of cement and they had gotten the ensuing outcome that microbes build up the property of customary cement, for example, increase in 13.75 percent strength brought up in 3 days, 14.28 percent in multi-week just as 18.35% in week one. In any case, on the off chance that solid could distinguish breaking and mend itself, at that point there would not exclusively be significant cost reserve funds yet additionally save an ecological increase furthermore in light of the fact that solid creation represents a significant amount of the world's CO2 discharges.

Experimental Setup:

Preparation of Sample

- ✓ To build a structure first we need to build its base or foundations. Likewise, first of Mix design for M25, grade of concrete is prepared according to the Indian standards code" IS 10262:2009.
- ✓ In the preparation of mix design for M25, grade of concrete various physical properties of the materials like specific gravity, nominal size, water absorption capacity, fineness Modulus etc. are required, also some other conditions like type of exposure to sun and water, material mixing technique etc. are to be assumed in accordance with Indian standard code IS 456:2000.
- ✓ After working out the quality of different materials in an appropriate proportion, it's time for the selection of materials.
- ✓ Keeping in mind the "Indian standards" materials are selected i.e., aggregates:- Conforming/full filling the various conditions as per IS 383:1970 and cement 53 grade OPC conforming to IS 12269:1987 are taken.
- ✓ Selected materials are mixed in a fixed proportion as per mix design to acquire the desired strength. Sampling & analysis of concrete is done according to IS 1199:1959.
- ✓ IS 2386 (Part 1): 1963 is used for the methods of tests for aggregates for concrete
- ✓ Specifically for shape and size of aggregates.
- ✓ Two important tests are performed on concrete namely
- ✓ Slump cone test

- ✓ Compaction factor test, after preparation of mix for physical properties of concrete.
- ✓ Standard moulds of size 150 mm x 150 mm x 150 mm are then cleaned and oiled.
- ✓ Concrete is poured into the moulds and differently shaped reinforcements are placed in the Moulds.
- ✓ After 24 hrs. Concrete cubes are unbolted from moulds and named with water resistant paint and placed in the curing tank filled with normal water at 27 ± 2 0C for 28 days.
- ✓ At the end of 7, and 28 days curing it's time for the final test which gives the actual strength of concrete i.e., compression strength test in accordance with the "Indian Standards code" IS 516:1959 for the test of concrete.

III.Analysis Results

Fig 1 : Expermental testing (UTM)

Table 2 : Flexural strength results for 0.5 % G.L + 105 cells/ML megatherium + 5 grams of calcium lactate adding to cement

Percentage of glass fiber adding to cement	7 days	14 days	28 days
0%	3.82	4.22	4.89
0.50%	4.01	4.76	5.07
0.5 % G.L + 105 cells / ML Megatherium + 5 grams of calcium lactate	4.89	5.41	5.91

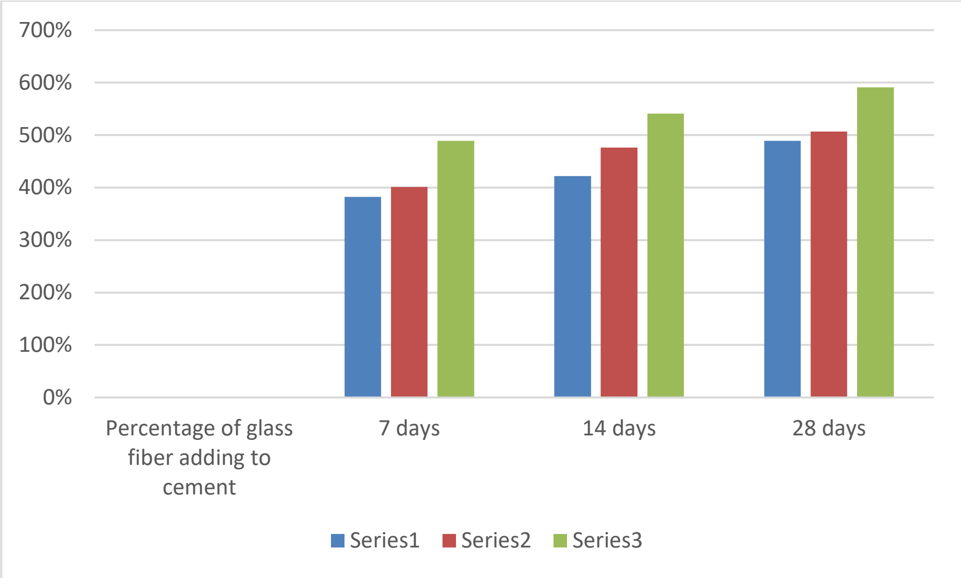

Fig 2 Glass fibers and Bacillus megaterium MTCC 105 cells/ml and 5 grams of calcium lactate vs flexural strength

Table 4. Flexural strength for different glass fiber 0.5 % + steel fibers + Bacillus megaterium MTCC 105 cells/ml.

Percentage of 0.5 % GF + steel fibers adding to cement	**7 days**	**14 days**	**28 days**
0%	4.02	4.79	5.05
0.50%	5.31	5.98	6.23
0.5 % of G.L + 1.5 % S.F + Bacillius megaterium MTCC 105 cells/ml and 5 grams of calcium lactate	5.96	6.32	6.79

IV.CONCLUSION

The project was done based on the compressive strength, flexural strength and split tensile strength by using Glass fiber and steel fibers replacement with different ratios (like 0 %, 0.5 %, 1.0 %, 1.5 %, 2.0 %)in the concrete mix.

The compressive strength of concrete with glass fiber (0, 0.5, 1.0 & 1.5 %) results compared with adding bacteria for Concrete. Results glass fiber concrete 19.75 N/mm2 for seven days and 25.66 N/mm2 strength get by adding Bacteria at the same % of glass fiber, and the same method continues for other days like 14 & 28. For 14 days 24.81 compared with 29.51 N/mm2 and for 28 days 33.64 N/mm2 compared with 38.41 N/mm2.

The compressive strength of concrete with glass fiber plus steel fibers (0, 0.5, 1.0 & 1.5, 2.0 %) results compared with adding bacteria for Concrete. Results glass fiber at 0.5 % plus steel fibers concrete 33.74 N/mm2 for seven days and 38.07 N/mm2 strength get by adding Bacteria at same % of glass fiber plus steel fibers, and the same method continues for other days like 14 & 28. For 14 days 39.44 compared with 45.22 N/mm2 and for 28 days 44.71 N/mm2 compared with 48.49 N/mm2.

The flexural strength of concrete with glass fiber (0, 0.5, 1.0 & 1.5 %) results compared with adding bacteria for Concrete. Results glass fiber (0.5 %) concrete 4.02 N/mm2 for seven days and 4.86 N/mm2 strength get by adding Bacteria at same % of glass fiber, and the same method continues for other days like 14 & 28. For 14 days, 4.79 N/mm2 compared with 5.39 N/mm2 and for 28 days, 5.05 N/mm2 compared with 5.89 N/mm2.

The flexural strength of concrete with glass fiber plus steel fibers (0, 0.5, 1.0 & 1.5, 2.0 %) results compared with adding bacteria for Concrete. Results glass fiber at 0.5 % plus steel fibers (1.5 %) concrete 5.31 N/mm2 for seven days and 5.96 N/mm2 strength get by adding Bacteria at same % of glass fiber plus steel fibers, and the same method continues for other days like 14 & 28. For 14 days 5.99 compared with 6.31 N/mm2 and for 28 days 6.22 N/mm2 compared with 6.78 N/mm2.

The split tensile strength of concrete with glass fiber (0, 0.5, 1.0 & 1.5 %) results compared with adding bacteria for Concrete. Results glass fiber (0.5 %) concrete 3.13 N/mm2 for seven days and 3.67 N/mm2 strength get by adding Bacteria at same % of glass fiber, and the same method continues for other days like 14 & 28. For 14 days 3.42 N/mm2 compared with 3.99 N/mm2 and for 28 days 3.82 N/mm2 compared with 4.25 N/mm2.

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Cite this article as :

Randhir Kumar Singh, Ajeet Saxena, "Experimental Investigation of a Self-Healing Concrete Considering Bacillus Megaterium Bacteri and Fibers", International Journal of Scientific Research in Civil Engineering (IJSRCE), ISSN : 2456-6667, Volume 5 Issue 1, pp. 33-38, January-February 2021.
URL : http://ijsrce.com/IJSRCE21513