EXPERIMENTAL INVESTIGATION ON STRENGTH CHARECTERSTICS OF BIO – CONCRETE

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Abstract - *Carbonate-producing bacteria have attracted lots of interest as a promising and natural eco-friendly technique to improve concrete characteristics. Considerable research has been conducted on utilizing microbial induced carbonate precipitation to mitigate concrete problems such as crack repair. Researchers have also focused on recycled materials for future development, while protecting the environment. Low cost, easy availability and simple recycling could be significantly applied in the construction industry.*
In this project, an investigation is carried out with the addition of Bacterial solution between 1ml to 3ml. This paper highlights about the behavior of Bacterial concrete when varying quantity of bacterial solution is added in concrete. Based on the general analysis of the results as well as the logical comparison to the acceptable standard, we can implement the healing property to the concrete structures. Not only that we can also widely improve the compressive strength, tensile strength, flexural strength of the concrete thereby increasing its durability and lifetime serviceability.

Key Words: Bio Concrete, Bacterial Concrete, Self-Healing, Cracks, Durability

1. INTRODUCTION

Concrete is the most widely used construction material and is applied in public infrastructural buildings. Based on the continuous research that is carried around the globe, various modifications have been made from time to time to overcome the deficiencies of cement concrete. Cracks in concrete are inevitable and are one of the predominant weaknesses in concrete and cause loss of strength of structure with time. They provide a pathway for harmful substances such as chlorides, carbon dioxide, and ultimately oxygen and water to get in to the reinforcement, cause corrosion, rust resulting in deterioration of concrete. Bacterial concrete or self-healing concrete is the one of the kind that uses bacteria which reacts with water and metabolize crystals, which close the crack and protects the steel within.

Mechanism

Water penetrating through cracks would not only dissolve calcite ($CaCO_3$) particles present in mortar mix, but also react with atmospheric carbon dioxide and non-hydrated lime constituents such as calcium oxide and calcium hydroxide to form the following.

$$CaO+H_2O \longrightarrow Ca(OH)^2\ Ca(OH)_2 +$$
$$CO_2 \longrightarrow CaCO_3 + H_2O$$

This precipitation forms a highly impermeable layer which can be used as crack remediation for the cracked concrete building or structures. The precipitated calcite has a coarse crystalline structure that radically adheres to the concrete surface in the form of scales. In addition, it has the ability to Continuously grow upon it and it is highly insoluble in water. The microbial organism used for manufacturing bacterial concrete should have long term and effective crack sealing mechanism during its lifetime serviceability. The principle behind healing mechanism is that the bacteria should be able to transform soluble organic nutrients into insoluble inorganic calcite crystals, which seals the cracks. For effective crack healing, both bacteria and nutrients incorporated into concrete should not disturb the integrity of cement - sand matrix pore diameter and should not negatively affect other important fresh and hardened properties of concrete. Concrete cracks up to 0.2 mm wide are healed autogenously. Such micro cracks are acceptable as these do not directly influence the safety and strength of concrete. The bacteria based self-healing process was found to heal cracks completely up to 0.5 mm.

2. MATERIALS REQUIRED

Cement

Portland Pozzolana Cement available in local market is used in this investigation. The cement used has been tested for various properties as per IS: 4031-1988 and found to be confirming to various specifications of IS: 1489-2013 having specific gravity of **2.95**.

Fine Aggregate

In our investigation we had used river sand which is locally available. The sand is tested and confirming that it is under **Zone II** according to IS-383. Specific gravity was found to be **2.70.**

Coarse Aggregate

In our investigation we had used the aggregate passing through 20mm IS Sieve and retaining on 12.5mm sieve. The specific gravity of aggregate was found out to be 2.80.

Water

Potable water available in laboratory with pH value of not less than 6 and conforming to the requirement of IS 456- 2000 was used for mixing concrete and curing the specimens.

Bacterial Solution

Bacillus subtilis bacteria, a type of bio-fertilizer, which is easily available in the agricultural shops. The culture of bacteria requires very careful handling and many pre- cautions. So we eliminated that by implementing new method of using bio-fertilizer which is already available in its matured form in Liquid Suspension Medium (LSM)

Calcium Lactate

It is a white crystalline salt prepared by the reaction between lactic acid and calcium hydroxide or calcium carbonate. Its chemical formula is $C_6H_{10}O_6$.

3. METHODOLOGY

Preparation of Test Specimens

In our investigation we have made M30 grade of concrete. The mix ratio obtained after the mix design as per IS456:2000, IS10262:1982 was M30(1:1.60:2.20). Further,
we have poured the concrete in the cube moulds and three different samples were made which are as follows,

a) Conventional concrete of grade M30
b) Concrete with 1 ml bacterial solution
c) Concrete with 2 ml bacterial solution
d) Concrete with 3 ml bacterial solution

Method of Mixing Bacterial Solution into the Concrete

There are different methods of mixing the bacterial solution in the concrete namely

a) Direct mixing
b) Indirect mixing
c) Injection mixing

In our investigation we have adopted the direct method in which, firstly the measuring jars were sterilized in oven for a temperature of about 37℃ for 5 minutes. After 5 minutes once it gets slightly cooled, the bacterial solution is poured from the flask in the measuring jar, so that the bacterium doesn't get contaminated by the other bacterium 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 of the concrete.

In this experimental work, 150mm X 150mm X 150mm size cubes &150mm diameter, 300mm length cylinders and 500mm x 100mm x100mm prism were casted for the testing of compressive strength, Split tensile strength and Flexural strength.

Fig -1: Specimen Casting

Curing

The casted specimens were removed from the moulds after 24 hours and the specimens were immersed in water tank. After curing the specimens for the period of 7,14 and 28 days, the specimens were removed from the water tank, and then allowed to dry under shade.

Fig -2 : Specimen Curing

4. TESTS AND OBSERVATIONS

Tests on Fresh Concrete

Slump Cone Test

The concrete slump test is an empirical test that measures the workability of fresh concrete. Slump cone test for conventional concrete specimen and different proportion of bacterial concrete specimens were conducted and the results were obtained.

Table -1: Slump Cone Test Result

Sl. NO	Bacteria in ml / lt of water	Slump value(mm)	Result
1	Conventional concrete	20	True slump
2	1	25	True slump
3	2	30	True slump
4	3	30	True slump

Compaction Factor Test

Compacting factor test also used to determine the workability of fresh concrete. The compacting factor test gives a more accurate workability of fresh concrete than slump test.

Table -2: Compaction Factor Test Result

Sl. NO	Bacteria in ml / lt of water	Partially compacted concrete (kg)	Fully compacted concrete (kg)	Compaction factor
1	Conventio nal concrete	10.24	11.51	0.89
2	1	10.37	11.55	0.90
3	2	10.46	11.75	0.91
4	3	10.50	11.80	0.93

Tests on Hardened Concrete

4.2.1 Compressive Strength Test Result

Compressive strength of concrete cube was carried out after curing period of 7, 14 and 28 days. The results are obtained and tabulated below

Table -3: Compressive Strength Test Result

Sl. NO	Bacteria in ml / lt of water	7 days N/mm²	14 days N/mm²	28 days N/mm²
1	Conventional concrete	15.60	28.22	30.45
2	1	16.00	28.75	30.89
3	2	16.80	29.92	33.00
4	3	17.20	30.80	35.70

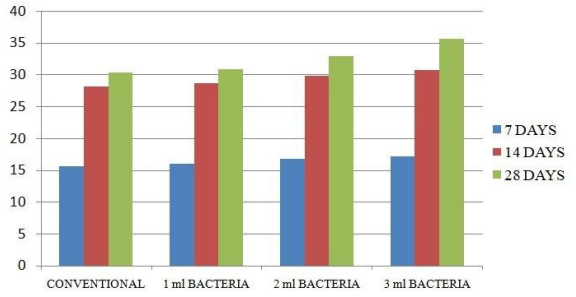

Chart -1: Compressive Strength

4.2.2 Split Tensile Test Result: Split tensile test for concrete cube was carried out after curing period of 7, 14 and 28 days. The results so obtained are tabulated below

Table -4: Split Tensile Test Result

Sl. NO	Bacteria in ml / lt of water	7 days N/mm²	14 days N/mm²	28 days N/mm²
1	Conventional concrete	2.30	2.45	2.70
2	1	2.38	2.57	2.78
3	2	2.48	2.76	2.87
4	3	2.55	2.85	2.98

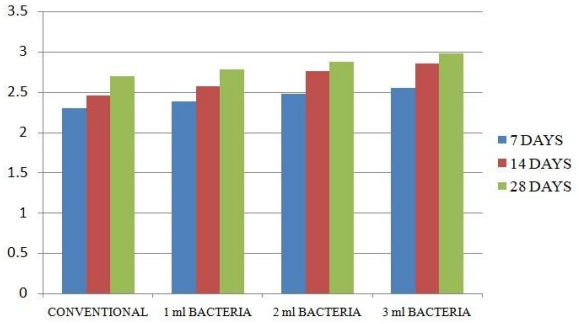

Chart -2: Split Tensile Strength

4.2.3 Flexural Strength Test Result

Flexural strength test for concrete cube was carried out after curing period of 7, 14 and 28 days. The results so obtained are tabulated below

Table -5: Flexural Strength Test Result

Sl. NO	Bacteria in ml / lt of water	7 days N/mm²	14 days N/mm²	28 days N/mm²
1	Conventional concrete	2.53	2.76	2.86
2	1	2.85	2.96	3.12
3	2	2.90	2.98	3.23
4	3	2.96	3.15	3.30

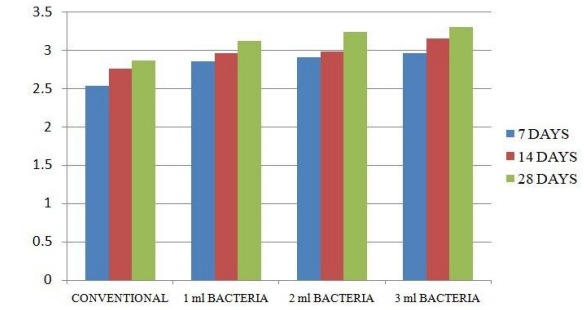

Chart -3: Flexural Strength

5. HEALING PROGRESSION

The healing property of the concrete is obtained by the formation of lime crystals due to the mineral precipitation of bacteria in the concrete. When cracks occur, they are in direct contact with the atmosphere. Water enters the cracks during rainy season and the bacterium starts germinating inside the concrete by absorbing the feed i.e. calcium lactate reacts with the atmospheric carbon dioxide to form crystals of lime. This impermeable layer of lime covers the cracks and fills them to prevent further deterioration of the concrete

Fig -3: Healing Process

6. CONCLUSIONS

Addition of bacteria shows increase in compressive strength, flexural strength and split tensile strength with respect to conventional concrete.

- Increase in strength is mainly due to the consolidation of the pores inside the cement mortar with microbiologically induced calcite precipitation.
- The combination of bacterial solution and calcium lactate with concrete shows a maximum increase of 18% more compressive strength i.e. 1.25 times the conventional concrete.
- From the bar graph, it is evident that shows the 10% increase in split tensile strength of concrete.
- From the bar graph, it is evident that shows the 15% increase in flexural strength of concrete.
- The self-healing property is successfully achieved by using bacteria.

6 REFERENCES

[1] IS 456:2000,"Plain and Reinforced Concrete-Code of Practice".

[2] J.Vinaya Singh, k.MalliKarjun Rao, G. HathiRam "Strength Characteristics of Bacterial Concrete," IJEEE, vol. 3, Dec. 2016, ISSN 2348-4748.

[3] ArunKChakaraborty,SandipMondal,"Bacterial Concrete : A way to enhance the durability of concrete structures " , ICJ ,July 2017 ,Vol.91 , No.7.

[4] Meera C.M ,Dr.Subha V , "Strength & Durability assessment of Bacteria based self-healing Concrete " ,IOSR – JMCE , e-ISSN: 2278-1684,p-ISSN: 2320-334X, PP 01-07.

[5] H.M.Jonkers, "Bacteria based self-healing concrete ",HERON Vol. 56 (2011).

[6] SathishKumar.R, "Experimental Study on the Properties of Concrete Made With Alternate Construction Material", International Journal of Modern Engineering Research (IJMER), Vol. 2, Issue. 5, Sept.-Oct. 2012, pp-3006-
3012.

[7] PradeepKumar.A and Akhila Devi, "An Experimental Work on Concrete by Adding Bacillus Subtilis," IJETE, vol. 2, April 2015, ISSN 2348-8050.

[8] H.S. Patil, D.B. Raijiwala, Hingwe Prashant and BhabhorVijay—Bacterial concrete "A self-healing concrete", International Journal of Applied Engineering Research, Vol. 3, No. 12, 2008, pp.1719–1725.

[9] S.S.P Reddy, M.V.Seshagiri Rao, P.Aparna and Ch.Sasikala. "Performance of standard grade bacterial ('Bacillus Subtilis') concrete", Asian Journal of Civil Engineering (Building and Housing) Vol. 11, No.1, 2010.

[10] Van Tittelboom, K., De Belie, N., De Muynck, W., and Verstraete, "Use of bacteria to repair cracks in concrete. " Cement Concrete Res 40: 157-166, W (2010)