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An Experimental Investigation on the Mechanical Properties of Bacterial Concrete

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A B S T R A C T

Concrete is the most broadly utilized structure material for development works in construction. Because of reasons like freeze-defrost responses, solidifying and this eventually prompts debilitating of the substantial and when the beads go into the substantial construction, because of absence of porousness it can harm the steel support in cement and crumbling of cement. This prompts breaks in concrete. There are gentle strategies for fixing the breaks in concrete, one of them is bacterial concrete. In our project, at the hour of blending, microbe‟s bacillus subtilis which structures calcium carbonate accelerate are applied to the substantial. Bacterial concrete is characterized as the capacity of cement to fix its miniature breaks which prompts the initiation of microscopic organisms from its phase of hibernation. The microbes stay as dead cells until it interacts with the dampness content present in air. By the metabolic exercises of microbes, during the way toward mending calcium carbonate accelerates into breaks recuperating them. The principal objective of our undertaking is to consider the mechanical properties of bacterial substantial utilizing bacillus subtilis for 7, 14, and 28 days. In the wake of directing the essential tests on materials, blend configuration was accomplished i.e., mix design for M25 grade concrete. This paper presents strength parameters like compressive strength, split tensile strength and flexural strength for 7, 14, 28 days for bacterial concrete and it was presumed that bacterial concrete has more strength contrasted with conventional concrete.

Keywords: Bacterial concrete, microbe‟s, calcium carbonate precipitation.

I. INTRODUCTION

Concrete is a composite material which is predominantly used all over the world. It is obtained by mixing cementing materials, aggregates and water in quantities. Concrete is the most commonly used man-made material on earth. It is an important construction material used extensively in buildings, bridges, roads and dams. Concrete is the building material used for construction works in the field of civil engineering. The main reason is due to low cost of materials and construction for concrete structural members as well as the maintenance cost is less. The load bearing capacity for compression load in concrete is usually higher whereas, the material is weak in tension. Due to reasons like freeze-thaw reactions, hardening and this ultimately leads to weakening of the concrete and when they enter into material is weak in tension. Due to reasons like freeze-thaw reactions, hardening and this ultimately leads to weakening of the concrete and when the droplets enter into the concrete structure, due to lack of permeability it can damage the steel reinforcement in concrete and deterioration of concrete. This leads to cracks in concrete. There are mild methods for fixing the cracks in concrete, one of them is bacterial concrete. In our project at the time of mixing, bacterial solution (bacteria bacillus subtilis) which forms calcium carbonate precipitate are applied to the concrete. “Bacterial concrete” is defined as the ability of concrete to repair its micro cracks which leads to the activation of bacteria from its stage of hibernation. The bacteria remain as dead cells until it comes in contact with the moisture content present in air. By the metabolic activities of bacteria, during the process of healing calcium carbonate precipitates into cracks healing them. In the present experimental investigation, the mechanical properties of bacterial concrete will be studied, by replacement of water with bacterial solution to 10% and 25% respectively for M25 grade of concrete. To study the strength parameters with respect to conventional concrete be compared with normal mix.

II. LITERATURE REVIEW

1. P.V. Yatish Reddy, B. Ramesh, L. Prem Kumar, "Influence of bacteria inself-healing of concrete- review”, Materials Today: Proceedings, July 2020: The examination was coordinated on M25 grade considerable using bacillus subtilis which decrease the help cost of the plan. This self-recovering property of concrete can extend the future of plans. The understanding of self-recovering of concrete is still at research the all-important focal point. Future assessments should zero in on the recovering capability and accelerate the retouching cycle. As shown by the composing overview, the Bacillus Subtilis with a cell gathering of 10^5 - cells/ml showed a fair improvement in mechanical properties. At the Ph of concrete, the Selected microorganisms ought to go against, and use calcium acidic corrosive deduction/lactate into calcium carbonate.

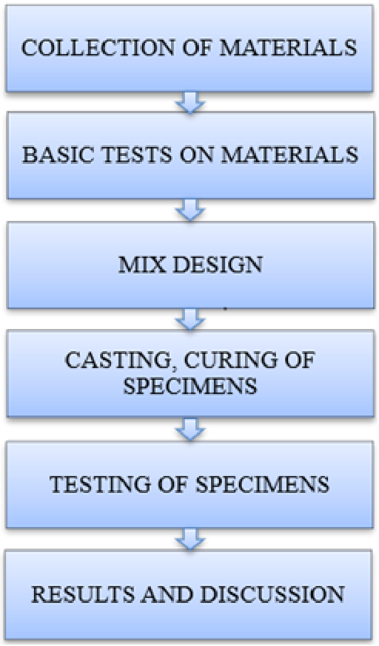
2. PartheebanPachaivannan, C. Hariharasudhan, M Mohanasundram, M. AnithaBhavani, “Experimental analysis of self- healing properties of bacterial concrete”, Materials Today: Proceedings, March 2020: This assessment makes a strength of fostering the energy and total durability of the considerable utilized in contemporary through introducing tiny organic entities (Bacillus subtilis). It uncovers a wonder called bio-calcification as a piece of its

metabolic activity. It is the strategy through which the microorganism distantly secretes calcium speed up, in which the occasion of a carbonate molecule structures CaCo3 which compensates for up the deficits inside the generous surface consequently making it more vital insignificant. This in flip improves the strength in concrete due to impact of the filler surface inside the pores of the generous blender. An assessment sees was made with significant 3D squares and shafts presented to compressive, pliable and flexural strength tests which might be casted with and without the tiny creatures.

III. Objectives

To conduct the basic tests on cement, fine aggregate and coarse aggregate.
To study the strength parameters like compressive strength, split tensilestrength and flexural strength for 7, 14 and 28 days for bacterial concrete.

IV. Methodology



A. Materials Required

- Cement (53 grade)
- Fine aggregate (M-sand, medium sand of grain size: 0.25mm to 0.50mm)
- Coarse aggregate (Crushed angular aggregate of 20mm size)
- Bacterial solution (bacteria bacillus subtilis)

Basic Test Results

1. Cement

Table 1: Test Results on Cement

Sl.No	Description	Results	PermissibleLimit
1.	NormalConsistency	33%	28to 36%
2.	InitialSettingTime	28min	30min
3.	FinalSettingTime	480min	600min
4.	SpecificGravit	3.07	3.15

2. Fineaggregate

Table2:TestResultsonFineAggregate

Sl.No	Description	Results	PermissibleLimit
1.	Finesness Modulus	4.456, sand adjustingtoZone IIaccordingtoIS:383-1970	-
2.	SpecificGravity	2.55	2.5 to3
3.	WaterAbsorption	4.6%	-

Table3:TestResultsonCoarseAggregate

Sl.No	Description	Results	PermissibleLimit
1.	SpecificGravity	2.65	2.5 To3
2.	WaterAbsorption	0.2%	< =0.6%

A. Mix Design For M25 Grade Concrete

❖ **Design Stipulations for Proportioning**

a. Grade designation : M25
b. Type of cement : 53 Grade
c. Maximum nominal maximum size of aggregates : 20mm
d. Minimum cement content : 300 kg/m^3
e. Maximum water cement ratio : 0.50
f. Workability : 75 to 100 mm (slump)
g. Exposure condition as per table 3 and table 5 of IS:456-2000 : Moderate (for reinforced concr
h. Degree of supervision : Good
i. Type of aggregate : Crushed angular aggregate
j. Maximum cement content : 450kg/m^3

Test Data for Materials

a.Cementused	:Bharathicementof53Grade
b.Specificgravityofcement	:3.07
c.Specificgravityof	
a.Coarseaggregate	:2.65
b.Fineaggregate	:2.55
d.Waterabsorption	
a.Coarseaggregate	:0.2%
b.Fineaggregate	:4.6%
e.Sieve analysis for fine aggregates	:ConfirmingtoZoneIIofIS:383-1970

Mix proportion for trial mix

Cement = 394.32 kg/m^3

Water = 197.16 kg/m^3

Fine aggregate = 654.075 kg/m^3

Coarse aggregate = 1109.025 kg/m^3

Water cement ratio = 0.5

Mix proportion

Cement: Fine aggregate: Coarse aggregate

1 : 1.66: 2.81

Then three mixes (blends) were designed;

Where; "Blend 1" is conventional concrete for 7, 14 and 28 days.

"Blend 2" is bacterial concrete for 7, 14 and 28 days replacing 10% for every 1000 ml of water.

"Blend 3" is bacterial concrete for 7, 14 and 28 days replacing 25% for every 1000 ml of water.

V. Results and Discussion

Tests on Fresh Concrete

Slump Flow Test

Conventional Concrete

Table 4: Test Results on Conventional Concrete

Test	Result
Slumptest	Height=46mm

Slump test conducted on conventional concrete at the time of mixing is found to be 48 mm which indicates a value between true slump and shear slump for conventional concrete. In the event that the substantial droops uniformly, it is called genuine droop. In the event that one portion of the cone slides down, it is called shear droop. If there should be an occurrence of a shear droop, the droop esteem is estimated as the distinction in stature between the tallness of the shape and the normal worth of the subsidence. Hence, workability of concrete is medium and are typically used for normal reinforced concrete.

Bacterial Concrete With 10% Addition of Bacterial Solution

Table 5: Test Results on Bacterial Concrete With 10% Addition of Bacterial Solution

Test	Result
Slumptest	Height=46mm

Slump test conducted on bacterial concrete with 10% addition of bacterial solution is found to be 46 mm which indicates a value between true slump and shear slump, and is almost same as slump for conventional concrete. Hence the addition of bacterial solution does not affect the slump of concrete.

Bacterial Concrete With 25% Addition of Bacterial Solution

Table 6: Test Results on Bacterial Concrete With 25% Addition of Bacterial Solution

Test	Result
Slumptest	Height=46mm

Slump test conducted on bacterial concrete with 25% addition of bacterial solution is found to be 46 mm which indicates a value between true slump and shear slump, which is almost same as value of slump for conventional concrete. Hence the addition of bacterial solution does not affect the slump of concrete.

Tests on Hardened Concrete

Compressive Strength Test for Concrete

The compressive strength test was carried on 3 cubes (150mm*150mm*150mm) for each blend for 7, 14 and 28 days. The normal of the test outcomes was found be:

Table 7: Test Outcomes on Compressive Strength Test for Concrete

Day of testing of concrete Cubs	Conventional concrete for Blend 1 (N/mm2)	Bacterial concrete for Blend 2(N/mm2)	Bacterial concrete for Blend 3(N/mm2)
7th day	9.56	9.96	11.21
14th day	16.89	21.18	22.76
28th day	26.52	29.75	31.68

Graph of Compressive Strength Test for Concrete

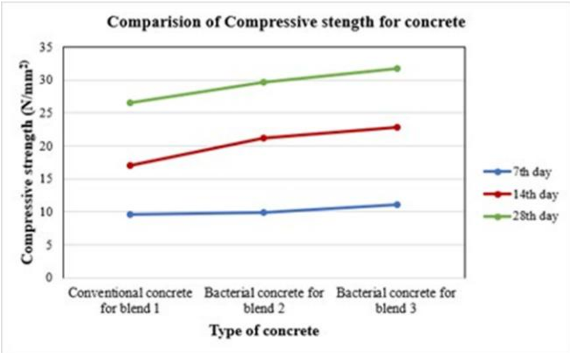


Fig 1: Graph of Compressive Strength v/s type of concrete

From the above test results and graphical portrayal, here it is observed that bacterial concrete usually has higher compressive strength than conventional concrete.

The compressive test directed on the 7th, 14th and 28th day results showed that the strength extended to 3.57%, 2.75% and 12.21% for bacterial concrete of blend 2.

Also 16.09%, 17.52% and 19.53% for bacterial concrete of blend 3 compared to conventional concrete.

Split Tensile Strength Test for Concrete

The Split tensile strength test was carried on with 2 cylinders (300mm height, 200mm dia) for each blend for 7, 14 and 28 days. The normal of the test outcomes was found be:

Table 8: Test Outcomes on Split Tensile Strength Test for Concrete

Day of testing of concrete Cylinders	Conventional concrete for Blend 1 (N/mm2)	Bacterial concrete for Blend 2 (N/mm2)	Bacterial concrete for Blend 3 (N/mm2)
7th day	1.16	1.28	1.4
14th day	2.42	2.68	2.76
28th day	3.45	3.84	4.2

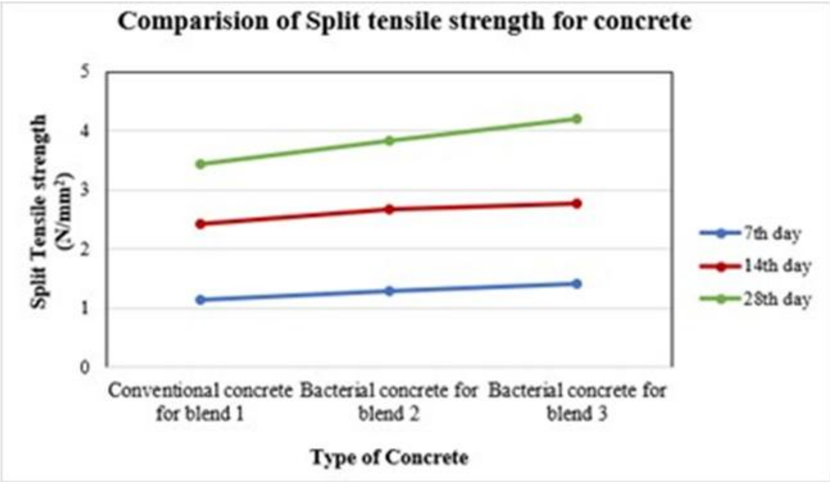


Fig 2: Graph of Split tensile Strength v/s type of concrete

Tensile test is the greatest contrasted with other look at strategy. Elastic property is the premier significant property of the material. Here it is seen that bacterial concrete has higher elasticity contrasted with conventional concrete as displayed from the above graphical portrayal.

The split tensile test directed on the 7th, 14th and 28th day results showed that the strength extended to 6.15%, 9.13% and 10.8% for bacterial concrete of blend 2. Also 16.5%, 17.8% and 19.2% for bacterial concrete of blend 3 compared to conventional concrete.

Flexural Strength Test for Concrete

The Flexural strength test was carried on with 1 beam (1000mm length, 150mm breadth, 150mm depth) for each blend for 7, 14 and 28 days. The normal of the test outcomes was found be:

Table 9: Test Outcomes on Flexural Strength Test for Concrete

Day of testing of concrete Cylinders	Conventional concrete for Blend 1 (N/mm2)	Bacterial concrete for Blend 2 (N/mm2)	Bacterial concrete for Blend 3 (N/mm2)
7thday	6.86	7.02	7.48
14th day	7.58	8.21	8.87
28th day	8.45	9.02	9.95

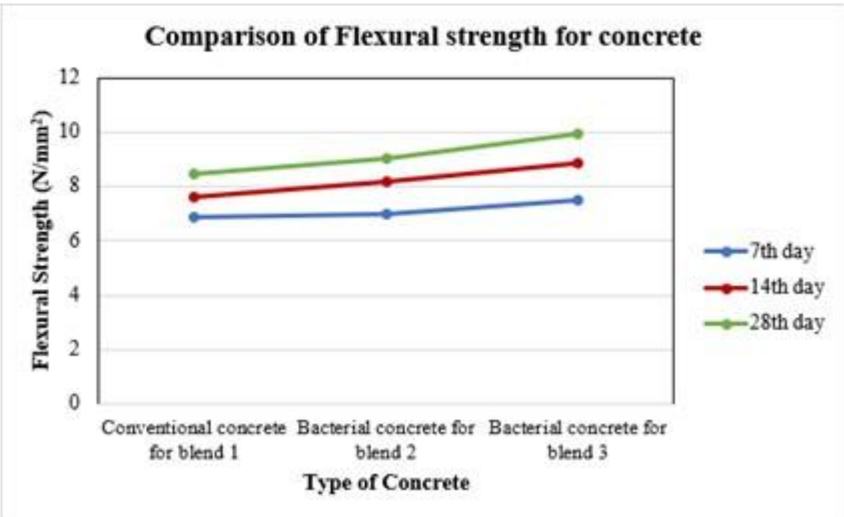


Fig 3: Graph of Flexural Strength v/s type of concrete

- It is seen that bacterial concrete has higher flexural strength than conventional concrete. The graphical portrayal of the comparison is also shown above.
- The flexural strength test outcome on the 7th, 14th and 28th day results showed that the strength extended upto 2.34%, 4.08% and 6.75% for bacterial concrete of blend 2.
- Also 12.3%, 14.24% and 16.45% for bacterial concrete of blend 3 compared to conventional concrete.

VI. CONCLUSION

The experimental work uncovers that microbe‟s bacillus subtilis ends up being protected due to its degree of biosafety and it is a bacterium found in the soil. Bacterial concrete has lower pace of water absorption contrasted with regular concrete, this is because of the presence of miniature creatures actuated calcium carbonate advancement in substantial voids, bringing about a lower void and accordingly lower penetrability. The results show that the considerable added organism's bacillus subtilis has a compressive strength, split elasticity and flexural strength that is almost higher with reached out in the strength regards showed in the above test results and graphical depiction. Bacterial concrete is likewise impervious to erosion of support when contrasted with regular concrete and it tends to be utilized for building where the designs need light weight.

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