# Investigating and Learning More about Self-Healing Concrete

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*Abstract* — Concrete is a widely accessible and inexpensive building material. Therefore, improvement in concrete aims to increase its compressive strength and structural longevity by the use of microorganisms harbouring MICP. The goal of the current work is to use a microbiologically induced unique growth to improve the performance of concrete. One of these has resulted to the creation of a highly specific type of concrete known as self-healing concrete, which uses bacteria to repair flaws in the mortar and concrete. Researchers using various microbes suggested various concretes. Using the bacteria "Bacillus subtilius," an attempt was made in this instance. According to this investigation, the presence of bacteria significantly increased the compressive strength. In this research we add 10ml, 20ml, and 30ml bacteria in concrete and check its compressive strength at 7days, 14days & 28days. We observed that 30ml Bacteria added in concrete gives maximum compressive strength in concrete.

***Keywords:*** Microbiologically Induced Calcite Precipitation, (MICP)

## I. Introduction

Concrete is used extensively in the building industry because it is affordable, widely accessible, and easy to cast. However, these materials have a problem in that they are weak in tension, which causes them to shatter under continuous loading and as a result of harsh environmental factors, ultimately reducing the life of the construction made of these materials. A common phenomenon in relation to durability is crack formation.

Crack percolation may result in leakage issues that deteriorate the concrete matrix or cause the embedded steel reinforcement to corrode.

In order to increase the service life, bacteria-based self-healing concrete has recently been developed.

The concrete mixture also contains a two component healing ingredient. The agent consists of bacteria and an organic mineral precursor compound.

### A. *Self-healing Concrete:*

Crack is a typical issue in constructions. There are numerous solutions for this widespread issue of building cracking both before and after the crack. The restorative technique BIO CONCRETE is one of them. It is a unique kind of concrete with the potential to repair cracks on its own The degree of un hydrated cement present, the composition of the concrete matrix, and the presence of water or humidity in the immediate environment all play a significant role in the success of autogenous healing. Additionally, it has been shown that autogenous repair can only fill fissures that are between 0.1 and 0.3 mm in size. Reducing the ratio of cement to water (w/c) is a doable technique to enhance autogenous healing. However, adding more cement to lessen the w/c ratio has a negative impact on shrinkage and workability and necessitates increased cement production. Through bacterial action. According to this investigation, the presence of bacteria significantly increased the compressive strength. The maximum compressive strength of M20 grade Concrete is achieved when 30ml of Bacillus subtilius is introduced. By adding bacteria to concrete, self-healing properties are successfully accomplished.

## II. Literature Review

Concrete can crack for a variety of causes, including the heating and cooling caused by changing seasons that cause it to expand and contract as well as stress that is produced, but researchers are exploring innovative solutions to the problem of cracking concrete. One of the inherent weaknesses of concrete is cracks. These fractures allow water and other salts to flow through, shortening the lifespan of the concrete. Therefore, an inherent biomaterial had to be designed. Bacterial concrete is a substance that may effectively repair fractures in concrete. This method is highly favoured since the mineral precipitation brought on by microbial activity is both pollution-free and organic. An increased bacterium means greater compressive strength. Calcite is created in concrete by adding Bacillius Subtilius. Bacterial culture is extremely important. When bacteria are ingested into concrete, the self-healing agent functions.

## III. Experimental Program

### A. *Introduction:*

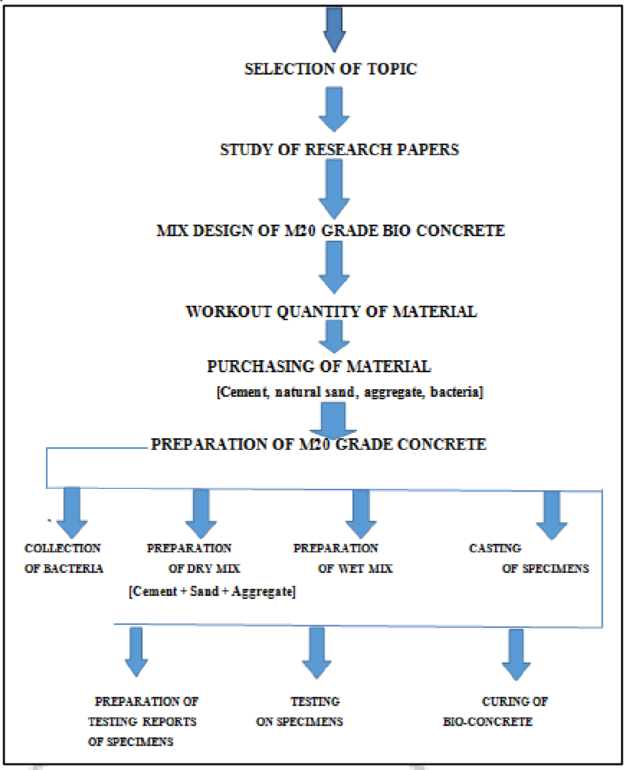
In this chapter study a bacteria is used as a source material. Basalt coarse aggregate in proper proportion and locally available river sand were used as fine aggregate, For preparing bioconcrete cubes were cast using mix design 1:1.60:2.85(one part Of cement, one part of fine aggregate, one part of coarse aggregate) with bacteria used 0ml, 10ml, 20ml & 30ml for one cube and bacterial water-to-cement ratio of 0.46. The procedure of mixing and casting bioconcrete cube is similar to cement concrete cubes as per IS 456. After 24 hours of casting, all cubes were remoulded and cured for 7, 14 and 28 days in portable water. The testing was carried out for compressive strength at the age of 7days, 14 days and 28 days of casting.

### B. *Test Program*

#### 1) *Objectives*

- To determine compressive strength of bio-concrete concrete by using Cube specimen[150 mm x 150 mm x 150 mm]
- To compare the bacterial concrete at different percentage.
- To create the self-healing property in the concrete.
- To reduce the cost of construction.

*2) Flow Chart*




*3) Test on source materials*

a) Fine aggregate:-

1) Type of sand: - Natural Sand
2) Maximum Size: - 4.75 mm
3) Water Content: - Nil

| Sr.No. | Particulars/Properties of Materials | SAND |
|---|---|---|
| 1 | Type | Natural |
| 2 | Shape | Spherical |
| 3 | Maximum size | 4.75mm |
| 4 | Specific gravity | 2.64 |
| 6 | Crushing value | --- |
| 7 | Impact value | --- |
| 8 | Silt content | 1.46% |
| 9 | Fineness modulus | 2.52 |

Table 1: Properties of Fine aggregate

b) Course Aggregate (CA):-

1) Maximum Size of Aggregate: - 20 mm
2) Shape of Aggregate: - Irregular

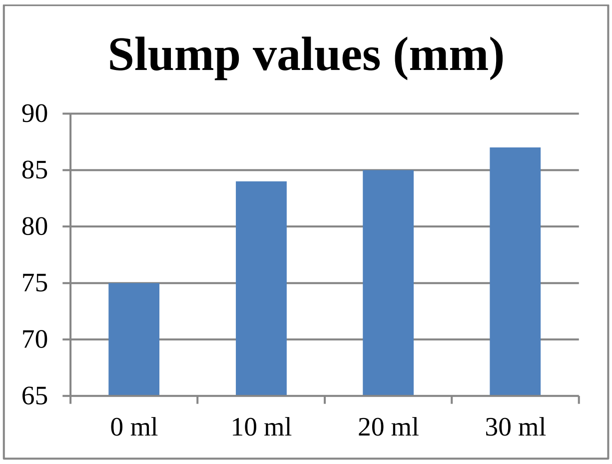
| Sr.No. | Particulars/Properties of Materials | CA |
|---|---|---|
| 1 | Type | Crushed |
| 2 | Shape | Angular |
| 3 | Maximum size | 20mm |
| 4 | Specific gravity | 2.89 |
| 6 | Crushing value | 20.19% |
| 7 | Impact value | 14.03% |
| 8 | Silt content | --- |

Table 2: Properties of Coarse Aggregate

c) Workability of concrete using slump cone test:-

| ml of Bacteria | Slump value |
|---|---|
| 0 ml | 75 mm |
| 10 ml | 84mm |
| 20 ml | 85 mm |
| 30 ml | 87 mm |

Table 3: Slump values




Graph 1: Slump value of M20 is gradually increased from 10ml to 30ml

Fig. 3.2.3.3: Workability test by using slump cone

## C. *Mix Design for M20 Concrete*

Mix proportions for trial number 1 per $m^3$ concrete.
Cement = 425.73 kg
Fine aggregate = 647.5
Course aggregate = 1124 kg
Water cement ratio = 0.45
C: FA: CA = 1: 1.52: 2.64
Therefore we adopt the Mix Proportion Taken is
C: FA: CA = 1: 1.5: 3

*1) Material for 1 Cube (150mmX150mmX150mm)*

| Concrete | M20 (1:1.5:3) |
|---|---|
| Cement | 1.5 Kg |
| Sand | 2.25 Kg |
| Aggregate | 4.5 kg |
| Water | 675 ml |
| Bacillus Subtilis | 10ml, 20ml, 30ml |

Table No.4:-Material for 1 Cube

Note: If we use bacteria in liquid form percentage of water reduces up to 30%.

# IV. TEST AND RESULTS

## A. *Compressive strength of cubes:-*

The compression test is used to find the hardness of cubical specimens of concrete. The cement, aggregate, bond, water-to-cement ratio, curing temperature, specimen age, and size all affect a concrete specimen's strength. The main element affecting concrete strength is mix design.. Cubes of size 15cm x 15cm x 15cm (as per IS: 10086-1982) should be cast. The specimen needs to have enough time to harden before being cured for 7, 14, and 28 days. The equipment for evaluating compression should be loaded to its highest capacity. Calculating compressive strength requires dividing the greatest load by the cross-sectional area. Compressive Strength (N/mm2) = Maximum load divided by the specimen's C/S area

Compressive Strength (N/mm2) =Ultimate load / C/S area of specimen

| ml of bacteria | 7 days Curing | |
|---|---|---|
| | Load (KN) | Compressive Strength (N/mm²) |
| 0ml | 270 | 12 |
| 10ml | 280 | 12.67 |
| 20ml | 350 | 15.55 |
| 30ml | 375 | 16.67 |

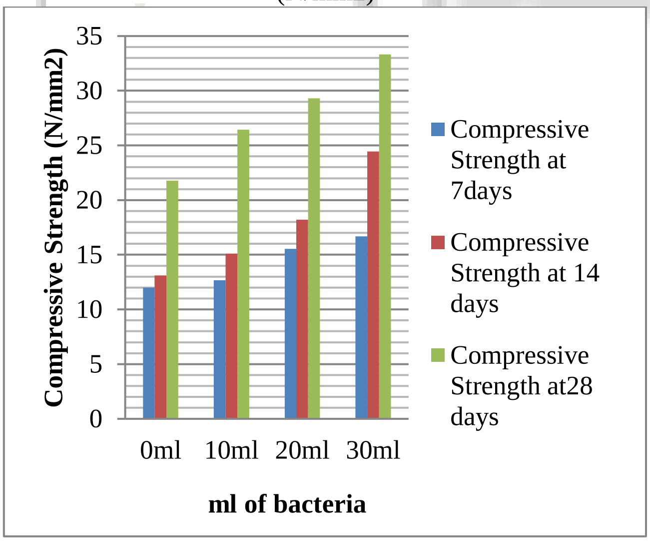
Table 5: Compressive Strength of Concrete for 7 days (N/mm2)

| ml of bacteria | 14 days Curing | |
|---|---|---|
| | Load (KN) | |
| 0ml | 295 | 0ml |
| 10ml | 340 | 10ml |
| 20ml | 410 | 20ml |
| 30ml | 550 | 30ml |

Table 6: Compressive Strength of Concrete for 14 days (N/mm2)

| ml of bacteria | 28 days Curing | |
|---|---|---|
| | Load (KN) | Compressive Strength (N/mm²) |
| 0ml | 490 | 21.78 |
| 10ml | 595 | 26.43 |
| 20ml | 660 | 29.32 |
| 30ml | 750 | 33.32 |

Table 7: Compressive Strength of Concrete for 28 days (N/mm2)




Graph 2: compressive test graphs

## V. CONCLUSION

The production of basicillus subtillis in a lab is both cost- and safety-efficient.

1) The greatest compressive strength is 33.32 MPa when 30 ml of bacillus subtillis bacteria are added.
2) The compressive strength of M20 grade bacterial concrete is higher than that of M25 grade concrete.
3) Bacterial concrete successfully achieves the self-healing characteristic.
4) Due to its eco-friendliness and ease of application, bacterial concrete technology has proven to be superior to many conventional methods.
5) This innovative concrete technology will soon proved the basis of alternative and high quality structures that will be cost effective and environmentally safe.
6) The use of microbial concrete in building could also streamline some currently complex procedures while revolutionising brand-new ones.

## VI. FUTURE SCOPE

1) Because a structure's cracks are the main source of damage, bacterial concrete will assist us solve this issue.
2) Due to its eco-friendliness and ease of application, bacterial concrete technology has proven to be superior to many conventional methods.
3) This cutting-edge concrete technology will soon serve as the foundation for alternative, superior constructions that are both economical and environmentally friendly.
4) The use of microbial concrete in building may also streamline some of the current construction procedures and completely transform brand-new construction techniques.

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