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# **Development of Bacteria-Based Self-Repairing Concrete**

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**ABSTRACT:** Attacks in concrete are preventable and its intrinsic weakness of concrete. Through these cracks, water, salts can seep. Initiates corrosion for reducing the lifetime of the concrete. So, there was a requirement to develop an incentive biomaterial, a self-repairing technique which might rectify the cracks and furiously developed in concrete. Bio-concrete is that the material which might successfully rectify cracks in concrete in this system is extremely desirable, because the activity of crack radiation is eco-friendly.

**KEYWORDS:** Self-repairing, Microbial activity, Auto treatment, Compressive Strength.

## **I. INTRODUCTION**

Self-repairing concrete is usually defined because of the ability of concrete to repair its small cracks autonomously. the concept of self-repairing concrete was inspired from the phenomenon by organisms like trees or animals. Damaged skin of trees and animals may be repaired autonomously. Remediating cracks in concrete structure is very important for its service durability and structural safety. the keyword of this text is self-repairing concrete. However, other similar keywords are self-repairing, self-repair, autonomous healing, automatic healing, auto-treatment, self-treatment, bio concrete, bio-inspired, biological concrete, calcite biomineralization, and calcite precipitation. Recently, developing self-repairing concrete technology has become a vital objective for researchers in biotechnology and applied science.

### **Objectives:**

1. Develop bacterial concrete by introducing the bacteria of bacillus Subtilis.
2. To find optimum dosage of bacteria required for bacterial concrete.
3. To increase the compressive strength of concrete.
4. To remediate the cracks developed in concrete.

## **II. LITERATURE SURVEY**

1. A review paper on self healing concrete by Gourav Suthar [1] Introducing the bacteria into the concrete makes it very beneficial. It improves the property of the concrete which is more than the conventional concrete. Bacteria repair the cracks in concrete by producing the calcium carbonate crystal which blocks the cracks and repairs it. Many researchers have done their work on the self healing nature of concrete and they have found the following result that bacteria improves the property of conventional concrete such as an increase of 13.75% in strength in 3 days, 14.28% in 7 days and 18.35% in 28 days.

2. Study of self-healing properties in concrete with bacteria encapsulated in expanded clay by S.S. Lucas,~H.[2]

Jonkers,~C.[3] Moxham,[4]~E. Tziviloglou[5] The results obtained with the tests conducted in this study confirmed that the replacement of aggregates with expanded clay impregnated with bacteria could effectively contribute to strength recovery in concrete. It has been demonstrated that the recovery has been in fact caused by the presence of calcium carbonate, the main reaction product resulting from the bacterial activity.

3. Self-Healing Concrete Using Bacteria by ~Mr. Sk. Alisha, [6] They kind of precipitation carbonate sucks. Once the suck is kind then the generated cracks square measure starts auto-filling. Once the micro-organism is added to concrete, the concrete achieves smart strength in twenty eight days. The minimum period to heal the cracks is thirty days. By the assistance of self-healing concrete structure, squares measure a lot of strength compared to traditional concrete.

### III. METHODOLOGY



#### 1. Identification of microorganism and cultivation:

Selection of the bacteria was carried out On the basis of the literature review, their abundance, and easy access. The culture of *Bacillus subtilis* (ATCC 6051) was obtained from NCIM, Pune.

The slant of the culture was procured by streaking the bacterial suspension onto a Nutrient Agar (NA) plate (HI media, India). Once after procuring the culture it was subculture in the laboratory The plates were allowed to be kept in an incubator at 37°C for 24-48 hours to allow for the growth of isolated colonies. Few colonies were selected well-isolated and sub-cultured onto a fresh NA plate to ensure purity. This process was performed for three consecutive subcultures to confirm the identity and purity of the culture. The colonies obtained after final subculture were used for further experimentation.

Media optimization for the culture was also being carried out to raise the cell yield profoundly. Media was formulated using basic ingredient's Peptone, Calcium lactate, Yeast extract, Hydrated glycerol, Polyethylene glycol 400 .It was sterilized using autoclave .Sterilizes broths with 500 ml capacity was made in triplicate. Upon autoclaving sterile



broths were checked for contamination if any and hence kept in an incubator a day long. After seeing no contamination similar flasks were used for further growing the Bacillus culture. It was inoculated under sterile conditions using a laminar air flow cabinet. Flasks were incubated in the incubator after 48 Hrs seeing the turbidity indication of the bacterial growth. Total cell count was taken up and cells were preserved in the refrigerator and revived on the time of experiment.

## **2. Concrete Mix design:**

### **Prepare concrete mix with M25:**

1. Cement {53 grade}
2. Aggregates {e.g., coarse aggregates, fine aggregates}
3. Water Bacterial culture {added to mix}
4. Nutrient supplements {e.g., calcium lactate}
5. Material Calculation for a 15 cm × 15 cm × 15 cm M25 Concrete Cube in Grams

### **Step 1: Cube Volume Calculation:**

Cube dimensions = 15 cm × 15 cm × 15 cm Total  
volume =  $15 \times 15 \times 15 = 3375 \text{ cm}^3$

### **Step 2: Density Assumption:**

1. Cement =  $1440 \text{ kg/m}^3$
  2. Sand =  $1600 \text{ kg/m}^3$
  3. Aggregate =  $1450 \text{ kg/m}^3$
- Dry concrete density =  $2500 \text{ kg/m}^3$  •**

### **Step 3: Material Calculation:**

1. Cement =  $(1/4) \times 0.003375 \times 2500 = 2.109 \text{ kg}$
2. Sand =  $(1/4) \times 0.003375 \times 2500 = 2.109 \text{ kg}$
3. Aggregate =  $(2/4) \times 0.003375 \times 2500 = 2.109 \text{ kg}$

### **1. Chemical calculation with respect to cement weight:**

1. Yeast Extract: 0.5% → 11 gm
2. Calcium Lactate : 1.0% → 21 gm
3. Hydrated Glycerol : 0.8% → 17gm
4. Sodium Lignosulfonate : 0.2% → 4gm
5. Polyethylene Glycol : 0.3% → 7gm
6. Sodium gluconate : 0.3% → 7 gm

### **2. Bacillus subtilis**

(Bacteria) -1%, 1.5%, 2%

Water cement ratio for M25 grade concrete:

w/C = 0.40– 0.50 By

taking average = 0.45

∴ Water required =  $0.45 \times 2109 = 949 \text{ gm}$  by weight  
of Cement.

### **3. Bacteria calculation with respect to cement weight:**

- 1% =  $21.09 = 20 \text{ gm}$   
1.5% =  $31.63 = 30 \text{ gm}$   
2% =  $42.18 = 40 \text{ gm}$

#### Step 5: Mixing and Casting

1. Mix concrete ingredients thoroughly.
2. Cast concrete into a cubic shape 15cm × 15cm × 15cm.
3. Compact and finish surface.

#### Step 6: Curing and Incubation

Cure concrete under controlled conditions {e.g., temperature, humidity}. Incubate for 7-28 days to allow bacterial growth and calcite precipitation.

#### Curing:

The test specimens are stored in moist air for 24 hours and after this period the specimens are marked and removed from the moulds and kept submerged in clear fresh water until taken out prior to test.

#### 4.5 Test On Concrete:

##### 7. Compressive Strength {CTM}:

Compression test is the most common test conducted on hardened concrete, partly because it is an easy test to perform and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. The standard compressive strength of concrete is determined through compression tests performed on concrete cube of size 15cm x 15cm x 15 cm. Freshly mixed concrete is filled in metal molds. The specimens are taken out of the molds after 24 hours and moist-cured for 7, 28, 56 days. After completion of above days the cubes are tested by loading them till failure using a compression machine. The recorded load value P at failure is used to determine the compressive strength.

##### 8. Self-repairing performance:

In the context of self-healing concrete, visual inspection refers to the examination of concrete surfaces with the naked eye or with simple optical aids to detect and assess cracks and other visible signs of damage, as well as any observable indications of the concrete's healing process.

### III. EXPERIMENTAL RESULTS

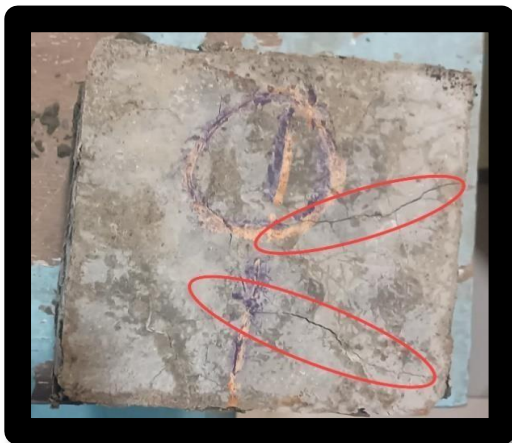
#### a) Compressive Strength after 7 Days:

% Mix	Specimen	Load (KN)	Stress (N/mm <sup>2</sup> )	Avg. (N/mm <sup>2</sup> )
0%	1	274.05	12.18	12.58
	2	292.95	13.02	
	3	282.15	12.54	
1%	1	343.60	15.27	14.62
	2	312.50	13.88	
	3	330.75	14.70	
1.5%	1	352.95	15.68	15.36
	2	344.95	15.33	
	3	339.55	15.09	
2%	1	325.80	14.48	13.57
	2	297.45	13.22	
	3	293.20	13.03	

b) Compressive Strength after 28 Days:

% Mix	Specimen	Load (KN)	Stress (N/mm <sup>2</sup> )	Avg. (N/mm <sup>2</sup> )
0%	1	583.20	25.92	26.48
	2	595.80	26.48	
	3	609.05	27.06	
1%	1	648.00	28.80	30.04
	2	713.21	31.70	
	3	666.90	29.64	
1.5%	1	699.45	31.10	32.96
	2	750.85	33.37	
	3	774.65	34.42	
2%	1	622.80	27.68	27.49
	2	583.20	25.92	
	3	650.01	28.88	

a) Visual Inspection:



BEFORE (1 DAY)



AFTER (6 DAY)



BEFORE (1 DAY)



AFTER (6 DAY)

b) Graph Analysis:

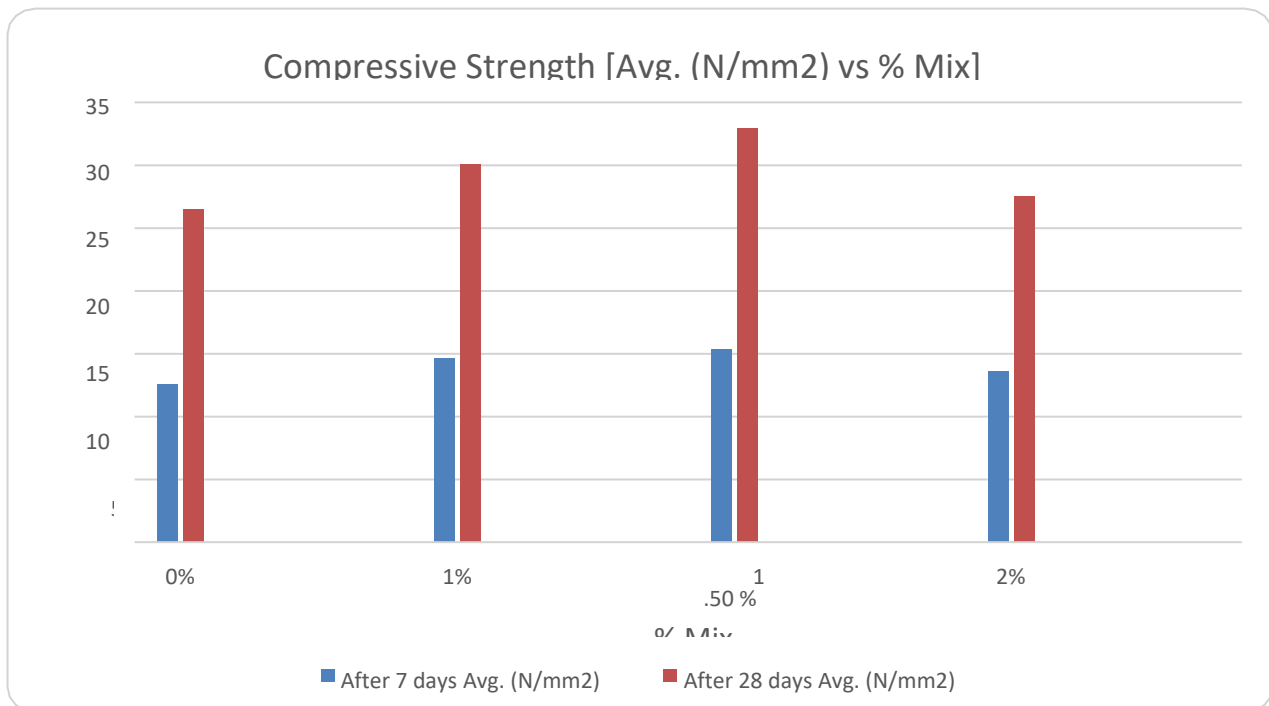


Fig. Graph analysis of compressive test after 7 days & 28 days

#### IV. CONCLUSION

1. From the graph of 7 days of compressive strength, It can be seen then the compressive strength of self-repairing concrete has increased for all mixes as compared to conventional concrete mix i.e. 0%.
2. At 1.5% mix gives maximum compressive strength at 7 days i.e. 15.36 N/mm².
3. From the graph of 28 days of compressive strength, It can be seen that the compressive strength for all mixes i.e. 1%, 1.5% & 2% as compared to conventional concrete mix i.e. 0%.
4. At 1.5% mix gives maximum compressive strength at 28 days i.e. 32.96 N/mm².
5. From visual inspection it is significantly proven that the 1.5% mix heals crack better than other content in a short time period.

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