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Experimental Investigation on Bacterial Concrete

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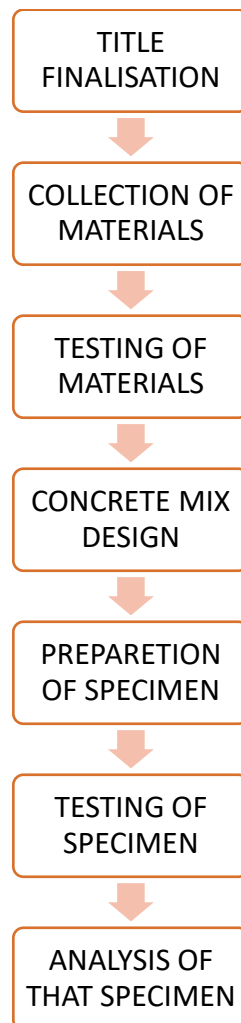
ABSTRACT: This project investigates the potential of bacterial concrete, an innovative self-healing material, to enhance the durability and longevity of concrete structures. Traditional concrete is prone to cracking, which can compromise structural integrity and necessitate costly repairs. Bacterial concrete employs specific strains of bacteria, such as *Bacillus subtilis*, to induce the precipitation of calcium carbonate (CaCO_3) within cracks, effectively sealing them

KEYWORDS: Self Healing, strength gaining, bacillus subtilis, bacterial stimulant system

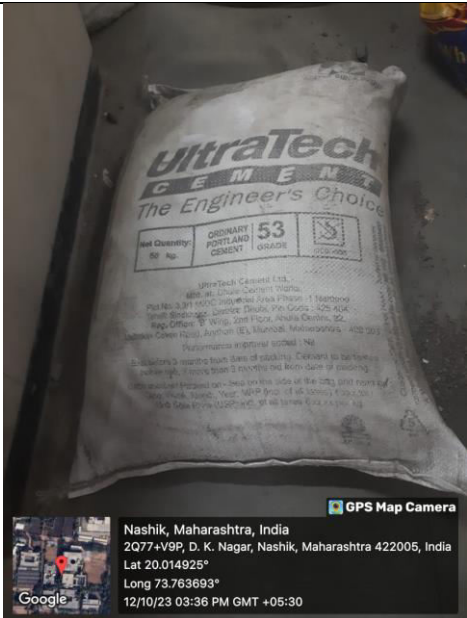
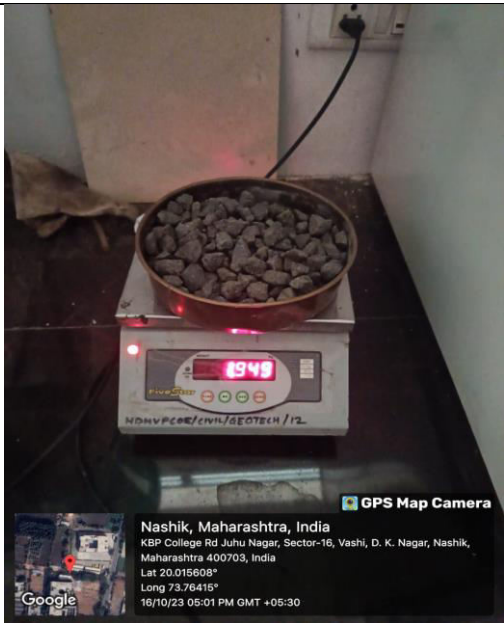
I. INTRODUCTION

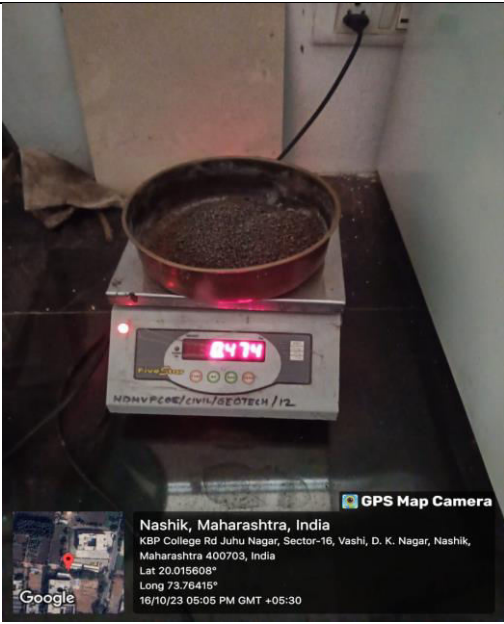
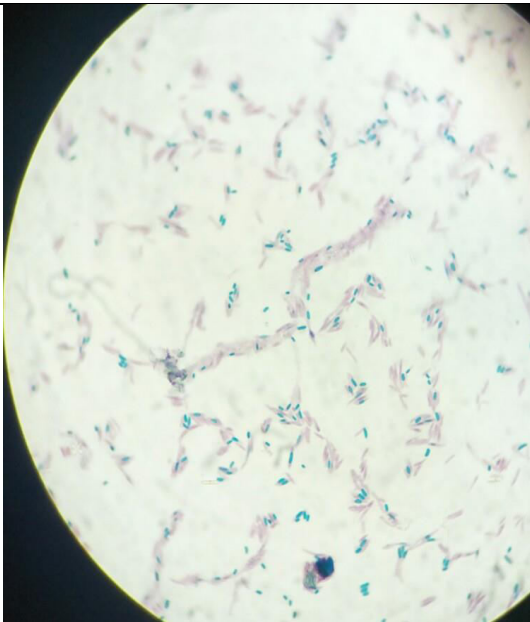
Concrete is a vital building material. It is most effective when reinforced by steel bar, because its tensile strength without reinforcement is considerably low relative to its compressive strength. Bacterial concrete is gaining popularity due to the advantages such as self-healing property, increased durability, enhanced strength etc. Self-healing is a well-established and well-known property of concrete due to its innate autogenous healing properties. After a period of time, fissures may mend due to the ongoing hydration of clinker minerals or carbonation of calcium hydroxide. Autogenous healing, on the other hand, is restricted to minor cracks and is effective only when water is accessible, which makes it difficult to fully control or predict its accuracy. However, concrete can be adapted to include a bacterial stimulant system for sealing cracks. In 2006, self-healing concrete was invented as a new type of concrete by the microbiologist professor Henk Jonkers, at Delft University of Technology, Netherlands. After 36 months of testing, he discovered the perfect healing agent, so-called bacillus. SHC has a distinct system and is commonly defined as concrete's ability to heal cracks autogenously or autonomously. It is also known as self-repairing concrete. SHC imitates the automatic healing of body wounds by the secretion of some kind of material. SHC is created by dispersing specific materials (e.g., capsules or fibers) containing repairing solutions into the concrete mix where, when cracks appear, the fibers or capsules shatter, and the liquid contained within them spreads immediately to cure the crack. Concrete cracks are a common occurrence due to the low tensile strength of the concrete systems. These developed cracks reduce the concrete's long-term durability because they allow dangerous liquids and gases to leak through. While concrete may be eroded by micro-cracks, steel reinforcement bars may also be affected by attacks resulting from the infiltration of harmful gases and liquids into the concrete system. Therefore, in order to keep the cracks from widening, it is crucial that they are treated quickly. Self-healing of concrete cracks could extend the lifespan of concrete structures and make the structure more environmentally friendly while simultaneously increasing its sustainability

II. FLOW CHART



III. MATERIALS

Sr.no	Item	Description
1		CEMENT OPC 53
2		COARSE AGGREGATES 20mm

<p>3</p>		<p>FINE AGGREGATES (WASH SAND)</p>
<p>4</p>		<p>BACILLUS SUBTILIS BACTERIA</p>

Mix Design:

Grade	Water(kg)	Cement(kg)	Fine Aggregate(kg)	Coarse Aggregate	W/C	Mix Proportion
M30	158	350	765	1625	0.45	1:2.18:4.64

Casting of Mortar cubes

Mortar cubes are essential for determining the compressive strength of mortar, which is crucial for ensuring the structural integrity and durability of masonry work. The casting and testing of these cubes follow standardized procedures to ensure consistency and reliability in results.

Materials Used

1. Cement: The binding material, usually Ordinary Portland Cement (OPC), is used for its high strength and durability properties.
2. Sand: Fine aggregate that provides bulk, strength, and other properties to the mortar. Typically, standard sand complying with relevant standards is used.
3. Water: Essential for the hydration of cement and for achieving the desired workability of the mortar mix. The water should be potable and free from impurities.

Mix Proportion

The mix proportion for mortar typically follows a specific ratio of cement to sand, and the water-cement ratio is adjusted to achieve the desired workability. Commonly used mix proportions include:

1:6 (Cement: Sand)

Casting Procedure

1. Preparation of Moulds: Clean the cube moulds thoroughly and apply a thin layer of oil to ensure easy demoulding.
2. Mixing: Measure the required quantities of cement and sand, and mix them thoroughly in a dry state. Add water gradually and mix until a uniform consistency is achieved



Bacterial solution



Curing of casted cubes



IV. RESULTS

7 days Strenght

Bacterial Concentration	Notation	Load (KN)	Compressive Strength (KN/mm)
$\times 10^4$	A1	129	26.12
	A2	130	
$\times 10^5$	B1	134	25.71
	B2	118	
$\times 10^6$	C1	125	28.46
	C2	154	
Normal	X1	120	24.48
	X2	129	

28 days Strenght:

Bacterial Concentration	Notation	Load (KN)	Compressive Strength (KN/mm)
$\times 10^4$	A1	159	34.53
	A2	162	
$\times 10^5$	B1	179	36.28
	B2	181	
$\times 10^6$	C1	191	37.85
	C2	180	
Normal	X1	159	32.28
	A1	164	

Casting of Concrete cubes

Concrete cube testing is a fundamental method used to assess the compressive strength of concrete. This is crucial for ensuring the quality and performance of concrete in construction projects. Compressive strength tests on concrete cubes provide a standardized way to determine the load-carrying capacity of the concrete.

Objective

The primary objective of concrete cube testing is to determine the compressive strength of the concrete mix. Compressive strength is a critical parameter influencing the structural integrity and durability of concrete structures.

Materials Used

1. Cement: The binding material that provides strength and durability.
2. Aggregates: Fine (sand) and coarse (gravel or crushed stone) aggregates provide bulk and contribute to the concrete's strength and stability.
3. Water: Necessary for the hydration of cement and achieving workability.
4. Bactria: Chemical additives that modify the properties of concrete for specific requirements.

Cube Size

Concrete cubes are typically cast in moulds of standard sizes:
 - 150 mm x 150 mm x 150 mm (standard size)

Mix Design

Grade	Water(kg)	Cement(kg)	Fine Aggregate(kg)	Coarse Aggregate	W/C	Mix Proportion
M30	158	350	765	1625	0.45	1:2.18:4.64

Procedure

- 1.Preparation of Moulds: Clean the cube moulds and apply a thin layer of oil to the inner surfaces to ensure easy demoulding.
- 2.Mixing Concrete: Measure the required quantities of cement, aggregates, and water. Mix them thoroughly to obtain a uniform consistency.



3. Filling the Moulds: Fill the cube moulds in layers, approximately one-third of the depth each. Compact each layer with a tamping rod (or vibrator) to remove air pockets and ensure proper compaction.



4. Surface Finishing: After filling and compacting, smooth the top surface of the cubes using a trowel to ensure a level finish.

5. Curing: After 24 hours, demould the cubes and place them in a curing tank with clean water to cure for the specified period, typically 7, 14, or 28 days.





28 Days Results:

Bacterial Concentration	Notation	Load (KN)	Compressive Strength (KN/mm)
$\times 10^4$	A1	778	34.77
$\times 10^5$	B1	805	35.77
$\times 10^6$	C1	452	20.85
Normal	X1	600	26.66

V. CONCLUSION

The experimental investigation into bacterial concrete demonstrates its considerable potential as a self-healing material for enhancing the durability and longevity of concrete structures. By incorporating bacteria such as *Bacillus subtilis* and suitable nutrients into the concrete mix, it is possible to induce the formation of calcium carbonate (CaCO_3) that effectively increase strength and prevents further deterioration.

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