A Strength Based Experimental Study Using Self-Healing Agent for Bacterial Concrete.

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Abstract - - *The fastest-spreading self-healing bacteria found in concrete is the best example of a self-sustaining unit. Concrete that increases its strength is a true advancement in the field of concrete technology. both growing fractures in the structure and compressive strength. Concrete constructions often fail due to cracks, which shorten their lifespan. Nowadays, additional chemicals or additives are utilized, such as bacteria and calcium lactate, a powder that is used in the mixing process, to prevent these cracks from occurring. In the past, these fissures could have resulted from shrinking or creeping or from adding too much water when mixing the concrete. This study will also address two problems that are commonly associated with concrete.*

Key Words*: *Conventional concrete, bacterial concrete, bacteria (bacillus Subtilis), calcium lactate, compressive strength, Tensile strength, Flexural strength, environment.

1.INTRODUCTION:

Concrete ranks second globally in the construction business. The fundamental material used in building construction is chosen because of its affordability, strength, and durability. Measuring, mixing, and adding bacteria and calcium lactate to the mixture yields a homogenous mixture in the context of concrete technology. Concrete is "work compacted" by placing it in the molds, letting it set, and then continuously moistening it for 28 days. Spores containing these bacteria are applied to concrete. Many researchers use a wide variety of microorganisms. Nonetheless, Bacillus subtilis was employed in this study. Extended lifespans and efficacy are essential for bacteria employed as self-healing agents, as they should be able to repair cracks.

1.1 Bacterial Concrete:

On the concrete's prepared with bacteria (bacillus subtilis) with mineral admixture (calcium lactate) for bacterial concrete. It is possible for moisture to seep into cracks in most concrete, exposing unreached cement grains. Then, hydration products could fill in and seal the crack, resuming the hydration process.

1.2 Merits and Demerits:

1. Improvement in compressive strength of concrete.
2. Prevent cracking in concrete.
3. Reduce maintenance and increases material durability
4. Cost of bacterial concrete is more than conventional concrete.
5. There is no IS code or other code is available for bacterial concrete.
6. Skilled labor is required for preparation of material.

2. AIM:

1. Comparing bacterial concrete to traditional concrete, the former exhibits to improved tensile compressive, and flexural strengths.
2. Bacterial concrete can prevent additional damage from happening by patching cracks as they appear, which lowers maintenance expenditures.
3. Bacterial concrete is thought to be more environmentally friendly than regular concrete, in addition to its capacity for self-healing.

2.1 Objectives of bacterial concrete:

1. Water seeps generate small cracks in a structure by corroding the steel reinforcing and deteriorating the concrete, ultimately causing the structure to disintegrate.
2. This is a result of the fractures being filled with bacterial concrete and the construction has a longer lifespan because of bacterial concrete.
3. Decrease upkeep and lengthen the lifespan of materials.

3. LITRATURE REVIEW:

- **S. Sanjay, S. Neha, and R. Jasvir (2016),** This paper was presented the experimental investigation on bacterial concrete to increase the strength of bio concrete and to inform the process involved in the bacterial concrete. To know the calcite crystals formed in bacterial concrete analysis of microstructure has been done that is used for the potential to recovery the cracks in bacterial concrete and also to inform the biological reaction in concrete. As a result, has been got because of good adaptability of nutrient broth medium of bio concrete at 28 days attained better strength when compare to conventional concrete.

- **B. Chithra P Bai and V. Shibi**, this paper was presented, bacterial concrete with various bacterial solution of 103ml, 105ml and 107ml and they have been used B. Subtilis bacteria species in this experiment and also bio concrete is formed by 10%,20%, and 30% fly ash replacing cement by its mass. The Ultrasonic Pulse Velocity, split tensile, Flexural and compressive strength tests have been doing after 28 and 56 days for M30 grade. All mechanical properties of bio concrete enhancing at 10% fly ash replacing cement and by 105ml bacterial solution achieved maximum values for all test they conducted. Finally, the precipitation of CaCO3 due to bacteria in the concrete by bio technology concept that improves mechanical properties of fly ash concrete.

4. MATERIAL AND METHDOLOGY:

4.1 Cement: We used regular Portland cement (grade 53) in this investigation. OPC is perfect for construction because of its strong compressive strength, superior workability, and durability, among other qualities.

Table-1: Properties of cement:

S. NO	Properties of cement	Values
1	Specific gravity	3.15
2	Fineness modulus	4.2%
3	Initial setting time	34 min
4	Final setting time	9:35 hrs.
5	Consistency	33%

4.2 Fine Aggregates and coarse Aggregate: This study used river sand, which has a fineness modulus of 2.45. Fine aggregate has a specific gravity of 2.45. and coarse aggregate is defined as coarse aggregate with a size greater than 4.75 mm. The coarse aggregate has a specific gravity of 2.66.

4.3 Water: One of the most crucial components of bacterial concrete is water, which aids in the reaction with calcium lactate upon contact. In accordance with IS Codes 3025-1904 and 456-2000, we used regular tap water.

4.4 Calcium Lactate: With the formula $C_6H_{10}CaO_6$, calcium lactate is a white, crystalline salt. Calcium hydroxide or calcium carbonate can react with lactic acid to produce calcium lactate. We are employing three different percentages of calcium lactate by the weight of the cement in this study: 6%, 8%, and 10%. Calcium hydroxide or calcium carbonate can react with lactic acid to produce calcium lactate. We are using various percentages in this investigation.

Table-2: Properties of calcium lactate:

Chemical formula	$C_6H_{10}CaO_6$
Appearance	White powder
Solubility in water	7.8 g/100ml
Odor	Efflorescent
Density	1.49 g/cm cub
Solubility	Soluble in ethanol
Molar mass	218.22 g/mol

4.5 Bacteria: We employed the Bacillus subtilis bacteria, commonly referred to as grass bacillus or hay bacillus, in this investigation. This bacterium is catalase-positive and gram-positive. These bacteria are stringent aerobes that produce endospores. However, more recent research has demonstrated that Bacillus subtilis can grow without oxygen. These bacteria usually have a rod-shaped texture, measuring between 4 and 10 micrometers in length and 0.25 and 1.0 micrometers in diameter.

When this bacterium comes into contact with calcium lactate in the presence of water droplets, it can produce precipitate. This bacterium can withstand pH levels between 7 and 9, and the choice of bacteria is entirely dependent on the water's pH level. The percentage of bacteria used for this investigation was 5%, 7%, and 9% based on the cement's weight.

Types of bacteria:

1.Bacillus pasteurii.
2.Bacillus subtilis.
3. Cohnii.
4. Sphaericus.
5. Bacillus coli.

4.6 Mix Design for Concrete:

Mix design by Indian standard recommended method for concrete mix design based on {IS10262-2019} M30 grade of concrete mix is taking by me.

(A) Design Required:

1. Grade designation = M30

2. Type of cement = OPC-53

3. Maximum Size of aggregate = 20 mm

3. Degree of site control = Good

4. Exposure condition = Severe

5. Workability = 75 mm(assumed)

6. Method of concrete placing = manual

7. Minimum cement content = 320 kg/m^3

(B) Test result for material:

1. Specific gravity of cement = 3.15

2. Specific gravity of coarse aggregate = 2.66

3. Specific gravity of fine aggregate = 2.45

4. Water absorption of coarse aggregate = 1 %

5. Water absorption for fine aggregate = 1.16 %

6. Conforming zone of sand = zone II

7. Type of aggregate = uniformly graded aggregate.

(C) Target mean strength = 38.25 N/mm^2

(D) Selection of water cement ratio = 0.45

(E) Selection of water content = 207.48 kg/m^3

(F) Cement content =361.87 kg/m^3

(G) Coarse aggregate (per m^3) = 1097.678 kg

(H) Fine aggregate (per m^3) = 591.488 kg

4.7 Tests on concrete:

Workability test: The slump test is the method most often used to assess workability. This test, which can be conducted at the construction site or in a laboratory, is the most widely used technique for determining the consistency of concrete. The mix ratio for conventional concrete is C:S:A :: 1:1.39:2.59 and for bacterial concrete is C:S:A :: 1.1.63:3.03.

Table-3 Slump Values of Conventional Concrete.

S. No.	W/C Ratio	Slump Value(mm)	Average Value
01	0.45	78	76
02	0.45	75	
03	0.45	75.5	

Table-3 Slump Values of Conventional Concrete.

S. No.	W/C Ratio	Slump Value(mm)	Average Value
01	0.45	81	81
02	0.45	80	
03	0.45	82	

5. RESULT AND DISCUSSION:

5.1 Casting Program:

The casting of the specimens was done as per IS 10086-1982: preparation of materials, weighing of materials, and casting of cubes, cylinders, and beams. The mixing, compacting, and curing of concrete are done according to IS 516:1959. The plain samples of cubes, cylinders, and beams were cured for 28 days in a water pond.

Fig-1: Casting of Cube, Beam and Cylinder.

Compressive Strength test:

A 150 × 150 × 150 mm concrete sample was cast, and its compressive strength was measured after 7 and 28 days of testing. It is possible to compute the compressive strength using equation (1). P/A equals compressive strength. P is the applied load, and A is the cross-sectional area (150 × 150 × 150 mm).

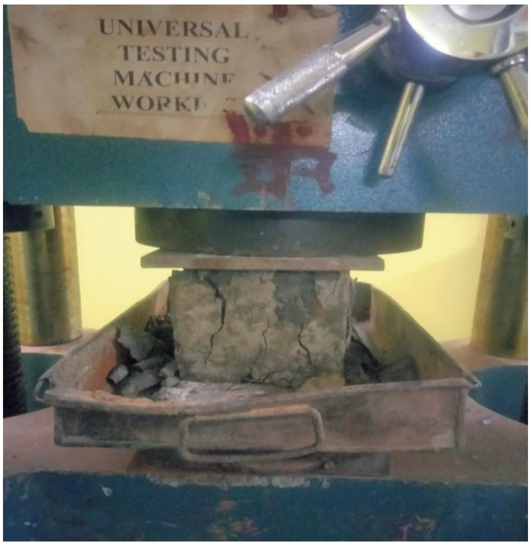

Fig-2: Compressive strength tests of concrete.

TABLE-5: Compressive Strength results for Conventional Concrete and bacterial concrete:

Control mix	% Bacteria (bacillus subtilis)	% Calcium lactate	7 days Compressive strength (N/mm²)	28 days Compressive strength (N/mm²)
Conventional concrete	0	0	18.47	38.13
Bacterial concrete MIX1	9	6	22.93	43.28
Bacterial concrete MIX2	7	8	25.65	46.49
Bacterial concrete MIX3	5	10	27.30	48.83

@ The compressive strenght of M30 grade concrete as per IS – 456:2000, is 30Mpa or 30N/mm^2 after 28 days of conventional concrete.

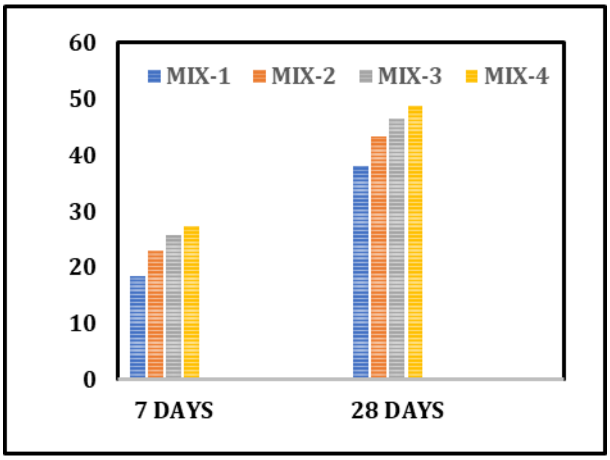

Chart-1: Compressive strength for conventional concrete after 7, and 28-days vs bacterial concrete.

Split tensile strength:

Using cylinders of 150 mm in diameter and 300 mm in height. The cylinder was cast, and it was tested in 7and 28 days. By using equations, we can determine the split tensile strength. Split tensile strength = 2P/πDL, where P = load, D = diameter of the cylinder, and L = length of the cylinder.

Fig- 3: Split tensile strength test in UTM

TABLE-6: Tensile Strength results for Conventional Concrete and bacterial concrete:

Control mix	% Bacteria (bacillus subtilis)	% Calcium lactate	7 days Split tensile strength (N/mm²)	28 days Split tensile strength (N/mm²)
Conventional concrete	0	0	8.60	11.37
Bacterial concrete MIX1	9	6	10.51	12.02
Bacterial concrete MIX2	7	8	10.67	12.08
Bacterial concrete MIX3	5	10	10.75	12.15

@ The Split tensile strenght of M30 grade concrete as per IS – 456:2000, is 4.87 N/mm^2 after 28 days of conventional concrete.

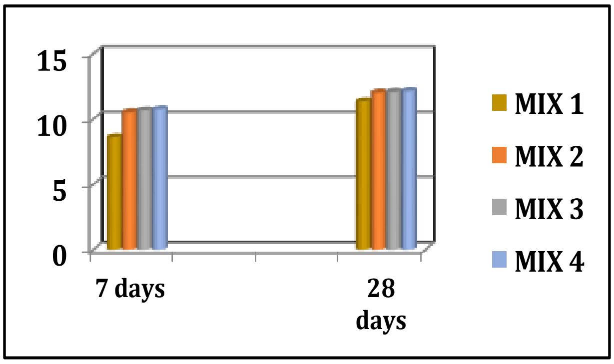

Chart-2: Tensile strength for conventional concrete after 7, and 28-days vs bacterial concrete.

Flexural Strength Test:

A universal testing equipment is used to test a beam specimen measuring 150 x 150 x 700 mm. A point loading force of 2000 KN is applied to the specimen to produce pure bending. Recorded is the applied load on the specimen. noted the concrete mix's strength after seven and twenty-eight days.

Fig- 4: Flexural strength test in UTM

TABLE-7: Flexural Strength results for conventional concrete and bacterial Concrete:

Control mix	% Bacteria (bacillus subtilis)	% Calcium lactate	7 days flexural strength (N/mm²)	28 days flexural strength (N/mm²)
Conventional concrete	0	0	1.70	3.85
Bacterial concrete MIX1	9	6	1.80	2.09
Bacterial concrete MIX2	7	8	2.18	2.61
Bacterial concrete MIX3	5	10	2.20	3.97

@ The flexural strenght of M30 grade concrete as per IS – 456:2000, is 3.83 N/mm² after 28 days of conventional concrete.

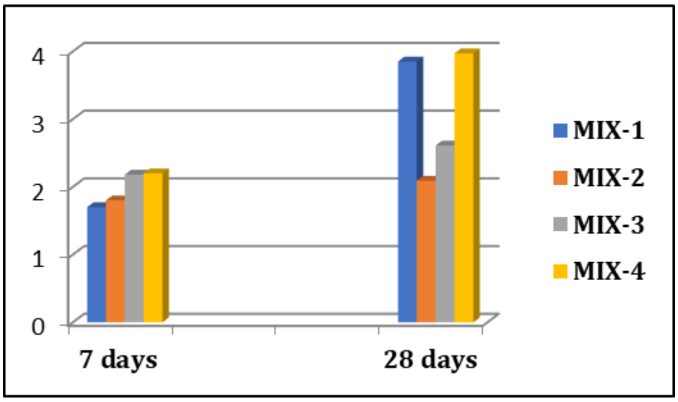

Chart-3: flexural strength for conventional concrete after 7, and 28-days vs bacterial concrete.

6. CONCLUSIONS:

- Comparing the compressive strength of 10% calcium lactate and 5% bacteria mixed concrete strength with standard concrete, the difference was 24% after 7 days of curing.
- After 28 days, the highest compressive strength of 28.06% was achieved with a 10% calcium lactate and 5% bacterium mix concrete.
- The study's findings demonstrate that, in comparison to conventional concrete, the strength of bacterial concrete is higher.
- Tensile strength of 10% calcium lactate and 5% bacterial mixtures results in a 6.8% improvement in concrete strength over traditional concrete.
- Ten percent calcium lactate and five percent bacteria combine to create concrete with a flexural strength that is 2.90% higher than regular concrete.

7. SCOPE OF RESEARCH:

- The addition of microorganisms and calcium lactate will make the concrete more workable.
- In some aspects, the substance is better than conventional abiotic-reinforced concrete.
- long-term viability for several factors.
- Numerous applications call for the use of bacterial concrete, including the lining of tunnels, walls, floors, bridges, highways, and maritime structures.

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