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Experimental Investigations on Strength Properties of Self-healing Bacterial Concrete Using M-Sand

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ABSTRACT
Cracks in concrete are unpreventable and major problem in the building structure which reduce the strength and durability of the entire structure. Through the cracks the water, salts or other chemical substance enter into the concrete which further reduce the life span of the concrete. By considering the above problems bacteria are introduced in the concrete. Bio concrete technique is highly desirable because the activity of bacteria is eco-friendly and natural. This paper discuss the healing of artificial cracks in the concrete by introducing bacteria different proportions such as 10ml, 20ml, 30 ml,40ml and the effect of compressive strength, flexural strength and split tensile test due to mixing in concrete is also discussed in this paper. The Bacteria which is going to be introduced should be alkali resistance against the stresses while mixing, transporting and placing. It is also noted that bacillus cereus arrest the cracks in the concrete and acts as an excellent self-healing agent.

1. INTRODUCTION

Concrete is the most used construction material worldwide because it is a strong and relatively cheap construction material. Several construction techniques without incorporating concrete have been developed but concrete still continues to be the most important building material for infrastructure. The major shortcoming of concrete is that it tends to crack when subjected to tension. Tiny cracks formed on the surface of the concrete make the whole structure vulnerable due to seepage of water into the concrete, promoting corrosion of the steel reinforcement, thus reducing the life span of the structure.

Autogenous crack-healing capacity of concrete has been recognized in number of studies recently. The main concern of the present research therefore was to develop a type of sustainable self-healing concrete using a sustainable self-healing agent.

The effects of durability problems reflect so much on the money spent for maintenance and repair works of concrete structure. Cracking of concrete is a common phenomenon and without immediate and proper treatments, cracks in concrete structure tend to expand further which eventually require costly repair. Self-healing materials like Bacteria used in such type of concrete have the ability to heal the damage inflicted on the concrete partially or completely. The long term goal is to understand the significance and behavior of micro-organisms in concrete structures.

Therefore bacterially induced calcium carbonate precipitation has been proposed as an alternative and environmental friendly crack repair technique. Durability problems such as crack formation are typically handled by manual inspection and repair,i.e.by impregnation of cracks with cement or epoxy-based or other synthetic fillers.The "Bacterial Concrete" can be made by embedding bacteria in the concrete that are able to constantly precipitate calcite. Bacillus Cereus is a soil bacterium, can continuously precipitate a new highly impermeable calcitelayer over the surface of an already existing concrete layer.

Tests are conducted to study the mechanical properties of the concrete with various percentages of Bacteria. The tests carried out are Compressive strength test, Split Tensile strength test. Self-healing system can achieve a tremendous cost reduction in terms of health monitoring,damage detection and maintenance of concrete structures, assuring a safe service life of the structure.

Main Challenge of this project was therefore to identify suitable bacteria which not only survive incorporation for prolonged periods,but also can additionally act as a self healing agent.

1.1 OBJECTIVE

1) To create self-healing property.
2) To reduce repairing cost of construction.
3) To study the variations in strength parameters – Compressive strength and Split tensile strength and Flexural strength test.

1.2 SCOPE

1) Due to bacterial activity,durability and strength of concrete is increased.
2) Due to bacterial activity,the fine cracks formed in concrete are arrested.
3) Due to culture of bacteria our surrounding eco system and fertility of soil will be preserved.

1.3 ADVANTAGES

1) Bacterial concrete helps the crack remediation
2) It resists against the reinforcement corrosion
3) Reduction in permeability

1.4 DISADVANTAGES

1) Cost of bacterial concrete is double than that of conventional concrete.
2) Growth of bacteria is not good in any atmosphere and media.

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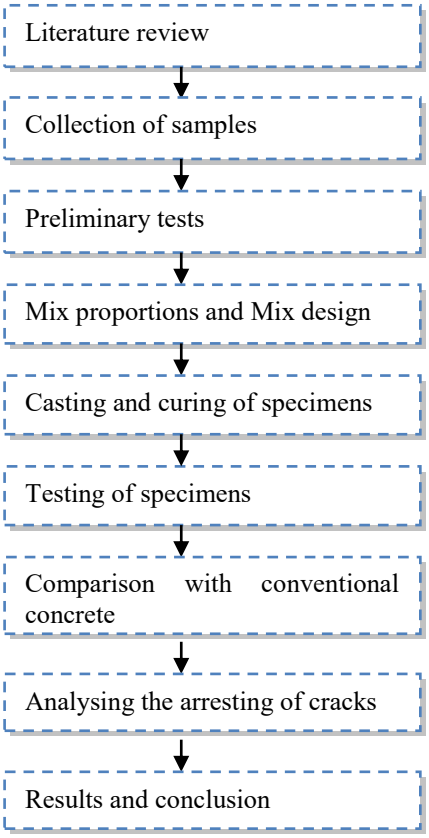
2. METHODOLOGY



3. MATERIALS

3.1 Cement

Cement is the most important ingredient and act as a binding material.PPC is used for casting concrete. The Physical Properties of Cement are shown in table 1.

Table 1. Physical Properties of Cement

Name of the tests	Tested value
Standard consistency test	33 %
Initial setting time	35 min
Fineness	6 %
Specific gravity	2.92

3.2 M-Sand

M-sand is also termed as Manufactured sand. The sand was sieved to remove pebbles. The sand was tested as per IS:2386 (Part III) -1963.The physical properties of fine aggregate are shown in table 2.

Table 2. Test results of M-sand

Description	M-sand
Specific gravity	2.64
Water absorption	1%
Sieve analysis	Conforming to zone III
Fineness modulus	3.90%

3.3 Coarse Aggregate

Hard granite broken stones of 20mm size were used as coarse aggregate conforming to IS 383:1970. The physical properties of coarse aggregate are shown in table 3.

Table 3. Test results of coarse aggregate

Description	Coarse aggregate
Specific gravity	2.68
Water absorption	0.65%
Fineness modulus	6.19%

3.4 Concrete mix proportion

The mixes were designated in accordance with IS 10262-2009 mix design method. Based on the results, the mix proportions M 25 was designed. Concrete mix with w/c ratio of 0.47 was prepared. The details of mix proportions for $1m^3$ of concrete are given in Table 4.

Table 4. Material required for $1m^3$ of Concrete (Kg/m^3)

Grade	Cement (kg)	FA (kg)	CA (kg)	Water (lit)
M25	420	790	1010	197

3.5 About Bacteria

Bacteria cereus is a large Gram positive rod-shaped, facultative aerobic bacterium. It was first successfully found in 1969 from a case of fatal pneumonia in a male patient. *B.Cereus* is a mesophillic, growing at the temperature 20° c and 40°c, and is capable of adapting to a normal of environment conditions.

4. VARIOUS TYPES OF BACTERIA USED IN CONCRETE

1) Bacillus megaterium
2) Bacillus pasteurii
3) Bacillus subtilis
4) Bacillus aeries
5) Sporosarcinapasteurii
6) Shewanella Species
7) Bacillus flexus

5. TESTING RESULTS

5.1 Compression Test:

Cube specimen as per BS: 1881-198 (Part 108).

Table 5. Compressive strength of concrete

S.No	Mix (ml)	Compressive strength (N/mm^2)		
		7 Days	14 Days	28Days
1	0	12.20	19.7	22.78
2	10	15.2	18.7	25.97
3	20	16.1	20.7	28.70
4	30	16.62	21.55	31.22
5	40	14.42	18.26	24.90

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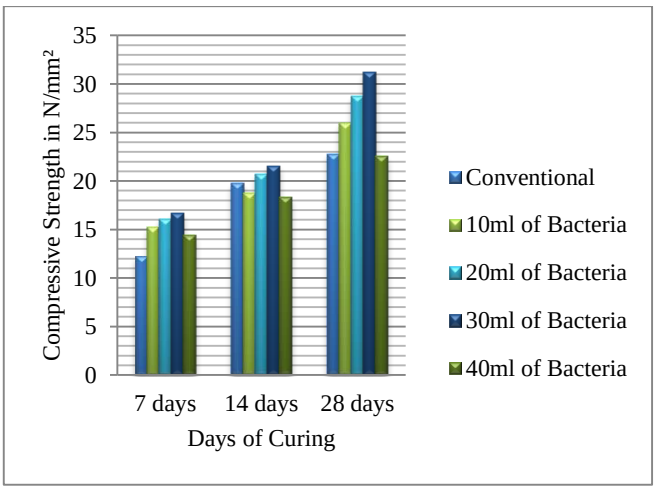

Figure.1 Compressive strength of Concrete

Figure.2 Testing of compressive strength

5.2 Flexural Strength Test

Table 6. Flexural strength of Concrete

S.No	Bacteria (ml)	Flexural strength (N/mm²)		
		7 Days	14 Days	28Days
1	0	1.66	2.25	3.5
2	10	2.5	4	5
3	20	4.5	5.5	7
4	30	6	7.5	8.5
5	40	4.7	5.83	6.4

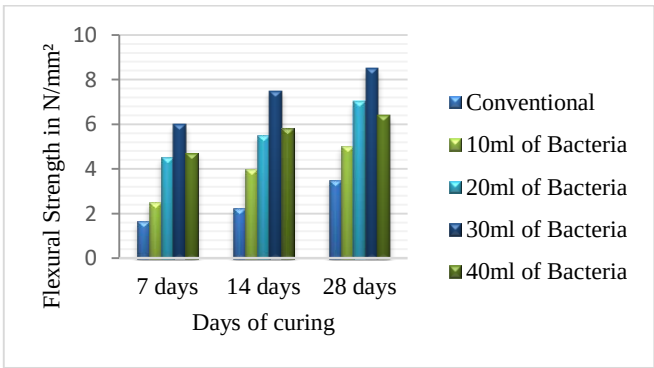

Figure.3 Flexural strength of Concrete

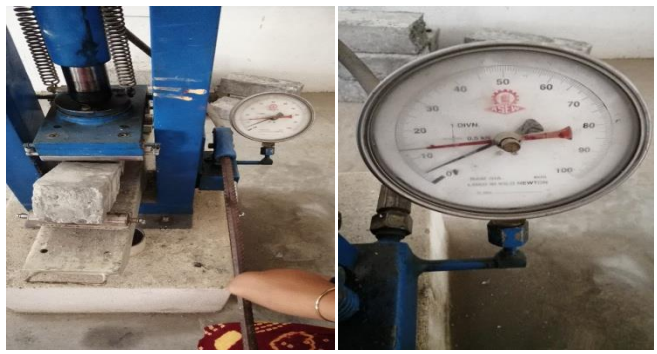

Figure.4 Testing of Flexural strength for concrete

5.3 Direct Tension Test

Cylinder specimen as per BS: 1881-198 (Part 117) of specimen size 150 x 300mm cylinder is taken.

Table 7. Split Tensile strength of concrete

S.no	Bacteria (ml)	Split Tensile strength (N/mm²)		
		7 Days	14 Days	28Days
1	0	1.43	2.613	2.99
2	10	2.26	2.82	3.11
3	20	2.82	2.97	3.39
4	30	3.22	3.32	3.53
5	40	2.6	3.08	3.46

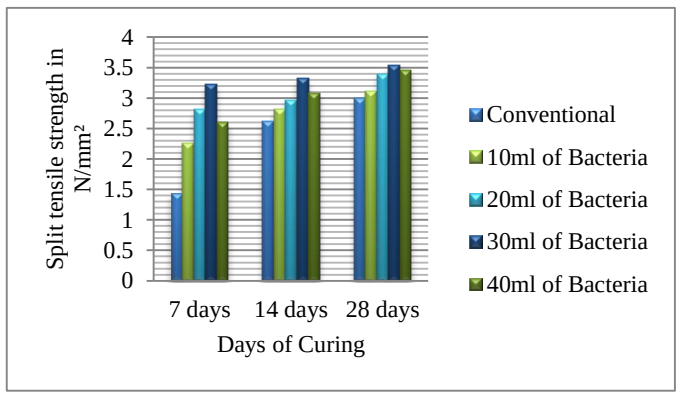

Figure.5 Split Tensile strength of Concrete

Figure.6 Testing of Split Tensile strength

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6. CONCLUSION

The Experimental study shows that the Concrete mixed with Bacillus Bacteria increases the strength of the concrete. The bacteria produced from laboratory are proved to be safe and economical. The use of bacteria in concrete enhances the strength of the concrete hence using this bacteria for self-healing mechanisms also. It has been found that the increase in mix proportions of bacteria increases the strength of concrete.

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