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EXPERIMENTAL STUDY ON BACTERIAL CONCRETE AND THE INFLUENCE OF VARIOUS CONCENTRATIONS OF BACTERIA ON THE PROPERTIES OF CONCRETE

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Abstract

It is well known that concrete is good in compression but it cannot take tensile loads for which the reinforcement is provided. The main disadvantage of concrete is that they undergo cracking over a period of time and these cracks get widened subsequently which reduces the load carrying capacity of the structures. However there are many techniques in increasing the load carrying capacity of the structure. But in this present study, addition of Bacillus subtili in various concentrations has implemented which is eco friendly and also helps in enhancing the load carrying capacity of the structure. A comparative experimental study is done for the conventional concrete and the bacterial concrete with various concentrations of bacteria. The bacterial concrete is prepared with manufactured sand and without manufactured sand. For this, a mix design of M20 is adopted. Specimens such as cubes, cylinders and beams are casted and cured for 28 days in water. The cubes and cylinders are tested in compression testing machine for compressive strength and split tensile strength respectively whereas the beams are tested in the loading frame for flexural strength. From these tests, graphs has been plotted for compression strength, split tensile strength and flexural strength for both conventional concrete as well as bacterial concrete with and without manufactured sand. From the results obtained, it can be concluded that bacterial concrete of 6ml/ liter concentration with the manufactured sand has performed well than the other concentrations and the conventional concrete.

Key words: Bacillus subtili, Bacteria, Eco friendly, Strength.

1.0 Introduction

Most of the structures are made up of concrete even though there are some materials of construction such as steel, glass and bamboo. Concrete is having many good properties but
the disadvantage is cracking. As the age of the concrete increases, there is a possibility of occurrence of cracks. These are formed by both natural process and the artificial process. Due to cracking, the service life of the structure gets depleted. There are many methods to avoid cracks and to increase the strength. They are retrofitting, fiber reinforced polymer coating, provision of base isolators etc. But in this paper, a new method of incorporating bacteria into the concrete is evolved. This process of adding bacteria is termed as bacterial concrete. This bacteria has a tendency to precipitate calcite which is known as Microbiologically Induced Calcite Precipitation which heals the cracks and acts as a self healing material. Besides it also increases the various strength properties. Bacteria can be induced in the new constructions as well as the existing constructions as a method of surface treatment. Mostly it is suitable for the underground structures where there is a possibility of leakages.

1.1 Need for bacterial concrete

As the population is increasing day by day, there is a necessity of high rise building which in turn requires concrete of more load carrying capacity. So, in order to

increase the load carrying capacity, bacteria is induced in various elements such as beams, columns and cubes etc. Besides inducing bacteria into the concrete, there are many by products to enhance the strength of concrete. But those by products obtained from the industries causes pollution to the environment. Therefore there is a need for bacteria which enhances the concrete strength and which is also eco-friendly in nature.

1.2 Materials used

The required materials are

1. Cement
2. Fine aggregate
3. Manufactured sand
4. Coarse aggregate
5. Water
6. Bacteria
7. Reinforcement

1.3 Advantages of bacterial concrete

1. For enhancement in the strength of concrete.
2. For remediating cracks in the structures.
3. For decreasing the permeability in concrete.
4. For reducing the corrosion in reinforced concrete.
5. Resistance to freezing and thawing action.

1.4 Disadvantages of bacterial concrete

1. Tests on calcite precipitation study is more costly.
2. Culture of bacteria should be appropriate.
3. Lack of specification of IS code for bacterial concrete.
4. Requirement of skilled microbiologist.

2. Scope and Objective

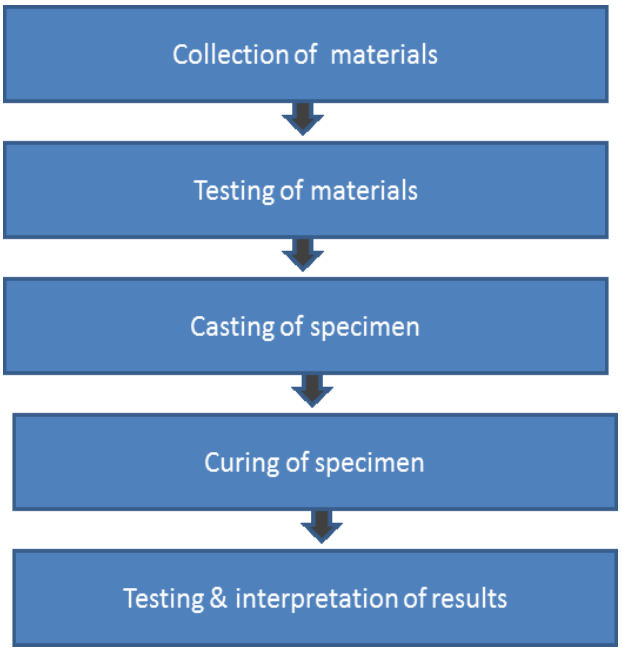
2.1 Scope of the work

1. Performance is to be studied for various concentrations of bacteria.
2. To increase the strength of conventional concrete by inducing bacteria.
3. Reduction in the cost of bacterial concrete by inducing industrial waste.
4. Implementation of bacteria in the construction field.

2.2 Objectives of the work

1. Basic tests for M20 grade of concrete.
2. Studying the properties of M-sand.
3. To evaluate the compressive strength of cubes with varying the concentration of bacteria.
4. To find out the split tensile strength of various bacterial concentrated cylinders.
5. To evaluate the flexural strength of different concentrated microbial beams.
6. To find the percentage of increase in compressive strength in bacterial concrete.
7. To find the percentage of increase in flexural strength in bacterial concrete.

3. Methodology



3.1 Compressive strength test

1. The specimens should be prepared of size 150 x 150 x 150 mm and stored in water, should be tested immediately on removal from water and while still in wet condition. Specimens which are dry should be kept in water for 24 hrs, before they are taken for testing.
2. The bearings of compression testing machine should be wiped off to remove any sand

particles or dirt present on it before conducting the test.

3. For a cubical specimen, it should be placed such that the load acts on opposite sides but not the top and bottom of the cube.
4. No packing should be used between the faces of the test specimen.
5. As the spherical seated block is brought to rest on the specimen, the movable portion should be rotated gently by hand so that uniform seating is obtained.
6. The load should be applied without shock and increased continuously at a rate of approximately 140 kg/sq.cm/min until the resistance of the specimen to the increasing load break downs and no greater load can be sustained.
7. The maximum load that the specimen could take should be recorded. Compressive strength is determined by the given formula.

Compressive strength = load/area
= W/(L x B)
W = Load at failure in N
L = Length of the cube in mm
B = Breadth of the cube in mm

3.2 Split tensile strength test

1. The cylinders should be casted of mould size having 150mm in diameter and 300mm in length.
2. These cylinders should be cured for 28 days in a curing tank containing water.
3. Before testing the specimen, the dimensions shall be noted.
4. Specimens should be removed from water only before testing.
5. The test specimen shall be placed in the cantering jig in the appropriate manner.
6. The load shall be applied without shock and increased continuously at a nominal range of 1.2 N/min to 2.4 N/min.
7. The maximum load applied then shall be recorded. The split tensile strength is calculated by the formula given below.

Split tensile strength = $2P/(\Pi LD)$
P = Load at failure in KN
L = Length of the cylinder in mm
D = Diameter of the cylinder in mm

3.3 Flexural strength test

1. The bacterial concrete beams of dimension 150 x 300 x 2000 mm were lifted using the hydraulic jack and placed on the loading frame.
2. The beams were arranged in a two point loading manner with an equal interval of 600mm each.
3. Loading cell of 1000kN capacity is used to apply uniform loading.
4. Two roller supports were provided 100 mm apart from both the ends of the beam.
5. Sensitivity 0.1mm LVDT is fixed at the center of the beam to note down the deflection.
6. Loading was applied at a rate of 2kN/sec.
7. The load was applied gradually by the hydraulic jack in increment till failure of specimen takes place.
8. The performance of the beam was observed throughout the loading period until the specimen fails.
9. Load deflection curves for each beam were obtained from the software and these are noted down in excel sheets by the software for each loading.
10. Also the pattern of failure, propagation of cracks were observed and recorded.
11. The maximum load that the specimen can take shall be recorded. Flexural strength can be calculated by using following formula

Flexural strength = PL/BD^2.
P = Maximum load applied to the specimen in
L = Length of the specimen from c/c of the supports in mm
B = Width of the specimen in mm
D = Depth of the specimen in mm

4. Results and discussions

4.1 Compressive strength of concrete

The investigation of the work is carried out to study the compressive strength of concrete. The results of the compressive strength of controlled concrete cubes and bacterial concrete cubes of various concentrations at 28 days for M20 grade concrete are tabulated as follows.

Table 4.1 compressive strength test results with and without bacteria

Bacterial concentration ↓	Compressive strength(average)	
	Cubes with fine aggregate(N/mm²)	Cubes with M-Sand (N/mm²)
0 ml	20.08	21.39
3 ml	28.52	30.24
6 ml	30.21	31.56
9 ml	27.34	28.94

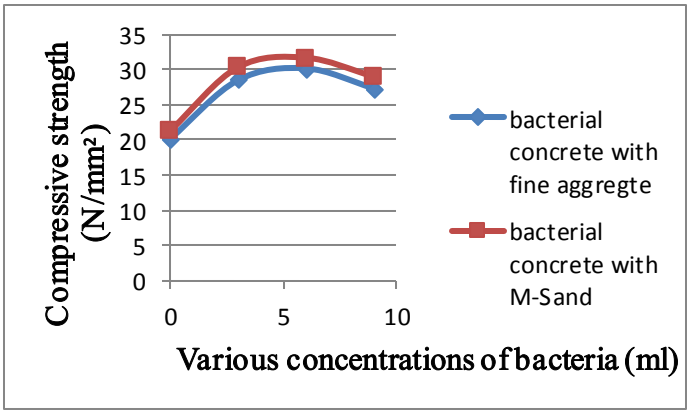


Fig 4.1 Compressive strength Vs Different concentrations of bacterial concrete

From the table 4.1 & fig 4.1, the bacterial concrete is having more compressive strength than the conventional one. It is observed that with the addition of bacteria, the compressive strength of concrete showed significant increase by 41.54%, 47.75% and 35.29% at 3ml, 6ml and 9ml bacteria per liter of water respectively.

4.2 Split tensile strength of concrete

The investigation of the work is carried out to study the split tensile strength of concrete. The results of the split tensile strength of controlled concrete cylinders and bacterial concrete cylinders of various concentrations at 28 days for M20 grade concrete are tabulated as follows.

Table 4.2 Split tensile strength test results with and without bacteria

Bacterial concentration ↓	Split tensile strength(average)	
	Cubes with fine aggregate(N/mm²)	Cubes with M-Sand (N/mm²)
0 ml	2.28	2.67
3 ml	2.58	2.97
6 ml	3.62	4.44
9 ml	3.42	4.00

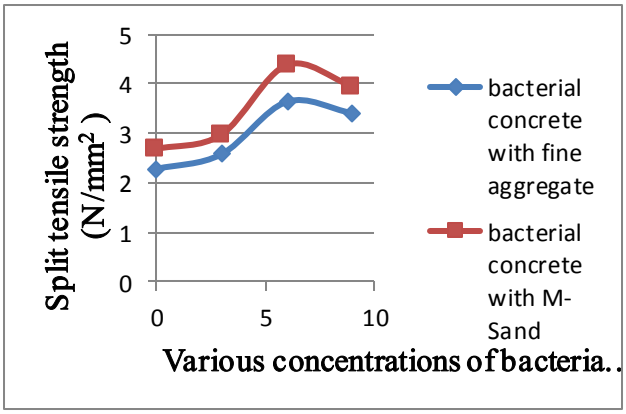


Fig 4.2 Split tensile strength Vs Different concentrations of bacterial concrete

From the table 4.2 & fig 4.2, there is a considerable increase in split tensile strength by 11.23%, 32.58% and 12.53% for 3ml, 6ml and 9ml bacteria per liter of water respectively.

4.3 Flexural strength of concrete

The investigation of the work is carried out to study the flexural strength of concrete beams. The results of the flexural strength of controlled concrete beams and bacterial concrete beams of various concentrations at 28 days for M20 grade concrete are tabulated as follows.

Table 4.3 Flexural strength test results with and without bacteria

Bacterial concentration ↓	Flexural strength(average)	
	Cubes with fine aggregate(N/mm^2)	Cubes with M-Sand (N/mm^2)
0 ml	4.27	5.33
3 ml	5.60	15.73
6 ml	10.13	18.40
9 ml	8.53	9.46

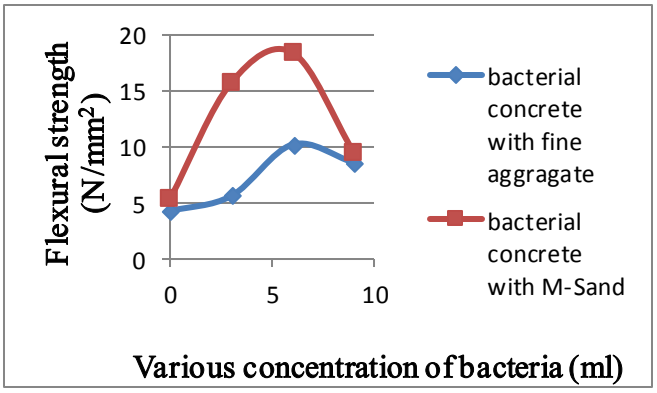


Fig 4.3 Flexural strength Vs Different concentrations of bacteria

From table 4.3 and fig 4.3, the addition of 6ml bacteria per liter of water has given more flexural strength. Also bacterial concrete with M-Sand has better performance compared to bacterial concrete with fine aggregate.

5 Conclusions

1. By comparing the compressive strength of bacterial concrete with M-Sand & without M-sand, it can be concluded that bacterial concrete with M-sand has more compressive strength than bacterial concrete without M-sand.
2. Flexural strength of bacterial concrete beams is greater when compared to that of conventional type.
3. For 6ml bacterial concentration per liter of water, the values are higher in all the tests i.e. compression test, split tensile strength and flexural test.
4. Incorporating of bacteria has enhanced strength of concrete.
5. The maximum failure load of the beam is 138 KN for 6ml concentration of bacteria.
6. Bacterial concrete is effective in increasing the strength and durability of concrete.
7. From the test results, optimum concentration of bacteria to be added is 6ml/ltr of water.
8. The concentration of bacteria plays a major role in its effectiveness.

6. Scope for future studies

1. Incorporating waste materials with that of economic materials in microbial concrete.
2. Using different bacterial combinations, there is a need to be studied of its effectiveness.
3. Possibility of using Fly ash, Silica fume, Metakaoline has to be studied.

4. The biological process of $CaCO_3$ precipitation needs more research as the task is very complex.

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