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Experimental Investigation of Biocrete using Bacillus Megaterium

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ABSTRACT

Bacterial concrete is the one of the gaily technique which have to be used for improving strength and durability of the concrete through self-healing the concrete cracks due to the serviceability of the structure. In this study mechanical properties of bacterial concrete are examined with varies concentration of Bacillus Megaterium Bacteria. This bacteria can be produced in the laboratory, which are not be harmful to the environment and non-pathogenic. The concrete grade of M20 is prepared with Bacillus Megaterium Bacteria at varies cell concentration of 0 to 107 cell/ml of bacteria at 5 intervals of concentration. The mechanical properties like compressive and split tensile strength were examined at 7 days, 14 days and 28 days to evaluate the optimum cell concentration of bacteria.

keywords

Bacillus Megaterium, self-healing, compressive strength, splitting tensile strength.

1.INTRODUCTION

Concrete is most constituent material in field on construction and It has high compressive and low tensile in strength. The steel bars provided in concrete take over the load when the concrete cracks in tension. The concrete on other hand protects the steel bars for attacks from the environment and prevent corrosion to take place. However, the cracks in the concrete form a problem. Here the excess of water and ions takes place and deterioration of the structure starts with the corrosion of the steel. To increase the durability of the structure either the cracks that are repaired later or in the design phase, extra reinforcement is placed in the structure to ensure that the crack width stays within a certain limit. This extra reinforcement is then only needed for durability reasons (to keep the crack width small) and not for structural capacity. Especially with current steel prices this extra steel is not desirable.

If cracks widths are too large, the cracks need to be repaired or extra reinforcement is needed as said already in design

Durability is one reason to prevent cracks or limit crack widths. Other reasons are water tightness of structures, loss of stiffness and aesthetic reasons. If in some way a reliable method could be developed that repairs cracks in concrete automatically, this would increase and ensure durability and functionality developed that repair cracks in concrete enormously. On the other hand it would save a lot of money.

The "Bacterial Concrete" can be made by embedding bacteria in the concrete that are able to constantly precipitate calcite. This phenomenon is called microbiologically induced Calcite precipitation. Calcium carbonate precipitation, a widespread phenomenon among bacteria, has been investigated due to its wide range of scientific and technological implications. Calcite formation by Bacillus Megaterium is a model laboratory bacterium, which can produce calcite precipitates on suitable media supplemented with a calcium source. A common soil bacterium, Bacillus Megaterium was used to induce CaCo3 precipitation. The basic principles for this application are that the microbial urease hydrolyzes urea to produce ammonia and carbon di-oxide and ammonia released in the surroundings subsequently increases pH, leading to accumulation of insoluble CaCo3. The favorable conditions do not directly exist in a concrete but have to be created. A main part of the research will focus on this topic. How can the right conditions are created for the bacteria not only to survive in the concrete, but also to feel happy and produce as much calcite as needed to repair cracks. Furthermore the bacteria should be suspended in a certain concentration, in a certain medium before they are mixed through the concrete ingredients. Optimization is needed here, which involves experimental testing.

2. EXPERIMENTAL INVESTIGATION

2.1 Materials Used

2.1.1 Cement

53 grade ordinary Portland cement grade confirming to IS 12269-1987 with specific weight 3.15 g/cm3

2.1.2 Fine Aggregate

Locally available river sand confined grading zone II of IS: 383-1970

2.1.3 Coarse Aggregate

Locally available crushed blue granite stones conforming to graded aggregate of nominal size 20mm as per IS: 383-1970.

2.1.4Water

Castings of specimens were done with the potable water.

2.1.5Bacteria

The pure culture of Bacillus Megaterium a commonly available soil bacterium was obtained from biotech firm, Coimbatore.

2.1.6Bacterial Treatment Solution

The concrete cubes were wiped with a blotting paper to remove any surface bacteria and cured in corresponding calcite precipitation media of Calcium chloride 50 g/Lt + Urea 20g/Lt at room temperature.

2.2Mix Proportion

The control mix was proportioned to obtain compressive strength of 25 MPa. The identification, mix proportion and quantity of material taken for one meter cube of concrete mixes are given in Table 2 .The mixes M1,M2, M3,M4,M5 and M6 were obtained by adding BecillusMegaterium bacteria of concentration 0 cells/ml , 10^3cells/ml,10^4 cells/ml, 10^5 cells/ml ,10^6cells/ml and 10^7cells/ml of mixing .

Table 1. Mix Proportion

Water	Cement	Fine aggregate	Coarse aggregate
197 Liters	518.2kg	755kg	968kg
0.38	1	1.45	1.87

Table 2. Mix Proportion In 1m^3

Mix	Cement (Kg/m^3)	Concentration of bacteria (cells/ml)	Fine Aggregate (Kg/ m^3)	Coarse Aggregate (Kg/m^3)	Water (lit)
M1	518.2	0	755	968	197
M2	518.2	10^3	755	968	197
M3	518.2	10^4	755	968	197
M4	518.2	10^5	755	968	197
M5	518.2	10^6	755	968	197
M6	518.2	10^7	755	968	197

3. RESULTS AND DISCUSSION

Concrete cubes of 150x150x150 mm, cylinders of 150 mm diameter x 300 mm height and prism of 100x100x500 mm were cast with the ratio provided. After casting and de-moldings, the specimens were cured in bacterial medium. The compressive, splitting tensile and flexural strength tests were performed at 7, 14 & 28 days.

3.1Compressive Strength

Table 3. Compressive Strength Result in MPa

Mix MPa	Cell concentration per ml of mixing water	Average Compressive Strength		
		7 Days	14 Days	28 Days
M1	0	14.8	22.7	26.9
M2	10^3	15.6	23.1	27.53
M3	10^4	16.1	24	28.73
M4	10^5	18.1	25.1	30.57
M5	10^6	16.9	23.83	29.4
M6	10^7	16.1	22.87	27.73

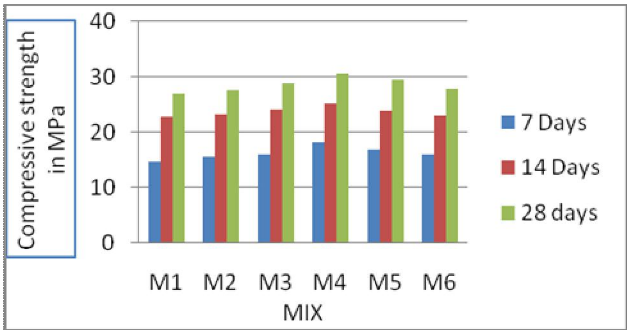

Figure1. Compressive Strength Results

3.3 Splitting Tensile Strength

Table 4. Split tensile Strength result in MPa

Mix	Cell concentration per ml of mixing water	Average Splitting Tensile Strength MPa		
		7 Days	*14 Days*	*28 Days*
M1	0	1.20	2.4	3.35
M2	10^3	1.25	2.67	3.38
M3	10^4	1.32	2.70	3.62
M4	10^5	1.40	2.90	3.87
M5	10^6	1.35	2.85	3.67
M6	10^7	1.30	2.75	3.5

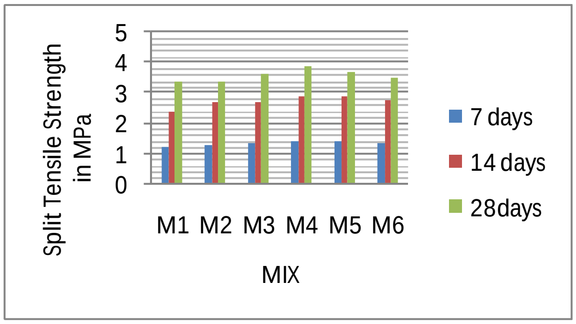

Figure 2. Split tensile strength results

4. CONCLUSION

i. Addition of fly ash leads to an increase in Bacillus Megaterium can be produced from lab, which is proved to be a safe and cost effective.

ii. The compressive strength of concrete at maximum with the addition of bacillus Megaterium bacteria for a cell concentration of 10^5 cells per ml of mixing water.

iii. The addition of bacillus Megaterium bacteria increases the compressive strength of concrete. In standard grade concrete, the compressive strength is increased up to 10.92% at 28 days by addition of bacillus Megaterium bacteria when compared to conventional concrete.

iv. The addition of bacillus Megaterium bacteria increases the split tensile strength when compared to conventional concrete.

v. From the above it can be concluded that bacillus Megaterium can be easily cultured and safely used in improving the strength characteristics of concrete.

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