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An Experimental Approach to Study the Properties of Self-Healing Concrete by Replacing Fine Aggregate with Glass Powder and Demolished Waste

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Abstract: Bacterial concrete is a material, which can successfully remediate cracks in concrete. This technique is highly desirable because the mineral precipitation induced as a result of microbial activities is pollution free and natural. To repair the cracks in concrete is a tedious job and in turn is expensive. So to avoid these, a special bacteria is induced in the concrete which reacts with calcium to form calcium carbonate crystals which blocks the cracks formed in the concrete. To make the Bacterial Concrete more affective in crack reduction, we used glass powder as partial replacement for fine aggregate of about 15 percentage. And construction waste is completely replaced in place of coarse aggregate.
Keywords: Bacterial Concrete, Calcium carbonate crystals, Glass Powder, Construction debris, Workability, etc.

I. INTRODUCTION

To overcome this problem (crack failures) the concrete is prepared with the addition of bacteria which tends to heal (block the cracks) the concrete by itself. A bacteria known as Bacillus Bacteria. Bacillus bacteria is a group of different Bacterial family which contains Bacillus Megaterium, Bacillus pseudofirmus, Bacillus subtillis, Bacillus pasteurii, Sporosarcina pasteurii, etc.,. The Bacillus Megaterium is the bacteria used in this experimental approach. Bacillus Megaterium reacts with calcium and forms precipitation of calcium carbonate crystals, which usually blocks the cracks. In addition to bacterial concrete, we use glass powder as partial replacement to fine aggregate (sand) of about 15 percentage. Glass powder gives shining appearance to the concrete, it is also act as a water resistant material. The coarse aggregate was fully replaced by the demolished waste (construction waste) which improves strength of concrete. These are some of the major waste materials produced from the community. So by implementing this technique we can reuse some amount of industrial & constructional waste in construction work.

II. OBJECTIVE OF THE STUDY

1) To develop and observe the strength comparison of self-healing concrete with normal concrete.
2) To Develop efficient self-healing techniques for the cracks developed by creep of concrete.
3) To observe the healing of cracks by bacterial precipitation.
4) To investigate the effect of bacillus megaterium bacteria in gaining strength.
5) To observe the effect of demolished waste and glass powder in concrete before and after mixing.

III. BACTERIA

Bacillus megaterium is a soil-dwelling bacteria that is commonly used in agriculture as a bio-fertilizer. It can fix atmospheric nitrogen in the soil, making it available to plants, and can also produce plant growth-promoting compounds such as indole acetic acid and gibberellins. Additionally, B. megaterium can also act as a bio-pesticide by producing compounds that inhibit the growth of plant pathogens. It can also be used to ferment organic waste and produce organic acids and enzymes which can be used as a soil conditioner. Bacillus megaterium is a motile rod-like, Gram-positive, mainly aerobic and spore forming bacterium ubiquitous in the environment. Bacillus megaterium bacteria is mixed in liquid form to concrete.
Properties of Bacillus Megaterium bacteria
Scientific Name = Priestia Megaterium
Size of Bacteria = 4*1.5 microns

Concentration = 1*109 cells per ml.
Produced by = Ponolab Bio-growth Private Limited, Bengaluru.

IV. MIX PROPORTIONS

Cement = 492.5 Kg / m3
Fine Aggregate = 664.15 Kg / m3
COARSE Aggregate = 980.3 Kg / m3
w / c ratio = 0.40
Water = 197 lit / m3
Percent of glass powder replaced with fine aggregate = 15%
Weight of glass powder used = 664.15 * (15 / 100)
Volume of glass powder = 99.62 kg / m3

V. RESULTS

A. *Effect Of Bacteria, glass powder and aggregate On Compressive Strength of Concrete*

Table : 1 7 days Strength Comparison Between Normal and SHC

7 days strength results	Strength in N/mm^2	Increase in strength (%)
Normal Concrete	19.11	-
1% bacteria	21.20	10.94
2% bacteria	21.41	12.10
3% bacteria	20.74	8.53

Table : 2 14 days Strength Comparison Between Normal and SHC

14 days strength results	Strength in N/mm^2	Increase in strength (%)
Normal Concrete	22.47	-
1% bacteria	25.93	15.40
2% bacteria	33.89	50.82
3% bacteria	27.85	23.94

Table : 3 21 days Strength Comparison Between Normal and SHC

21 days strength results	Strength in N/mm^2	Increase in strength (%)
Normal Concrete	28.59	-
1% bacteria	27.71	-3.10
2% bacteria	36.89	29.03
3% bacteria	35.41	23.85

Table : 4 28 days Strength Comparison Between Normal and SHC

28 days strength results	Strength in N/mm^2	Increase in strength (%)
Normal Concrete	33.11	-
1% bacteria	32.74	-1.12
2% bacteria	37.71	13.89
3% bacteria	37.11	12.10

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B. Effect of Bacteria, Glass Powder and Aggregate on Tensile strength of Concrete

Table : 57 days Tensile Strength Comparison Between Normal and SHC

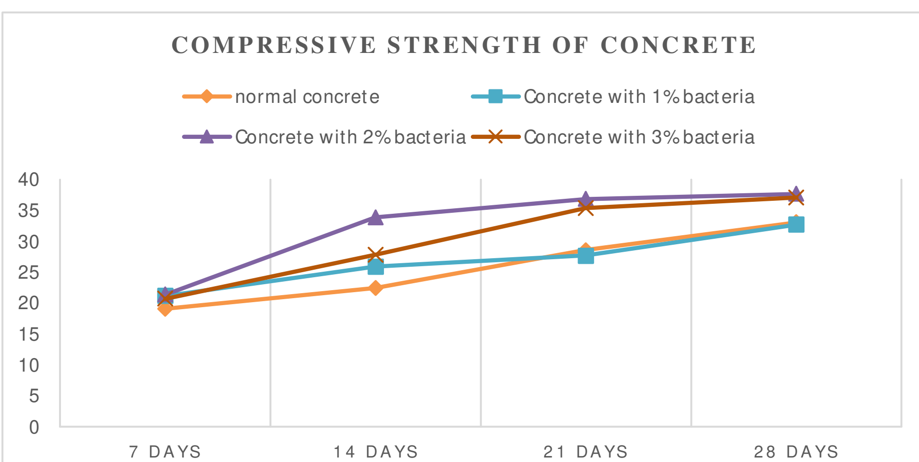
7 days strength results	Strength in N/mm^2	Increase in strength (%)
Normal Concrete	2.41	-
1% bacteria	2.51	4.15
2% bacteria	2.55	5.81
3% bacteria	3.35	39.00

Table: 6 14 days Tensile Strength Comparison Between Normal and SHC

14 days strength results	Strength in N/mm^2	Increase in strength (%)
Normal Concrete	4.62	-
1% bacteria	3.63	-21.43
2% bacteria	3.18	-31.17
3% bacteria	3.98	-13.85

Table : 728 days Tensile Strength Comparison Between Normal and SHC

28 days strength results	Strength in N/mm^2	Increase in strength (%)
Normal Concrete	4.91	-
1% bacteria	6.08	23.83
2% bacteria	6.60	34.42
3% bacteria	5.78	17.72



Graph shows the strength variation of M30 grade of concrete

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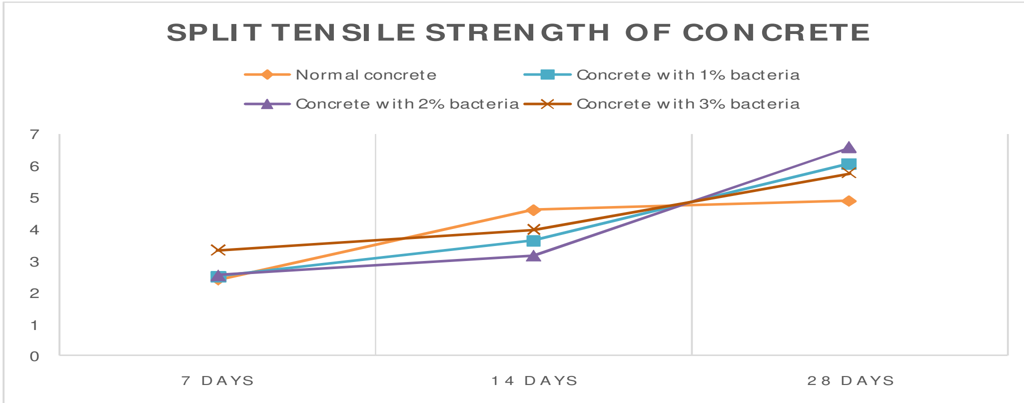
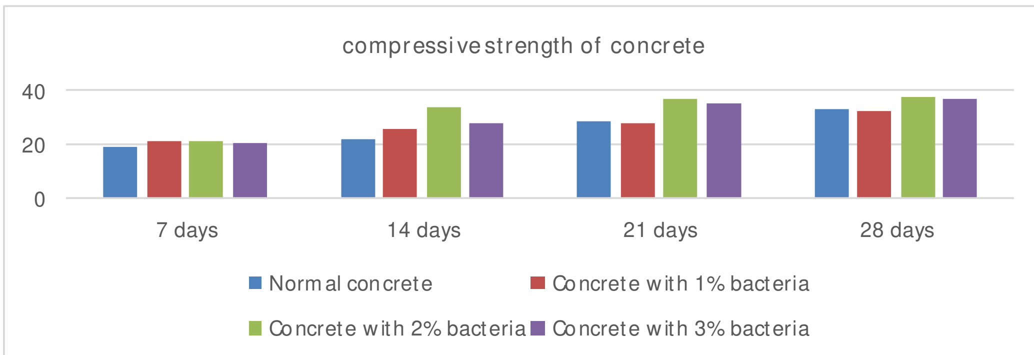
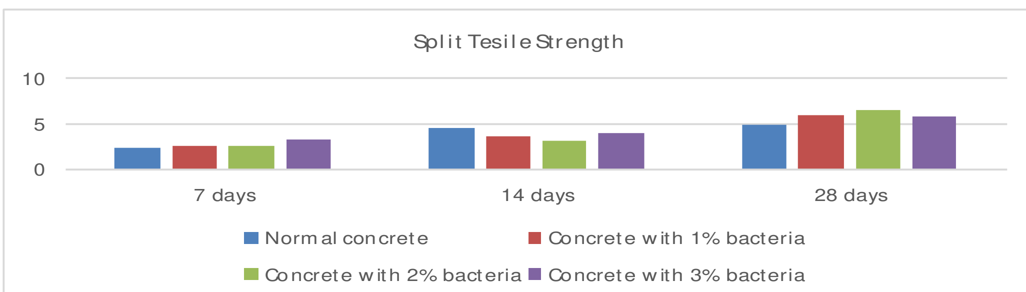




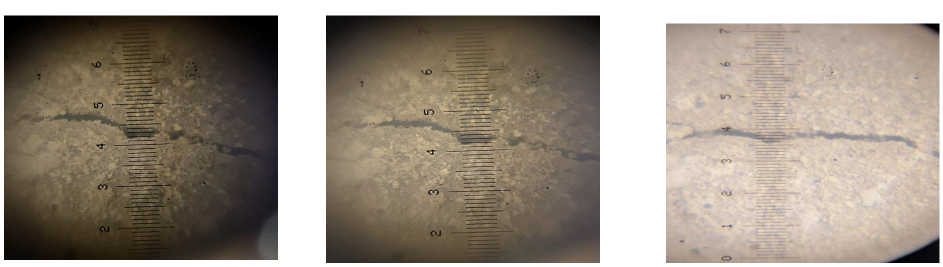


VI. MICRO-STRUCTURE ANALYSIS

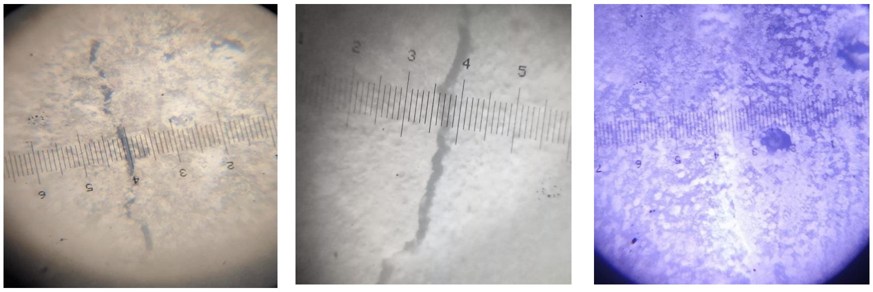
Bacterial concrete heals itself whenever a micro cracks occurs due to the creep of concrete, shrinkage cracks and tension cracks. These cracks provide a path for water to penetrate and react with reinforcement. Bacillus Megaterium bacteria reacts with calcium and forms precipitation of calcium carbonate crystals.

A. Concrete Which Contains 3% of Bacillus Megaterium Bacteria

Without injecting water, (1^{st} day, 10^{th} day and 20^{th} day respectively)



By curing with water, (1st day, 10th day and 20th day respectively)



VII. CONCLUSIONS

The significance of this study is to comprehend the utilization of urea-developing bacterial isolate, for instance, Bacillus Megaterium species, in healing cracks in concrete.

1) The compressive strength of bacterial concrete with 1% of bacteria gives good strength variation when compared to the normal concrete. The % increased in strength in concrete is 10.94% and 15.40% for 7 & 14 days respectively. There is decrease in strength in bacterial concrete of 3.1% and 1.12% for 21 & 28 days with respect to normal concrete. The split tensile strength of bacterial concrete shows the following variations with respect to the normal concrete. 4.15%, -21.43% and 23.83% for 7, 14 & 28 days respectively.
2) The compressive strength of bacterial concrete with 2% of bacteria gives good strength variation when compared to the normal concrete. The % increased in strength in concrete is 12.10%, 50.82%, 29.03% and 13.89% for 7, 14, 21 and 28 days respectively. The split tensile strength of bacterial concrete shows the following variations with respect to the normal concrete. 5.81%, -31.17% and 34.42% for 7,14 & 28 days respectively.
3) The compressive strength of bacterial concrete with 3% of bacteria gives good strength variation when compared to the normal concrete. The % increased in strength in concrete is 8.53%, 23.94%, 23.85% and 12.10% for 7, 14, 21 and 28 days respectively. The split tensile strength of bacterial concrete shows the following variations with respect to the normal concrete. 39.0%, -13.85% and 17.72% for 7,14 & 28 days respectively.
4) From the above study the bacterial concrete with demolished waste and partial replacement of glass powder has a good strength variation when compared to conventional concrete.
5) The bacterial concrete with 1% of bacteria doesn't have good strength than normal concrete. But the concrete with 2% bacteria has gains good strength at the age of 14 days then it improves slowly. Concrete with 3% bacteria gives good workable conditions with its slump ranges from 125 mm. and the strength is also good.
6) The split tensile strength in self-healing concrete gains strength slowly but the final tensile strength is acceptable after 28 days of curing.
7) The self-healing concrete has crack healing nature. But the healing action takes place only in the presence of moisture (water). When the moisture is not available the cracks heals very slowly. Adding 1% of bacteria to the mix doesn't show ay crack healing nature. Adding 2% and 3% of bacteria has higher accuracy of healing cracks generated in the concrete.

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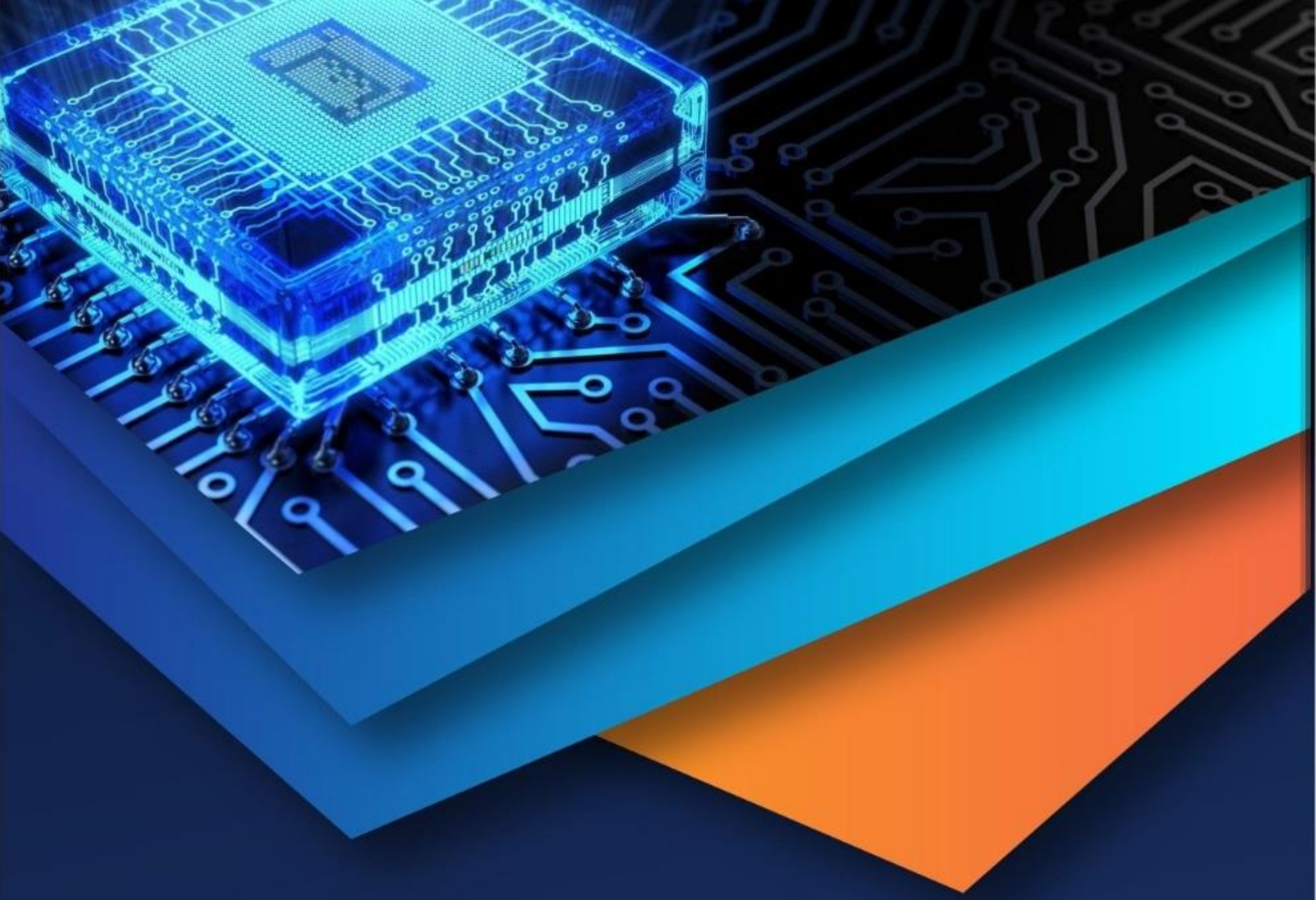

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