

BIO CONCRETE AND BACTERIA BASED SELF HEALING CONCRETE

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Abstract

Concrete is cheap and easily available construction material in the world. So advancement in the concrete is to improve its compressive strength and durability of structures by using micro organisms carrying process of MICP. This project discusses the filling of voids in fresh concrete and plugging of artificially cracked cement mortar using *Bacillus Sphaericus* and *Proteus Vulgarious* bacteria combined with sand as a filling material in artificially made cuts in cement mortar which was cured in urea and CaCl_2 medium. The effect on the compressive strength, flexural strength due to the mixing of bacteria along with effect of water absorption and sorptivity on concrete cubes is also discussed in this project. The main aim of the project is to evaluate the strength in comparison with conventional and bio concrete cubes. The evaluated results suggest that there is significant increase in the strength of concrete

Keywords: Microbiologically Induced Calcite Precipitation, Whitish Yellow Turbid Solution

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1. INTRODUCTION

Bio concrete is the science of precipitation of minerals by living organisms. Bacteria have a remarkable ability to precipitate Calcite, Carbonate, Phosphate, Oxides, sulphite. In bio concrete Bacterial species like, *B. Sphaericus* *Proteus Vulgarious*, etc., deposit calcium carbonate by their bacterial activity in this system. This result decreases in water absorption and permeability. Presence of layer of Calcium precipitation improves its strength and durability.

Cracking is a common phenomenon in concrete due to the relatively low tensile strength. Without immediate and proper treatment, cracks tend to expand further and eventually require costly repair. Inducing bacteria along with precursor compound heals crack by calcite precipitation which compressive strength and durability of structure.

2. METHODOLOGY

Combination of two bacteria will give good results as compared to one bacteria. Hence we came up with two bacteria which are totally harmless *Bacillus Sphaericus* and *Proteus Vulgarious*.

2.1 Preparation of Bacterial solution

Primarily 12.5 grms of nutrient growth added to 500 ML conical flask containing distilled water. Then it is covered

with thick cotton plug and is made air tight with paper and rubber band. Then it is sterilized using a cooker for 10 - 20 Min. Now solution is free from contamination and solution is clear orange in colour before the addition of bacteria. Later flask is open up and 1 ML of bacterium is added to sterilized flask and kept in shaker at speed of 150 - 200 rpm overnight. After 24 hrs bacterial solution was found to be Whitish Yellow Turbid solution.

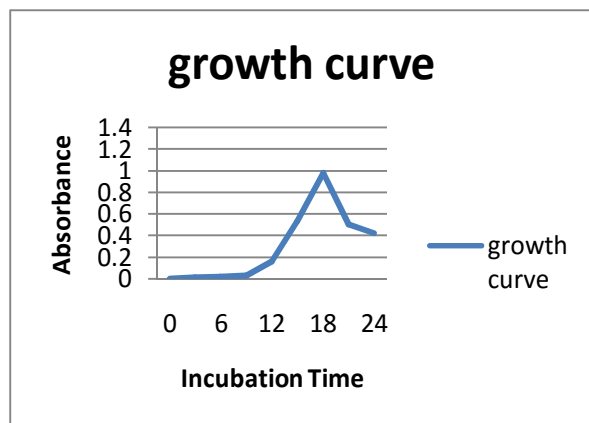


Fig. 1 : Whitish yellow turbid bacterial solution

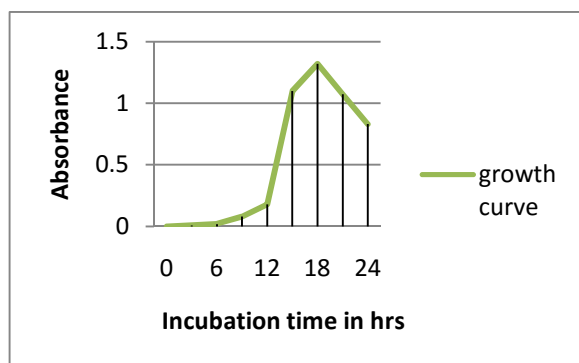
2.2 Bacterial Growth Curve

1. It is an experiment to determine the growth curve of the *Bacillus sphaericus* and *Proteus vulgarious* carried out using shake flask culture technique to set a growth of bacteria.

2. A colony of an overnight culture used to inoculate 30ml of media (nutrient broth) in a 250 ml conical flask.
3. The culture incubated at 37°C by shaking for 24 hrs at 120 rpm.
4. The sample is taken from the culture at 3 hrs time interval which measures O.D. (optical density) colorimetrically at 530nm



Graph 1. Graph Growth Curve of Proteus Vulgaris



Graph 2. Graph Growth Curve of Bacillus Sphaericus

2.3 Precipitation Test On Bacteria

Estimation of calcite precipitation by EDTA titration –

The sample is first adjusted to pH of 10 using sodium hydroxide buffer solution. A few drops of Eriochrome Black (0.5 % wt/vol.) indicator was added and sample was titrated against 0.01M of sodium ethylene diamine tetra acetate (EDTA). EDTA draws the calcium and magnesium ions into complex, so neither one has free ions in solutions. The indicator initially turns red in presence of calcium and magnesium and then it turns to metallic blue when enough EDTA solution has been added to combine with all calcium and magnesium. The total precipitation of bacterial sample (consortia of bacillus sphaericus, proteus vulgaris) is calculated using the precise volume of EDTA solution added when indicator changes colour. The calcium carbonate concentration was calculated according to following equation:

$$\text{Ca}_2\text{CO}_3(\text{Mg/l}) = \frac{[\text{Vol. EDTA}(\text{ml})/\text{sample volume}(\text{L})] \times [\text{Ca}_2\text{CO}_3(\text{ml})/\text{EDTA}(\text{mol})]}{1}$$

Result of the Test

Change in colour from wine red to steel blue by reducing EDTA

Total hardness 10 ml of bacteria solution (5 ml of bacillus sphaericus culture + 5 ml proteus vulgaris culture) + 2% of urea + 25Mm CaCl₂ = 1.125 mg/lit

2.4 Casting of Bio Concrete Cubes (15) and Cuboids (3)

We casted batch of M25 grade concrete on 2nd February 2016. In this batch of bio concrete we used the mixture of Cement, Sand, Artificial Aggregate and Bacterial solution. There was no use of water and admixtures. After casting all moulds were placed in room temperature for period of 24 hours. After 24 hours these moulds were removed and the test specimen of bio concrete were put for curing on 3rd Feb, in the bacterial solution including its precursor compound as calcium chloride and urea in a separate tank.

Accordingly the 3rd, 7th and 28th day compression tests were conducted. The 28th day flexure, Water absorption and sorptivity tests are performed on 1st March 2016.

Then the graph for Compressive strength verse No. of days and one more graph for Flexural strength verses No of days is plotted. The results between conventional concrete and bio concrete is compared.

Similarly the conventional cubes are casted, by replacing bacterial solution with water.

3.4 Tests On Conceret Cubes

1. Compressive Strength test.
2. Flexural Strength Test.
3. Water absorption test.
4. Sorptivity test

The compressive, flexure and water absorption tests are performs as per IS... and the sorptivity test is as follows :

Sorptivity Test

Sorptivity gives capillary action of water. For sorptivity test 150mm × 150mm × 150mm 6cubes (3 conventional, 3 bio concrete) was casted. After 28 days continuous curing the specimen was oven dried for 24 hours and cooled at room temperature. Then we coated the cubes with Dr fixit from 4 sides. The base portion was kept open. We weighted this cube as (W₁). Again the specimen was kept in water where the height of specimen immersed only 5mm for 60 minutes. After 60min the weight of specimen measured in gm (W₂).

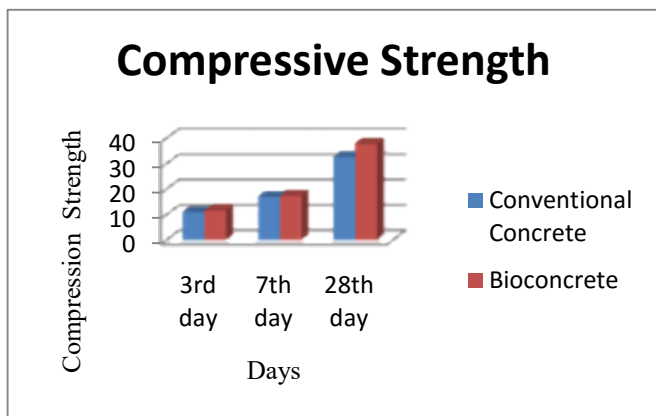


Coating of cubes by Dr. Fixit (bio concrete cubes)

RESULT AND DISSCUSSION

Table 1. Compressive strength

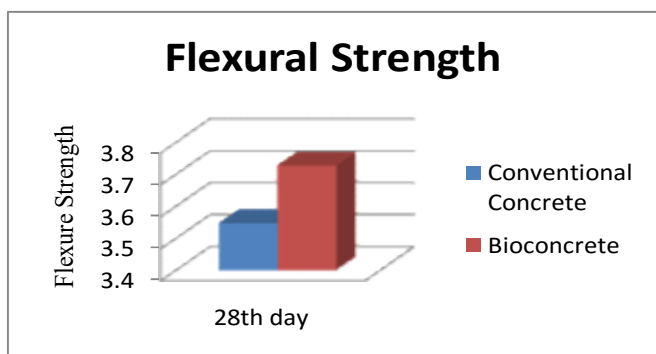
Compressive Strength	Conventional concere	Bio concrete	% increase
3 rd day	11.82	11.95	1.15
7 th day	17.15	17.67	3.05
28 th day	32.85	38.04	15.80



Graph 3: Compressive Strength

Table: Flexural Strength

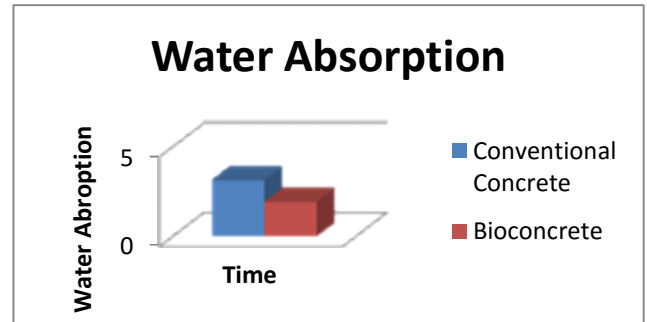
Flexural Strength	Conventional concere	Bio concrete	% increase
28 th day	3.55	3.73	5.18



Graph 4: Flexural Strength

Table: Water Absorption

Water Absorption	Conventional concere	Bio concrete	% decrease
28 th day	3.17	1.965	3.83



Water Absorption

Sorptivity Test

Sorptivity Test	Conventional concere	Bio concrete	% decrease
28 th day	4.01	2.29	6.89

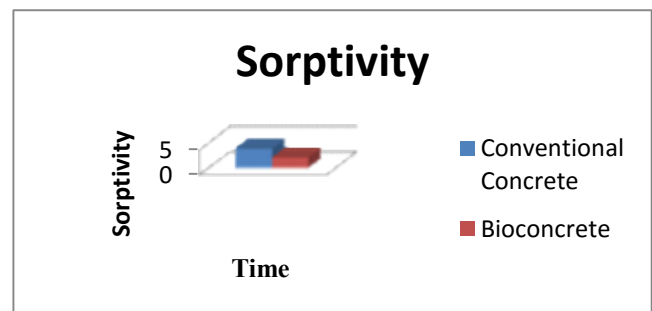


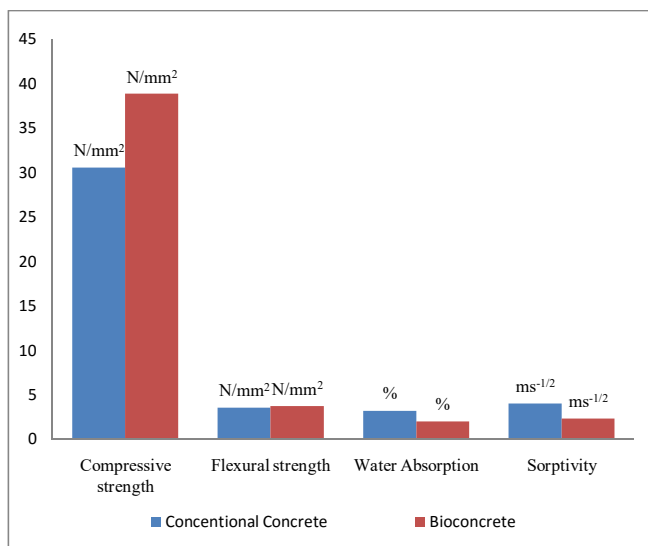
Fig -1 Sorptivity Test

Comparative Analysis Of Convensional Concrete (M25) and Bio Concrete :

The compressive strength test results reveals that there is increase in the strength for all the samples in which bacteria was incorporated as compared to specimen of the conventional concrete. There is significant increase of 1.15%, 3.05%, 15.08% was observed for cell concentration of 10¹⁰ cells per ml for 3, 7 and 28 days respectively.

The flexural strength result was carried out after 28th day. There is increase in strength of 5.18% for bioconcrete.

Water absorbtion test is performed after 28th days of curing for oven dried specimen and results are plotted. Water absorbtion for bioconcrete specimen is less than conventional concrete specimen (M25).



3. CONCLUSIONS

1. Thus we studied the percentage increase in compressive and flexural strength of bio concrete cubes compared to conventional cubes. From this project it is concluded that use of bacteria in concrete increases the percentage strength and reduces its water absorption and sorptivity.
2. Use of bacteria improves the compressive strength of concrete by filling the pores by calcite formation in fresh concrete. By using the bio concrete the compressive strength of concrete and durability of structure can be better than the conventional concrete. The impermeability of bio concrete will be increased than the conventional concrete.
3. Study of self healing process concluded that bacteria repairs the cracks in concrete by producing the calcium carbonates crystals which blocks the cracks and repairs it.

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