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AN EXPERIMENTAL INVESTIGATION OF BACTERIAL CONCRETE INCORPORATED WITH BACILLUS CEREUS

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ABSTRACT

Concrete is one of the most important materials in construction. Concrete is weak in tension, so it affects ductility and also cracking. Based on the continuous research work is carried out around the world, various changes have been made from day to day time to overcome the deficiencies of cement concrete structures. The current research is going on the field of concrete technology; the lead to overcome the development of special concrete structures, while considering the faster construction, good strength, durability and the environmental friendliness of concrete with industrial waste material such as fly ash, GGBS, silica fume, metakaolin etc. Use of these Bio mineralization concepts involves in concrete leads to modern invention of new developed material called as Bacterial Concrete. In this present work studies were made by using the bacteria is Bacillus Cereus. Bacillus cereus is cultured in a model laboratory, the microorganisms are used to obtain the calcium carbonate precipitation in concrete, it will induced as a result of biological activities is free from pollution and natural. In this study, Cement is partially replaced with fly ash by 35% and for these replacements; specimens are casted with bacteria and without bacteria separately. The Compressive strength of the specimens with and without bacteria is compared. Results shows that the addition of bacteria improves the compressive strength of the concrete. In addition, this bacterial concrete concept of calcite formation is not only environment safe but also cost effective.

INTRODUCTION

Concrete can be considered as a kind of artificial rocks with the properties similar to that of some kinds of rocks. The most of the construction materials are used around the world, which can easily be recognized in rural areas. Normally the concrete as we all know is good in compression but week in tension. The most of the crack which forms initially is due to tension. Cracks can form at any stages of its life of concrete and where they cannot be seen for until a year, the major repairs are needed to concrete. Damage is mainly caused by freeze/thaw, corrosion, severe loads, chemical affects and any other environmental activities. Therefore, maintenance to concrete structures is frequent and costly. More costs are spent every year on infrastructure of buildings, bridges and highways maintenance and materials requiring less frequent repairs very pleasing. Its production level lies more than 2.35 billion metric tons per year and contributes an 10% of CO_2 emissions into the atmosphere.

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Here the self healing would enables the fewer repairs works or even failure of a structure through which the production level can even be decreased along with the reduced CO_2 emission. Minor cracks on the concrete surface make the entire structure, water seeps in to the cracks and damage the concrete and decay the steel reinforcement, greatly reducing the lifetime of a structure. The present study was to develop a self-healing concrete using a sustainable self-healing agent like limestone producing bacteria and actually acid producing bacteria, have been considered as harmful organisms for concrete.

Need for bacterial concrete

The infrastructure in industrialized countries accounts for at least 50% of our national wealth. From that it can be inferred that the performance characteristics and excellence of our infrastructure are of fundamental importance to the urban sustainability and their comfort of our surroundings. In the view of large collision of the building industry and the environment, promoting self healing materials can be considered as a matter of sustainable environmental stewardship. Since concrete is, volume wise, the most often used man-made building material, enormous savings are potentially achievable and even if we make small improvements. Apart from the lower consumption of resources, a longer life span of structures is also reduces the cost of construction associated transport. Significant that in industrialized countries 30 – 50% of the travel is related to building activities, extending the service life of our infrastructure, thus reducing the transport costs related to new built.

Bacillus Cereus

In this paper, study was made by using the bacterium called Bacillus cereus. The main advantage of embedding bacteria in the concrete is that it can continuously precipitate calcite. This occurrence is called microbiologically induced calcite precipitation. Calcium carbonate precipitation is an extensive phenomenon among bacteria, has been investigated due to its extensive range of scientific and technological implications. Bacillus cereus is a laboratory cultured soil medium also it results on the strength and durability is studied here.

MATERIALS AND METHODS

Cement

Ordinary Portland Cement of 53 Grade was used in this investigation. The Cement was tested for various properties as per the IS: 4031-1988 and confirming to various specifications of IS: 12269-1987 having specific gravity 3.1.

Fly ash

Ordinary Class F fly Ash of Cementitious property collected from the nearer Thermal power plant of specific gravity 2.31 is taken. The quality parameters of fly ash for use in concrete and confirming to IS: 3812 (part 1) - 2003 has been used.

Fine aggregate

Locally available natural river sand having fineness modulus of 2.89 and specific gravity of 2.67 and conforming IS: 383 - 1970.

Coarse aggregate

Crushed angular aggregate of size 20 mm nominal size from the local source with specific gravity of 2.84 was used as coarse aggregate and conforming IS: 383-1970.

Water

Locally available potable water confirming to standard specified in IS: 456-2000 is used.

Microorganisms

Bacillus cereus, a model laboratory soil bacterium is cultured and grown at Food Technology (Microbiology lab). Biotech Laboratory was used at a total cell concentration of 10^5 cells per ml by serial dilution in the Concrete.

Mix deign

The Mix proportion for the ordinary grade concrete and standard grade concrete is designed using IS: 10262-2009. Materials required for 1 m^3 of concrete in ordinary grade concrete (M 30) is 1: 2.17: 3.76: 0.40

Determination of Calcium carbonate

20ml of bacterial culture media was used for titration process and added 2ml of ammonia buffer solution along with EBT indicator it forms wine-red color. It was titrated with EDTA, the calcium present in the medium first reacts to form Ca-EDTA+2 complex releasing the free indicator (blue) and the color changes from wine-red to blue at the end point as shown in Figure 1.

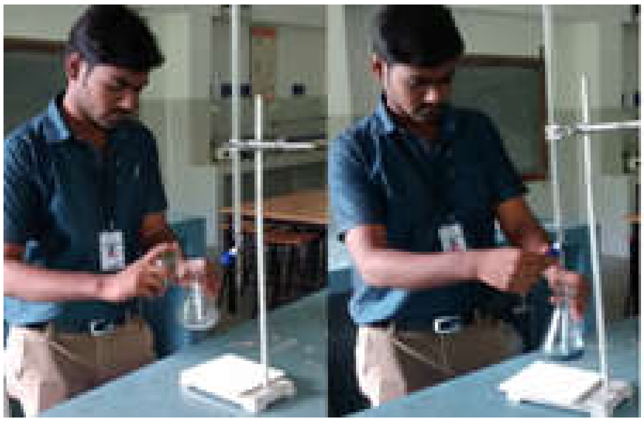

Figure 1. Identification of Calcium Carbonate by Titration Process

Test for bacteria culture

The temperature test of Bacillus cereus in bacterial concrete was carried out at various temperatures and the results are tabulated in Table 1. The results revealed that Bacillus Cereus was found to be alive at -3°C low temperature to 90°C high temperature.

Table 1. Bacteria Temperature Test

Temperature	Bacteria stage
-3°C	Alive
10°C	Alive
20°C	Alive
30°C	Alive
40°C	Alive
50°C	Alive
60°C	Alive
70°C	Alive
80°C	Alive
90°C	Alive
100°C	Dead

RESULTS AND DISCUSSION

Compressive Strength

The strength characteristics of the standard cubes (150mm x 150mm x 150mm) with and without the bacteria were casted and tested as per the IS code. The several cubes were tested for the compressive strength and remaining for the healing phenomenon analysis i.e. the self repairing phenomenon by calcite precipitate formation. The standard results of the compressive strength are tabulated in Table 2. The increased in the compressive strength of concrete in bacteria induced specimen is nearly 9.93% as in table 3 than the controlled specimens. For the crack healing study, the bacteria induced concrete is allowed to develop the first crack by loading and then the crack healing phenomenon is studied by allowing the ingress water and atmospheric air to pass through the developed crack. The study reveals that the crack is healed to some extent by means of the calcite layer formation, i.e. microbiologically induced calcite precipitation. The table 2 & 3 shows the compressive strengths of concrete cube and percentage increase with the days.

Table 2. Effect of bacillus cereus bacteria addition on Compressive strength

Nature of concrete	Compressive Strength of Concrete Cube (N/mm^2)		
	7 days	14 days	28 days
Controlled concrete	19.98	27.61	34.42
Self Healing Concrete	22.32	29.70	37.84

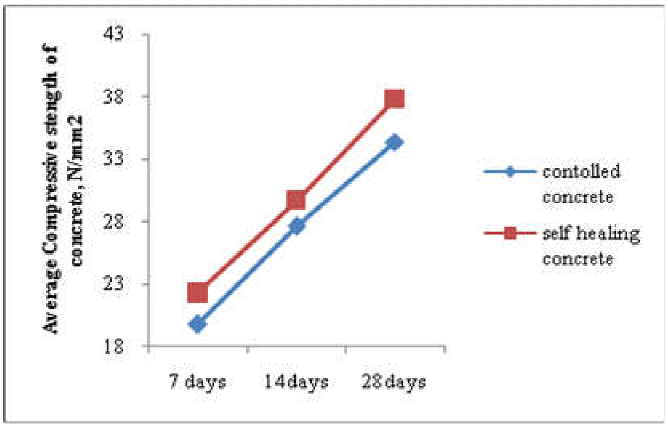

Figure 2. Comparison of Compressive strength of Controlled and Self healing concrete

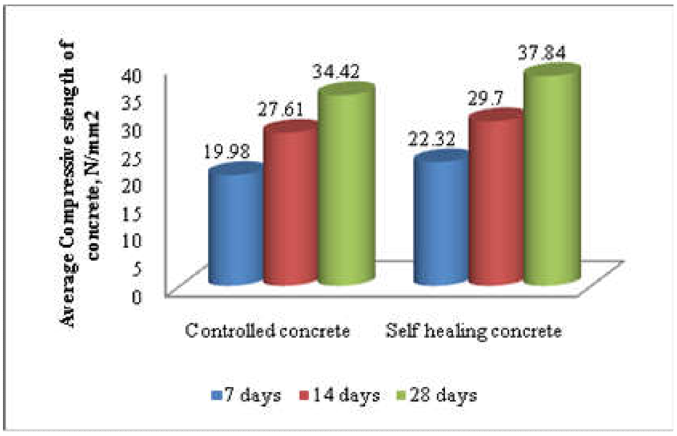

Figure 3. Comparison of Compressive strength of Controlled and Self healing concrete

Table 3. Effect of bacillus cereus bacteria addition on Compressive strength

% Increase of Compressive Strength of Concrete Cube (N/mm^2)		
7 days	14 days	28 days
11.71 %	7.56 %	9.93 %

Water absorption

For measuring the absorption of the hardened concrete specimens, the ASTM standard test method was used. A balance, water bath and container suitable for immersing the specimen are needed for performimg the test. The 100 x100x100mm cubes were cured in the curing tank and after that put into the oven for 8hours at 100 C. The dried samples were taken into the oven and placed in cool area for about 30 minites. The specimen were weighed (M_a) using a weight balance. The concrete specimen is immersed in water tank for 24hours. After 24hours, the samples were removed from water tank and their surface is dried with a paper towel to obtain a saturated surface dry condition is weighted (M_b).

Water absorption capacity = $(M_b - M_a / M_a) \times 100$

Table 4. Water absorption capacity for concrete specimen

	Controlled concrete	Self healing concrete
	M30	M30
M_a	2.50	2.52
M_b	2.61	2.57
Water absorption capacity %	4.4	1.98

Conclusion

Bio-mineralisation precipitation is resultant from microbial actions of some specific bacillus family in concrete to improve the in general behavior of concrete has become an important area of research. The following are the summary of research outcomes done at the final project. A bacillus cereus bacterium is incorporated in concrete to improve the strength of the concrete.

Based on this Experimental investigation, the behavior of Fly ash in Concrete with and without bacteria is concluded below.

- The Maximum Average Compressive strength for Self healing concrete of 7, 14 and 28 days is at 35% replacement of Flyash and it is 22.32 N/mm^2, 29.70N/mm^2, 37.84N/mm^2 respectively. The 7, 14 and 28 days strength are 11.71% and 7.56% and 9.93% more than the Controlled concrete.
- The bacteria incorporated concrete have less water absorption capacity to controlled concrete due to pore plugging with bacteria produced calcite minerals.

The use of bacillus cereus in concrete is found to be more effective in strength. The study on use of bacterial concrete and fly ash replacement in the concrete proves to be more significant.

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