



Article Title: Experimental Investigation on Strength Conventional Bacteria Concrete

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ABSTRACT

Concrete is the foremost building material broadly used in building construction, but cracks in concrete are inevitable and are one of the inherent weakness of concrete. The major downside of concrete is its low tensile strength due to which micro crack occurs when the load applied is more than its limit and this paves way for the seepage of water and other salts. This initiates corrosion and makes the whole structure vulnerable and leads to the failure of structure. To remediate this type of failure due to cracks and fissures, an approach of using bio mineralization in concrete has evolved in recent years. In this method, of enhancing the performance of concrete, the *Bacillus sphaericus* bacteria is introduced into concrete. Thus, this paper is an attempt to define bacterial concrete, types and classification of microorganisms, working of bio concrete as a repair material, advantages and disadvantages of bacterial concrete and applications by literature review are discussed.

1 Introduction

Concrete forms major component in the construction industry as it is cheap, easily available and convenient to cast. But drawback of these materials is it is weak in tension so, it cracks under sustained loading and due to aggressive environmental agents, which ultimately reduce the life of the structure which are built using these materials. This process of damage occurs in the early life of the building structure and during its lifetime. Synthetic materials like epoxies are used for remediation. But, they are not compatible, costly, reduce aesthetic appearance and need constant maintenance. Therefore bacterial induced Calcium Carbonate (Calcite) precipitation has been proposed as an alternative and environment friendly crack remediation and hence improvement of strength of building materials.

2 Literature Review

Cracks in concrete being a major problem, has become a subject for studies and experiments through years. Many scientists have developed so far different techniques to eliminate the cause of cracks suggesting methods to repair concrete. One among such technique involving use of biologically available material – bacteria, has promisingly seen significant improvement in healing cracks along with increasing strength of concrete. Various studies have been worked with this technique and the reviews of earlier work are as following.



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3 Materials Used and Experimental Investigation

The concrete used in the test program consisted of cementing materials, mineral aggregates and corrosion inhibitor with the following Specifications:

- Ordinary Portland Cement (53 Grade)
- Graded fine aggregates.
- Graded coarse aggregates.
- Water.
- Bacteria – *Bacillus Sphaericus*
- Calcium lactate

Cement

Ordinary Portland cement of 53 grade, available in local market is used in the investigation. The cement used for all tests is from the same batch. The cement used has been tested for various properties and found to be conforming to various specifications of IS: 12269-1987. The cement is a binding material. It conforms to IS: 456-2000-53 grade. It consists of grinding the raw materials, mixing them intimately in certain proportion depending upon their purity and composition and burning them in a kiln at a temperature of about 1300 – 1500 degree centigrade. At this temperature, the material center partially fuses to form modular chapped clinker. The clinker is cooled and ground to a fine powder with addition of 2 to 3% of gypsum the product formed by using this procedure Portland cement. Of all the materials that influence the behavior of concrete, cement is the most important constituent, because it is used to bind sand and aggregate and it resists atmospheric action. Here we used DalmiaSuperoof ordinary Portland cement of 53 grade.

Coarse Aggregate

Locally available well graded granite aggregates of normal size greater than 4.75 mm and less than 16mm having fineness modulus of 2.72 was used as coarse aggregates. Hard granite broken stones were used as coarse aggregate. The specific gravity, water absorption, void ratio, porosity and bulk density of the coarse aggregate were tested.

Fine Aggregate

Aggregates are inert granular materials such as sand, gravel, or crushed stone that, along with water and Portland cement, are an essential ingredient in concrete. The materials smaller than 4.75 mm size are called fine aggregates. Natural sand conforming to grading Zone III of IS – 383 – 1970 was used as fine aggregates.

Water

The amount of water in concrete controls many fresh and hardened properties of concrete including workability, compressive strengths, permeability and water tightness, durability and weathering, drying shrinkage and potential for cracking. For these reasons, limiting and



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controlling the amount of water in concrete is important for both constructability and service life. Potable water has been used here for casting concrete specimens.

Is free from oils, acids, and alkalis. As per IS 456 – 2000, the permissible limit for chloride is 500 mg/lit for reinforced concrete; hence the amount of chloride present is very less than the permissible limit. The water in laboratory with pH value of not less than 6 and the requirement of IS 456-2000 was used for mixing concrete and curing the specimen.

Bacteria

The bacteria used in the preparation should have the ability to thrive the hostile situation created as a result of mixing of cement and water. Cement and water have a pH value of up to 13 when mixed together, usually a hostile environment for life, most organisms die in an environment with a pH value of 10 or above.

Scientists founded that strains of Eolithic bacteria of genus Bacillus were found to thrive in this high -alkaline environment. As a result the bacteria which could be used in the preparation include:

- Bacillus pasteurizing
- Bacillus sphaericus (used in the present Experiment)

Bacillus subtitles

Bacillus sphaericus Bacillus sphaericus is strictly aerobic gram positive rod shaped bacterium. It is an insecticide against certain strains of diseased mosquitoes. Bacillus Sphaericus are pore forming bacterium, dormant for several years and would be able to withstand extreme temperature. It is an obligate aerobe bacterium used as a parricide for mosquito control and forms spherical endospores. `20 Bacillus sphaericus is a gram positive bacterium, with rod shaped cells that form chains-Medium- sized, smooth colonies with an entire margin and also Rod-shaped cells. Gram-variable, large, spore-forming rods with a diameter < 0.9 µm. Catalase -positive. Lecithinase-negative. Growing range of temperature: 37o c Optimum Temperature- 35-37o c. Preparation of bacteria mixing of Bacteria Luria Berta-powder form (6.75gms)+500ml of distilled water peptone(3gms)+yeast extract(1.5gms)+Beef extract(1.5gms) +sodium chloride (3gms/100ml) +1Loop of Bacteria (gel medium) = Incubator 37oC Preparation of Nutrient Agar Bacteriological media came in wide range of types. Nutrient Agar is a complex medium. Nutrient Agar contains beef extract (0.3%), peptone (0.5%), and Agar (1.5%) in water. Beef extract is prepared as dehydrated form of autolysis beef and is supplied in the form of paste. Peptone is casein (milk protein) that has been digested with the enzyme pepsin and is dehydrated and supplied as a powder. Peptone and Beef extract contains a mixture of amino acids and peptides. Beef extract also contains water soluble digest products of all other macro molecules (nucleic acids, fats, polysaccharides) as well as vitamins trace minerals. Agar is purified `21 from red algae in which it is an accessory polysaccharide (polyalacturonic acid) of their cell walls. Agar is



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added to microbiological media only as a solidification agent. Agar for most purposes has no nutrient value. Agar is an excellent solidification agent because it dissolves at near boiling point solidifier at 45°C. Thus one can prepare molten (liquid) agar at 45°C, mix cells with it, and then allow it to solidify thereby trapping living cells. Below 45°C agar is a solid and remains so as the temperature is raised melting only when greater than 95°C is obtained. Any desired nutrients may be incorporated into the broth (or) agar to grow bacteria. Organism grown in broth cultures causes turbidity in the broth. On agar, masses of cells known as colonies appear after a period of incubation certain separated on agar so that as the cell divides and produces a visible mass. The colony isolated from other colonies, isolated colonies are assumed to be pure culture.

Calcium Lactate

Calcium lactate is a black or white crystalline salt made by the action of lactic acid on calcium carbonate. It is used in foods (as an ingredient in baking powder) and given medicinally. It is created by the reaction of lactic acid with calcium carbonate or hydroxide. In medicine, calcium lactate is most commonly used as an antacid and also to treat calcium deficiencies. It is also added to fresh-cut fruits, such as cantaloupes, to keep them firm and extend their shelf life, without the bitter taste caused by calcium chloride, which can also be used for this purpose. In this experiment calcium lactate is provided as the food for bacteria. Bio concrete has higher engineering concrete properties and durability compared to normal concrete but the natural production of calcium carbonate is limited to the calcium content in cement. Therefore, additional calcium is added as an additional calcium source to initiate the process of biomineralisation.

3.1 Experimental Investigation

The following test procedures were conducted on the various materials used in the preparation of bio-concrete in order to find out if they conform to the requirements as per IS specifications. **Tests on cement**

1. Fineness of cement
2. Consistency of standard cement paste
3. Initial and final setting time

Tests on aggregate

1. Bulk density, void ratio, porosity
2. Specific gravity of aggregates

Tests on fresh concrete

1. Workability test – in. Slump test
2. Compaction factor test



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Tests on hardened concrete

1. Compressive strength test
2. Flexural strength test`24

Tests on Cement

Fineness of cement Fineness is a measure of total surface area of cement. For fine cement surface area will be more. The fineness influences the rate of hydration, rate of strength, develop shrinkage, bleeding, cracking and also for cost of cement.

3.2 Objective

To find the fineness of cement sample by dry sieving APPARATUS 90micron IS sieve, weighing balance sensitive to 0.1gm.

4 Procedure

- Break down ay air lumps in the cement
- Weigh accurately 100gm of cement
- Place it on standard IS 90 micron sieve. Sieve continuously until no micro fine material pass through it.
- Weigh the residue
- Repeat the procedure for two or more sample is specification Fineness of cement shall not exceed 10%

5 Conclusions

The project deals with the comparative study of strength of normal concrete and bio-concrete. The main objectives of the project include casting bio concrete and working on its self-healing mechanisms, to compare the strength by conducting various tests to find out other properties of bio-concrete and to enlighten on the advantages of bacterial concrete thus paving an away for new era of construction.

Various tests like compressive strength test, flexural strength test, test to find out workability including slump test and compaction factor test were conducted on M15 and M10 grade concrete for both normal mix and bio concrete mix. The amount of addition of bacteria is 4 ml per grade of concrete followed by the addition of 20gm calcium lactate.

Following conclusions are drawn from the study:

- The slump value as well as compaction factor of bacterial concrete indicates its increased workability compared to normal mix.
- From compressive strength test of M15 concrete it was obtained that bacterial concrete showed 44.05 % increase in strength for 7 days and 22.98 % increase for 28 days.
- From flexural strength test of M15 concrete bacterial concrete showed 55.04%



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increase in 7 days and 33.25 % increase in 28 days.

- For M10 mix, bacterial concrete showed 32.90 % increase in compressive strength for 7 days and 38.2 % Increase for 28 days.
- For flexural strength test bacterial concrete showed 51.07 % increase for 7 days and 30.34 % increase for 28 days in case of M10 mix.
- From the comparative study it is observed that the effect of bacillus sphaericus bacteria on concrete mix is promising in addition to its normal constituents.

There is significant percentage increase in strength which could improve the durability of concrete structures to a greater level.

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