An Experimental Analysis of Bacterial Concrete from Food Wastage

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Abstract— The objective of the present investigation is to obtain the performance of the concrete by using bacteria from the food wastages. One such thought has lead to the development of a very special concrete known as Bacterial Concrete where bacteria is induced in the mortars and concrete to heal up the faults. Researchers with different bacteria have proposed different bacterial concrete's. Bacillus cereus bacteria's are mostly available in the food wastages. Cement concrete cubes and Cylinders with four particular cell concentrations were cast and control specimen was also cast. This study showed a significant increase in the compressive strength was observed due to the addition of bacteria for a cell concentration ml of mixing water. By visual analysis, it is noted that pores were partially filled up by material growth with the addition of the bacteria. Reduction in pore due to such material growth will obviously increase the material strength. Concrete cubes with and without addition of bacteria were cast and it is observed that there is an improvement in the compressive strength for the cubes with the addition of bacteria. Concrete Cylinder with and without additions of bacteria were cast and it is observed that there is an improvement in the split tensile strength for the Cylinder with the addition of bacteria.

Key words: Bacillus Cereus

I. INTRODUCTION

Concrete is by far the most widely using building material in the world. Concrete has a large load bearing capacity for compression load, but the material is weak in tension. That is why steel reinforcement bars are embedded in the material to be able to build structures. The steel bars 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 ingress of water and ions take 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 formed are repaired later or in the design phase extra reinforcement is placed in the structure to ensure that the crack width stay 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. 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. Of course repair cracks of cracks that develop in concrete structures would go down. But also the extra steel that is used to limit crack widths could probably be saved to a large extent.

Cracks widths in concrete structure should be limited, mainly for durability reasons. If cracks widths are too large the cracks need to be repaired or extra reinforcement is needed already in the design. If a method could be developed to automatically repair cracks in concrete this would save an enormous amount of money, both on the costs of injection fluids fro cracks and also on the extra steel that is put in structures only to limit crack widths. For structural reasons this extra steel has no meaning. A reliable self-healing method for concrete would lead to a new way of designing durable concrete structures, which is beneficial for national and global economy. 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 sub tilisis a model laboratory bacterium, which can produce calcite precipitates on suitable media supplemented with a calcium source. A common soil bacterium, Bacillus sub tilis, was used to induce $CaCO_3$ precipitation. The basic principles for this application are that the microbial urease hydrolyzes urea to produce ammonia and carbon dioxide, and the ammonia released in surroundings subsequently increases pH, leading to accumulation of insoluble $CaCO_3$. The favourable 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 be 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.

In future bacterial precipitated glue play vital role in the production of habitation agent to arresting of fine cracks formation the structure. Due to culture of bacteria our surrounding Eco- System and fertility of soil will be preserved. It serves as good remedial measures for Earthquake affected building. The bacterial concrete widely used in earthquake resistance structure because of precipitation of calcite layer in the concrete offers lateral stability.

II. LITERATURE REVIEW

As part of the research during the year 2010: A bacteria that can knit together cracks in concrete structures by producing a special 'glue' has been developed by a team of students at " Newcastle University ".They named the concrete as a Bacterial Concrete. 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 (MICP) .Under favourable conditions for instance Bacilla Filla, a common soil bacterium, can continuously precipitate a new highly impermeable calcite layer over the surface of an already existing concrete layer. The genetically-modified microbe has been programmed to swim down fine cracks in the concrete. Once at the bottom, Bacilla Filla produces a mixture of calcium carbonate and a bacterial glue which combine with the filamentous bacterial cells to ‘knit’ the building back together. The nine students, whose backgrounds range from computer science, civil engineering and bioinformatics to microbiology and biochemistry, took part in the International Genetically Engineered Machines contest (iGEM), is run out of the Massachusetts Institute of Technology (MIT) in Cambridge, Boston. Over 130 teams took part in this year’s event and it is now the third time Newcastle University has won Gold. Around five percent of all man-made carbon dioxide emissions are from the production of concrete, making it a significant contributor to global warming. Finding a way of prolonging the lifespan of existing structures means we could reduce this environmental impact and work towards a more sustainable solution. This could be particularly useful in “Earthquake zones” where hundreds of buildings have to be flattened because there is currently no easy way of repairing the cracks and making them structurally sound. The BacillaFilla spores only start germinating when they make contact with concrete and they have an in-built self-destruct gene which means they would be unable to survive in the environment. Once the cells have germinated, they swarm down the fine cracks in the concrete and are able to sense when they reach the bottom because of the clumping of the bacteria. This clumping activates concrete repair, with the cells differentiating into three types: cells which produce calcium carbonate crystals, cells which become filamentous acting as reinforcing fibres and cells which produce a Levans glue which acts as a binding agent and fills the gap. Ultimately hardening to the same strength as the surrounding concrete, the Bacilla Filla has been developed to prolong the life of structures which are environmentally costly to build.

The long-term novel goal of the research is to remediate cracks in granite, concrete, and structures utilizing calcite that is induced by common soil bacteria such as Bacillus pasteurii. Cracks in concrete allow water and chemicals to enter, a process that may lead eventually to the unwanted corrosion of the steel reinforcement and the deterioration of the concrete structure. Within the framework of the “Self-Healing Materials Research Project of the Delft Centre” for Materials, the possible application of bacteria to extend the lifetime of concrete is studied. The goal of this project is to incorporate dormant but viable bacteria in the concrete matrix which will contribute to the concretes self-healing potential. Water entering freshly formed cracks will activate the dormant bacteria which in turn will seal these cracks through the process of metabolically mediated calcium carbonate precipitation. Concrete, however, is due to its high internal pH (>12), relative dryness and lack of nutrients needed for growth, a rather hostile environment for common bacteria. Yet, certain extremo philic bacteria may be able to endure this artificial environment for their growth of bacteria. In this study they tested the applicability of alkaliphilic spore-forming bacteria of the genus Bacillus as self-healing agent in concrete. They found that incorporation of high numbers of bacteria (10^9cm-3) as well as some suitable organic growth substrates in concrete did not negatively affect compressive- and flexural tensile strength. ESEM analysis revealed furthermore the self-healing potential of immobilized cells, as bacterial- but not control cement stone samples were found to deposit a new layer of calcium carbonate minerals on its surface. This research was awarded by the Florida Department of Environmental Protection (FDEP), Florida. So we are eagerly undergone, similar research by using Bacillus sub tilis producing cheapest rehabitation glue for arresting fine cracks. In order to modify conventional concrete properties like Texture, Compression Strength & Spilt Tensile strength.

III. MATERIALS & METHODOLOGY

A. Materials Used

The following are the details of the materials used for concrete making:

1) Cement

Ordinary Portland cement of 53 grade available in local market is used in the investigation. The cement used has been tested for various properties as per IS: 4031-1988 and found to be confirming to various specifications of IS: 12269-1987 having specific gravity of 3.15.

2) Fine Aggregate

The sand available in the market is used in the investigation. The sand has been tested as per IS: 2386-1963 and found to be to conforming various specifications of IS: 383-1970 having specific gravity of 2.72 and falls under zone

3) Coarse Aggregate

Crushed broken stone angular aggregate of size 20 mm nominal size from local source was used as coarse aggregate having specific gravity of 2.85.

4) Water

Locally available portable water confirming to IS 456 is used.

5) Micro Organisms

Bacillus cereus, a commonly available soil bacterium is used Biochemical characteristics of the pure culture bacillus cereus Characteristics Bacillus cereus Shape, size, gram stain Long rods, 0.6-0.8 µm in width and 2.0 to 3.0 µm in Length, gram positive.

6) Culture of Bacteria

The basic culture of the Bacillus cereus was obtained from micro biological laboratory. Whenever required a single colony of the culture is inoculated into nutrient broth of 25 ml in 100 ml conical flask and the growth condition are maintained at 37◦ C temperature and placed in 125 rpm orbital shaker.

Concrete mix design is defined as the appropriate selection and proportioning of constituents to produce a concrete with predefined characteristics in the fresh and hardened states. Mix design was carried out as per IS: 10262-1982 with respect to the design stipulations and data mentioned.

There are different methods of mixing the bacterial solution in the concrete which are

- Direct mixing
- Indirect mixing

– Injection method

In our investigation we have adopted the direct method mixing. The compressive strength is determined using compressive testing machine.

IV. EXPERIMENTAL METHODS AND TESTS

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. In our investigation we have made M30 grade of concrete as per IS 10262. Further, we have poured the concrete in the cube moulds and five different samples were made which are as follows.

V. RESULTS & DISCUSSIONS

A. *Compressive Strength Test*

Fig. 4.1: Compressive Strength Test of Concrete

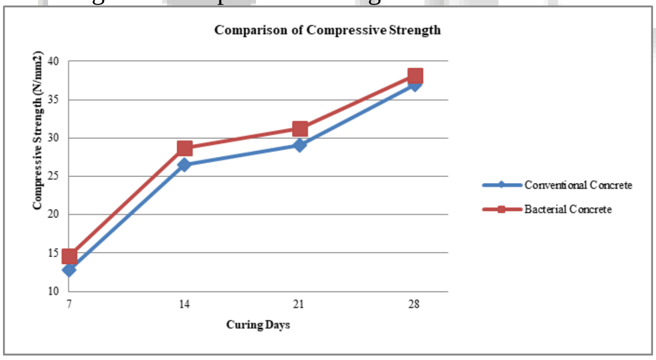

Fig. 4.2: Comparison of Compressive Strength

Figure: 4.3 Split Tensile Strength Test of Concrete

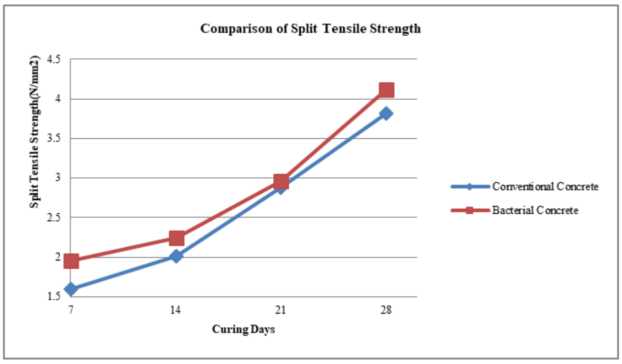

Fig. 4.4: Comparison of Split Tensile Strength

VI. CONCLUSION

From the obtained split tensile strength and compressive strength results the incorporation of high numbers of bacteria in the concrete mix, result in a significant gain of strength due to self-healing property of bacteria's. As the durability of bacterial concrete is increased with the increase in the concentration of bacteria more number of bacteria's may be added. Due to the inclusion of bacteria in concrete, we achieved approximately 10% of increase in compressive strength and also 30% increase in flexural strength. From the results it can be concluded that easily cultured Bacillus cereus be safely used in improving the performance and characteristics of concrete. Hence we can effectively use the Bacterial concrete in the structures, to get more strength and durability.

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