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Experimental Study on Influence of Bacteria in Concrete

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Abstract: Concrete is a composite material composed of fine and coarse aggregate bonded together with a fluid cement (cement paste) that hardens over time. The elasticity of concrete is relatively constant at low stress levels but starts decreasing at higher stress levels as matrix cracking develop.
Therefore, it is important to control the crack width and to heal the cracks as soon as possible. Since the costs involved for maintenance and repair of concrete structures are usually high, apart from conventional methods of repairing cracks with sealants or treating the concrete with adhesive chemicals to prevent the cracks from widening, a microbial crack healing approach has shown promising results and this research focuses on the development of self-healing concrete. Self-healing of cracks in concrete would contribute to a longer service life of concrete structure and would make the material not only more durable but also more sustainable.
Keywords: Normal concrete and Bacterial concrete, Bacillus bacteria, Compressive strength comparison.

I. INTRODUCTION

Concrete is most commonly used construction material which is strong in compression and weak in tension. The major drawback of concrete is formation of cracks, which affects the serviceability of concrete. When the applied load exceeds the limit, cracks develops on the structure through which water, salts and other foreign matters enters into the concrete and leads to the failure of the structure. Concrete is a composite material composed of fine and coarse aggregate bonded together with a fluid cement (cement paste) that hardens over time. The elasticity of concrete is relatively constant at low stress levels but starts decreasing at higher stress levels as matrix cracking develop. Therefore, it is important to control the crack width and to heal the cracks as soon as possible. Since the costs involved for maintenance and repair of concrete structures are usually high, apart from conventional methods of repairing cracks with sealants or treating the concrete with adhesive chemicals to prevent the cracks from widening, a microbial crack healing approach has shown promising results and this research focuses on the development of self-healing concrete. Self-healing of cracks in concrete would contribute to a longer service life of concrete structure and would make the material not only more durable but also more sustainable. Crack in concrete because crack form an open pathway to the reinforcement and can lead to durability problems like corrosion of the steel bars. These cracks should be repaired because they can reduce the service life of the structure. In case of historical monuments cracks spoils appearance of the structure.

II. LITERATURE REVIEW

1) H.m. Jonkers, a. Thijssen et al (2010) concluded that the addition of specific organic mineral precursor compounds plus spore-forming alkaliphilic bacteria as self-healing agents Produces up to 100-µm sized calcite particles which can potentially seal micro- to even larger-sized cracks. Further development of this bio-concrete with significantly increased self-healing capacities could represent a new type of durable and sustainable concrete with a wide range of potential applications.
2) Breugel (2012) studied on self-healing material concepts as solution for aging infrastructures. The comparison between bacterial and control specimens performed and it reveal a significant difference in Permeability of concrete.
3) Pelletier et al. (2013) developed a self-healing concrete that was inexpensive to produce by creating a concrete matrix that was embedded with a micro-encapsulated sodium silicate healing agent. When cracks were formed in the concrete, the capsules ruptured and released the agent into the adjacent area. It was found that the sodium silicate reacted with the calcium hydroxide already present in the concrete, and formed a calcium-silica-hydrate gel that healed the cracks and blocked the concrete's pores. When Pelletier's concrete was stress-tested to the point of almost breaking; it proceeded to recover 26% of its original strength. By contrast, conventional concrete only recovers 10%. Pelletier believes that she could boost the strength of her mix even higher, by increasing the quantity of the healing agent.

4) Wang et al. (2014) (17) The bacteria with microencapsulation had a higher impact on crack repair than bacteria with direct immobilisation, according to the report. Crack healing rates vary from 48 to 80 percent. In terms of the feasibility of bacteria penetration into concrete, microencapsulation is a safer methodology.
5) Ravindranatha et al. (2014) (19) have published a paper on Self-Healing Material Bacterial Concrete. A comparative analysis was conducted with concrete cubes and beams that were subjected to compressive and flexural strength tests with and without Bacillus pasteurii. The concrete cubes and beams were prepared by adding calculated quantity of bacterial solution and they were tested for 7 and 28 day compressive and flexural strengths. It was found that their w the concrete cubes and beams were prepared by adding a measured amount of bacterial solution, and their compressive and flexural strengths were tested after seven and twenty-eight days. On the concrete specimens, there was a significant improvement in strength and healing of cracks subjected to packing. As a result of the loading on the concrete specimens, there was a significant improvement in strength and healing of cracks. By achieving a very high initial strength improvement, the microbe proved to be successful in improving the properties of the concrete. The bacteria's calcium carbonate has filled a portion of the void volume, rendering the texture more compact and resistant to seepage.

III. DETAILS OF STUDY MODEL

A. Collection of Materials
The materials are cement, fine aggregate, coarse aggregate, water and Bacillus bacteria

B. Culturing of Bacteria
The pure culture of Bacillus Subtilis was collected from the department of Agricultural Microbiology, EMEA College Kondotty. The pure culture was preserved, and maintained constantly on nutrient agar slants. The bacteria can thus act as a nucleation site which facilitates in the precipitation of calcite which can eventually plug the pores and cracks in the concrete. This microbiologically induced calcium carbonate precipitation (MICCP) comprises of a series of complex biochemical reactions. It forms irregular dry white colonies on nutrient agar.

C. Preliminary test on Materials
Primary tests are specific gravity, standard consistency, initial and final setting time tests for cement and sieve analysis, bulk density, specific gravity tests for fine aggregate and coarse aggregate.

D. Casting of Specimen
We need three normal concrete cube specimens and three bacterial concrete cube specimens of size of cube specimen is 15x15x15 cm are made by using moulds, the casting moulds are chosen to be made of cast iron and must be rubbed with grease on inner side for easy removal of cubes. The specimen casted with 3 layers (5cm each) and properly compacted in order that honeycombing formation does not take place. In compacting through tamping bar, 35 strokes must be done in all parts of a cube for proper compacting. This tamping bar has the dimension of diameter 16mm and length of 0.6m.

E. Concrete Mixing
1) Mixed the cement and fine aggregate on a watertight none-absorbent platform until the mixture is thoroughly blended and is of uniform colour.
2) Added the coarse aggregate and mix with cement and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch.
3) Add water and mix it until the concrete appears to be homogeneous and of the desired consistency.

Fig. 1 Concrete mixing for casting specimen

F. Casting

The casting moulds are chosen to be made of cast iron and must be rubbed with grease on inner side for easy removal of cubes. The specimen casted with 3 layers (5cm each) and properly compacted in order that honeycombing formation does not take place. In compacting through tamping bar, 35 strokes are done in all parts of a cube for proper compacting. This tamping bar has the dimension of diameter 16mm and length of 0.6m. After filling the moulds leveled the top surface of mould or cube. Then allow the required time for setting of the specimen. After setting, removed moulds carefully and submerged to water for curing after marking the specimens. The normal concrete and bacterial concrete are place under water separately with numbered.

Fig. 2 Casting Mould and Casted Cube

G. Curing of Cubes

After completion of required time for setting of specimens removed the mould carefully and allow to submerged in water where curing tank.

Fig. 3 Specimen Placed in Curing Tank

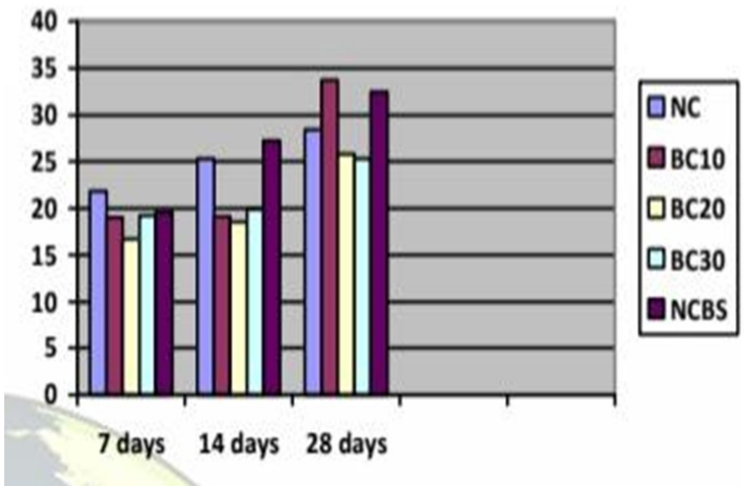
IV. RESULT AND ANALYSIS

Compressive strength of cubes at 7 days,
- Normal concrete = 21.8
- Bacterial concrete, for 10ml = 18.99
- Bacterial concrete, for 20ml = 16.75
- Bacterial concrete, for 30ml = 19.24

Compressive strength of cubes at 14 days,
- Normal concrete = 26.54
- Bacterial concrete, for 10ml = 20.22
- Bacterial concrete, for 20ml = 19.61
- Bacterial concrete, for 30ml = 20.46

Compressive strength of cubes at 28 days,
- Normal concrete = 27.28
- Bacterial concrete, for 10ml = 34.86
- Bacterial concrete, for 20ml = 28.24
- Bacterial concrete, for 30ml = 25.46

V. COMPARISON OF RESULT



Compressive strength comparison graph

VI. CONCLUSIONS

Based on the experimental investigation, we concluded the following results.

1) The Compression strength 10ml specimen of M25 grade is 34.86 N/mm2 higher than the normal specimen of M25 grade.
2) The Compression strength of 20 ml specimen of M25 grade is 28.24 N/mm2 higher than normal specimen of M25 grade.
3) The Compressive strength of 10ml specimen of M25 grade is show greater influence in bacterial concrete
4) Therefore, it is advisable to use such as 10ml bacterial concrete.
5) Healing property of concrete is also achieved; hence it is used in repair techniques also.
6) The compressive strength was found to increase with bacterial addition and this increase is mainly due to deposition of microbial induced calcium carbonate precipitation on the microorganism cell surfaces and within the pores of the mortar. It was noticed that in normal mortar, the compressive strength was increased with the increase in bacterial cell concentration up to 10ml. Maximum increase in compressive strengths was achieved at 10ml.
7) The percentage increase in compressive strength of 10ml and 20ml bacterial concrete using B. Subtilis for 28 days is higher than conventional concrete.

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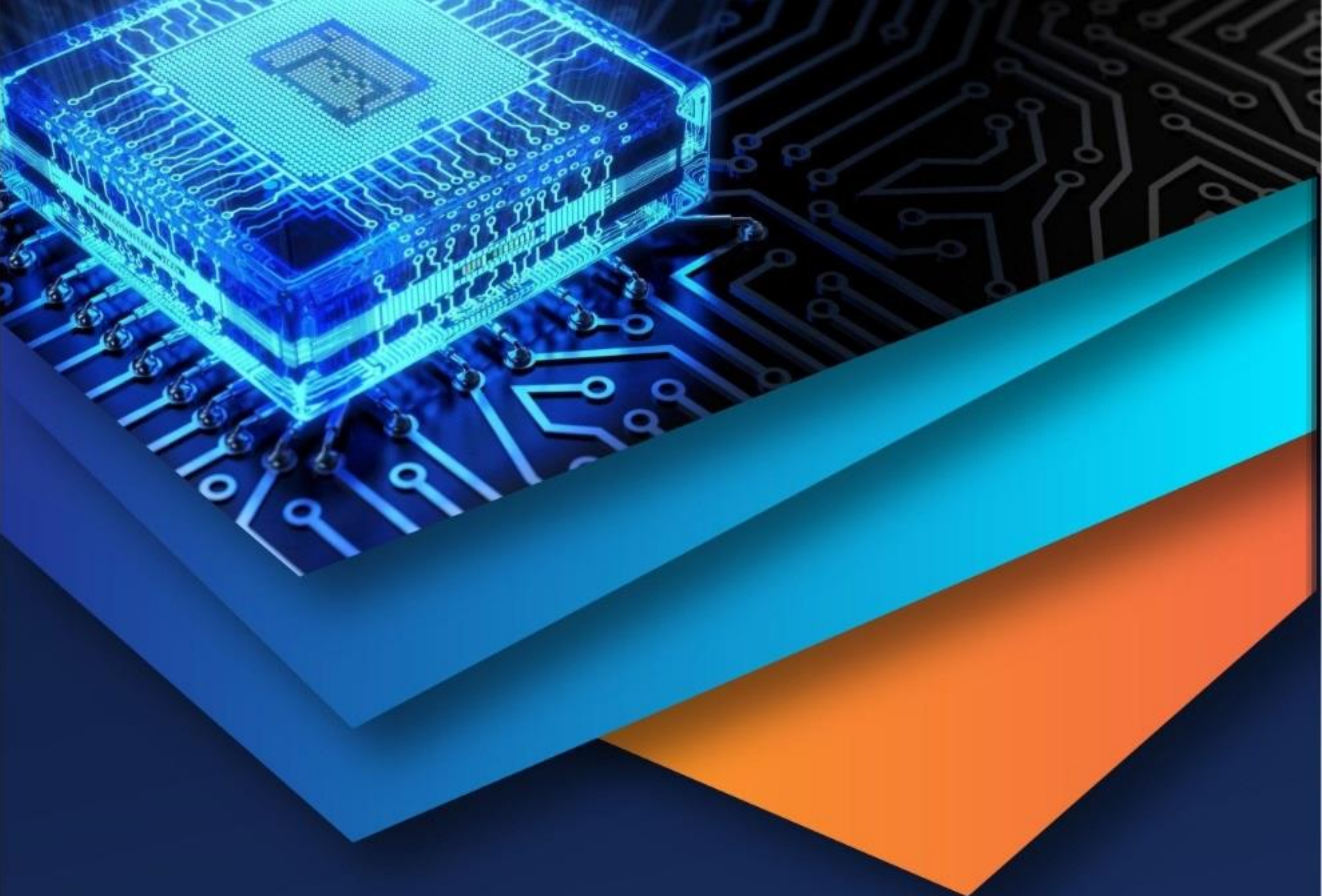

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