A Review Paper on Application of Bacillus Subtilis Bacteria for Improving Properties and Healing of Cracks in Concrete

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Abstract: Formation of Cracks in concrete is a common phenomenon in the concrete structure. The strength and durability of the concrete is diminished due to the formation of cracks. Repairing these regular cracks is an expensive process. Self-healing concrete is a bacterial concrete which heals itself automatically without any maintenance. For self-healing concrete Bacillus subtilis is an ideal bacterial species. When the bacteria in concrete comes in contact with air, water and moisture, it gets activated and forms lime as a result cracks heals itself. Bacterial concrete fulfills less maintenance, more durability and corrosive resistance of a building. Now a days, construction industry has accepted bacterial concrete as a challenging composition for self repairing and incrementing the compressive strength of the concrete.

Keywords —Bacterial concrete, Bacillus subtilis, Self-healing, Self repairing

I. INTRODUCTION

Quickly creating development, especially in creating countries, contributes to natural contamination, high energy utilization and common assets. These activities have an immediate effect on the solace and heath of building inhabitants. In the European development industry, the correct decision of building materials is an significant factor in accomplishing reasonable turn of events. Standards of reasonable advancement are being presented for the whole life pattern of structures.

Sustainable building materials are such materials that:-

- Reduce the consumption of resources
- Minimise the impact on the environment
- do not pose a threat to human health

Cracks in concrete are a common phenomenon due to the relatively low tensile strength. Durability of concrete is impaired by these cracks since they provide an easy path for the transportation of liquids and gasses that potentially contain harmful substances. Treatments for the cracks are a very expensive procedure. There are moderate techniques to repair the cracks in concrete by itself called Self Healing concrete. This bacterial remediation technique surpass other techniques as it is bio-based, eco-friendly, cost-effective and durable.

Concrete is highly alkaline material, the bacteria added is capable of withstanding alkali environment. If any cracks will be formed in concrete, bacteria participate calcium carbonate. The "Bacterial concrete" can be made by embedding bacteria in the concrete that are able to constantly precipitate calcite. Bacillus sphaericus is a soil bacterium, can continuously precipitate a new highly impermeable calcite layer over the surface of an already existing concrete layer. Adopting bacteria induced carbonate precipitation to fill the cracks is very innovative. The microbial precipitation depends on several factors including the concentration of dissolved inorganic carbon, the PH, and the concentration of calcium ions and the presence of nucleation sites. Also, when Bacteria are used to work for the healing of cracks in concrete, the major hindering factor is the high alkaline environment of concrete, restricting the growth of the bacteria. Therefore, necessary measures need to be taken to protect bacteria in concrete. Now a days, Bacterial concrete has been accepted in the construction industry as a challenging composition for self repairing and incrementing the compressive strength of the concrete. Bacterial concrete also plays the helping role in a seismic zone at a primary stage.

II. THE BACTERIA-BACILLUS SUBTILIS

Firstly bacillus subtilis is known as Vibrio subtilis, this bacteria was discovered by Christian Gottfried Ehrenberg in 1835. It was renamed in 1872 by Ferdinand Cohn. Bacillus subtilis (B. subtilis) is a Gram-positive, aerobic bacteria. It is rod-shaped.

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FIG. 1: BACILLUS SUBTILIS

- Bacillus Subtilis is a non-pathogenic and non-toxicogenic bacteria.
- Self healing property of a concrete is achieved by introducing the Bacillus Subtilis bacteria into a concrete matrix during mixing.
- When a crack formed in the concrete surface, the ingress water reacts with the bacteria and which in turn produce Calcium carbonate (caco3) which is a main composition of lime.
- Since, the bacteria need a food to survive so we chose Calcium lactate as a chemical precursor to do the work.

III. LITERATURE REVIEW

S. Sanjay, S. Neha, and R. Jasvir (2016),This paper was presented the experimental investigation on bacterial concrete to increase the strength of bio concrete and to inform the process involved in the bacterial concrete. To know the calcite crystals formed in bacterial concrete analysis of microstructure has been done that is used for the potential to recovery the cracks in bacterial concrete and also to inform the biological reaction in concrete. As a result, has been got because of good adaptability of nutrient broth medium of bio concrete at 28 days attained better strength when compared to urea medium [1].

A. Thakur, A. Phogat, K. Singh (2016), This paper has presented the overview of several paper in the current years on the use of bio concrete for improving in the mechanical properties, durability and permeation features of normal concrete. They have been studies the analysis on bio concrete by XRD and SEM tests and also several types of bacteria's, their isolation process, several methods used in the adding of bacterial species in concrete and their belongings on water absorption and compressive strength. Finally, they concluded the bacterial type such as B. cereus and S. pasteurii extreme rise in the compressive strength and the maximum reduce in water absorption for 28 days curing period of specimen respectively. The bacterial like bacillus sphaericus, B. pasteurii, and Bacillus flexus are not harm the human body and also, they have the potential to precipitate calcite but some other bacterial species is dangerous for human health [2].

N. Amudhavalli, K. Keerthana and A. Ranjani (2015), this paper has presented the overview of bacterial concrete, bacteria the state of art results in all projects show that material designed as self-healing agents. Some of the bacteria is drawbacks not directly functional in construction structure like houses and offices because of health concerns this bacteria like B. Pasteuri, B. megaterium, B. subtilis. Lastly, they achieve that bacterium that have used in concrete in better way because of their advantages than other bacteria that are B. Sphaericus and Escherichia Coli [3].

N. Chahal and R.Siddique (2008) this study has been presented that with use of Sporosarcina pasteurii which would make it, self-healing. They observed that newly formed cracks healed by the presence of bacteria. In the concrete mix 10%, 20% and 30% and also 5% and 10% dosage of fly ash and silica fume respectively replacing cement in the bacterial solution of 103, 105 and 107 cells/ml. They did tests on the water absorption and porosity, chloride permeability and compressive strength by using up to age 91 days. They concluded that by the presence of S. pasteruii increase compressive strength, cut downs the permeability and porosity of silica fume and fly ash concrete [4]

IV. OBJECTIVES OF WORK

- To increase compressive strength and to remediate the cracks developed in concrete.
- To study the durability of concrete under various weathering conditions and check the performance of bacillus subtilis by durability test.
- To heal cracks by bacterial precipitation.
- To investigate the effect of Bacillus species bacteria in gaining strength in contrast to conventional concrete.
- Efficient use of bio concrete in the marine structure.

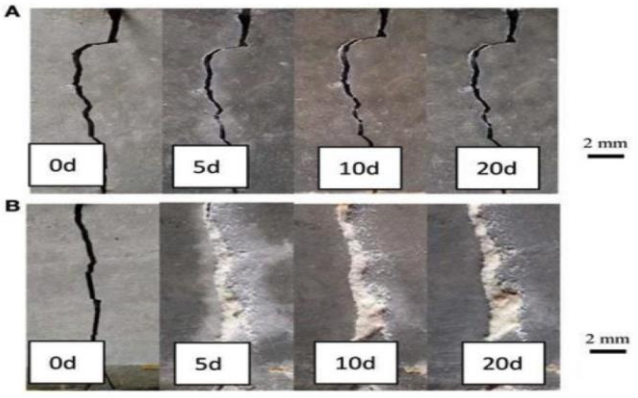

FIG. 2: CRACK COMPARISON BETWEEN BACTERIAL CONCRETE AND CONVENTIONL CONCRET

V. WORKING PROCESS

• Culture of Bacteria:

Firstly bacillus subtilis is known as Vibrio subtilis, this bacteria was discovered by Christian Gottfried Ehrenberg in 1835. It was renamed in 1872 by Ferdinand Cohn. Bacillus subtilis (B. subtilis) is a Gram-positive, aerobic bacteria. It is rod-shaped.

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• Mix design:

Selecting suitable ingredients of concrete(M25) such as cement, aggregates, water and determining their relative proportions with the object of producing concrete of required minimum strength, workability and durability as economically as possible.

• Mixing, Casting and Curing:

Mixing: Mixing is done with the cement, sand and aggregate in the proportion of 1:2:2 (M25 Grade) with respective proportion of bacteria.

Casting: A total 18 cubes and 18 cylinders were casting for performing the Compressive strength and Tensile strength including both with and without bacteria concrete.

Curing: The cubes and cylinders are kept immersed in water for curing at the intervals of 7 days, 14 days and 28 days.

Preliminary test of the concrete using Bacteria:

Compression test: - A total 18 cubes were tested for Compressive Strength including both with and without bacteria concrete. Compression strength test will be carried out on 7 days, 14 days and 28 days.

Tension test :- A total 18 Cylinders were tested for split tensile strength including both the specimens of with and without bacteria. Tension test will be carried out on 7 days, 14 days and 28 days.

VI. APPLICATIONS

• It can be used to strengthen both existing and new types of structural building.

• It is effective in areas where buildings undergo freezing and thawing.

• This can prove to be economical in case of irrigation works, dams etc. which are directly in contact with water.

• It is new technology that can give way to sustainable roads.

VII. ADVANTAGES

• It helps to fill the cracks.

• Improves compressive strength of concrete.

• Reduces permeability of concrete and corrosion of reinforced concrete.

• Helps to reduce maintance and repair.

• It can operate at internal levels which means that the smallest cracks can be reached.

VIII. DISADVANTAGES

- The cost of self-healing concrete is double that of conventional concrete.
- No code is available to standardize the self-healing concrete.
- Growth of any bacteria is not good in any atmosphere media.
- Skilled labour is required.

IX. CONCLUSION

Utilization of Bacillus subtilis in self-healing is a safe and financially savvy technique which is additionally very eco-accommodating, and helpful. Likewise, Bacillus subtilis is a nonpathogenic microorganism. This interaction of biomineralization in self-healing additionally will decrease the work cost. Self-healing concrete have capacities to expand sturdiness of different structure materials, giving them higher strength with more noteworthy bearing limit and broadening the structure life.

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