Experimental Study on Self-Healing Concrete

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Abstract - Self-healing concrete is a promising technology that could increase the useful life of concrete constructions while requiring less upkeep. Incorporating microcapsules containing therapeutic drugs into concrete is the subject of this experimental study to determine its efficacy. In order to conduct the study, concrete samples containing various amounts of microcapsules must be prepared and mechanically damaged. Several tests, including those for water permeability, strength recovery, and fracture healing, are used to assess the concrete's self-healing capabilities. The findings demonstrate that adding microcapsules improves the concrete's capacity for self-healing, and that as the percentage of microcapsules rises, so does the effectiveness of the healing process. This study offers insightful information on how self-healing concrete might be used in the building sector.

Index Terms - Methods

1. Concrete Preparation
2. Mix Proportions
3. Mix proportions for M20 grade concrete
4. Mix proportions for M40 grade concrete

I. INTRODUCTION

1.1 General

The most often utilised building material is concrete, which is employed in public structures.

One of the inherent weaknesses of concrete is cracks. On the basis of ongoing research conducted all around the world, numerous adjustments have occasionally been made to address the shortcomings of cement concrete. With the use of industrial materials like fly ash, blast furnace slag, silica fume, etc., ongoing research in the field of concrete technology has led to the development of special concretes that take into account the speed of construction, the strength of concrete, durability of concrete, and the environmental friendliness of concrete. Recently, it has been discovered that the general behaviour of concrete can be enhanced by microbial mineral precipitation brought on by the metabolic activities of beneficial microorganisms.

By incorporating bacteria that can continuously precipitate calcite into the concrete, bacterial concrete can be created. Microbiologically generated calcite precipitation is the name given to this event. Concrete cracks can be successfully repaired by Bacillus subtilis. A common soil bacterium, bacillus subtilis je3, is employed to induce CaCa3 precipitation. Calcite generation by bacillus subtilis is a laboratory bacteria that may manufacture calcite that precipitates on suitable medium supplied with a calcium source. The ideal circumstances are not directly present in concrete. The majority of the effort will be devoted to examining how the ideal circumstances might be developed for the bacteria to manufacture as much calcite as required to fill gaps in addition to allowing them to survive in the concrete.

1.2 Self-Healing of concrete

Concrete that self-heals cracks in itself would increase the material's durability and sustainability while also extending its useful life in buildings.

It is possible to create "self healing concrete" by incorporating microorganisms that can continuously precipitate calcite into the concrete. A soil bacteria called Bacillus Sphaericus has the ability to continuously precipitate a fresh coating of calcite that is incredibly impermeable over the top of an existing concrete layer. The ideal circumstances must be constructed because they do not naturally exist in concrete. This subject will be the main area of the study.

BACILLUS SUBTILIS CONCRETE'S SIGNIFICANCE:

The soil bacterium Bacillus subtilis continuously produces calcite crystals, greatly enhancing the durability and strength of concrete over time. Most human-safe bacteria are caused by the Bacillus genus. This method makes use of Bacillus bacteria as well as bacterial nutrients. This category includes chemicals like calcium, nitrogen, and phosphorus compounds. During the manufacturing process, every component is added to the concrete. An environmentally friendly and biodegradable chemical is Bacillus subtilis.

II. Literature survey

M. Monishaa et al(2017), a review of recent findings from an experimental study on self-healing concrete was undertaken. The spore-forming, calcite mineral-precipitating bacterium "Bacillius subtilis" makes an attempt in bacterial concrete. Different bacterial cell concentrations, such as 10-4, 10-5, and 10-6 per millilitre of water, were used in the M20 grade concrete that was created. As reinforcement, polyethylene fibre is employed and kept constant at 0.4%. Bacillius subtilis and polyethylene fibre have been used to create self-healing concrete, which has had its overall strength and durability compared to normal concrete. A high number of polyethylene fibres were easily connected to crystallisation products because the polyethylene fibres were bridging over the fracture. The ideal concentration is discovered to be 10 5 bacterium.

Jasira Bashir et al (2016), conducted an experiment on self-healing bio-concrete, and an effort was made to use various microorganisms in order to monitor and compare the strength gain as a result of the sprouting of filler materials inside the concrete that is in the pores of the cement sand matrix. To assess the strength of the concrete, tests for compressive strength, split tensile strength, and flexural strength are performed. Further research is done using X-Ray Diffraction (XRD) analysis and scanning electron microscopy (SEM) to demonstrate the part that the isolated ureolytic bacteria played in the precipitation of calcium carbonate. A good comparison between the strengths of various specimens of bacterial concrete using various bacteria and conventional concrete can be drawn from the tests conducted on various specimens of bacterial concrete using various bacteria. According to the experiment's findings, when water seeps into concrete cracks, dormant bacteria become activated through the precipitation of calcium carbonate, which is mediated by metabolism, increasing the strength of bio concrete relative to conventional concrete. It has been discovered that bio concrete is strong, environmentally benign, and provides higher resistance against freeze-thaw and corrosion. Bioconcrete crack repair is superior to epoxy and other external crack treatments.

III. METHODOLOGY

An effort was made to confirm if it would be possible to produce bacillus subtilis concrete at a reasonable cost in all practical circumstances based on a careful analysis of the literature. Concrete made with bacillus subtilis in a lab performs best when the aggregate particles are mortared together with cement. So, using different bacillus subtilis dosages, an experimental programme was created to evaluate the mechanical properties of bacillus subtilis concrete. The main objective of the ongoing experimental research is to gather exact experimental information that will help in understanding the bacterial concrete and its

properties. In the current experimental investigation, studies on the behaviour of fresh and hardened characteristics of common grade concrete and standard grade concrete with and without bacteria addition were conducted. By carrying out the necessary laboratory experiments on hardened concrete, the properties of hardened concrete, such as compressive strength, are evaluated.

CONCRETE PREPARATION

Coarse and fine aggregate are added to an electrically driven concrete mixer and stirred for three minutes. To ensure homogeneity, cement is poured into a concrete mixer with the aggregate and allowed to mix for a while. The mixture of cement, coarse aggregate, and fine aggregate is stirred for an additional 3 minutes before water and a tiny number of bacteria are added. Combinations that have just been created are resistant to segregation. Before being inserted into cube moulds with dimensions of 150 x 150 x 150 mm, three layers of Bacillus subtilis concrete are compressed and vibrated to remove air holes. The specimens are demolded 24 hours after casting.

Samples are kept outside in the curing tank until the setting age.

MIX PROPORTIONS

Five mixes were taken into consideration, with bacillus subtilis contents ranging from 0 to 5 to 10 to 20 to 30 ml. To achieve homogeneity, bacillus subtilis is first combined with water. The weights of the cement, fine aggregate, coarse aggregate, water, and bacteria are then calculated, and concrete is then produced.

TABLE 1: Mix proportions for M20 grade concrete

S.NO	1	2	3	4	5
Cement (kg/m3)	359	359	359	359	359
Coarse aggregate (kg/m3)	1118.1	1118.1	1118.1	1118.1	1118.1
Fine aggregate (kg/m3)	678.36	678.36	678.36	678.36	678.36
Water (kg/m3)	197.16	197.16	197.16	197.16	197.16
Bacillus subtilis (bacteria) (ml)	0	5	10	20	30

TABLE 2: Mix proportions for M40 grade concrete

S.NO	1	2	3	4	5
Cement (kg/m3)	450	450	450	450	450
Coarse aggregate (kg/m3)	1101.4	1101.4	1101.4	1101.4	1101.4
Fine aggregate (kg/m3)	668.24	668.24	668.24	668.24	678.36
Water (kg/m3)	197.16	197.16	197.16	197.16	197.16
Bacillus subtilis (bacteria) (ml)	0	5	10	20	30

IV. RESULTS AND DISCUSSION

CONCRETE CUBE COMPRESSIVE STRENGTH

The term "compressive strength" refers to a material or structure's ability to withstand pressures applied to its surface without cracking or deflection. A material's size changes depending on how tightly it is crushed or tensioned. Cubes measuring 150mm x 150mm x 150mm are cast in accordance with instructions after specimen preparation of Ordinary grade concrete and Standard grade concrete design mix. Both microbial and microbial-free cubes are cast. The specimens are removed from the moulds after 24 hours and placed in the freshwater curing tanks. The samples are gathered and kept in the shade after the drying period. Following the necessary amount of curing time, the cube specimens are removed from the curing tank and cleaned. After 7 and 28 days, a set of cubes' compressive strength is assessed. M20 concrete grade.

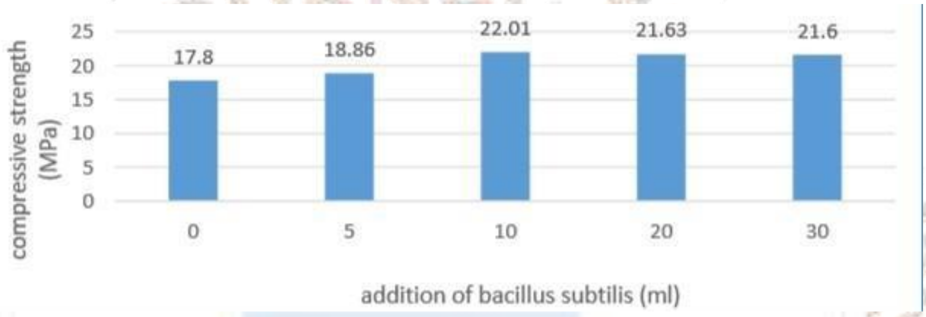

FIG 1: COMPRESSIVE STRENGTH FOR VARYING BACILLUSCONTENT AT SEVEN DAYS

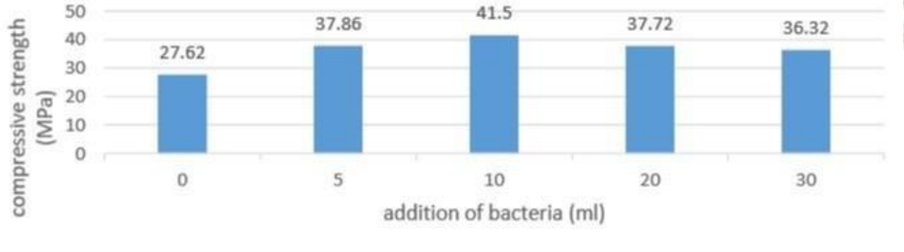

Fig 2: Compressive strength for varying bacilluscontent at 28 days

After reaching an ideal level of bacillus subtilis, the compressive strength of M20 grade concrete steadily diminishes. Seven days after adding 10 ml of bacillus subtilis (bacteria), the compressive strength of bacillus subtilis concrete reaches its maximum level. When compared to the small mix's compressive strength at seven days, the compressive strength of the bacillus subtilis concrete increased by 23.65%. The bacillus subtilis concrete reaches its maximum compressive strength 28 days after 10 ml of the bacteria are added. After 28 days, bacillus subtilis concrete's compressive strength increased by up to 50.2 percent in comparison to the little mix's compressive strength.

M40 concrete

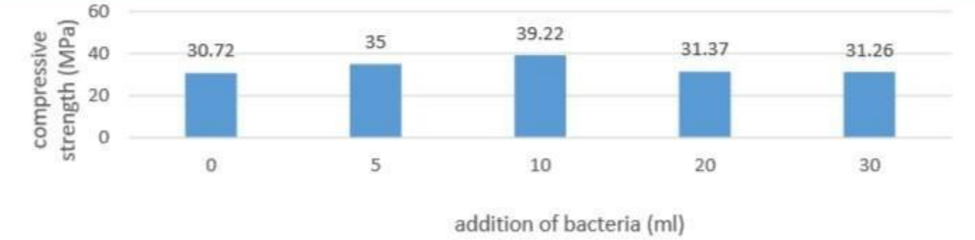

Fig 3: Compressive strength for varying bacilluscontent at seven days

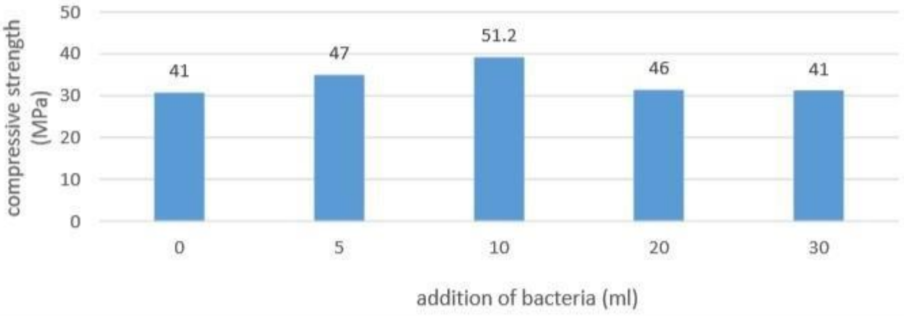

Fig 4: Compressive strength for varying bacillus content at 28 days

After reaching the ideal concentration (10ml) of bacillus subtilis, the compressive strength of M40 grade concrete rapidly decreases. Bacillus subtilis concrete's maximal compressive strength lasts for seven days after 10 ml of the bacteria are added. After seven days, bacillus subtilis concrete's compressive strength increased by 28.92% in comparison to the small mix's compressive strength. The addition of 10 ml of bacillus subtilis (bacteria) results in the best compressive strength of bacillus subtilis concrete after 28 days.

When compared to the small mix's compressive strength at 28 days, the compressive strength of the bacillus subtilis concrete increased by 13.41%.

V. CONCLUSION

The findings are displayed below and allow for the following deductions:

1. Because long-term compressive and tensile strength increases depending on the bacteria introduced, including bacteria enhances mechanical properties.
2. The compressive strength of the little mix, the compressive strength of bacillus subtilis concrete at seven days and 28 days is raised by 23.65% and 50.2 percent, respectively. This is achieved by adding 10 ml of bacillus subtilis to M20 concrete grade.
3. The highest compressive strength for seven days and 28 days is achieved with the addition of 10 ml of bacillus subtilis to M40 concrete grade; the compressive strengths of bacillus subtilis concrete are increased by 28.92% and 13.41%, respectively, at seven days and 28 days.
4. As a result, the presence of Bacillus subtilis results in an initial rise in compressive strength that reaches a maximum and then a decrease.
5. When 30ml of bacillus subtilis bacteria are added, the maximum slump value is 87mm.
6. When 30ml of bacillus subtilis bacteria are added, the compressive strength reaches a maximum of 29.91MPa.

VI. REFERENCES

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