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AN EXPERIMENTAL STUDY ON THE PROPERTIES OF BACTERIAL CONCRETE

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Abstract: This research shows that using Bacillus Subtilis microorganisms to build a tough framework and put forward a concentrated effort mending concrete as a strategy for break control to improve administration existence in solid structures is successful. The Microbiologically Induced Calcite Precipitation (MICP) method is used in this article. A 24 ml liquid form of Bacillus Subtilis with a cell concentration of 105 cells/ml was used in a 1:1.3: 2.75:0.45 mixing proportion. The compressive and flexural strength of concrete mixes was tested using 150mm x 150mm x 150mm cubes for compressive strength and 150mm x 150mm x 70mm rectangular beams for flexural strength. The specimens used for recovery are purposefully broken. The research shows that there is a significant improvement in the consistency of bacteria-added cement or bacterial concrete as compared to traditional concrete, and that calcium carbonate precipitation is visible after 3-4 weeks in small scale splits.

Index Terms – Bacillus Subtilis microorganisms, MICP, Bacteria-added cement, small scale splits

I.INTRODUCTION

Concrete is a combination of natural cracks that is homogeneous. Water and other salts seep through the cracks, causing the concrete to deteriorate and its lifetime to be reduced.

Steel corrosion can also be caused by water and salt seepage, which weakens concrete reinforcement. As a result, rehabilitating concrete is critical in order to extend the economic life of structures. Bacteria are used to produce an inherent biomaterial, a self-healing substance, to patch concrete cracks. Bacterial concrete is an excellent tool for crack repair because it induces calcium carbonate deposition as a result of microbial activity. When microbes are given the right environment and calcium source, they will thrive, calcium carbonates can precipitate in concrete due to a few strains of microbes. This precipitation potential has been evaluated in recent decades to justify improvements in concrete strength and durability properties.

1.1 Concept of Bio mineralization

Bio mineralization refers to the process of living beings arranging minerals, which is a natural wonder. Through an organically actuated mineralization process, bio mineralization can be mastered. Mineralization that is spontaneously prompted occurs in an open domain as a consequence of unregulated microbial metabolic movement. Bio minerals are framed in this procedure by the interaction of metabolic products formed by microorganisms with the surrounding environment.

1.2 Bio concrete mechanism

When the solid is mixed with microbes (bacillus subtilus), the microscopic organisms go into a slow state, similar to seeds. To activate their capabilities, all microorganisms need to be exposed to the air. Any splits that may occur include the crucial presentation. Microbes close to the split begin accelerating calcite precious stones at the point where the splits frame breaks. When a solid structure is harmed and water starts to leak through the breaks that appear in the solid, microorganism spores grow on contact with the water and supplements.

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The fluid calcium lactate is converted to insoluble limestone as the microorganisms absorb oxygen. The limestone adheres to the damaged area and repairs it. As steel corrodes, oxygen is a crucial ingredient, and once bacteria have absorbed it all, it expands the strength of steel-fortified solid inventions.

1.4 Activation of bacteria to remediate cracks by bacteria

Bacteria from a variety of natural environments have been confirmed to be capable of precipitating calcium carbonate in both natural and laboratory settings. Different types of bacteria, as well as abiotic factors (salinity and medium composition), appear to contribute to calcium carbonate precipitation in a number of ways in a variety of environments. $CaCO_3$ precipitation needs a large enough volume of calcium and carbonate ions so that the ion activity product (IAP) exceeds the solubility constant. Precipitation of calcium carbonate is a simple chemical process governed by four main factors:

- The calcium concentration.
- The concentration of dissolved inorganic carbon.
- The PH.
- The availability of nucleation sites.

1.5 Objective

• Optimization of bacteria density

• To determine the ideal bacteria dose for bacterial concrete.

• To study the crack healing process by bacteria on plain cement concrete.

• To suggest a better constructive material for sustainable building.

1.6 Scope

• To enhance the microbial activities for pollution free and natural environment.

• To introduce bio mineralization in concrete enhancing the performance of concrete.

• To remediate cracks and fissures occurring on concrete.

• Develop efficient self-healing techniques that enable concrete to regain liquid tightness by suitable micro-organisms.

• To maintain a crack-removal method that is both environmentally sustainable and reliable.

II.MATERIALS AND METHODS

2.1 Cement

Binder is a building material that sets, hardens, and adheres to other materials to hold them together. Cement is typically used to bind sand and gravel (aggregate), rather than being used alone. Concrete is made from sand and gravel, while masonry mortar is made from cement mixed with fine aggregate. Concrete is the world's most widely used material, accounting for more than a fifth of all building projects.

Table 2.1 Chemical composition of cement

Components	SiO2	Al2O3	Fe2O3	CaO	MgO	SO3
PPC %	21.28	5.60	2.85	64.18	1.66	2.57

Table 2.2 Properties of cement

Particulars (IS 456:2000)	Range
Specific Gravity	3.2
Consistency	37%
Fineness modulus	10% should be retained
Initial setting time	30 mins
Final setting time	600 mins

2.2 Aggregate

Aggregate is a building and construction material that is combined with cement, lime, gypsum, or another adhesive to create concrete or mortar. The aggregate guarantees consistency and volume in the finished product, as well as resistance to wear and erosion and other physical properties. Fine aggregate is used to make thin concrete slabs or other smooth-surfaced structural members, while coarse aggregate is used to make thick concrete slabs or other rough-surfaced structural members.

2.2.1 Classification of the Aggregates

The coarse Aggregates are mainly classified are as follows

- According to the source or the nature of the formation of the aggregate.
- According to the size of the aggregate
- According to the shape of the aggregate

2.2.2 Fine aggregate

Fine aggregates are any natural sand particles extracted from the ground through the mining process. Fine aggregates are made up of natural sand or crushed stone particles with a diameter of 14 inches or less. Because of the scale, or grading, of this particular aggregate, it is sometimes referred to as 1/4"' minus.

2.2.2.1 Sand

Fine aggregate, which is made up of natural sand or crushed stone, is an important component of concrete. The hardened properties of concrete are highly affected by the fine aggregate density and strength.Fine aggregates are the structural filler in concrete mix formulations, accounting for the bulk of the volume. The production can be significantly affected by the composition, form, scale, and other properties of fine aggregate.

Fig 2.1 River sand

Table3.3 properties of sand

Particulars (IS383)	Range
Specific gravity	2.65
Bulk density	1.71 kg/m^3
Fineness modulus	5.24

2.2.2.2 M-sand

River sand extraction is detrimental to the ecosystem because it lowers groundwater levels and dries up river water. Excess dragging of sand from the river, the water table level decreases, and tree roots may be unable to receive water in the absence of sand. In the absence of sand, river water evaporates due to direct sunlight.It is suggested that crushed sand be used. It is a cost-effective and environmentally friendly alternative to natural sand. Except for plaster and waterproofing work, crushed sand can be used in construction for anything except bedding under the stone. For better results, 50 percent m sand and 50 percent river sand should be used for hardscape work.

Fig2.2 Manufactured sand(msand)

Table 3.4 Properties of Msand

Particulars (IS383)	Range
Specific Gravity	2.5-2.9
Bulk density	1.75 kg/m^3
Fineness modulus	4.66
Grading	Zone I, Zone II, Zone III, Zone IV.
Water absorption	The ability to old surface moisture of Crushed sand is up to 10%.

2.2.3 Coarse aggregate

Coarse aggregates are irregularly broken stone or naturally rounded gravel that are used to make concrete. Coarse aggregates are materials that are too wide to pass through a 4.7 mm sieve. Blasting in stone quarries, or breaking them by hand or with crushers, are the most common methods for extracting coarse aggregates. Machine-crushed aggregates are made up of stones of different sizes, while hand-broken aggregates are made up of just one size stone.

To make graded aggregates for high-class concrete, they're mixed together again in various proportions. With a maximum size of 20 mm and a minimum size of 10 mm, coarse aggregates must be well graded and uniform in scale.

Table3.5 Properties of coarse aggregate

Specific gravity	2.78
Water absorption	1.0%
Impact value	5.7%
Crushing value	18.72%
Bulk density	1935.3kg/m^3

Fig2.3 Coarse aggregate

2.3 Water

Water is the least costly but most essential component of concrete. Water used to mix concrete should be sterile and clear of harmful impurities such as tar, alkali, acid, and other chemicals. For mixing, curing and other constructional works portable water is used.

2.4 Bacteria

Bacteria are single-celled organisms with a limited footprint. Bacteria can be found almost anywhere on the earth and are essential to its ecosystems. Some animals are able to survive in extremes of temperature and pressure. Bacteria

III. Mix design for M25 grade of concrete

Table3.1 Mix design for plain concrete(IS 456:2000)

Material	1:1.55:2.45:0.44
Cement(kg/m)	435.45
Sand(kg/m)	676
Aggregate(kg/m)	1067
Water(L)	191.5

Table3.2 Mix design for bacterial concrete(IS10262:2009)

Material	1:1.3:2.75:0.45
Cement (kg/m)	403.2
Sand (kg/m)	642
Aggregate(kg/m)	1052
Water(L)	201.6

IV. Casting of cubes

4.1 Cube Mould - The cube moulds of required size 150 x 150 x 150 mm for nominal size aggregate not exceeding 38 mm. cube moulds shall be provided with a base plate and they shall be as per IS:10086-1982.

• Tamping rod - As per IS10086-1982, 16 mm diameter and 600 mm long with rounded working end and shall be made of mild steel.

Figure 4.1 Casting of cubes

4.2 Demoulding

Between 16 and 24 hours after being made, test concrete test specimens should be demoulded. If the concrete has not reached sufficient strength to enable demoulding without damaging the specimens after this time, the demoulding should be postponed for another 24 hours.

Fig 4.2 Demoulded block

V. RESULTS AND DISCUSSION

5.1 Compression test

The compression test of plain concrete cube and bacteria concrete cube could do with the help of the Universal testing machine with the capacity of 400 KN. The compressive strength of the concrete blocks was measured on 150 mm x 150 mm x 150 mm. All cubes were casted and kept in curing tank until the testing dates. The first compression test for plain concrete block and bacteria concrete should be done at 7 days. The strength of self-healing concrete is higher than the plain concrete.

5.2 Flexural test

The flexural strength of concrete is a strong predictor of its tensile strength. At the point of failure in bending, it is the maximum stress on the strain face of an unreinforced concrete beam or slab. It's calculated by pouring three times the depth span capacity of 150 x 150 mm concrete beams. Flexural strength is calculated Using ASTM C293 standard test methods and expressed as Modulus of Rupture (MR) in MPa (center-point loading). Since the size of the specimen and the form of loading affect the flexural power measured, comparisons and specifications should be made for the same beam size and loading configuration

V SUMMARY AND CONCLUSIONS

5.1 Summary

The aim of this project is to describe self-healing concrete using the Bacillus subtilis bacteria. Many other bacteria have been identified in the literature as having the ability to enhance the strength and other chemical properties of concrete. Many literatures were studied related to our project to gain knowledge and to develop our creative and innovative skills. The properties of materials such as sand, Msand, aggregates, and cement were tested and compared with IS considerations which should be satisfied. Then the bacterial concrete 1:1.3:2.75 were allowed to prepared. The hardened specimen was tested at the required testing date. Till the test date the specimen was kept in curing tank, where we observe the change of water colour in bacterial concrete tank which shows the activation of bacteria

As compared to traditional concrete, the compressive strength of bacterial concrete gradually increases. The open porosity and apparent density of concrete mix ratio were considered to be different for conventional concrete to bacterial concrete to study the variance of compressive strength.

5.2 Conclusions

Self-healing concrete has the potential to address the issue of concrete buildings rotting long before their service lives are over. From building foundations to bridge structures and underground parking lots, concrete is one of the most commonly used materials in the construction industry.. When exposed to tension, traditional concrete has a flaw: it cracks.

Concrete self-healing technology is one of the possible solutions for eliminating carbon dioxide emissions from cement production while also avoiding unnecessary concrete structure repair and maintenance. Concrete as a construction material would be in higher demand as the need for infrastructure expansion grows. Concrete manufacturing has a high carbon footprint and requires a lot of resources. Due to limited capital and environmental considerations, concrete material cannot be sustained in the long run. As a result, a sustainable concrete material must be developed to meet demand while still preserving the environment. The properties of this concrete will be better understood in the coming years as a result of a greater number of full-scale experiments, and the manufacturing methods will be less expensive. It has the potential to be a long-term solution to the concrete industry's current problems. Both the manufacturing industry and the general public are looking for products that use less energy and emit less carbon dioxide from the moment they are produced until they naturally decompose. It's also anticipated that such materials and structures would last a long time, at least 50 years (according to the standard), and will be simple to repair.

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