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BACTERIAL BASED SELF COMPACTING CONCRETE

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ABSTRACT
Concrete that uses bacteria as a self-healing agent to improve its own crack sealing performance is known as bacterial-based self-healing concrete. Concrete's inherent fragility makes cracks impossible to avoid. Salts and other liquids can seep in via the cracks in the pavement. As a result, the concrete's lifespan is cut short even further. As a result, it was necessary to create an intrinsic bio-material and a self-repairing technique for fixing concrete cracks and fissures. Cracks in concrete can be repaired with bio-concrete. Eco-friendly and natural crack treatment makes this method a popular choice. Bacillus megaterium is used to seal an artificial fissure in cement concrete. Cement concrete cubes with bacteria mixed in are analysed for compressive strength and water absorption in this study. Bacillus Megaterium has been shown to increase the concrete's compressive and flexural strength and stiffness. Compared to normal concrete, it also demonstrates that water absorption has been reduced. To withstand the stresses of mixing, transporting, and placing concrete, the bacteria that will be introduced into it must be alkali-resistant and form endospores as well.
Bacillus Megaterium, compressive and flexural strength, alkali-resistance, and self-healing are all terms associated with the material.

I. INTRODUCTION

1.1 General

Concrete is the most used construction material. Tension and compression weaken the material, and cracks are inevitable. Cracks in concrete can shorten the life expectancy of structures built with it. It is highly undesirable to have micro-cracks and pores in concrete because they allow water and harmful substances to enter the concrete, causing corrosion of reinforcing and reducing the strength and durability of the concrete. Although numerous methods exist for repairing the fissures, they are expensive and time-consuming. Self-healing concrete is a moderate method of repairing concrete cracks.

1.2 Self-Healing Methods

The hydration reaction of cementitious materials within the concrete matrix has no effect on autogenous self-healing, which is dependent on the composition of the concrete. 15 to 25 percent of the cement in the typical concrete matrix is un-hydrated. Unhydrated cement grains may be exposed to moisture if cracks in the concrete form. Hydration products may fill in and repair the crack if the procedure restarts. Known as autogenous healing, this innate self-healing process has been around for a long time. It's best for little cracks, but it can't repair large ones. It works better in fresh concrete because it requires a steady supply of water.

1.3 Self-healing mechanism

It's called Microbial Induced Calcium Carbonate Precipitation (MICCP) or Bio-mineralization when it comes to the use of bacteria in bio-concrete. Bacteria produce calcium carbonate as a byproduct of metabolic processes such as sulphate reduction, photosynthesis, and urea hydrolysis. Precisely the same bacteria, such as Bacillus Pasteurii and Bacillus Subtilis that precipitate calcium carbonate in the lab as well as under natural conditions, can precipitate calcium carbonate from Bacillus Sphaericus. DIC (Dissolved Inorganic Carbon) concentration, pH value, calcium concentration, and nucleation sites are the primary factors influencing precipitation. The bacteria must be able to transform organic nutrients into insoluble inorganic calcite crystals that fill the fractures in order to achieve the self-healing phenomenon.

II. REVIEW OF LIETRATURE

Concrete, the most used building material on the planet, has a high tensile strength, which makes it vulnerable to cracking. It's more difficult to repair damage if the cracks are hidden or difficult to get to.

As a result, the product's durability deteriorates and its life cycle expenses rise (Fregonara, E, 2016). Because of this, self-repair of concrete fractures is of paramount importance: When looking at broken water tanks and pipelines in 1937, Turner (Turner, L. 1937) realised that water was the key to self-repairing. As a result of this delayed hydration, the crack width was reduced and, in some cases, the damaged zone was completely filled when the mix reacted with water after it had formed cracks.

Cracks could be sealed thanks to the formation of calcium hydroxide and calcium carbonate crystals by the interaction of carbon dioxide and calcium hydroxide. When Hearn and Morley published their findings sixty years later, they validated Turner's thesis that water was required to start the self-healing process in partially hydrated cementitious materials and backed up Turner's findings. According to Neville (Neville, A.M. 2002), the phenomenon is affected by water temperature and relative humidity in addition to carbon dioxide and water.

Self-healing using mineral additions, self-healing by bacteria, and self-healing based on encapsulated adhesives are all alternatives to the autogenous healing of concrete previously described (Van Tittelboom, 2013).

The mineral additives scattered in cementitious materials also have a role in the self-healing process (Ahn, T-H. 2010, Roig-Flores, M. 2016). During the manufacture of the concrete, these minerals are incorporated. There are mineral additions that are positioned on top of the cracks that are filled with reaction products when water seeps inside, causing them to expand.

III. OBJECTIVE OF THE STUDY

- To create a 30MPa mix design technique.

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Bacillus megaterium will be added to concrete to see whether it can help the concrete self-heal.

• Slump and Compaction Factor tests are used to measure the workability of freshly prepared concrete.

After seven, 14, and 28 days, the compressive strength of cubes is measured.

at 7, 14, and 28 days, to assess the Cube flexural strength.

To find out how much water self-healing concrete absorbs.

IV. MATERIALS AND METHODOLOGY

4.1 Materials

Concrete's strength comes from hydration, which occurs when water is added to the mixture of cement, fine particles, and coarse aggregates. Concrete's bonding strength and compressive strength are mostly determined by the type of cement and particles used. The following ingredients are being used in the current research.

4.1.1 Cement

During the investigation, the cement was discovered to be Ordinary Portland Cement (53 grade) according to IS: 12269 – 1987, the standard for cement.

Fig.4.1:Cement

4.1.1.1 Testing on Cement

a) Cement Standard consistency:

A metric called "standard consistency" must be utilised to determine cement's initial setting time, final setting time, and strength. When describing the consistency of a cement paste, it is said to be standard when a Vicat plunger of 10 millimetres in diameter and 50 millimetres in length is able to go down 33-35 millimetres into the paste. IS: 5513-1976 was used to conduct the test.

Fig 4.2 Cement Standard consistency

b) Cement Initial & Final setting time:

To make things easier to understand, initial setting time is defined as the time passed between adding water to the cement and seeing a decrease in paste plasticity. A cement mixture's final setting time can be calculated by determining how long it takes for a mixture of cement and water to harden and become resistant to specific types of pressure. IS: 5513-1976 was used to conduct the test.

Fig 4.3 Final setting time

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Fig.4.4: Initial setting time

c) Cement Fineness Test

Dry sieving with a 90 micron sieve is used to measure cement fineness. Weight of cement retained on a 90 micron filter to the total weight of the sample obtained is called the cement retention ratio. Cement with a fineness of less than 10% is considered to be of high grade. The test was carried out in accordance with IS: 460-1962.

Fig.4.5: Cement Fineness Test

d) Specific gravity of cement test:

To clean the 300ml Density bottle, use purified water and a soft cloth. The weight W1 of the clean, dry density bottle with the cap is recorded. Cement fills up about a third of the density bottle. Using the density bottle and cement solids, the weight W2 of each is calculated. We use a small amount of kerosene and wait for all the pores to fill up with water before we remove the container from the soil and refill it. To ensure that the density container is entirely full, more kerosene is put into it. The outside of the density bottle is drenched in a drying agent. There is a determination of the weight W3 of the density bottle and its contents The density bottle's contents are emptied. Kerosene is poured into the container to the top of the cap. In order to determine the density bottle's weight, the outside of the bottle is dried and marked W4.

The sample's specific gravity is calculated using

$$G=\frac{w2-w1}{(w2-w1)-(w3-w4)0.79}$$

V. MIX DESIGN

5.1 Cement concrete mix design

Following are the site considerations used for the mix design for nominal concrete in our experimental work

Concrete Grade	: M30
Type of Cement	: OPC 53
Type of aggregate	: 20mm Sub rounded
Exposure Condition	: Severe
Specific Gravity Of Cement	: 3.14
Specific Gravity Of Fine Aggregate	: 2.61
Specific Gravity Of Coarse Aggregate	: 2.83
Zone Provision	: Zone II
Workability	: 75 mm (slump)

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Step 1: Calculation of Target Mean Strength

$$f'_{ck} = f_{ck} + 1.65\ s$$

Where s = standard deviation

f_{ck} = Characteristic compressive strength at 28 days

f'_{ck} = Target mean compressive strength at 28 days

Standard deviation value for M30 grade concrete = 5.0 N/mm^2

Therefore f'_{ck} = 30 + 1.65 x 5.0

= 38.25 N/mm^2

Step 2: Selection of W/C Ratio

From table 7, W/C ratio obtained is 0.45 and the maximum W/C ratio for plain cement concrete for a severe exposure condition is 0.50.

Hence W/C ratio of 0.45 is taken as a value satisfying both the conditions.

Step 3: Calculation of Water Content

Water content: 186 + 3% of 186 = 191.58 litres.

Therefore, water content obtained is 191.58 litres.

Step 4: Calculation of Cement Content

Cement content = $\frac{\text{water content}}{\text{water-cement ratio}}$

$= \frac{191.58}{0.45}$

= 425.73 kg

The cement content obtained should be greater than the limiting cement content as given in durability criteria which is satisfactory for the above obtained value and the exposure conditions adopted.

Hence, cement content is **425.73 kg**

VI. EXPERIMENTAL INVESTIGATION

6.1 Bacteria – Based Self Healing Concrete Mix Design

6.1 Mixed design proportions for Bacterial based Self healing Concrete

- 15 standard cubic specimens of size were cast for the compressive strength of concrete and were maintained under curing for seven, fourteen, and 28 days. During compressive strength testing, there were a total of nine cubes.
- This study examined the flexural strength of concrete in 10 standard beams that were cast and then aged for 7, 14, and 28 days. 9 flexural strength test beams were used in total.
- • The amount of ingredients needed will be determined based on a 10% waste assumption for a batch of nine cubes.
- 9*1.10*(0.15)3 = 0.03342125 cubic metres of Cube's volume
- • The required mass of ingredients will be computed for a total of nine beams, with a 10% waste assumption.
- • The beam's volume is equal to 9*1.10*((0.10)2*(0.50)) = 0.0495 m3/s

Table 6.1: Material Proportions Cubes & Beams

Materials	Cubes	Beams
Cement (Kgs)	14.64	21.68
water (lit)	6.587	9.76
fine aggregate (Kgs)	21.574	31.962
Coarseaggregate (Kgs)	35.88	53.166

based on microbes The ability to heal oneself Conventional cement concrete is produced using the same machinery. Here is a breakdown of the steps involved.

Mixing is the sixth and last step.

Mixing the dry components (cement, fine aggregates, and coarse aggregates) in a pan mixer for 4 minutes is standard procedure in conventional construction. Water is added at a later time to ensure the proper mixing. A further 2 to 5 minutes of wet mixing is required to ensure that the concrete ingredients are thoroughly blended. As a result, the workability of concrete can be verified.

The dry components (cement, fine aggregates, and coarse aggregates) are put into a pan mixer and stirred well for four minutes. Bacteria-infected water is then added to ensure a proper mix. To ensure that the concrete materials are mixed uniformly, the wet mixing process is repeated for an additional 2 to 5 minutes. Concrete can now be put through its paces to see if it is suitable for use.

Fig.6.1: Mixing of all ingredients for preparation of concrete

VII. RESULTS AND DISCUSSIONS

Results for various trials were achieved in accordance with the experimental plan. Tables or graphs will be displayed in this chapter to show the data.

7.1 Evaluation of Usability

It's a Slump Test

Concrete made from Bacteria-based Self Healing Concrete had its workability tested using the Slump test. The following findings support the notion that adding bacteria to concrete improves its workability: I Table 7.1 displays the results of the Slump test.

Table 7.1: Results of Slump test

Concrete	Slump value (cm)
Bacterial concrete	120
Conventional concrete	110

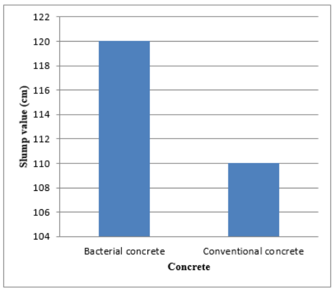

Fig 7.1 : Slump test results

The above figure 7.1 shows the slump results. It was observed that, the slumps was more than as the Bacterial added content were increased in the mix.

7.1.2Compaction factor test

The workability of the Bacterial based Self healing concrete was tested by conducting a compaction factor test. The following findings support the notion that adding bacteria to concrete improves its workability: I The theoretical maximum compaction factor is between 0.96 and 1.0. Results for the Slump test are provided in Table 7.2 below.

Table 7.2: Results of compaction factor test

Concrete	Compaction factor (%)
Bacterial concrete	0.9
Conventional concrete	0.87

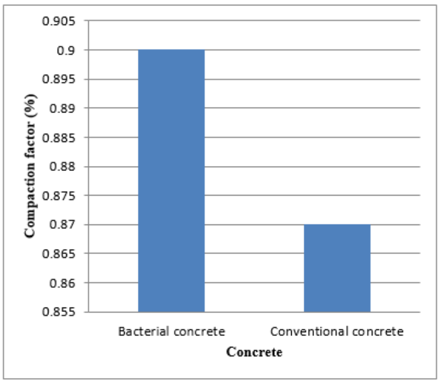

Fig 7.2 : Compaction factor test results graph

CONCLUSIONS

1. Bacillus megaterium, a bacterium capable of precipitating calcium

carbonate, is an important component of this study since it provides insight into the healing process of concrete cracks. Bacillus megaterium bacteria can be utilised to repair concrete cracks, according to a new study.

2. Bacillus megaterium-based self-healing concrete has also been shown to have increased compressive and flexural strength. There were significant increases in the concrete's compressive and flexural strength compared to traditional cement.
3. Water absorption in concrete can be improved by using bacteria such as Bacillus megaterium in self-healing concrete. When compared to standard concrete, the water absorption value dropped by 33.42 percent.
4. This study shows that self-healing concrete can be a viable alternative and high-quality concrete sealant that is environmentally friendly, cost-effective, and results in an increase in the longevity of the building components.

FUTURE SCOPE

Ecologically sound way for producing environmentally friendly, self-healing concrete. This was done to extend the useful life of concrete structures, which in turn helps to improve environmental sustainability. There are a number of mineral admixtures that we'll need to use in the future for the manufacture of self-healing concrete.

Bacteria can be added to concrete to improve its resistance to water absorption, making it more durable. We'll need to look for Acid attack Tests in the future.

Microorganisms embedded in the concrete matrix affect the effectiveness of crack repair and the recovery of lost strength. We'll need to use a variety of metal plates in our future work to create cracks in concrete.

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