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An Experimental Study on Bacteria Based Selfhealing Concrete

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ABSTRACT: Concrete is the most critical elements applied in public infrastructure/buildings and is often difficult to service, yet requires lengthy service periods. Recent research has shown that specific species of bacteria can actually be useful as a tool to repair cracks in already existing concrete structures. The major downside of concrete is its low tensile strength due to which micro crack occurs when the load applied is more than its limit and this paves way for the seepage of water and other salts. This initiates corrosion and makes the whole structure vulnerable and leads to the failure of structure. To remediate this type of failure due to cracks and fissures, an approach of using bio mineralization in concrete has evolved in recent years. This new concrete, that is equipped torepair itself, presents a potentially enormous lengthening in service-life of public infrastructure/ buildings and also considerably reduces the maintenance costs. In addition, concrete by its nature is very prone to deformations that expose its reinforcements, corroding them. Self-healing concrete offers a solution to prevent.The “Bacterial Concrete” is a concrete which can be made by embedding bacteria in the concrete that can constantly precipitate calcite. In this method, of enhancing the performance of concrete, the calcite precipitating spore forming bacteria is introduced into concrete. When water enters through the cracks, it reacts with bacteria and forms precipitates of calcium carbonate, as a byproduct, which fills the cracks and makes crack free concrete. This type of concrete prepared with bacteria is called as bacterial concrete.A novel eco-friendly self-healing technique called Bio calcification is one such approach on which studies were carried out to investigate the crack healing mechanism in enhancing the compressive and tensile strength of concrete.

Keywods : Bacterial concrete, self-Healing concrete, Bacillus Subtilis , Compressive strength.

I. INTRODUCTION

Concrete is one of the major construction material being utilized worldwide construction. . Concrete is made usually by proper proportional mixer of cement to meet the global demand of concrete in the future, if is becoming a challenging task to find suitable alternative construction material which can partially replace the natural aggregate and sand without affecting the property of concrete.The strength of the concrete is determined byadding the main concrete ingredients with alternative materials in various percentage for M_{20}mix.InConcrete,Cracking is a common phenomenon due to relatively low tensile strength .Durability of concrete is also impaired by these cracks,since they provide an easy path for the transport o liquids and gases that potentially contain harmful substances leading to corrosion of reinforcement.Cracks are therefore precursors to structural failure.For crack repair,a variety off techniques are available but tradtional repair systems have a number of disadvantageous aspects such as diferential thermal expansion coefficient compared to concrete and environmental hazards.The bacterial concrete can be made by embedding bacteria in the concrete that are able to constantly precipitate calcite.This phenomenon is called microbiologically induced calcite precipitation. Bacillussubtilis, which can successfully remediate cracks in concrete.A common soil bacterium , bacillus subtilis,is used to induce CaCO3 precipitation.The favorable conditions do not directly exist in concrete.

II. SELF-HEALING OF BACTERIA:

Chemical process to remediate cracks by bacteria Crack-penetrating water would not only dissolve calcite (CaCO3) particles present in mortar matrix, but would also react together with atmospheric carbon dioxide with not fully hydrated lime constituents such as calcium oxide and calcium hydroxide according to the following reactions:

$CaO + H2O \rightarrow Ca(OH)2$

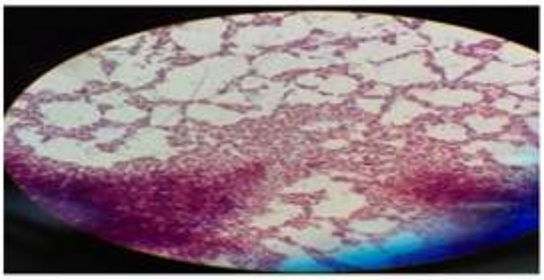
$Ca(OH)2 + CO2 \rightarrow CaCO3 + H2O$

The freshly produced minerals from the above stated reactions and from dissolved and re-crystallized calcite minerals, precipitated on the surface of cracks what resulted in crack-sealing and concomitant reduction Permeability of the mortar.

2.1 Bacillus Subtilis

Bacillus subtilis cells are rod-shaped, Gram-positive bacteria that are naturally found in soil and vegetation. For this bacterium also include Bacillus uniflagellatus, Bacillus globigii, and Bacillus natto. Bacillus subtilis bacteria were one of the first bacteria to be studied. These bacteria are a good model for cellular development and differentiation.

Bacillus subtilis grow in the mesophilic temperature range. The optimal temperature is 25-35 degrees Celsius. Stress and starvation are common in this environment, therefore, Bacillus subtilis has evolved a set of strategies that allow survival under these harsh conditions. One strategy, for example, is the formation of stress-resistant endospores.



2.2 Self-healing Concrete

Concrete restoration begins with the first concrete curing, but beyond this term, it includes the correction of the surface of concrete after cracking, carving, and in general, concrete demolition. To begin the restoration process, an appropriate and yet a comprehensive assessment must be conducted regarding the cause and effect of concrete damage. Using the results of this assessment, one can find the type of material and the appropriate repair method. The repaired concrete surface should be replaced by the damaged concrete in order to achieve the required structural performance like the initial state and to protect the underlying layer. All possible stresses including those in the joint section are repaired and the underlying layer must be examined and analyzed as well. The joints in the restored part due to the change in the relative volume between the restoring part and the bottom concrete layer as well as in the types of loading the tensions in restored part must be within the capacity of the existing materials, otherwise failure may occur. When a part of the material is affected by a variety of tensions, it restores around the restored part.It is repeatedly distributed as well. In order to prevent reloading the negative effect on the restored part, restoration should be during the course of the complete recovery operation. The repair process is carried out by candling and jacking and the restoration materials are fully utilized and put into operation. Then, after reaching the specified resistance, having a load bearing, and reloading on the member, it is intended to avoid damage to the restored part.

III. MATERIAL COLLECTION

3.1. Cement

Portland pozzolana cement of 53 grade available in local market is used in the investigation.

3.2. Coarse Aggregate

Crushed granite angular aggregate of size 20mm.

3.3. Fine Aggregate

Natural river sand is used.

3.4. Water

Locally available potable water is used.

IV. BACILLUS SUBTILIS

4.1. Culture of Bacteria

The pure culture of bacteria i.e. Bacillus Subtilis is preserved on nutrient agar slants. It forms irregular dry white colonies on nutrient agar slants. Two colonies of the bacteria are inoculated into nutrient both of 350 ml in 500ml conical flask and incubated at the temperature of 37 degree Celsius and 150rpm orbital shaker.

4.2. Casting of Cubes

4.2.1. Slump Test

The concrete slump test is an empirical test that measures the workability o fresh concrete . More specificallyiteasures the consistency o the concrete is that specific batch .This test is performed to check the concictency of freshly made concrete.

4.2.2. Mixing of concrete

Mix design can be defined as process of selecting suitable ingredients of concrete(M20) 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.For M20(1:1.5:3) 10ml,20ml,30ml of bacillus subtilis.

4.2.3. Specimen Preparation

Standard grade concrete design mix is made and cubes of 150mm*150mm*150mm are made .The cubes are cast with bacteria and without bacteria.Aftercasting,the specimens are demoulded after 24 hours.

4.2.4. Curing

After the cube preparation,immediately submerged in clean fresh water of the tank.After the completion of curing period the specimens are taken and kept in shade to dry off.

4.3. Compressive Strength Test

The cubes are tested after 7 days,14 days,28 days and the compressive strength of the cubes have been obtained,using compression testing machine.

V. RESULT AND DISCUSSION

5.1 Compressive strength of concrete

Table5.1 Compressive strength analysis

ml of bacteria	7 days curing		14 days curing		28 days curing	
	Load (KN)	Compressive Strength (Mpa)	Load (KN)	Compressive Strength (Mpa)	Load (KN)	Compressive Strength (Mpa)
0ml	270	12	295	13.33	480	21.33
10ml	290	12.89	350	15.56	590	26.22
20ml	365	16.22	420	18.67	660	29.33
30ml	390	17.33	560	24.89	760	33.78

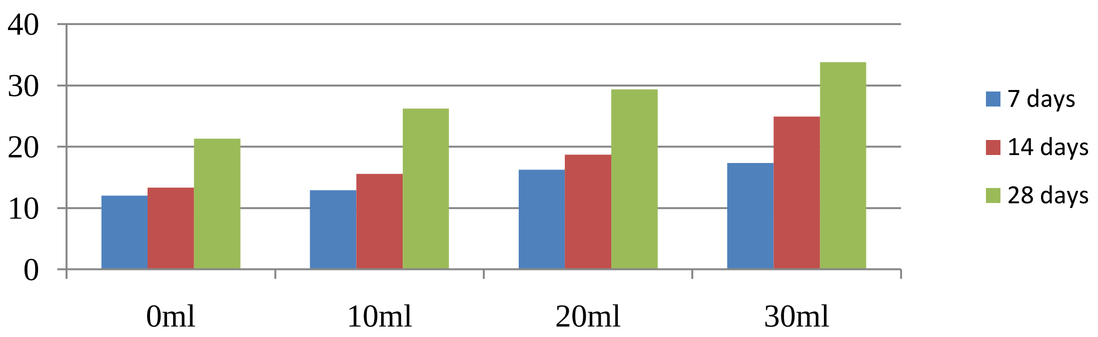


Fig 5.1Comparison Of Compressive Strength

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Table 5.1 Comparison Of M25 To M20 Bacterial

Days of curing	M25(1:2:4)	M20(1:1.5:3)
	Normal concrete	Bacterial concrete(30ml)
7 days	12	17.33
14 days	13.11	24.89
28 days	16.35	33.78

Here compressive strength of concrete is gradually increased from 10ml to 30ml of bacteria.

5.2 Comparison Of M25 To M20 Bacterial Concrete

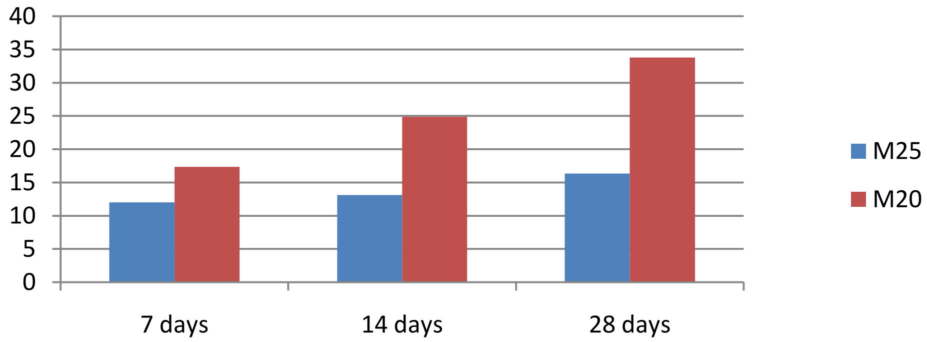

Fig5.2Comparison Of M25 To M20Bacterial Concrete

From the above chart we can analysis,our M20 grade bacterial concrete having compressive strength than the normal M25 grade concrete,so we can replace normal M25 concrete by our M20 bacterial concrete.Hence cost of construction is reducing.

5.3 Self –Healing Analysis

Cracks can be healed by using calcium carbonate precipitating micro-organismms.These organisms are embedded in the concrete matrix after immobilization on diatomaceous earth,and will start the precipitation of CaCo3 once a crack occurs.Through this process the bacterial cell will be coated with a layer of calcium carbonate, resulting in death of the micro-organism, but in the meantime the crack faces may be bond together.

After Healing

Before Healing

VI. CONCLUSION

Based on the present experimental investigation the following conclusion is drawn.

- Bacillus subtilis can be produced in the laboratory is to be safe and cost effective.
- The compressive strength is 33.78Mpa,that is maximum,when the addition of bacillus subtilisbacteria is 30ml.
- The M20grade bacterial concrete having higher compressive strength then the normal M25 grade concrete.
- The self-healing property is successfully achieved in bacterial concrete.
- Bacterial concrete technology has proved to be better than many conventional technologies,because of its eco-friendly nature and very convient for usage.

- The application of microbial concrete to construction may also simplify some of the existing construction processes and revolutionize the ways of new construction process.

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