EXPERIMENTAL STUDY ON SELF HEALING CONCRETE BY USING BACTERIA

1Prof. Manish Bhatkar (bhatkar.manish1993@gmail.com)
2Shrikant Muramkar (shrikant.11muramkar@gmail.com)
3Vitthal Ahirkar (vitthalahirkar@gmail.com)

1Assistant Professor, Dept. of Civil Engineering, JCOET Yavatmal, India
2,3Dept. of Civil Engineering, JCOET Yavatmal, India

ABSTRACT

Cracks formation is extremely common phenomenon in concrete structure which allows the water different form of chemical into the concrete through the cracks and reduces their durability, strength and which also affect the reinforcement when it comes connected with water. For repairing the cracks developed within the concrete, it requires regular maintenance and special sorts of treatment which able to be very expensive. So, to beat from this problem independent self healing mechanism is introduced within the concrete which is able to help to repair the cracks and pores within the concrete. The bacteria presents in self healing concrete improves the structural properties like tensile strength, water permeability, durability and compressive strength. This concrete is beneficially from environmental point of view also reconstruction cost reduction and eco-friendly, which results to improve the durability of building materials and life of structure.

Keywords: Bacterial concrete, strength, concrete crack healing, permeability, eco-friendly

[1] INTRODUCTION

Concrete, it is the foremost widely used material for the development. Concrete is weak in tension and powerful in compression and cracks are inevitable in concrete. Once cracks form in concrete it should reduce the lifespan of the concrete structures. Micro-cracks and pores in concrete are highly undesirable because they supply an open pathway for the ingress of water and deleterious substances which winds up within the corrosion of reinforcement and reduces the strength and durability of concrete. Various repair techniques are available to repair the cracks, but they're highly expensive and time consuming process. There are moderate techniques to repair the cracks in concrete by itself called Self-Healing Concrete. Cement concrete is that the key material utilized in construction works which is recyclable. It's strong, locally available, durable and versatile. It is a material with combined fine aggregates, coarse aggregates, water, cement
that hardens over time. And, no matter how the concrete mixture is handled it eventually leads in cracking. We all know that structures are susceptible to cracking which makes the water to enter and degrade the strength of concrete and desires expensive and highly health-risk maintenance in sealing of cracks.

Self healing concrete could be a concrete which heals itself when it contact with air and water is produced lime on outer layer of concrete. Self healing material is described as a cloth that's capable of repairing itself back to the initial state. the most keyword of this project is self healing concrete. However, other similar keywords during this area are self-healing, self prepare, autonomous healing, automatic healing, auto- treatment, self-treatment, bio-concrete, bio-inspired, biological concrete, calcite bio-mineralization, and calcite precipitation. The concept of self healing concrete (SHC) that happens over time (autogenic) has been noticed for over 20 years. It will be observed in many elderly structures which have remained standing for the long period of your time in spite of the actual fact that they need limited maintenance. As for the bogus thanks to repair crack in concrete, which is man-made self- healing process was first invented in 1994 by Dutch scientist Hendrik Jonkers. the most method and first approach was to use a healing agent (adhesive) which is encapsulated inside a micro capsule, once a crack forms, it causes the activation of healing agent, hence the cracks heals automatically. simpler mechanism were later approached by researchers at Cardiff University, the University of Cambridge, University Bath, and Korea Institute of construction. Many factors are considered within the natural way of healing, such as, temperature, degree of demand, freeze-thaw cycles, the age of the concrete and therefore the mortar state.

Self-healing concrete could be a results of biological reaction of non-reacted limestone and a calcium based nutrient (calcium lactate) with the assistance of bacteria to heal the cracks appeared on the building .Special form of bacteria’s referred to as Bacillus subtilis are used together with calcium nutrient referred to as salt. While preparation of concrete, this products are added within the wet concrete when the blending is completed. When the cracks appear within the concrete, the water seeps within the cracks. The spores of the bacteria germinate and starts feeding on the salt consuming oxygen. The soluble salt is converted to insoluble limestone. The insoluble limestone starts to harden. Thus filling the crack, automatically with none external aide. Bacteria can lie dormant within the concrete up to 200years. the opposite advantage of this process is, because the oxygen is consumed by the bacteria to convert calcium into limestone, it helps within the prevention of corrosion of steel because of cracks. This improves the sturdiness of steel ferroconcrete construction. “Bacillus Subtilis” is rod shaped, form a tricky protective endscope allowing it to tolerate extreme condition

[2] LITERATURE REVIEW

PAPER:- “Properties Of Bacterial -based Self Healing Concrete”.

AUTHOR:- Rama Mohan Rao

SUMMARY:-

In this paper shown that the ability to heal the micro-cracks with the help of bacteria and healing agent was seen by Scanning Electronic Microscope (SEM) analysis and confirmed by XRD, that Ca Co3 precipitation helps in sealing the microcracks. The amount of bacteria added in concrete affects the chloride penetration results showed that high
amount of bacteria added gives unsatisfied results.

The compressive strength observed for 91 days given satisfying results than compared to 28 day compressive strength observed for a bacterial concentration of 105 cells/ml. S.pasteurii formerly known as Bacillus pasteurii showed reduction in water absorption which increases the durability of concrete structures. The bacterial cells are potential admixtures in concrete helps in enhancing the mechanical performance of concrete.

**PAPER:** “Bacteria based Self-Healing Concrete”.

**AUTHOR:** Suyug S. Pawar

**SUMMARY:**
In this paper reviewed different types of bacteria that can be used for healing cracks, use of urease producing bacteria isolates, such as Bacillus subtilis, bacillus pastueuri species in healing of cracks in concrete. Due to its eco-friendly and self-healing capacity bacterial concrete has been proved to be better than the conventional concrete. Bacterial concrete is durable, cost effective and environment friendly. A point should be consider that, as the process of mixing the bacteria in concrete is somewhat complicated, so it requires skilled labours.

[3] **AIM AND OBJECTIVES:**

[1] **AIM :-**
This project is executed with the aim of Experimental study on Self Healing Concrete (SHC) and detailed study of properties of Bacteria (Bacillus subtilis) in terms of compressive strength, split tensile strength, flexural strength.

[2] **OBJECTIVE**:
- Analysis of compressive strength with varying bacterial concrete.
- Analysis of split tensile strength.
- Effect of bacterial concrete.

[4] **METHODOLOGY**

**FOLLOWING ARE THE STEPS INVOLVED:**
1. Research and discussion for project selection.
2. Collection of data for detailed study of the project.
3. Planning and scheduling of project tasks.
4. Preparation of report and presentations.
5. Performing initial tests of materials for achieving better quality.
6. Conducting mix design and preparation of concrete mix.
7. Casting SHC as cubes and cylinders of standard dimensions.
8. Casted cube and cylinder are immersed in water for curing in 7, 14 and 28 days.
9. Testing the casted specimens and obtaining results from tests performed.
Analysis of the results obtained through experimental observations.

[5] MATERIALS

BACTERIA :-
Firstly bacillus subtilis is known as Vibrio subtilis, this bacteria was discovered by Christian Gottfried Ehrenberg in 1835. It was rename in 1872 by Ferdinand Cohn. Bacillus subtilis is a aerobic bacteria. It is rod shaped. 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 mix during mixing.

CALCIUM LACTATE:-
The bacteria need a food to survive so we choose Calcium lactate as a chemical supporter to do the work. Calcium lactate is food for the bacteria. When a crack formed in the concrete surface, the water reacts with the bacteria and produces the Calcium carbonate (caco3) which is a main composition of lime.

CEMENT ( PPC )

SAND (FINE AGGREGATE)

AGGREGATE

WATER

[6] MIX DESIGN :-
The mix design of grade M25 is use. Mix design can be defined as the process of selecting suitable ingredients of concrete 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. The mix proportions ordinary grade concrete and standard grade concrete are designed using IS : 10262-1982.

MIX PROPORTION FOR M25 GRADE OF BACTERIAL CONCRETE 1 M³

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Mix Proportion</th>
<th>Grade of concrete</th>
<th>Cement (Kg/m³)</th>
<th>Fine Aggregate (Kg/m³)</th>
<th>Coarse Aggregate (Kg/m³)</th>
<th>Bacteria (ML)</th>
<th>W/C Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1:1.50:2.66</td>
<td>M 25</td>
<td>436</td>
<td>654</td>
<td>1160</td>
<td>20 ml for 1 lit. water</td>
<td>0.44</td>
</tr>
</tbody>
</table>

[7] TESTS AND RESULTS
7.1 WORKABILITY BY SLUMP CONE TEST:

Table 7.1: Slump Cone Test Results (Average)

<table>
<thead>
<tr>
<th>Type of mix</th>
<th>Slump (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>80</td>
</tr>
<tr>
<td>10 ml</td>
<td>84</td>
</tr>
<tr>
<td>15 ml</td>
<td>86</td>
</tr>
<tr>
<td>20 ml</td>
<td>90</td>
</tr>
</tbody>
</table>

![Slump Test](image)

7.2 COMpressive Strength TEST:

Table 7.2: Comparison Between Compressive Strength of Conventional Concrete and Bacterial Concrete

<table>
<thead>
<tr>
<th>No. of Days for Curing</th>
<th>Compressive strength (MPa)</th>
<th>Conventional Concrete</th>
<th>Bacterial Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 DAYS</td>
<td>19.53</td>
<td>24.73</td>
<td></td>
</tr>
<tr>
<td>14 DAYS</td>
<td>23.25</td>
<td>30.07</td>
<td></td>
</tr>
<tr>
<td>28 DAYS</td>
<td>30.51</td>
<td>37.62</td>
<td></td>
</tr>
</tbody>
</table>

![Compressive Strength Test](image)
7.2. Comparison Between Compressive Strength of Conventional Concrete and Bacterial Concrete

[7.3] SPLIT TENSILE STRENGTH TEST:

Table 7.3. Comparison Between Split Tensile Strength of Conventional Concrete and Bacterial Concrete

<table>
<thead>
<tr>
<th>No. of Days for Curing</th>
<th>Tensile strength (MPa)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conventional Concrete</td>
<td>Bacterial Concrete</td>
</tr>
<tr>
<td>7 DAYS</td>
<td>1.98</td>
<td>3.11</td>
</tr>
<tr>
<td>14 DAYS</td>
<td>2.40</td>
<td>4.10</td>
</tr>
<tr>
<td>28 DAYS</td>
<td>3.11</td>
<td>5.37</td>
</tr>
</tbody>
</table>

Fig. 7.3 Comparison Between Tensile Strength of Conventional Concrete and Bacterial Concrete

[8] OBSERVATION OF SHC :-
1) For equities point of view kept cubes, cylinder, and beams under the observation for 7, 14 & 28 days of curing.
2) During and after curing we observe the change like shrinkage, expansion, and the crack formed.
3) In that change occurred we have seen the drastic change occurred in beam. i.e. some minor crack formed due to shrinkage or expansion effect are get filled automatically due the open contact of crack with moisture and air.
4) Due to this virtual contact the bacteria gets activated and as a result the crack were filled due the formation of lime.

[9] CONCLUSION

1) Compressive strength of bacterial concrete on 7 days increases by 5.2%, on 14 days increases by 6.82% and on 28 days increases by 7.11% as compare to conventional concrete.
2) Split tensile strength of bacterial concrete on 7 days increases by 1.13%, on 14 days increases by 1.70% and on 28 days increases by 2.26% as compare to conventional concrete.
3) Flexural strength of bacterial concrete on 14 days increases by 2.75%, and 28 days increases by 4.00% as compare to conventional concrete.

ACKNOWLEDGEMENT

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REFERENCES