Abstract
The present investigation is to obtain the performance of the concrete by the microbiologically induced special growth. One such has led to the development of a very special concrete known as bacterial concrete where bacteria is induced in the mortars and concrete to heal up the faults. Researchers with different bacteria proposed different concretes. Here an attempt was made by using the bacteria “Bacillus subtilis strain no jc3”. This study showed a significant increase in the compressive strength due to the addition of bacteria. When 30 ml of “Bacillus Subtilis” is added in M20 grade concrete it attains maximum compressive strength. In concrete self-healing property is successfully achieved due to addition of bacteria.

1. Introduction
1.1 General
Concrete is the most widely used construction material and in applied in public infrastructure/buildings. Cracks in concrete are one of the inherent weakness of concrete.

Based on the continuous research carried out around the globe, various modifications have been made from time to time to overcome the deficiencies of cement concrete. The ongoing research in the field of concrete technology has led to development of special concretes considering (1) the speed of construction (2) the strength of concrete (3) the durability of concrete & (4) the environmental friendliness with the use of industrial material like fly ash, blast furnace slag, silica fume, etc.. Recently, it has been found that microbial mineral precipitation resulting from metabolic activities of favorable micro-organisms in concrete can improve the overall behavior of concrete.

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. Bacillus subtilis, which can successfully remediate cracks in concrete. Calcite formation by bacillus subtilis is a laboratory bacterium, which can produce calcite which precipitates on suitable media supplemented with a calcium source. a common soil bacterium, bacillus subtilis jc3, is used to induce CaCO3 precipitation. The favorable conditions do not directly exist in concrete. The main part of the work will focus on how the right conditions can be created for the bacteria not only to survive in the concrete but to produce as much calcite as needed to repair cracks.

1.2 Bacillus Subtilis
Bacillus Subtilis, known also as the hay bacillus or grass bacillus, found in soil and gastrointestinal tract of humans. A member of the genus Bacillus, Bacillus subtilis is a rod-shaped, and form a tough, productive endospore, allowing it to tolerate extreme environmental conditions. It is considered the best studied gram positive bacterium and a model organism to study bacterial chromosome replication and cell differentiation.

1.3 Self-Healing Of Concrete
Self-healing of cracks in concrete would contribute to a longer service life of concrete structures and would make the material not only more durable but also more sustainable.

1.4 Objective
1. To compare the compressive strength of normal concrete with Bacterial concrete

www.ijete.org
2. To create self-healing property
3. To reduce cost of construction

2. Methodology
2.1 Flow Chart

2.2 Material Collection

2.2.1 Cement
Ordinary portland cement of 53 grade available in local market is used in the investigation

2.2.2 Coarse Aggregate
Crushed granite angular aggregate of size 20mm

2.2.3 Fine Aggregate
Natural river sand is used

2.2.4 Water
Locally available potable water is used.

2.2.5 Microorganisms
Bacillus subtilis JC3, a laboratory cultured bacterium is used.

2.3 Bacillus Subtilis

2.3.1 Culture of Bacteria
The pure culture is maintained constantly on nutrient agar slants. It forms irregular dry white colonies on nutrient agar. Whenever required a single colony of the culture is inoculated into nutrient both of 200ml in 500ml conical flask and the growth conditions are maintained at 37 degree temperature and placed in 125 rpm orbital shaker. The medium composition required for growth of culture is Peptone, NaCl, yeast extract.

2.3.2 Maintenance of stock culture
Stock cultures of bacillus subtilis jc3 were maintained on nutrient agar slants. The culture was streaked on agar slants with an inoculating loop and the slants were incubated at 37 degree celsius. after 2-3 days of growth slant cultures were preserved under refrigeration (4 degree celcius ) until further use. Sub culturing was carried out for every 90 days. Contamination from other bacteria was checked periodically by streaking on nutrient agar plates.

2.4 Casting of Cubes

2.4.1 Slump Test
The concrete slump test is an empirical test that measures the workability of fresh concrete. More specifically, it measures the consistency of the concrete is that specific batch. This test is performed to check the consistency of freshly made concrete

2.4.2 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

2.4.3 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. After casting, the specimens are demoulded after 24 hours.

Fig 2.1 Cultured Bacteria
2.4.4 Curing  
After the cube preparation, immediately submerged in clean fresh water of the curing tank. After the completion of curing period the specimens are taken and kept in shade to dry off.

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

3. Experimental Analysis  
3.1 Slump Test  
The slump test result is a slump of the behavior of a compacted inverted cone of concrete under the action of gravity. It measures the consistency or the wetness of concrete.

Table 3.1 Slump test for M20

<table>
<thead>
<tr>
<th>ml Of Bacteria</th>
<th>Slump Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 ml</td>
<td>81 mm</td>
</tr>
<tr>
<td>10 ml</td>
<td>84 mm</td>
</tr>
<tr>
<td>20 ml</td>
<td>85 mm</td>
</tr>
<tr>
<td>30 ml</td>
<td>87 mm</td>
</tr>
</tbody>
</table>

Fig 3.1 Slump Test For M20

4. Result and Discussion  
4.1 Compressive Strength of Concrete  

Table 4.1 compressive strength analysis

<table>
<thead>
<tr>
<th>ml of bacteria</th>
<th>7 days curing</th>
<th>14 days curing</th>
<th>28 days curing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Load (KN)</td>
<td>Compressive Strength (Mpa)</td>
<td>Load (KN)</td>
</tr>
<tr>
<td>0 ml</td>
<td>270</td>
<td>12</td>
<td>295</td>
</tr>
<tr>
<td>10 ml</td>
<td>280</td>
<td>12.67</td>
<td>340</td>
</tr>
<tr>
<td>20 ml</td>
<td>350</td>
<td>15.55</td>
<td>410</td>
</tr>
<tr>
<td>30 ml</td>
<td>375</td>
<td>16.67</td>
<td>550</td>
</tr>
</tbody>
</table>
Here compressive strength of concrete is gradually increased from 10ml to 30ml of bacteria.

### 4.2 Comparison Of M25 To M20 Bacterial Concrete

<table>
<thead>
<tr>
<th>Days of curing</th>
<th>M25(1:2:4) Normal concrete</th>
<th>M20(1:1.5:3) Bacterial concrete(30ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 days</td>
<td>12</td>
<td>16.67</td>
</tr>
<tr>
<td>14 days</td>
<td>13.33</td>
<td>24.44</td>
</tr>
<tr>
<td>28 days</td>
<td>15.56</td>
<td>33.32</td>
</tr>
</tbody>
</table>

From the above chart we can analysis, our M20 grade bacterial concrete having higher 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.

### 4.3 Self-Healing Analysis

Cracks can be healed by using calcium carbonate precipitating micro-organisms. 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.

### 5. 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 33.32 MPa , that is maximum , when the addition of bacillus subtilis bacteria is 30 ml.
• The M20 grade bacterial concrete having higher compressive strength then the normal M25grade 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 convien for usage.
• This innovative concrete technology will soon proved the basis for an alternative and high quality structures that will be cost effective and environmentally safe
• The application of microbial concrete to construction may also simplify some of the existing construction processes and revolutionize the ways of new construction process

References
1. IS 10262,”Recommended Guideline For Concrete Mix Design”.
2. IS 456:2000,”Plain and Reinforced Concrete- Code of Practice”.
5. Engineered bacteria can fill cracks in aging concrete .. Prof.claydillow.,(2010)