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SELF HEALING CONCRETE – A SOLUTION TO CRACK FORMATION

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***Abstract*— Concrete is a homogenous mixture and has a tendency to form cracks under different conditions which reduce the life of the concrete structure so that there is a need to repair these cracks. Repairing of these cracks usually need big machines and instruments which increase the cost and high time-consuming. Thus to solve these problem bacterial self-healing concrete is developed. This technique is highly attractive because the treatment of crack remediation is eco-friendly and natural. The paper discusses the mechanical strength of conventional and bacterial concrete containing E-coli, Pseudofirmus, and Bacillus Subtilis with different percentages 1%, 2%, 3%, 4%, and 5%. From the research, it is shown that there is a significant increase in the strength of concrete by using bacteria. Microbial metabolic activities are responsible for enhancing strength and durability. This technique is called microbial induced calcite precipitation (MICP). This technique comes under the biomineralization category.**

Keywords—**self-healing concrete, mechanical strength, bacterial concrete, E-coli, Pseudofirmus, and Bacillus Subtilis.**

I. INTRODUCTION

Concrete is one of the most used construction material in these days because of its good strength and durability. Due to some activates major and micro-cracks developed in it which may resultant in the failure of structures. Once cracks formed in concrete it is highly undesirable because they provide the pathway for water and other harmful substances which leads to the corrosion of reinforcement and reduce the strength and durability of the structure. In the market, various repair techniques are available to repair the cracks, but they are a highly expensive and time-consuming process. Therefore there are new techniques to repair the cracks in concrete by itself known as self-healing concrete. Self –healing concrete contraction the crack probably due to the precipitation of calcium carbonate and congestion of particles. When the crack is healing in this way the strength recovery is limited and is a useful one in the cause of creak is smaller than 0.2mm. In this research, we use nonpathogenic bacteria such as bacillus subtilis, Pseudofirmus and Escherichia coli. And they are non-host bacteria that are capable of multiplying and refilled in concrete. When cracks appear in a concrete structure and water starts to seep in through the spores of the bacteria they start microbial activities when contact with water and oxygen. The use of biological techniques in the concrete lead to the invention of a new building material i.e. bio-concrete. The biologically induced concrete has exhibited better durability and crack repairing performance compared to normal concrete.

Various types of bacteria used in concrete:

- Bacillus pasteurii
- Escherichia coli
- Bacillus sphaericus
- Bacillus subtilis
- Bacillus cohnii
- Bacillus pseudofirmus
- Bacillus balodurans

In this research Escherichia coli, Bacillus subtilis and Bacillus pseudofirmus are used with different percentages 1%,2%,3%,4% and 5% by weight of cement to find out their mechanical strength compared with conventional concrete.

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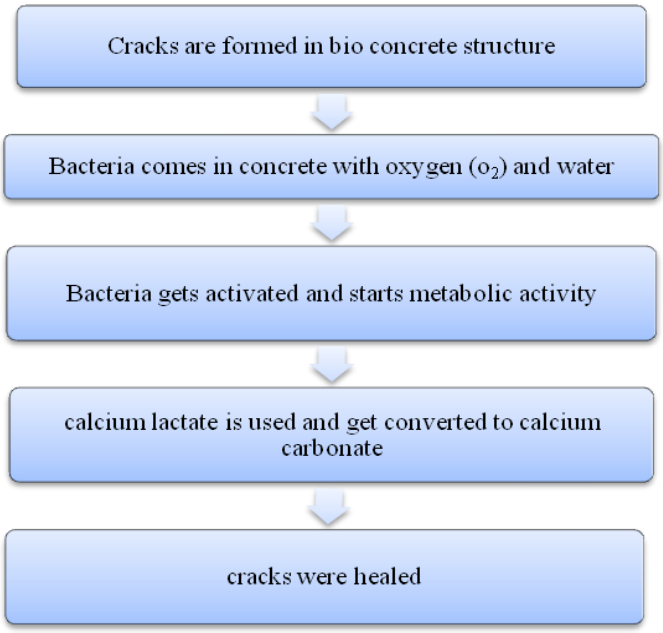
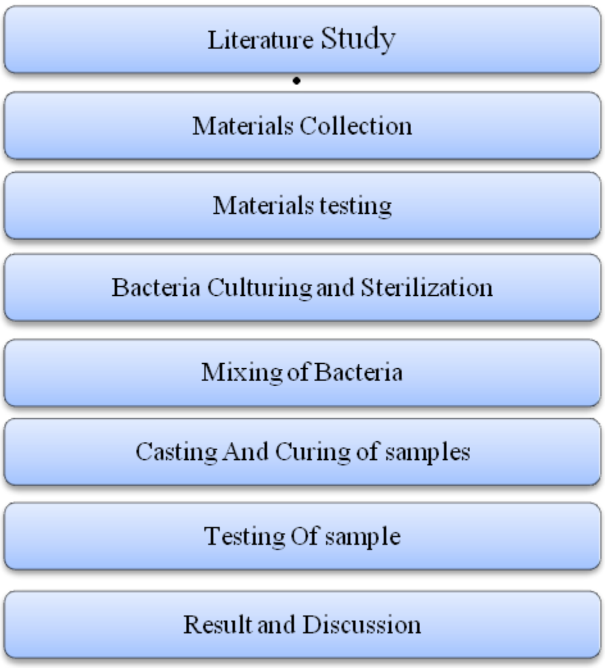
II. MECHANISM:



III. METHODOLOGY:



*A. Preparation of **culture** broth solution and medium:*

Nutrient Broth is a basic medium to grow bacillus. It is composed of a simple peptone and a beef extract. Peptones contribute organic nitrogen in the form of amino acids and long-chained fatty acids. The nutrient broth is prepared by using 10 gm/lit beef extract 5 gm/lit sodium chloride and 10 gm/lit peptone and mixed well. After centrifugation, the supernatant was absolute to the optical density (600 nm) reached 1 in UV/VIS Spectrometer. This intermediate is used to breed the bacterial genus.

B. Culturing bacteria

Prepare Nutrient broth in distilled water and mix properly with a frequent stir. After completion gives out into an appropriate container and sterilizes in the autoclave for 15 minutes at a temperature of 121°C. Then allow cooling and placed that culture in UV Chamber for 15 minutes and immunize the bacteria with the help of immunization disk. After that, we can place the culture in Incubator for 24 hours at a temperature of 35°C. The prepared culture should be stored in a freezer for future use.

IV. MATERIALS USED:

A. **Cement:** In this research ordinary Portland cement (OPC) of grade 53 used with a specific gravity of 3.12 and fineness 1.8%.

B. **Fine aggregate**: local river sand of zone 2 is used with specific gravity 2.62 and water observation 0.89%**.**

C. **Coarse aggregate:** A crushed stone of the size of less than 20mm with a specific gravity of 2.7.

D. **Water:** local available portable water of Ph 6.8- 7.4 used.

E. **Bacteria**: the bacteria used in this research are E-coli, Pseudofirmus, and Bacillus Subtilis. They are mixed in concrete with different percentages 1%, 2%, 3%, 4%, and 5%. Of cement mass

V. MIX DESIGN:

Concrete mix design is according to IS code IS 10262-2009. And bacteria are used in different percentages 1%, 2%, 3%, 4%, and 5%. By weight of cement.
The proportions of materials used in concrete are:

	water	**cement**	**Fine aggregate**	**Coarse aggregate**
Quantity (kg/m^3)	**171.4**	**340**	**662.8**	**1324.35**
Ratio	**0.5**	**1**	**1.94**	**3.89**

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VI. RESULTS AND DISCUSSION:

A. Compression strength:

Compression strength may be defined as the "ability of the material to resist compressive forces which tends to compress it" compressive test is done under compression testing machine (CTM). For this test cubes of size 150mm x150mm x150 mm. In this research compressive test is performed on one conventional concrete and bacterial concrete with different percentages of dosages 1%, 2%, 3%, 4%, 5%.the compression strength is calculated as load/area.

It is shown that the compression strength of concrete at a 5% use of bacterial (E-coli, Pseudofirmus, and Bacillus Subtilis) given higher compression strength is shown in figure 1 and table no I. and pseudofirmus give high compressive strength among others. If the dosage of the percentage of bacteria increased the compression strength also increased.

Table I: Compression strength test at 28 days of curing.

S.No	Percent-age of bacteria used	Convent-ional concrete (N/mm^2)	E-coli, (N/mm^2)	Pseudofirmus, (N/mm^2)	Bacillus Subtilis. (N/mm^2)
1	0%	30.8	…….	…….	……
2	1%	…..	26.2	26.9	25.6
3	2%	…..	28.0	28.9	26.4
4	3%	……	29.5	29.9	27.6
5	4%	……	30.1	30.1	28.4
6	5%	…….	30.6	31.2	29.9

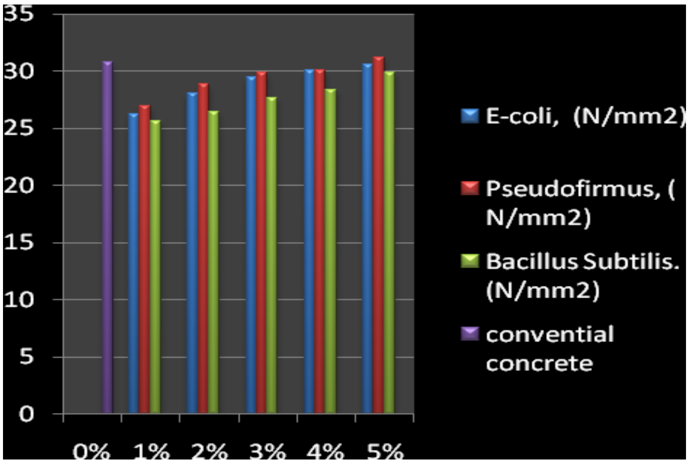

Figure 1: Compression strength test at 28 days of curing.

B. SPLIT TENSILE STRENGTH:

Used to determine the tensile strength of concrete it is obtained by laying the cylinder longitudinally and compressive force applied which may cause split of the cylinder into two parts along longitudinally. The cylinder of diameter 150mm and height 300mm used.
Resultant Split tensile strength is calculated using the formula

$$T=2P/\pi dl$$

Pseudofirmus by use of 5% gave higher split tensile strength shown in fig no 2 and table no.II. There is frequently increased in split tensile strength.

Table II: Split tensile strength of concrete at 28 days

S.No	Percentage of bacteria used	Conventional concrete (N/mm^2)	E-coli, (N/mm^2)	Pseudofirmus, (N/mm^2)	Bacillus Subtilis. (N/mm^2)
1	0%	2.8	…….	…….	……
2	1%	…..	2.2	2.4	2.1
3	2%	…..	2.3	2.5	2.2
4	3%	……	2.6	2.7	2.4
5	4%	……	2.7	2.9	2.5
6	5%	…….	2.9	3.1	2.7

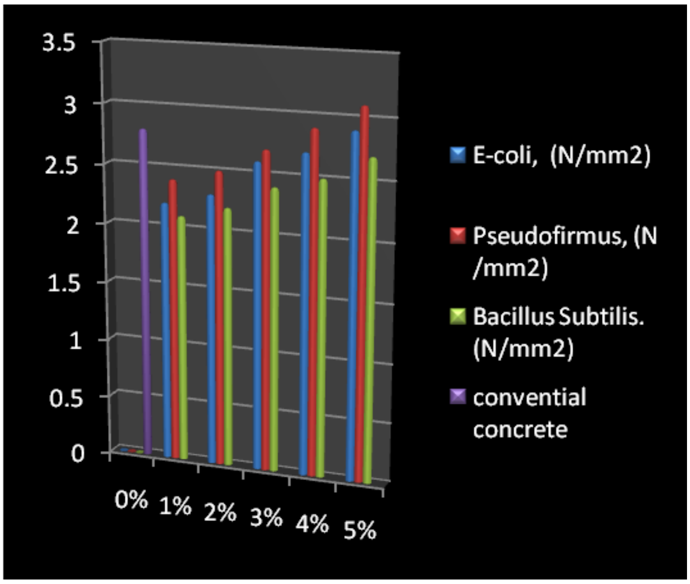

Figure 2 Split tensile strength of concrete at 28 days

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C. FLEXURAL STRENGTH TEST:

The capacity of concrete to resist bending stress the size of the beam used for that test is 100x100x500mm and test at 28 days of curing shown in table no III and fig no 3.

By the use of Pseudofirmus bacteria 5% of the flexural strength increased. Compare to conventional concrete E-coli, Bacillus

Pseudofirmus and Bacillus Subtilis gives higher values by a dosage of 5%.

Table III: Flexural Strength of Concrete at 28 Days

S.No	**Percentage of bacteria used**	**Conventional concrete (N/mm^2)**	E-coli, **(N/mm^2)**	Pseudofir-mus, **(N/mm^2)**	Bacillus Subtilis. **(N/mm^2)**
1	**0%**	**4.9**	**…….**	**…….**	**……**
2	**1%**	**…..**	**4.4**	**4.5**	**4.2**
3	**2%**	**…..**	**4.6**	**4.7**	**4.4**
4	**3%**	**……**	**4.8**	**4.9**	**4.7**
5	**4%**	**……**	**5.1**	**5.2**	**4.9**
6	**5%**	**…….**	**5.3**	**5.5**	**5.1**

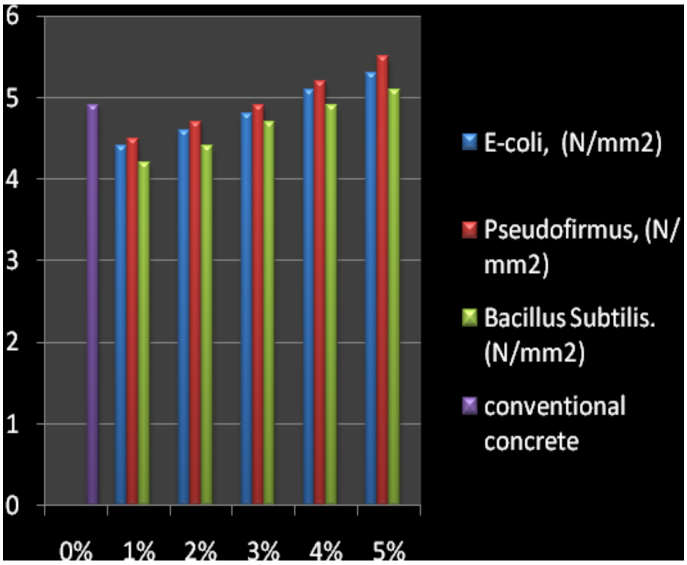

Figure 3 Flexural Strength of Concrete at 28 Days

VII. ACKNOWLEDGMENT:

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VIII. CONCLUSION:

Based on the results we conclude that:

- Self-healing concrete is a better technology to prevent cracks because of its eco-friendly nature, self-healing ability, and durable.
- The study reviewed different types of bacteria (E-coli, Pseudofirmus, and Bacillus Subtilis) that can be used as a self-healing concrete among all of these Pseudofirmus, gives better results.
- In the study, it is shown that there is the enhancement of compression strength, tensile strength, and flexural strength.
- The 0.5% of Pseudofirmus is the optimum value and for e-coli and bacillus subtilis 0.5% gives much better results.
- The compressive strength increased at a rate of 1.3%, split tensile strength increased at a rate of 10.7%, and flexural strength increased at a rate of 10.9%, by the use of Pseudofirmus, bacteria.
- From the above study, it is shown that Pseudofirmus, will give maximum strength compared to all other bacteria added to concrete hence it is preferable. And bacteria can live in concrete for over 100 years.

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