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Experimental Study on effect of Introducing Bacteria into Self-Healing Concrete

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Abstract – With ever increasing emissions from the construction industry, Biological construction material offer are being looked upon to offer a technology to that would combat these emissions. Researchers in the field of civil engineering and biotechnology have turned to the microorganisms for the production of bio-construction materials which are not only environment friendly, having lesser social impact, and economically feasible but can also produce high strength. However, the cracks in the hardened concrete pose a major concern regarding the durability. Corrosion is initiated when moisture and other chemicals present in the environment, seep through these cracks, and result in reduced life of concrete. Hence there is an ardent requirement in the construction industry to develop a bio-material, that has self-repairing properties, which can remediate the cracks and fissures developed in the concrete. Researchers are continually working on bacterial concrete, which can successfully remediate cracks developed in concrete. The current paper is a review of various researches which have been conducted in the area of developing bacterial concrete for use in crack repairing in existing buildings.

Index Terms – bacillus subtilis, self-healing concrete, minor cracks.

I. INTRODUCTION

Concrete in its fresh and hardened form is one of the most widely consumed materials for in the field of civil engineering. Concrete in its fresh phase can be molded into any shape and once it hardens into a rock like structure which can take a large load bearing capacity for compression load. However, concrete can develop cracks due to virous reasons like shrinkage, freeze-thaw reactions, low tensile strength of concrete, improper mixing and placing etc., cracks thus occurring can be doors to the entry of moisture and other hazardous chemicals present in the environment that can reduce the durability and hence the life span of the concrete structures. Synthetic coatings are sometime given on the surface of reinforcement bars, that protect the reinforcement bars from being corroded, but they are costly and require regular maintenance. Use of chemicals like epoxy also has an environmental impact and should be avoided. The immediate need for an environment friendly and cost effective alternate crack remediation technique has led to the development in the research in the area of bio-materials in concrete. This paper presents an extensive review of various researches that have been done in the recent times in the field of bacterial concrete.

Bacterial concrete produces limestone biologically and this limestone helps in healing the cracks that appear on the surface of concrete structures. Few of the specially selected types of the bacteria Bacillus, along with a nutrient that is calcium based along with nitrogen and phosphorus, are mixed with the ingredients of concrete during the process of mixing. Whenever the concrete structure develops cracks and the spores of the bacteria get in contact with the moisture and other nutrients, the bacteria gets activated and feeds on the calcium lactate. In the process of bacteria starting to feed, the oxygen gets consumed and the calcium lactate which is found in the soluble form is then converted to CaCo3 (limestone) in insoluble form. In this process the limestone thus developed gets solidified on the cracked surface, leading to it getting sealed up. During the conversion of calcium lactate to limestone oxygen is consumed and this has an extra advantage. As the oxygen is a vital element during the corrosion process of steel its consumption leads to an increased durability of steel in RCC structures.

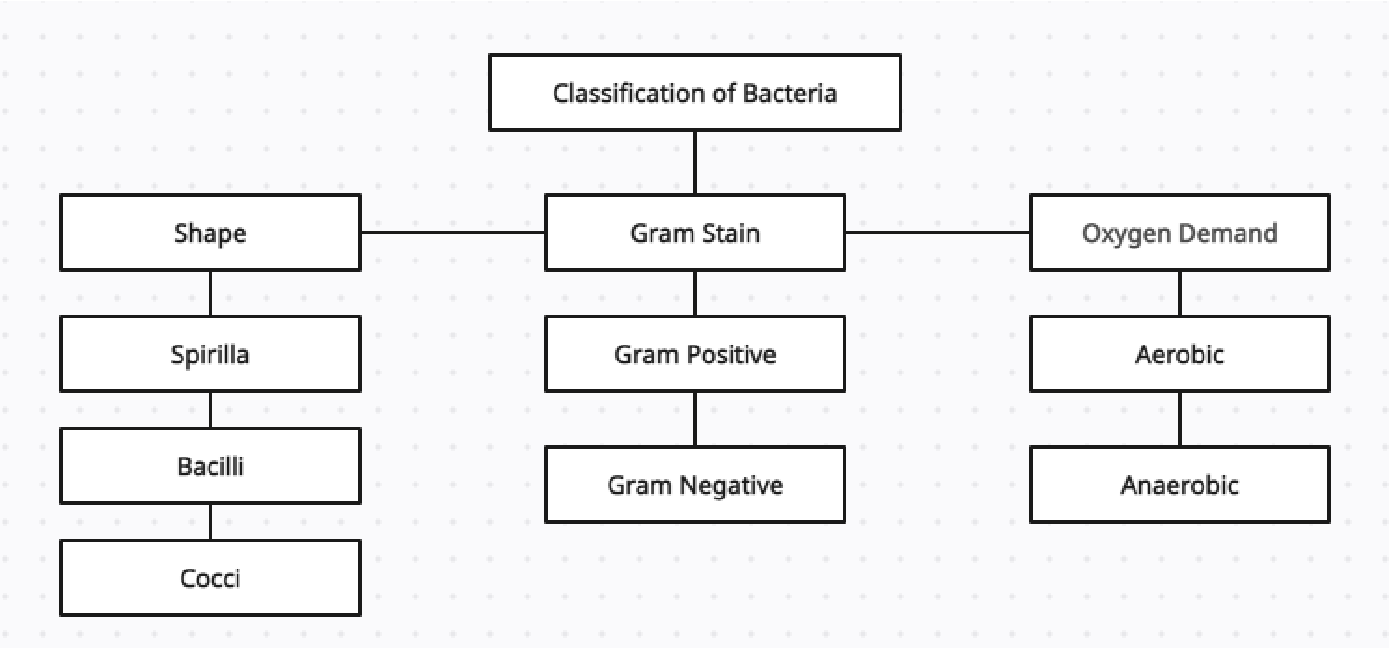

Fig. 1 Classification of Bacteria

Originally the microbe Bacillus subtilis is a microbe that was initially found in the year 1835. It is known by various names such as Bacillus globigii, Bacillus uniflagellatus or Bacillus natto. The bacteria used in this investigation is named Bacillus subtilis which is a Gram-positive bacterium that is rod-shaped. It is found to occur naturally in soil and vegetation. It has an optimum temperature range of 25-35 degrees Celsius. Bacillus has evolved strategies to survive in harsh environments. One such strategy essential for the development of self-healing concrete is stress-tolerant endospores. Soil is the primary habitat for endospore-forming Bacillus. Bacillus subtilis strains also act as biofungicides, providing benefits to agricultural crops and antimicrobials. It also reduces corrosion of structural steel. Bacillus subtilis is a non-toxic bacterium that provides a user-friendly interface for self-healing concrete. Bacillus subtilis must be grown thoroughly in liquid and water conditions before impregnating the concrete mix. The usual bacterial concentration required is 56 x 106 bacteria/ml. The concentration of bacteria may be calculated using the given formula: Bacterial count = total growth (counts/mL) x solution used (mL). Total solution used (mL) Results may vary depending on bacterial count

II. RESEARCH OBJECTIVES

- To study the effect of using Bacillus subtilis on self-healing property of concrete.

III. METHODOLOGY OF THE STUDY

Selection of Bacteria: The Bacillus family Bacillus plays an important role. There are various species of Bacillus that can be used in common concrete, B.subtilis, B.pasteurii, and B.sphaercius. The bacterium B. subtilis is used, depending on its availability in India. It is formally known as hay or grass fungus and is Gram-positive.

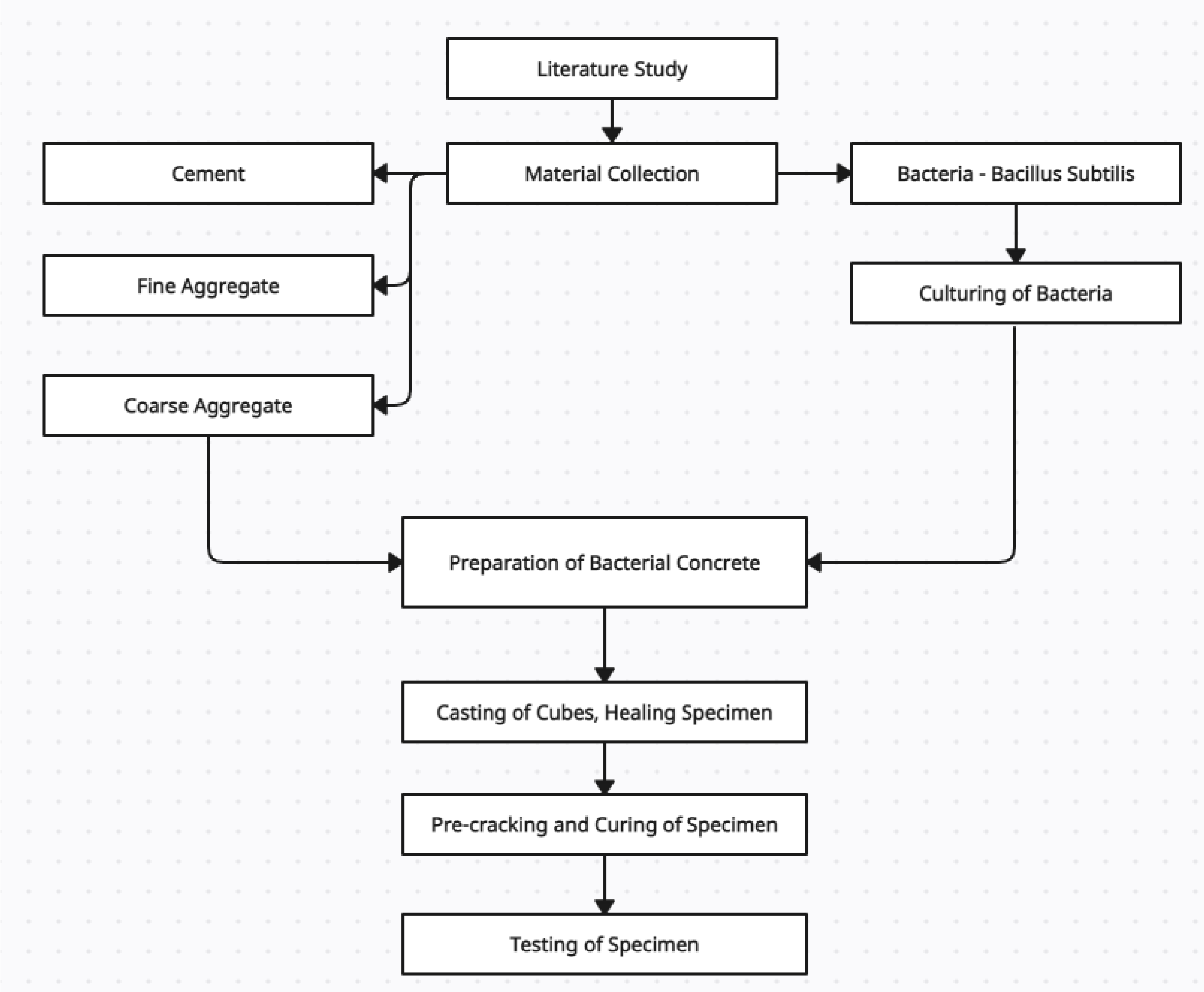

Fig. 2 Methodology of Study

IV. RESULTS AND DISCUSSIONS

A. Density:

Table 1. Density test on concrete blocks

Sl. No.	Percentage of Bacterial Solution Added (%)	Density of Concrete Cubes (kg/m^3)	Percentage increase in density of concrete cubes (%)
1.	0	2488.80	
2.	1	2521.48	1.31
3.	3	2533.33	1.79
4.	4	2568.80	3.2
5.	5	2551.11	2.5
6.	6	2533.30	1.78
7.	8	2509.60	0.84
8.	9	2489.90	0.04

B. Compressive Strength:

Table 2. Compression test on concrete blocks

Sl. No.	Percentage of Bacterial Solution Added (%)	Compressive Strength (N/mm^2)
1.	0	40.62
2.	1	41.83
3.	3	42.57
4.	4	45.11
5.	5	48.97
6.	6	43.57
7.	8	42.66
8.	9	42.97

(a) Day 1 **(b) Day 14** **(c) Day 28**

Fig. 3 Picture representing crack healing on day 1, day 14 and day 28.

V. CONCLUSIONS

The addition of bacteria was found to increase the compressive strength, and this increase was mainly due to the deposition of microbially-induced calcium carbonate precipitates on the microbial cell surface and within the pores of the mortar. Bacterial concrete also had a significant impact on the durability of the structure by repairing cracks in the structure. Concrete is also called a “smart biomaterial” due to its inherent ability to continuously deposit calcite by bacteria. It has proven to be superior to conventional concrete due to its environmental friendliness and self-healing properties. Bacterial concrete will soon be developed to build durable, high quality, low cost and environmentally friendly buildings. Since skilled workers are required, it is economically and practically efficient and easy to use.

microorganisms have been found to be effective in improving the properties of concrete, achieving very high increases in early strength. made more compact and more resistant to leaching. When bacterial concrete matures, it may become another alternative to replace OPC and its detrimental effects on pollution. Therefore, it also has good corrosion resistance, so it can also be used for construction purposes.

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