

## International Journal of Innovative Research in Science, Engineering and Technology

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# Experimental Study on Bacterial Concrete with Replacement of Cement by Using Flyash

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**ABSTRACT:** The aim of this project is the development of a new type of concrete in which integrated bacteria promote self-healing of cracks. Concrete is the most popular construction material. But its low tensile strength makes it prone to cracking, which will decrease the service life of concrete structures. Now self healing of cracks has become a hot topic because it is more economical, convenient and smart, with a great potential in practical application. Concrete structures usually show self-healing capacity, i.e. the ability to heal or seal freshly formed micro-cracks. In this project a new type of self healing concrete in which bacteria mediate the production of minerals which rapidly seal freshly formed cracks, a process that concomitantly decreases concrete permeability, and thus better protects embedded steel reinforcement corrosion. In this study spores of specific alkali-resistant bacteria related to the genus *Bacillus* were added to the concrete mixture as self-healing agent and the newly produced compound such as calcium carbonate based mineral precipitated that is Calcium Lactate is added. It is expected that further development of this new type of self-healing concrete will result in a more durable and moreover sustainable concrete which will be particularly suited for application in wet environment where reinforcement corrosion tends to impede durability of traditional concrete constructions.

**KEYWORDS:** *Bacillus subtilis*, fly ash, self healing process, strength test.

### I. INTRODUCTION

Concrete which forms major component in the Construction Industry as it is cheap, easily available and convenient to cast. But drawback of these materials is it is weak in tension so, it cracks under sustained loading and due to aggressive environmental agents which ultimately reduce the life of the structure which are built using these materials[1]. This process of damage occurs in the early life of the building structure and also during its life time. Synthetic materials like epoxies are used for remediation. But, they are not compatible, costly, reduce aesthetic appearance and need constant maintenance. Therefore bacterial induced Calcium Carbonate (Calcite) precipitation has been proposed as an alternative and environment friendly crack remediation and hence improvement of strength of building materials. Bacteria are the most diverse and abundant group of organisms on Earth. Bacteria inhabit practically all environments where some liquid water is available and the temperature is below +140 °C. They are found in sea water, soil, air, animals' gastrointestinal tracts, hot springs and even deep beneath the Earth's crust in rocks. Bacteria are often dismissed as germs, but help us do a range of useful things like production of antibiotics, nitrogen fixation, live in the guts of animals (including humans) or elsewhere in their bodies, or on the roots of certain plants. Bacteria are of great importance because of their extreme flexibility, capacity for rapid growth and reproduction [2]. A micro-organism is an organism that is microscopic (too small to be seen by the naked human eye).

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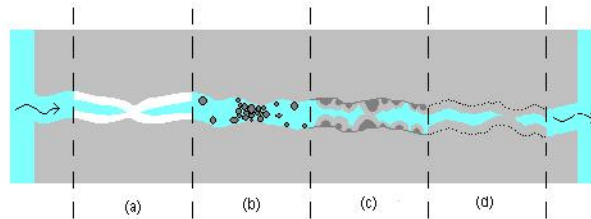


Fig 1. Possible causes of self healing: (a) formation of calcium carbonate or calcium hydroxide, (b) sedimentation of particles, (c) continued hydration, (d) swelling of the cement matrix

Bacterial concrete is the new innovative technique, in which the bacteria are added to the concrete mix to enhance the strength and also it act as a excellent self healing agent. The “Bacterial Concrete” can be made by embedding bacteria in the concrete that are able to constantly precipitate calcite [3]. This phenomenon is called microbiologically induced calcite precipitation.

### II. LITERATURE REVIEW

**Amudhavalli.N.K. , Keerthana.K. , Ranjani.A, “Experimental Study on Bacterial Concrete” IJSEAS, Vol-01, (2015) 456-458**

This paper explains about the overview of bacterial concrete. Bacterial concrete is the new innovative technique, in which the bacteria are added to the concrete mix to enhance the strength and also it act as an excellent self healing agent. In this the test for Bacterial concrete such as Calcium carbonates estimation, X ray diffraction, Scanning Electron Microscope, Strength aspects such as compressive and tensile strength of bacterial concrete, and Numerical analysis such as Modeling of crack region and Analytical Investigation were done.

**Beena Kumari “Microbial Concrete: A Multi-Purpose Building Material-An Overview” Vol-07, (2015), 1608-1619**

This paper presents an overview of the uses of microbial concrete is presented here. Various factors which cause cracks in concrete as building material have been discussed. Conventional remedies and non-conventional remedies for concrete crack remediation are discussed in detail. Microbial concrete biologically build limestone to heal cracks that appear on the surface of concrete structures. The bacteria group Bacillus, along with a calcium-based nutrient (known as calcium lactate), nitrogen and phosphorus, are added to the ingredients of the concrete when it is being mixed. These self healing agents can lie dormant within the concrete for a very long period but when a concrete structure is damaged and ingress of water starts to percolate through the cracks in the concrete, the bacteria start growing on contact with the water and nutrients. Microbial calcite precipitation was quantified by X-ray diffraction (XRD) analysis and visualized by SEM. The specimens with bacteria did not develop any micro cracks, as they did not expand much unlike control specimens when subjected to alkali aggregate reactivity, sulphate attack, drying shrinkage and freeze-thaw. It increases compressive strength; reduce water absorption capacity, increase resistance towards alkalinity and sulphate attack. Surface treatments play an important role in limiting the ingress of water and consequently of detrimental components into concrete. It can also be used as water purifier.

**Chintalapudi Karthik, Rama Mohan Rao.P, “Properties of Bacterial-based Self-healing Concrete- A review” Vol-09,(2016), 182-188**

In this journal the experiments have shown that the ability to heal the micro-cracks with the help of bacteria and healing agent was seen by SEM analysis and confirmed by XRD, that Ca Co<sub>3</sub> 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 10<sup>5</sup> cells/ml. *S.pasteurii* formerly

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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. Increase of durability, compressive strength and reduction of permeability in concrete is attained. Ability to heal and seal the cracks in concrete was observed.

### **Koustubh A. Joshi, Madhav B. Kumthekar, Vishal P Ghodake “Bacillus Subtilis Bacteria Impregnation in Concrete for Enhancement in Compressive Strength” IRJET Vol- 03, (2016), 1229-1234**

This journal describe bacteria from bacillus family are impregnated in concrete which are having calcium as their food from concrete and when these bacteria gets in contact with atmosphere they use water and carbon dioxide from surrounding environment and its Rita produces the precipitate of calcium carbonate (lime stone) which ultimately seals the cracks and enhances compressive strength of concrete. Cubes of standard sizes 150x150x150mm as per I.S. 516 are cast. Three cubes each of 7 days & 28 days test are cast. After curing, these cubes were tested on Compression Testing machine then the failure load was recorded. Thus *Bacillus subtilis* has positive impact on concrete's compressive strength. Change in compressive strength as bacterial count changes.

### **Lakshmi.L, Meera .C.M, Eldhose Cheriyan, “Durability and Self Healing Behavior of Bacterial Impregnated Concrete” Vol-05, (2016), 14887-14892**

In this study, durability and crack healing behavior of bacterial impregnated concrete using *bacillus subtilis* bacteria was conducted. Experimental results showed a better durability performance by bacterial impregnated concrete compared to conventional M25 Concrete. Bacterial concrete exhibited crack width reduction when immersed in water which strengthens self- healing property of it. An experimental program was conducted on M25 grade concrete cubes of size 100x100x100 mm with and without addition of *b.subtilis*. For salt and acid durability test, specimens were immersed in 5% solution of NaCl and 5% solution of H<sub>2</sub>SO<sub>4</sub>. Tests were carried out at regular intervals of 7 days for a period of 28 days. Saturation water absorption test was conducted at the age of 28 days on 100mm cubes in accordance with IS 2185-1979. The water absorption percentage of conventional concrete compared with bacterial concrete. To study the crack healing capacity of bacterial concrete cubes with different crack width (0.1mm, 0.22mm, 0.3mm, 0.4mm, 0.45mm and 0.5mm) were casted for this study. Continuous examination carried out to identify the healing capacity. Bacteria (*Bacillus subtilis*) were added along with the water in the concentration 10<sup>5</sup> cells/ml at the time of mixing. By immersing the conventional concrete cube specimen in salt water percentage weight increase occurred is 0.85% while for bacterial impregnated concrete is 0.36%. By immersing the conventional concrete cube specimen in sulphuric acid percentage weight loss occurred is 0.66% while for bacterial impregnated concrete is 0.99%. Result obtained due to the effect of acid 38.71% reduction in compressive strength occurred in case of conventional concrete while for bacterial concrete is only 14.28%.

### **Prof. M. Manjunath, Prof. Santosh A. Kadapure, Ashwinkumar A. Kalaje, “An Experimental Investigation on the Strength and Durability Aspects of Bacterial Concrete with Fly Ash” IISTE, Vol-06, (2014)61-68**

This paper presents the results of an experimental investigation carried out to evaluate the influence of *Bacillus sphaericus* bacteria on the compressive strength, split tensile strength, flexural strength, shear strength, water absorption and chloride permeability of concrete made without and with fly ash. Cement was replaced with two percentages (10 and 20) with fly ash by weight. Three different cell concentration (0, 10<sup>3</sup>, 10<sup>5</sup>, 10<sup>7</sup> cells/ml) of bacteria were used in making the concrete mixes. Tests were performed at the age of 28 days. Test results indicated that inclusion of *B. sphaericus* in fly ash concrete enhanced the compressive strength reduced the water absorption and chloride permeability of fly ash concrete. Maximum increase in compressive strength 15.47% was observed with 10<sup>5</sup> cells/ml of bacteria. Then the calcite precipitation in concrete was carried out by SEM analysis. The specimens with bacteria did not develop any micro cracks, as they did not expand much unlike reference specimens.

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### **Mayur Shantilal Vekariya, Prof. Jayeshkumar Pitroda, “Bacterial Concrete: New Era for Construction Industry” IJETT, Vol-04, (2013) 4128-4136.**

The applicability of specifically calcite mineral precipitating bacteria for concrete repair and plugging of pores and cracks in concrete has been recently investigated and studies on the possibility of using specific bacteria as a sustainable and concrete -embedded self-healing agent was studied and results from ongoing studies are discussed. Recently, it is found that microbial mineral precipitation resulting from metabolic activities of favorable microorganisms in concrete improved the overall behavior of concrete. Hence in this paper define the bacterial concrete, its classification and types of bacteria, chemical process to fix the crack by bacteria, advantages and disadvantages and possibilities of application of MICP (Microorganism used for Calcium Carbonate Precipitation in Concrete) in construction area are discussed.

### **Meera C. M, Dr. Subha V, “Strength and Durability assessment Of Bacteria Based Self-Healing Concrete” (2016), 1-7**

The study was carried out on a bacteria based self-healing concrete using *Bacillus Subtilis* bacteria. The present paper describes the effect of these bacteria on the strength of concrete. An investigation on the strength assessment of the bacteria-based self-healing concrete by finding out the optimum amount of bacterial content to be added to obtain maximum strength is depicted in this. The cubes and cylinders were prepared for concrete mix of M20 grade with and without addition of microorganisms (*B. Subtilis*). The size of the cubes was 150mm x 150mm x150mm and cylinders was taken as 100mm diameter 200mm height respectively. Cubes were tested for compressive strength at 7 days and 28 days. Cylinders were tested for split tensile strength at 28 days and an experimental program was conducted on M20 grade concrete cubes of size 150mm x 150mm x150mm with and without addition of microorganisms (*B. Subtilis*). Specimens were immersed in 5% solution of H<sub>2</sub>SO<sub>4</sub> for Acid Durability Tests, 5% solution of NaCl for Chloride Test and in distilled water for Water Absorption Test.

### **Mian Luo, Chun-xiang Qian , Rui-yang Li, “Factors affecting crack repairing capacity of bacteria-based self-healing concrete” Vol-87,(2015)1-7**

In this journal the cylindrical specimens with dimensions of 75 x 35 mm (diameter x height) were used for water permeability test and prismatic specimens with dimensions of 40 x 40 x 160 mm were used for the image characterization of crack healing efficiency. Then the specimens were loaded on compression test machine. When the surface appears visible micro cracks, the loading was stopped. After that, different diameter nails were embedded in micro cracks at both ends in the specimen surface to form different width cracks varies from 0.1 mm to 1 mm, which depended on the diameter of the nail. Then the specimens were cured under three ways of curing i) water curing ii) wet-dry curing iii) wet curing. From this water curing was shown to be the best way for bacteria-based self-healing concrete. For crack-healing quantification under different cracking age, the cylindrical specimens were taken out after 7, 14, 28, 60 and 90 days curing, respectively. The precipitations formed at the cracks surface of the cement paste specimens were analyzed with Scanning Electron Microscope (SEM) equipped with an Energy Dispersive X-ray Spectrometer (EDS), and then examined by X-ray Diffraction (XRD). The image processing of specimen surface cracks before and after healing were carried out.

### **Mohini P. Samudre, M. N. Mangulkar, S. D. Saptarshi, “A Review of Emerging Way to Enhance the Durability and Strength of Concrete Structures: Microbial Concrete” Vol-03, (2014), 9311-9315**

This paper outlines the basic mechanism involved in microbial concrete on which studies were carried out to investigate the causes involved in enhancing the strength and durability of concrete. Due to microbial activities of the bacteria, microbiologically induced calcite precipitation (MICP), a highly impermeable calcite layer is formed which contributes to increase the performance of concrete structure and also has excellent resistance to corrosion. Recent research has shown that specific species of bacteria can be useful to enhance the durability and strength of concrete structures. This microbial concrete presents a potentially enormous lengthening in service-life of infrastructure, substantially reduces the maintenance costs and also considerably increases the safety of structures. Many researchers have recorded the benefits of microbial concrete which includes the enhancement of compressive strength, reduction in

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permeability and reinforced corrosion in construction materials. The use of microbial concrete in Civil Engineering has become increasingly popular. Microbial concrete technology has proved to be better than many conventional technologies because of its eco- friendly nature, self-healing abilities and very convenient for usage.

### III. CONCLUSION

The partially replacement of cement with fly ash and addition of *Bacillus subtilis* does not affect the original properties of concrete. At the same time it increases the compressive strength, split tensile strength, and flexural strength of concrete mix.

### REFERENCES

- [1] Amudhavalli.N.K., Keerthana.K. , Ranjani.A, “Experimental Study on Bacterial Concrete” IJSEAS, Vol-01, (2015) 456-458.
- [2] Beena Kumari “Microbial Concrete: A Multi-Purpose Building Material-An Overview” Vol-07, (2015), 1608-1619.
- [3] Chintalapudi Karthik, Rama Mohan Rao.P, “Properties of Bacterial-based Self-healing Concrete- A review” Vol-09,(2016), 182-188.
- [4] Koustubh A. Joshi, Madhav B. Kumthekar, Vishal P Ghodake “Bacillus Subtilis Bacteria Impregnation in Concrete for Enhancement in Compressive Strength” IRJET Vol- 03, (2016), 1229-1234.
- [5] Lakshmi.L, Meera .C.M, Eldhose Cheriyan, “Durability and Self Healing Behavior of Bacterial Impregnated Concrete” Vol-05, (2016), 14887-14892.
- [6] Prof. M. Manjunath, Prof. Santosh A. Kadapure, Ashwinkumar A. Kalaje, “An Experimental Investigation on the Strength and Durability Aspects of Bacterial Concrete with Fly Ash” IISTE, Vol-06, (2014)61-68.
- [7] Mayur Shantilal Vekariya, Prof. Jayeshkumar Pitroda, “Bacterial Concrete: New Era for Construction Industry” IJETT, Vol-04, (2013) 4128-4136.
- [8] Meera C. M, Dr. Subha V, “Strength and Durability assessment Of Bacteria Based Self-Healing Concrete” (2016), 1-7.
- [9] Mian Luo, Chun-xiang Qian, Rui-yang Li, “Factors affecting crack repairing capacity of bacteria-based self-healing concrete” Vol-87,(2015)1-7.
- [10] Mohini P. Samudre, M. N. Mangulkar, S. D. Saptarshi, “A Review of Emerging Way to Enhance the Durability and Strength of Concrete Structures: Microbial Concrete” Vol-03, (2014), 9311-9315.