International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 11 Issue 5 ǁ May 2023 ǁ PP. 825-828

Bio-Concrete Innovation: Review on Percentage Healing of Concrete Cracks by Incorporation of Bacillus Subtilis Bacteria

[1]Akshay T. Vanare, [2]Dr. Rahul V. Kajave
[*1]*P.G. Student, Department of Civil Engineering, TKIET, Warananagar, Maharashtra, India*
[2]*Assistant Professor, Department of Civil Engineering College, TKIET, Warananagar, Maharashtra, India*

Abstract
Concrete has a common phenomenon of cracking and cracking prone to leakage of moisture content inside the structure leading to corrosion of steel provided as reinforcement. It can be avoided by numerous modern techniques and equipment's within short time span. But how wonderful it can be if healing of cracks is done by self-mechanism and no external technique is required. Self-healing concrete reacts to cure cracks itself without any human intrusion. Bacillus Subtilis microorganism which are incorporated in concrete, impacts eco-friendly to self-healing process in current project. In this technique, bacteria Bacillus Subtilis are mixed in concrete which are having calcium lactate as their food from concrete and when these bacteria get in contact with atmosphere, they use water, oxygen and carbon dioxide from surrounding environment and produces precipitate of calcium carbonate (CaCO3) (lime stone) which seals the cracks and enhances compressive strength of concrete.

Keywords: *Bacillus Bacteria, Percentage healing, Precipitation, Calcium Carbonate (CaCO3), Efficiency*

Date of Submission: 16-05-2023 Date of acceptance: 30-05-2023

I. INTRODUCTION

A potential method for preventing crack growth is bio-concrete. Since these bacteria normally creates spores with specialized cells capable of resisting strong mechanical forces and hostile environment. Spore forming bacteria associated with genus Bacillus Subtilis are frequently used as healing agent for fracture repairs. The creation of calcium carbonate is influenced by several variables such as pH, inorganic compounds dissolved in it; presence of calcium ions throughout is directly tied to self-healing process. Instead of external application, these bacteria and organic material are mixed into concrete during mixing process for improved action at depth. These bacteria can sleep in concrete for over 200 years. If concrete gets damage, then bacteria will rise and multiply when water will come in contact. Hence, bio-concrete has potential to save annual maintenance when utilized in different construction projects.

1.1. DEFINATION

"Bio concrete is self-healing technique using bacteria that can fill the cracks in concrete by inducing calcium carbonate precipitation through biomineralization." The basic mechanism of bacteriabased crack healing happens when the concrete crack occurs. The water will then leak through the formed cracks and capillary pores of concrete. With the presence of water and nutrient inside the concrete matrix, the process of germination of bacteria will takes place and the limestone (CaCO3) produced can fill the cracks. The bacteria can be added to concrete mix to restrain the growth of cracks by calcium carbonate precipitation. In comparison with other conventional healing materials, such as silicon-based polymers and acrylic resin, bacteria are more preferable. Since the calcium carbonate, has good thermal compatibility and mechanical property with cementitious composites.

1.2. PURPOSE

In the field of bio concrete many researchers have done lot of works to increase the strength and durability of concrete. They have briefly investigated about the increase in the compressive strength, tensile strength, etc. They worked with different proportions of bacterial strains since there is no any standard code provision yet done for it. So, the purpose of the work is to find out a standard proportion of bacterial strain which will be sufficient for the specific grade of concrete. Hence there will be no need for repetitively work along different quantities of bacteria.

1.3. NEED OF STUDY

Current situation about the degradation of concrete and the economic impact of the maintenance and repair of concrete structures, have drawn the attention to processes of concrete deterioration, and to the methods to delay or even to get rid of concrete degradation. The service environment and properties of concrete determine the risk of damage and the speed at which it can develop. Many of physical and chemical deterioration mechanisms of concrete are related to aggressive substances present in aqueous solution. An important measure to protect concrete against damage is then diminishing the uptake of water. Surface treatments play an important role in limiting the infiltration of water and harmful components into concrete. Nowadays lots of organic and inorganic products are available in the market for the protection of concrete surfaces, such as a variety of coatings, water repellents and pore blockers.

These conventional means of protection, however, shows beside their favorable influences and also a number of disadvantageous aspects such as:

1. Different thermal expansion coefficient of the treated layers.
2. Degradation over time.
3. Need for constant maintenance.

Furthermore, the use of certain solvents contributes to environmental pollution. To partially offset these disadvantages, more ecologically, friendly methods have been suggested. Within this framework, bacterial induced carbonate mineralization has been proposed as a novel and environmentally friendly strategy for the protection and remediation of concrete.

1.4. OBJECTIVES

1. To examine the use of bio concrete for the building construction.
2. To investigate the physical and mechanical properties of bio-concrete blocks.
3. To study the efficiency of Bacillus Subtilis bacteria to heal concrete blocks.
4. To study cost comparison in bacterial concrete blocks and conventional concrete blocks.
5. To study the proportionality of bacteria mixed with concrete to achieve the standard mix.

1.5. SCOPE OF STUDY

1. By adopting this method, the durability of concrete can be increased by self-healing the cracks.
2. As we are using organic materials as healing agents, they do not have any adverse effects on environment.
3. Adopting new idea of bacterial healing approach for healing purpose can reduce the cost of repairing as conventional method are costlier.
4. The time required for regular repairing of structure is more as compare to bio concrete. Also, the efforts of labors are reduced by these techniques.

II. LITERATURE REVIEW

Salifu E., Gutteridge F., Wittie K. in year, 2021 revealed attention to microbial biotechnology transitioning towards eco-friendly cementitious technology. It approaches to create low-cost, lowcarbon microbial based products like bio-bricks, bioconcrete, etc.

Yang Wang, Jun feng, Bingcheng Chen in 2021, aimed at formation of noval self-healing concrete consisting of fly ash, quartz sand, Superplastizers, Polyvinyl Alcohol (PVA) fiber. They found the strength recovery of 14% for repeated bending for crack range 0.3mm.

Gupta and Naval, 2020, noted that in humid environment, strength decreases due to penetration of chemical through microcracks in the structure. It is better to repair these cracks at early age stages and for that purpose bio concrete is best alternative. This is because every micro crack in the structure cannot be detected by any other means.

Adam Souid, David Elloitt, 2019, studied how to encapsulate the bacteria. It compares the incubation methods for prepared specimens, I. Soil incubation. II. Water incubation. The results showed that soil incubation is better than water incubation for healing purpose.

Tripathi, Arora and Shrivastava 2017, used bacteria Bacillus cereus. They tested 3 different bacterial concentrations in Portland cement. It was discovered that addition of bacteria significantly increases the strength of concrete.

Khaliq and Ehsan 2015, worked on the process of incorporation of bacteria. The incorporation is done with the carrier compound for bacteria such as Light weight aggregates (LWA) and Graphite Nano platelets (GNP). This incorporation made the inner core bulkier and hence compressive strength increases.

Mion Luo, Qian, Li 2015, studied the factors affecting crack repairing capacity of bacteria. The Bacteria used was Bacillus sphaericus. Effects due to width, availability of microbes, age of crack, etc. were

checked in this study. They found that there is delay in crack healing if width of cracks increases and same for the age of crack. The availability of microbes at the place of damage influences the efficiency of healing.

III. METHODOLOGY

1.Direct method

• Direct Mixing
• Mixing by encapsulation of bacteria with protective membrane

DIRECT METHOD: -

In the direct method, bacterial liquid and calcium lactate are added initially into concrete when mixing of concrete is done. The bacteria and calcium lactate does not change the normal properties of concrete when mixed. When cracks are occurred in the structure due to obvious reasons, the bacteria are exposed to climatic changes. When water encounters this bacterium, they germinate and feed on calcium lactate and produces limestone, and seals the cracks. By encapsulation method, the bacteria, and calcium lactate as food for bacteria, are placed inside treated clay pellets and concrete is prepared. About 6% of the clay pellets are added for making bacterial concrete. For concrete structures made with bacterial concrete, when crack occurs in the structure and clay pellets are broken, the bacteria germinate and consumes the calcium lactate in presence of water, oxygen and carbon dioxide, and produces limestone, which hardens and thus seal the cracks. Minor cracks about 0.8mm width can be treated by using bacterial concrete. Among these two-methods encapsulation method is commonly used, even it is costlier than direct method.

PROCEDURE: -

1. This study employs a systematic literature review and observes how the use of bioconcrete can be adopted for the construction of buildings in the construction industry.
2. First, we will prepare concrete blocks with different proportions of Bacillus bacteria incorporated within it and without it.
3. Then the blocks will be subjected to mechanical loading to form artificial cracks.
4. Then curing will be done and along with that observations will be taken for 7, 14 & 28 days to examine the healing of cracks.
5. The bacteria will precipitate calcium carbonate ($CaCO_3$) by feeding on calcium lactate as food in presence of atmospheric water and carbon dioxide.
6. The percentage healing comparison will be done to find out the most suitable mix proportion which will serve as standard proportion for any work.

EXPERIMENTAL WORK: -

A) MATERIAL REQUIRED FOR PROJECT
(I) Cement.
(II) Graded Fine Aggregate.
(III) Graded Coarse Aggregate.
(IV) Water as per design Ratio.
(V) Bacteria culture.

B) SELECTED BACTERIA FOR THE PROJECT – Bacillus Subtilis

C) PREPERATION OF BACTERIA CULTURE –
1. Preparation of culture of bacteria in Biotechnology laboratory. (3 Days)
2. Preparation of bacteria using culture and nutrient broth by placing in shaker with incubator at 37oC.

D) PREPARATION OF BACTERIAL CONCRETE –

- ❖ BY DIRECT APPLICATION –

  In the direct application method, bacterial solution is added into concrete directly when mixing of concrete is done.

E) CASTING OF CUBES. Size of cube: 150mm x 150mm x150mm
F) CURING OF CUBES.
G) TESTING OF CUBES (AFTER 7 / 14 / 28 DAYS).
H) OBERSERVATIONS FOR PRECIPITATION.
I) INTERPRITATION OF RESULT.

REFERENCES

[1]. Adam Souid, Mohamed Esaker, David Elliott, Omar Hamza, 2019. Experimental data of bio self-healing concrete incubated in saturated natural soil.

[2]. Gopikumar, S., Kiruthika, K., Suriyaprakash, C. R. T., & Vignesh, P. Next Generation Low-Cost Bio Concrete for Sustainable Building.2022

[3]. Gupta, A., & Naval, S. (2020). A Critical Literature on Auto Repair Behavior of Bio Concrete. LIAST [International Journal of Advanced Science and Technology], 29, 2043- 2047.

[4]. Jun Feng, Bingcheng Chen, Weiwei Sun, Yang Wang 2021. Microbial induced calcium carbonate precipitation study using Bacillus Subtilis with application to self-healing concrete preparation and characterization.

[5]. M. Sarkar, N. Alam, B. Chaudhuri, B. Chattopadhyay, S. Mandal, Development of improved e. coli bacterial strain for green and sustainable concrete technology, RSC Advances 5 (41) (2015) 32175–32182.

[6]. Wasim Khaliq, Muhammad Basit Ehsan 2015. Crack healing in concrete using various bio influenced self-healing techniques.

[7]. Mian Luo, Chun-Xiang Qian, Rui-yang Li. (2015) Factors affecting crack repairing capacity of bacteria-based self-healing concrete.

[8]. Peter Adekunle, P., Aigbavboa, C., & Akinradewo, O. Intervention of Biomimicry for Sustainable Construction: The Use of Bio-Concrete. EPPM 2021, 13.

[9]. Saxena, S., & Tembhurkar, A. R. (2022). Optimization of process parameters by Taguchi method for maximizing strength and durability of bio concrete. Innovative Infrastructure Solutions, 7(4), 1-13.

[10]. Salifu, E., Gutteridge, F., & Witte, K. (2021, April). Recent advances in engineered microbial technologies for the construction industry. In Young Researchers' Forum V.

[11]. Tripathi, E., Arora, R. K., & Srivastava, M. (2017). Strength Comparison of Bio-Concrete with Conventional Concrete. International Journal of Advanced Scientific Research and Management, 2(7), 64-70. [12]. T, SAI SANKAR, K. MUNI SWAMY, "BIO CONCRETE" 2017 IJCRT | Volume 5, Issue 4 November 2017 | ISSN: 2320-2882, 1-3.

[12]. Y. Su, J. Feng, Q. Zhan, Y. Zhang, C. Qian, Non-ureolytic microbial self-repairing concrete for low temperature environment, Smart Material Structures 28 (2019) 12 pp