

Repairing the Cracks on Concrete Surfaces Using Bio Concrete: A Review

R. Saranya^[1], N.N. Ezhilarasan^[2], N. Ezhil Maran^[3]

^[1] Assistant Professor, Department of Civil Engineering,

^{[2],[3]} UG Scholar, Department of Civil Engineering,

M.KUMARASAMY COLLEGE OF ENGINEERING, KARUR.

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Abstract:

The formation of crack was formed by different phenomenon in a concrete structure. The crack formation decreases the strength and durability of concrete.^[4] To restoration the cracks occurred in concrete surface, the cost for repairing and maintenance was too high. To overcome this, the self-healing mechanism introduced in the concrete. In the self-healing mechanism, the healing was done by using bacteria known as bacillus subtilis and the calcium lactate powder. The combination of bacteria and calcium lactate forms the white precipitate which is known as limestone.^[7] The bacteria introducing into the concrete increase the strength and durability of concrete. The limestone was formed by the chemical reaction of calcium lactate, water, CO₂ and other chemicals. This type of concrete used in the real time application is eco-friendly to environment.^[6] The bacteria which introduced in the concrete property of alkali resistance and it can withstand the stresses produce in the concrete. This highly desirable because the process of crack remediation is natural. It reduces the water absorption and water permeability compared to normal concrete. In this concrete the corrosion resistance was high.^[8] Crack repairing bio concrete is best than epoxy treatment. Bacteria increases the conventional concrete's resilience, water porosity, sturdiness and compressive strength.

Keywords: *Bacillus subtilis, concrete, Self-healing, Calcium lactate, compressive strength.*

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1. INTRODUCTION:

A crack is the important cause for the weakness of building. The larger crack can affect the structure. But the smaller cracks which is in size of 0.2mm^[2] width is a little problem, which does not cause a major damage in structure. The water droplet that can enter the damage in concrete structure. Normally the concrete has the high compressive strength and load bearing capacity.^[9] Due to the water penetration, the concrete loses its strength and durability to overcome this, the synthetic material like epoxy acquire. But this is costly and not compatible, it needs regular maintenance.^[17] So, the remedy for that, the biological approach was done in concrete. The bacteria are mixed with calcium

carbonate by making pellets. These pellets were mixed with concrete. So, when the water interacts with the pellets, the white precipitation called limestone formed on concrete surfaces and heal the crack.^[7] This bacterium inserted concrete has a life span about 200 years.^[3] Also, the bacteria induced concrete has high compressive strength. Normally, the production cement-based materials cause 10% of CO₂ emissions in environment. It can be overcome by introducing the bio-concrete. This concrete is really become the major need for construction.^[14] Because concrete is the major material for construction. So, the cracks appeared on the concrete is very dangerous for the building (or) any super structure.

2. MECHANISM OF BACTERIAL CONCRETE

Concrete self-restoration is the result of the biological reaction of unreacted calcium and a primarily dependent calcium nutrient with the aid of bacteria to repair the cracks considered at the foundation. Alongside calcium nutrient also called as calcium lactate, different forms of bacteria called *Bacillus* are used.^[20] This merchandise is added within the wet concrete when the installation is complete and the concrete is being taught. This microorganism could be about 200 years in dormant degree. If the cracks emerge inside the concrete, inside the cracks the water can seep. The bacteria spore germinates and begins feeding on the oxygen-eating calcium lactate.^[1] The soluble lactate of calcium is transformed to an insoluble chalk. Starting to harden, the insoluble limestone evolved. Filling the gap, then, regularly without any external support.

In bio concrete, the crack was repaired by self-healing mechanism. There are two types of self-healing mechanism;

- Autogenous self-healing.^[5]
- Autonomous self-healing.^[5]

2.1AUTOGENOUS SELF HEALING

It is natural process normally the cement-based material has the capability of self-healing in oncrete surfaces, by itself, this is called autogenous self-healing. In this mechanism, it enables the micro cracks of concrete to be healed. Widely within these mixtures of 15-25% is United Nations hydrous.^[8] Because of this, it higher the greater than the solid cementitious materials and lesser than the liquid cementitious materials. Due to this, the cracks are occurred on concrete. At that point the cement primarily based materials is glowd to wetness inside the crack. By this the atomic number 1 method is stirred and process once more. From this the atomic number 1 product heal the cracks by exchange the gap in cracks.

2.2 AUTONOMOUS SELF HEALING:

It is an artificial process. When the cracks are occurred on concrete surfaces, it can be healed by the process of encapsulation is known as autonomous self-healing.^[17] In this process, the capsules which are in combination of the chemical substances.

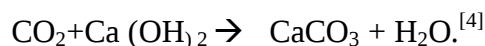
While the cracks are occurred on concrete surface, the capsules which are encapsulated will breaks and the chemicals are released and interact to the surface cracks and filled the voids spaces and through a chemical reaction the surface bond together.

Mostly, the autonomous self-healing method is used in fields. In the fields. In this the substances that added on the capsules for encapsulation is bacteria, which is called *bacillus subtilis*. The bacteria have capability to perform as a self-healing agent for a longer life span with high compressive strength in concrete.^[2] The bacteria act as a stimulator and transfer an ignition compound to corresponding cracks. The compound calcium carbonate which is produced as a new compound is added to a bacterium for encapsulation. From this, it acts as bio-cement which healed the cracks newly formed. The chemical reaction of the calcium lactates to be followed as;

In this the carbonation reaction takes place by the product of calcium carbonate.

Carbonation is a process of penetration of air into concrete through pores by the carbon dioxide.

In this the carbon dioxide reacts to the calcium hydroxide forming with the hydration substance.



Hydration is a chemical reaction which is used to hardening the concrete by bonding the cement-based material with water molecule to become hydration products. Then the calcium carbonate is produced by *Bacillus subtilis* which performs as an ignition compound. Due to that nutrient was produced was

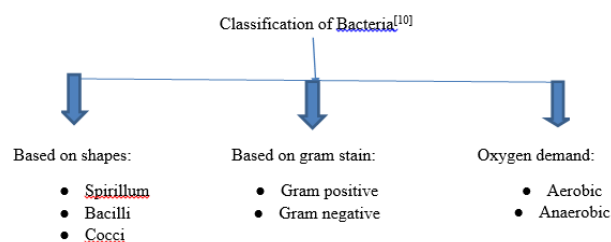
produced in the concrete by the bacteria acts as a catalyst.



3. MATERIALS:

3.1 BACTERIA:

Bacteria are single celled living organisms. These are classified based on their special feature like shape, gram stain and oxygen demand.



The list of bacterias suitable for the crack healing agent and surface treating agent is given below in the table

S.no	Applications	Types of bacteria
1.	CRACK HEALING AGENT ^[10]	B.pasteurii
		Deleya halophila
		Halomona sruihalina
		Myxococcus xanthus
		B.megaterium
2.	SURFACE TREATING AGENT ^[10]	B.sphaericus

3.1.1 GROWTH CONDITIONS/CULTURE OF BACTERIA

Many kinds of bacterial culturing method are applicable in field. It is cultured based on characteristics & feature.^[16]

- Culture by broth.
- Agar plates.
- Stab cultures.
- Culture collections.
- Solid plate subculture of thermophile microorganisms.
- Isolation of pure cultures.

a) CULTURE BY BROTH

It is cultured in liquid medium with help of broth. Broth is a type of flask used to preserve the micro-

organism and some efficient nutrients. Which are in liquid stage.^[6]

In that flask, the nutrients are grown into a bigger than that of their normal growth.

This culture is done by an instrument to check their growth in appropriate conditions. Also, with this instrument, the duration of growth of bacteria is maximum one day.

b) AGAR PLATES

Microbiological cultures can be developed in petri dishes of contrasting sizes that have a slight layer of agar-based development medium.^[12] When the growth medium in the petri dish is immunized with the ideal microscopic organisms, the plates are incubated at the ideal temperature for the developing

of the chosen microbes. After the ideal degree of development is accomplished, agar plates can be stored in a cooler for extended period time frame to save microscopic organisms for future tests. There are so many additives can be added to agar before it is filled a plate and permitted to harden.^[19] A few kinds of microscopic organisms can just develop within the sight of specific added substances. This can likewise be utilized when making built strains of microorganisms that contain an anti-toxin resistance quality. At the point when the selective anti-biotic is added to the agar, just bacterial cells containing the gene supplement presenting resistance will have the option to develop.^[8] This permits researchers to choose just the settlements that were effectively changed.

c) STAB CULTURES:

These type of stab cultures are also like the agar plates, however this method is framed by solid agar in a test tube. Microorganisms is presented by means of an immunization needle or a pipette tip being wounded into the focal point of the agar.^[20] Microscopic organisms develop in the punctured area. Stab cultures are most generally utilized for short term storage.

d) CULTURE COLLECTION

Microbial culture collection mainly focus around the procurement, verification, creation, safeguarding, catalogueing and conveyance of suitable cultures of standard reference microorganisms, cell lines and different materials for examine in microbial systematics. Culture collection are additionally archives of type strains.

e) SOLID PLATE SUB-CULTURE OF THERMOPHILE MICROORGANISMS.

Microorganism Example for this method is *Bacillus acidocaldarius*, *Bacillus stearothermophilus*, *Thermus aquaticus* and *Thermus thermophilus* and so on, developing at temperatures of 50 to 70 degrees^[9] C, low acyl clarifies gellan gum has been

demonstrated to be the favored gelling agent contrasting with agar for the confinement or both of the above thermophilic microbes.

f) ISOLATION OF PURE CULTURES.

Creating Pure culture procedures is urgent to the perception of the example being referred to. The most well-known strategy to segregate singular cells and produce an pure culture is to set up a streak plate.^[10] The streak plate technique is an approach to genuinely isolate the microbial population, and is finished by spreading the immunize to and fro with a vaccinating circle over the solid agar plate.^[12] Upon hatching, states will emerge and single cells will have been confined from the biomass. When a microorganism has been disconnected in pure culture, it is important to safeguard it in reasonable satisfy for additional examination and use. Stock cultures must be kept up, with the end goal that there is no loss of their organic, immunological and social characters.

3.2 CALCIUM LACTATE:

Calcium lactate is salt that be made up of of 2 lactate anions for every metal ion (Ca^{2+}).^[10] it's ready commercially by the neutralization of carboxylic acid with carbonate (or) calcium hydrate. It is additionally offered in numerous hydrate forms, wherever salt pentahydrate is that the most typical. The main purpose of the calcium lactate is nutrients for bacteria development.

4. MAKING OF BIO CONCRETE

Bio concrete is formed via two methods. In one method, the bacteria are directly introduced in concrete. With the help of micro-organism and nutrient do not change the normal features of concrete. Bacteria while the water contacts with bacteria; it grows and supply the energy to nutrients to produce limestone. In another method, the calcium lactate powder is mixed with bacteria to make pellets. In this minimum 5% of pellets should be embedded into concrete.^[18] When crack occurred in surface these capsules are cracked and helps to grow

the bacteria and digest the nutrients make limestone. Which gets hard and simultaneously seal the crack. Small crack which is in 0.5 mm.^[12] Among those two techniques encapsulation technique is generally used, although it's dearer than direct application.

5. APPLICATIONS OF BACTERIA IN CONSTRUCTION FIELD

When a concrete shape cracks, water seeps into its crevices and corrodes the steel reinforcements conserving up the structure. Once the corrosion is terrible sufficient, the structure can fall apart. Imagine a crumbling concrete constructing or bridge this is able to patch itself lower back up with none help from human hands.^[20]

The drugs containing the micro-organism, as soon as penetrated by means of water, open and release the micro-organism to germinate, grow and feedstuff at the lactate. The micro-organism also combines with the calcium to shape calcite, or limestone, and ends up the cracks.

This idea of self-recuperation concrete remains a factor of the future for commercial and residential homes due to the manufacturing price. However, this concrete is presently being looked at for use in building underground bins for risky waste. As this generation continues to expand within the future, the self-restoration concrete could^[13] make a large impact on the development industry, as well as the surroundings

ADVANTAGES^[8]

- It used to seal the crack
- Increases the compressive strength in concrete
- It resists against freeze thaw.
- Less permeability in concrete.
- Reduced corrosion in reinforced concrete.

DISADVANTAGES^[8]

- It is economically higher than the conventional concrete
- Germination of bacteria is not stable is all medium.
- The Nutrients are high expensive to prepare

- Lack of skilled labours.

6. CONCLUSION:

It clearly shows in this paper that bio-concrete is not harmful to our climate. Also, it is clearly understood from this paper that concrete improves compressive power, workability and durability. The bacteria and calcium lactate self-healing process were elaborately explained. The reduction of CO₂ emissions in the products dependent on cement is confirmed. The holes, whose sizes are in zero,^[1] are recovered according to the examination and research of various authors. Compared with normal concrete it is highly durable. Bringing the microscopic species into the solid makes it beneficial to improve the solid's property that is more than the normal cement. Numerous scientists have accomplished their research on self-recovering existence of cement and have discovered the subsequent result that microbes boost the value of ordinary cement, such as a 13.67% improvement in quality extended in 3 days, 14.20% in 7 days and 18.33% in 28 days.^[15] The enhancement of precious stone calcium carbonate reduces water porousness by reducing the break width from 0.5 mm to 0.35 mm.^[15] Compressive consistency increased by 30,74 percent in 3 days, by 44,15 percent in 7 days and by 30,21 percent in 28 days,^[9] and in scientific modular it was found that the bacterial solid showed better anxiety estimation when compared with managed cement for high quality cement evaluation. Due to the use of self-recovery material used in the solid, the regular analysis for the solid would be less required. Evaluated splits recovering solid limit containing LWA (light weight total) Encapsulation self-mending operator. They see that the split width was below 0.46 mm^[13] for examples based on microscopic species. From the hair-like water suction test it was discovered that the bacterial solid displays the lower estimates of relative fine file as a contrast to the exolytic blended material, and from the gas penetrability tests it was discovered that the

porousness decreases in bacterial concrete as a contrast to the ordinary cement.

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