# A REVIEW ON "BACTERIAL CONCRETE"

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**ABSTRACT:**
Concrete is a construction material that is used world-wide because of its first-rate properties. However, the drawback of this material is that it easily cracks due to its low tensile strength. We all are well aware of the fact that concrete structures are very sensitive to cracking and due to this chemicals and water enters in the concrete and degrade the concrete , and due to this performance of the structures gets reduced and it requires high maintenance cost in the form of repairs. In this report, the following notable points regarding effect of bacteria on compressive strength of concrete, self-healing of cracks in concrete, chemical process for crack remediation, self-healing mechanism of bacteria, application of bacteria in construction field, Advantages and disadvantages of bacterial concrete etc., are observed and identified from the other research works. Cracking in the surface layer of concrete mainly reduces its durability, since cracks are responsible for the transport of liquids and gases that could potentially contain hazardous substances. On the other side the concrete structures have some self healing capacity ,i.e. the ability of a concrete to heal the micro-cracks on it's own. When micro-cracks growth reaches the reinforcement, not only the concrete itself may be damaged, but also corrosion occurs in the reinforcement due to exposure to water and oxygen, and possibly CO2 and chlorides too. Self-healing of concrete can be done by many ways such as application of specific calcite precipitating bacteria for concrete repair, usage of synthetic polymers such as epoxy treatment, bio-mineralization of bacteria in concrete etc.

**Keywords:** crack remediation, self-healing, bacillus subtilis.

## 1.INTRODUCTION:

Now a days concrete is the most widely used construction material because of its huge requirement in the construction areas. Cracks in concrete is one of the undesirable property of concrete. Based on the continuous research carried out around the globe, various modifications have been made from time to time to overcome the deficiencies of cement concrete because bacterial concrete is a material, which can successfully heal the cracks in concrete. The running researches in the area of concrete technology has led to improvement of expressly concretes considering the speed of construction, the potency of concrete, the permanency of concrete & the environmental friendliness with the use of factories material like fly ash, silica fume, etc. self-healing concrete repairs itself by biologically producing limestone to heal cracks that appear on the surface of concrete structures, it is also called bio-concrete. The bacterial concrete can be made by adding bacteria in the concrete that are able to constantly precipitate calcite. This phenomenon is called microbiologically induced calcite precipitation. *Bacillus subtilis*, which can successfully heal cracks in concrete. But, the costs of the technology are still quite high. Calcite formation by *bacillus subtilis* is a laboratory bacterium, which can produce calcite which precipitates on allowable media supplemented with a calcium source. A common soil bacterium, *bacillus subtilis jc3*, is used to induce $CaCO_3$ precipitation. The required conditions do not directly present in the concrete. The main part of the work is to focus on how the correct conditions can be made for the bacteria not only for living in the concrete but to create as much calcite as necessary to repair cracks.

### 1.1 *Bacillus Subtilis:*

*Bacillus Subtilis*, known also as the hay bacillus or grass bacillus, found in soil and gastrointestinal tract of humans. A member of the genus *Bacillus*, *Bacillus subtilis* is a rod-shaped, and form a tough, productive endospore, allowing it to tolerate extreme environmental conditions. It is considered the beststudied gram positive bacterium and a model organism to study bacterial chromosome replication and cell differentiation.

### 1.2 Self-Healing Of Concrete:

In self-healing concrete crack formation is senses by a concrete and the reactions takes place so as to cure itself without any human help. Limestone is produced in the Bacterial concrete and this helps to heal the cracks which appear on the surface of the structures. Specially selected types of the bacteria *Bacillus Subtilis*, is added to the ingredients of the concrete when it is being mixed. This bacteria can lie nescient within the concrete for up to 200 years.

### 1.3 Classification of bacteria:

Table no.1:classification of bacteria

| Type of bacteria | Application | Metabolism |
|---|---|---|
| Bacillus cereus | Biological morter | Oxidative deamination of amino acids |
| Bacillus subtilis | Crack in concrete remediation | Hydrolysis of urea |
| Bacillus sphaericus | Crack in concrete remediation, for surface treatment | Hydrolysis of urea |
| Bacillus subtilis | Bacterial concrete | Hydrolysis of urea |
| Bacillus subtilis | Bacterial concrete | Oxidative deamination of amino acids |
| Bacillus pasteurii | Crack healer in concrete | Crack healer in concrete |

## 2.Review of literature:

**Li-li Kan(2010)[1]**has been studied that, Crack characteristics of M45-ECC and HFA-ECC specimens pre-loaded to strain levels of 0.3%, 0.5%, 1.0% and 2.0% were investigated in this paper. This was done at different ages, resonant frequency and mechanical recovery behavior of re-healed ECC materials, new crack paths after reloading and the chemical analysis of healing products.The self-healing behavior of high tensile ductility M45-ECC and HFA-ECC have been investigated in this paper. The crack characteristics of different ages ECC materials at 0.3%, 0.5%, 1.0% and 2.0% pre-loading were studied.

**Soundharya and Dr.K.Nirmalkumar(july2014)[2]**have studied that, Concrete is a construction material that is used world-wide because of its first-rate properties. However, the drawback of this material is that it easily cracks due to its low tensile strength. It is a well-known fact that concrete structures are very susceptible to cracking which allows chemicals and water to enter and degrade the concrete, reducing the performance of the structure and also requires expensive maintenance in the form of repairs. Due to its eco-friendly nature, self-healing abilities and increase in durability of many building materials, the bacterial concrete is found to be more advantageous than that of the conventional concrete.

**Anestraj.S(April2015)[3]***et al* have studied that, the present investigation is to obtain the performance of the concrete by the microbiologically induced special growth. One such has led to the development of a very special concrete known as bacterial concrete where bacteria is induced in the mortars and concrete to heal up the faults. Researchers with different bacteria proposed different concretes. Here an attempt was made by using the bacteria *"Bacillus subtilis* strain no jc3". This study showed a significant increase in the compressive strength due to the addition of bacteria. When 30 ml of *"Bacillus Subtilis"* is added in M20 grade concrete it attains maximum compressive strength. In concrete selfhealing property is successfully achieved due to addition of bacteria. *Bacillus subtilis* can be produced in the laboratory is to be safe and cost effective.The compressive strength is 33.32 MPa , that is maximum ,when the addition of *bacillus subtilis* bacteria is 30 ml.The M20 grade bacterial concrete having higher compressive strength then the normal M25grade concrete

**SalmabanuLuhar(2015)[4]***et al*. Have studied that, Crack formation is very common phenomenon in concrete structure which allows the water and different type of chemical into the concrete through the cracks and decreases their durability, strength and which also affect the reinforcement when it comes in contact with water, CO2 and other chemicals. For repairing the cracks developed in the concrete, it requires regular maintenance and special type of treatment which will be very expansive. So, to overcome from this problem autonomous self-healing mechanism is introduced in the concrete which helps to repair the cracks by producing calcium carbonate crystals which block the micro cracks and pores in the concrete. Introducing the bacteria into the concrete makes it very beneficial it improves the property of the concrete which is more than the conventional concrete. Bacteria repair the cracks in concrete by producing the calcium carbonate crystal which block the cracks and repair it.

**Wasim K. and Muhammad B.(2015)[5]**has been studied that, Crack formation and progression under tensile stress is a major weakness of concrete. These cracks also make concrete vulnerable to deleterious environment due to ingress of harmful compounds. Crack healing in concrete can be helpful in mitigation of development and

propagation of cracks in concrete. This paper presents the process of crack healing phenomenon in concrete by microbial activity of bacteria, *Bacillus subtilis*. Bacteria were introduced in concrete by direct incorporation, and thorough various carrier compounds namely light weight aggregate and graphite nano platelets. Specimens incorporated with graphite nanoplatelets (GNP) as carrier compound displayed uniform distribution and protection of bacteria at samples pre-cracked at early age of 3 and7 days, resulting in maximum crack healing efficiency.
**Mian Luo(2016)[6],** has been studied that, Bacterially induced calcium carbonate precipitation has been proposed as an alternative and environmental technique to develop self-healing cementitious materials system in recent years. This study investigated the influences of bacteria-based self-healing agents on the rheology, hydration kinetics and compressive strength of cementitious materials to further verify the feasibility of bacteria-based selfhealing agents for crack repairing. The results showed that the rheology of cement mortar was significantly improved by the addition of bacteria-based self-healing agents. The study investigated the influences of bacteria-based self-healing agents on the rheology, hydration kinetics and compressive strength of cementitious materials to further verify the feasibility of bacteria-based self-healing agents for crack repairing. Based on the present experimental investigation, the following conclusions are drawn.
**PAWAR B(Nov2016)[7].***et al* have studied that , When the loads is applied on any structures cracks inconcrete are formed which allow water and other chemicals toenter thus making it vulnerable which leads to unwanted corrosion of the steel reinforcement and deterioration of concrete structure. For these project we use M25 grade of concrete because of its superior properties. As mentioned above in cases like this where there is a formation of cracks there is an acute need of Self-healing concrete to achieve this weadded *bacillus subtillus* which is a gram positive bacterium to the mixture.
Enhancement of compression strength, reduction in permeability, water absorption reinforced corrosion have been seen in various cementitious and stone materials.

**Abhishek T.(2017)[8],***et al* have studied that, The concrete structures have various durability issues due to the different physiological conditions and it results to irretrievable damage to the structure and eventually reduction in the strength of concrete structure. The main reason behind the downgrading of the durability and mechanical aspects of concrete is the pore structure of concrete. In the recent years MICCP (microbiologically induced calcium carbonate precipitation) by the bacteria considered as anenvironment friendly method to enhance the properties of concrete, also for the repair of concrete structure and to consolidate different construction materials. Currently, the designing of bacterial concrete is the most popular research topic for the researchers. Till now it has been found that the use of bacterial concrete can enhance the durability, mechanical and permeation aspects of concrete.

**Applications**
1. Enhancement in durability of cementious materials to improvement in sand properties
2. Repair of limestone monuments
3. Sealing of concrete cracks
4. Used in construction of low cost durable housing
5. Used in construction of low cost durable roads
6. Helpful in green roofing

**Advantages**
1. Cracks remediation can be done effectively using bacterial concrete.
2. Significant enhancement in the strength of concrete and mortar can be seen using bacteria.
3. As entry of gases and liquids sealed inside concrete the chances of corrosion in reinforcement are reduce.
4. Better Resistance towards Freeze – Thaw action.
5. Reduction in Permeability of concrete.

**Disadvantages**
1. Growth of bacteria is not good in any atmosphere and media.
2. There is no available IS Code or other code for the design of Bacterial concrete.
3. Initial cost of bacterial concrete is more than conventional and the investigations involved in calcite precipitation are costly.

**Conclusion:**

Based on the present experimental investigation the following conclusion is drawn.

- We can produced *Bacillus subtilis* in the laboratory is to be very safe and cost effective.
- Bacterial concrete technology has proved to be better than many conventional technologies, because of its eco-friendly nature and very convenient for usage.
- This innovative concrete technology will soon proved the basis for an alternative and high quality structures that will be cost effective and environmentally safe.
- The application of bacterial concrete to construction may also simplify some of the already constructed structure and innovative ways of new construction process.
- By doing this, it prevent water to percolate into reinforced steel concrete and hence it does not comes in contact with reinforcements.

**Summary**

The aim of this paper is to give introduction about bacteria-based bacterial concrete, currently developed in the laboratory. To the concrete mixture the bacteria(healing agent) is added, consisting of two components immobilized in expanded clay particles. Due to bacteria present in a concrete, a layer of calcium is deposited on the crack surfaces and due to this layer , deteriorating substances can not entre in the concrete. More research and development should be done so as to make the material ready for it's more applications in the actual practice. Currently available system can be limited in the field of applications. When substantial quantity of light weight aggregates are added then it affects the material properties , can also impose economic restraints. Since potential advantages are mainly anticipated in reduction of costs for maintenance and repair and service life extension of concrete structures, the self-healing material needs to be cost efficient and durable.

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