

Bio-Concrete: The Future of Concrete Science

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Publishing Date: September 07, 2018

Abstract

In modern construction era, concrete has become a very important construction material and also with the name concrete, it is a very well-known fact that the structures made with concrete are very prone to cracking due to a number of reasons, which allows moisture and other chemicals to enter the concrete surface leading to degradation, reducing the performance of structure, which sometimes even requires a very expensive repairing cost. As cracking in concrete mainly affects the durability, as these cracks are generally responsible for the movement of liquid and gaseous substances through the surface probably containing the deleterious substances and with the timely growth of these cracks, they not only damages the concrete but also leads to the exposure of moisture and oxygen, sometimes chlorides and carbon dioxide as well to the reinforcement of the structure causing corrosion, such micro cracks are most important factor responsible for the failure of structures, So overcome these issues, a new mechanism of self-healing is introduced by adding bacteria in the concrete. Currently at most places synthetic polymers such as epoxy treatment are used for repairing the concrete but on the other sides such epoxy treatments are very harmful to the environment. That's why the use of such biological repairing technique in concrete is focused. The remedy of such disappointing issues created because of breaks and crevices, an approach of using bio mineralization or adding bacteria to the concrete comes into the place lately. In this technique of improving the properties of concrete, the calcite encouraging spore shaping microscopic organisms are brought into concrete and when moisture enters the crack, it initially responds with the added bacteria causing the structure encouraging calcium carbonate, as a result, which fills the splits and makes the surface split free concrete. An overview of development of bioengineered concrete using bacterial strain *Bacillus subtilis* JC3 are studied in this paper.

Keywords: *Bacterial concrete, bacillus subtilis, self-healing, bio mineralization.*

Introduction

Bioengineered concrete or bacterial concrete when comes in touch with water, due to its self-repairing properties biologically produces calcium carbonate crystals to seal those cracks appeared on the surface of the concrete structures due to various

reasons. In such specific spore forming alkali philic bacteria genus *Bacillus* supplied with a calcium-based nutrient are absorbed in to the concrete mixture suspended in mixing water. It is also believed that such bacteria based self healing agents remains in the concrete structures for a long duration of time i.e. upto 200 years. When Cracking in concrete structures happens and due to the appeared cracks water enters the concrete, When contacting with water and oxygen the spores of the bacteria starts its bacterial activity of precipitating calcite crystals through nitrogen cycle due to which the soluble nutrients are converted to insoluble CaCO_3 , as a result CaCO_3 repairs the crack by solidifying itself resulting in a split free concrete surface(Kadian,A.2018).

Literature Review

The Writing accessible uncovers that microbes can be utilized to upgrade the execution of the solid. The idea of bacterial cement was first presented by V Ramakrishnan, a novel procedure in remediating cracks in concrete by using microbiologically prompted calcite (CaCO_3) precipitation. The pioneering work on repairing concrete with microbiologically prompted calcite precipitation (MICP) is accounted for by the exploration gathering of Ramakrishnan V. what's more, others at the South Dakota School of Mines and Innovation, USA.

Sakina Najmudd in Saifee et .all distributed a paper on Basic evaluation on Bacterial Cement. In this paper they talked about the diverse kinds of microbes and their applications. The bacterial cement is particularly helpful in expanding the durability of cementous materials, repair of limestone landmarks, fixing of solid splits to exceedingly strong breaks etc. It additionally valuable for development of ease sturdy streets , high strength structures with all the more bearing limit, disintegration anticipation of free sands and minimal effort tough houses. They have additionally advised about the working rule of

bacterial concrete as a repair material. It was likewise seen in the examination that the metabolic exercises in the bacteria's occurring inside the solid outcomes into expanding the general execution of cement including its compressive strength. This examination likewise discloses the synthetic procedure to remediate breaks.

Meera C M and Dr Subha V, have distributed a paper on Strength And Durability evaluation Of Microscopic organisms Based Self-Recuperating Concrete. In this paper they have talked about the impact of Bacillus subtiles JC3 on the strength and durability of cement. They utilized 3D shapes of sizes 150mm x 150mm x 150mm and chambers with a measurement of 100mm and a tallness of 200mm with and without expansion of smaller scale living beings, of M20 review concrete. For strength appraisals, solid shapes were tried for various bacterial fixations at 7 days and 28 days and chambers were tried for part elasticity at 28 days. It was watched that the compressive strength of cement indicated critical increment by 42% for cell grouping of 105 of blending water. And furthermore, with the expansion of microscopic organisms there is a critical increment in the rigidity by 63% for a bacteria's grouping of 105cells/ml at 28 days. For durability appraisal, acid durability test, chloride test and water assimilation test were finished. From the outcomes it could be deduced that the expansion of microscopic organisms keeps the loss in weight amid acid presentation to a specific point of confinement, demonstrating the bacterial cement to have higher Acid Attack Factor. The Water Retention Test, demonstrated a lesser increment in weight of microscopic organisms solid specimen than control, from which it could be figured that the solid will turn out to be less permeable because of the development of Calcium Carbonate, because of which it brought about lesser water assimilation rate. Chloride test comes about demonstrated that the expansion of bacteria's diminishes weight reduction, because of Chloride introduction and upgrades the Compressive Strength.

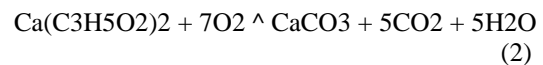
Working of Bio-Engineered Concrete as a Repair Material

Bio-Engineered concrete delivers calcium carbonate crystals to fix the cracks appeared on the surface of concrete structure. Uniquely choosing various kinds of microscopic organisms such as bacillus, alongside calcium based supplement known as calcium lactate and nitrogen and

phosphorous are added to the elements of the solid when it is being mixed. As, when a solid structure is harmed and cracks appears on the surface leading the water to move through the cracks that show up in the solid, the spores of the microscopic organisms, sprout on contact with water and supplements, Having been enacted, the bacteria's begin to feast upon the calcium lactate. As the bacteria's sustains oxygen is devoured and the dissolvable calcium lactate is changed over to insoluble calcium carbonate which hardens on the cracked surface fixing it up. On the surface of control solid, Calcium Carbonate will be shaped because of the response of CO₂ giving Calcium Hydroxide showing in the solid grid as per the accompanying response:



As Ca(OH)₂ is a solvent mineral, it gets broke down in entering water and diffuse out of the break through filtering. The self-mending process in microscopic organisms fused concrete is significantly more productive because of the dynamic metabolic change of Calcium supplements by the bacteria's show in concrete:



Here Calcium Carbonate is created straightforwardly because of microbial metabolic process and further more in a roundabout way due to autogeneous mending. This procedure brings about proficient microscopic organisms based break fixing component. (Kadian, A. 2018)

Self-Healing Mechanism Using Bacteria

The bacteria used for making bio-concrete must have a long-term effective crack fixing mechanism throughout its lifetime serviceability. The main objective after bacterial crack repairing or fixing mechanism is that the bacteria or microorganisms used should be able to convert soluble organic nutrients into insoluble inorganic calcite crystals which as a result seal the cracks. For effective healing mechanism, it must be taken care of that both bacteria and nutrients into concrete should not disturb the overall integrity of cement sand matrix and also not affecting other important fresh and hardened properties of concrete. Only spore-forming gram positive strain bacteria can survive in high pH environment of concrete sustaining various stresses. It is also observed that when bacteria is directly added to the concrete mixture in suspension, their life-span is mainly affected due to

the reasons that the continuation of cement hydration results in reduction of cement sand matrix pore –diameter and secondly due to insufficient nutrients available to precipitate calcite crystals.

Traditional Concrete Repairing Methods

Traditionally repairing of cracks in concrete of any structure involves application of concrete mortar over the damaged surface. Sometimes, the mortar is keyed into the damaged surface of the structure with metal pins to prevent it from falling off. such repairs are time consuming and expensive as well and also it often becomes very difficult to access some parts of the structure to get the job done such as cases in which the repairing is to be done underground or at great heights in a tall building. For crack repairing a number of techniques are available but due to reasons such as unavailability of skilled labour etc. this traditional way of repairing is adopted but there are a number of disadvantages as well such as different thermal expansion coefficient compared to concrete and also have impact on environment and health. Therefore, bio based calcite precipitation has been proposed as an alternative and sustainable environmental friendly crack repair technique.

Conclusions

This study examined various effects of different losses i.e. in the form of cracks and cavities that occurs with time in a concrete structure due to a number of climatic and other reasons which can be self cured with the help of bio-engineered concrete, as microorganisms used in bio-engineered concrete repairs itself with its self-healing characteristics such as sealing of cracks by the formation of calcium carbonate. However, further studies on bio-engineered concrete should be undertaken with the aim of adopting bio-engineered concrete technology for future.

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