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A STUDY OF PERFORMANCE OF BACILLUS SPHAERICUS ON CONCRETE CRACKS

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Abstract: Cracking in concrete is a very common phenomenon and irreversible process. Concrete in most structures is designed to crack in order to let embedded steel reinforcement take over tensile stresses. Concrete are the most important materials used in construction industries where the external forces more than the design loads mainly the lateral forces which leads to the deformation and produce cracks in the joints of the structural member. In recent years a bacteria-based self-healing concrete is being developed in order to extend the service life. So therefore we are going to find eco-friendly solution for repairing cracks using bacillus sphaericus non-pathogenic bacteria. This paper deals with the study of the different kinds of bacteria which are used in the bio-concrete and their effect on the strength parameters of the concrete like compressive strength and water absorption under the influence of the factors like bacterial cell concentration at different temperatures is explicitly studied.[2]

Keywords: Bacterial concrete, Crack filling, Concrete cubes, Self-healing agent

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INTRODUCTION

Concrete is mixture of cement, water, aggregate and admixtures. Sometimes admixtures are added to modify the properties. It is a composite material composed of fine and coarse aggregate bonded together with a cement paste that helps to harden it over time. Concrete has relatively high compressive strength, but it has much lower tensile strength. Concrete has a very low coefficient of thermal expansion and shrinks as it matures. Due to shrinkage and tension, the cracks are develops in all concrete structure to some extent.

a) Different types of the concrete are below

Normal-strength concrete, Light-weight concrete, Air entrained concrete, High-Strength concrete, High performance concrete, Self-consolidated concrete, Shotcrete, Pervious concrete

b) How we can used bacillus bacteria in the concrete:

Self-healing concrete is a result of biological reaction of non-reacted limestone and a calcium based nutrient with the help of bacteria to heal the cracks appeared on the building. Special type of bacteria's known as Bacillus are used along with calcium nutrient known as Calcium Lactate**.** While preparation of concrete, this products are added in the wet concrete when the mixing is done. This bacterias can be in dormant stage for around 200 years. When the cracks appear in the concrete, the water seeps in the cracks. The spores of the bacteria germinate and starts feeding on the calcium lactate consuming oxygen. The soluble calcium lactate is converted to insoluble limestone. The insoluble limestone starts to harden. Thus filling the crack, automatically without any external aide (*N. De Belie et al 2009).*

The other advantage of this process is, as the oxygen is consumed by the bacteria to convert calcium into limestone, it helps in the prevention of corrosion of steel due to cracks. This improves the durability of steel reinforced concrete construction.(*N. De Belie et al 2009)*

c) Cost the bacteria using in the concrete:

The rate of bacteria is Rs.1200-1500/liter.

Cracks in concrete are inescapable and are one of the inherenct weakness of concrete. Water and other salts seep through these cracks in concrete, then the corrosion initiates and this effect the life of concrete or it reduces the life of concrete. Due to the negative side-effects of some of the customary techniques, bacterial induced carbonate mineralization has been proposed as a novel and environmental friendly strategy for the protection of stone and mortar. Bacterial concrete is a material, which can successfully rectify cracks in concrete. As the mineral precipitation ($CaCO_3$) produced as a result of microbial activities is pollution free and natural, this technique is highly beneficial. As the cell wall of bacteria is anionic, metal accumulation (calcite) on the surface of the wall is substantial, thus the entire cell becomes crystalline and they eventually plug the pores and cracks in concrete. The technique can be used to improve the compressive strength and stiffness of cracked concrete specimens. .(*N. De Belie et al 2009)*

In concrete, cracking is a common phenomenon due to the relatively low tensile strength. High tensile stresses can result from external loads, imposed deformations (due to temperature gradients, confined shrinkage, and differential settlement), plastic shrinkage, plastic settlement, and expansive reactions (e.g. due to reinforcement corrosion, alkali silica reaction, sulphate attack). .(*N. De Belie et al 2009)*Without immediate and proper treatment, cracks tend to expand further and eventually require costly repair. .(*N. De Belie et al 2009)* Durability of concrete is also impaired by these cracks, since they provide an easy path for the transport of liquids and gas that potentially contain harmful substances. .(*N. De Belie et al 2009)* If micro-cracks grow and reach the reinforcement, not only the concrete itself may be attacked, but also the reinforcement will be corroded when it is exposed to water and oxygen, and possibly carbon dioxide and chlorides. Micro-cracks are therefore precursors to structural failure. For crack repair, a variety of techniques is available but traditional repair systems have a number of disadvantageous aspects such as different thermal expansion coefficient compared to concrete and environmental and health hazards. Therefore, bacterially induced calcium carbonate precipitation has been proposed as an alternative and environmental friendly crack repair technique. In 1995, Gollapudi et al. were the first to introduce this novel technique in fixing cracks with environmentally friendly biological processes. The microbial precipitation of $CaCO_3$ is determined by several factors including: concentration of dissolved inorganic carbon, ph, concentration of calcium ions and the presence of nucleation sites. The first three factors are provided by the metabolism of the bacteria while the cell wall of the bacteria will act as a nucleation site. .(*N. De Belie et al 2009)*

I. Review of literature:

A. Pappupreethi K, RajishaVelluva Ammakunnoth and P. Magudeaswaran :

The paper describes that due to its self healing abilities, eco-friendly nature, increase in durability etc, it is better than the conventional technology. It is very effective in increasing the strength and durability of concrete. It also shows better resistance to drying shrinkage, resistance to acid attack, better sulphate resistance. Bacterial concrete prepared with admixtures like silica fume, fly ash etc, also gives better strength and durability.

B. M.Hanuman Thrao, G.Vishwanadh:

In this research paper they conclude that the some bacteria such as Bacillus Pasteuri, Bacillus megaterium, Bacillus subtilis are having some disadvantages and also Pseudomonas aeruginosa are undoubtedly pathogen and cannot be directly applied in building structures like houses and offices because of health concerns. So they finally conclude that the Bacillus Sphaericus and Eschericheria Coli have some advantageous than above bacteria.

C. Medapati Abhinav Reddy:

This research paper conclude that the most optium pH for the bacteria growth is 7.4. The maximum compressive strength attained by the cube containing bacillus sphaericus is 38.7 kN/mm2 at 105 cells/ml at 30ºC and bacillus cereus achieved 39.5 kN/mm2 at 106 cells/ml at200ºC. The most resistance offered to the water absorption is bacillus sphaericus as its water absorption is only 1.2Kg/m2 at 30ºC(105 cells/ml) and water absorption by bacillus sphaericus is least at 3.8 (106 cells/ml). Therefore it can be concluded that bacillus sphaericus can be used as in bacterial concrete at lower temperature and bacillus cereus can be used in bacterial concrete subjected to high temperature. The optimum cell concentration of bacillus species at 105

D. Pratyush :

In this research paper he conclude that as the microbial concrete is ecofriendly and self-healing material, it is becoming popular in Civil Engineering as this technology is proving better than any available conventional technology. It improves the physical properties, increases durability of various building materials, improves compressive strength, reduces permeability and water absorption, arrest the corrosion in steel and very convenient for usage[3]. The B.cohnii and Bacillus megaterium were found urease positive and able to precipitate calcite within mortar specimen. Nickel as a promoter of urease activity has a profound effect on bacterial growth when incorporated in urea based broth prior to inoculation In addition to this, a dose of 0.5 gm of the dry bacterial biomass can be used as a standard dose to fulfill the aim of crack filling as response of 0.5gm of dose was found to be best than all other doses used.

E. Smita G. Khade, Sachin J. Mane:

In this paper they did experiment on spore, forming alkali-resistant bacteria can be isolated from its source. For research work they used Bacterial strains such as Bacillus sphaericus, Bacillus cereus etc. The bacterial activity in the presence of two different types of nutrients have been studied with two different concentrations of bacterial cells. The following conclusions are made:

1. Supply of nutrients play a significant role in the bacterial activity in cement mortar
2. It is understood that waste water rich in organic sources supply sufficient nutrients for the survival of bacteria. From the results obtained with and without bacterial concentrations in cement mortar cured in water, it is revealed

F. Massimiliano Marvasi *et al*, (2009)

Although the implications of calcium carbonate precipitation by microbes in natural environments are quite relevant, the physiology and genetics of this phenomenon are poorly understood. They have chosen *Bacillus subtilis* 168 as their model to study which physiological aspects are associated with calcium carbonate (calcite) formation during biofilm development when grown on precipitation medium. A *B. subtilis eftA* mutant named FBC5 impaired in calcite precipitation was used for comparative studies.

G. Dr. K.V. Ramana Reddy, M. Padmaja, P.Sankar Kumar Reddy:

In this research paper they conclude that due to the inclusion of bacterial cultures in the concrete matrix the cube compressive strength of concrete at the age of 28 days has been increased by 31.2% i.e. from 38.52 N/mm2 to 50.54 N/mm2 by the replacement of water by bacterial solution. The splitting tensile strength of concrete for an age of 28 days is 3.062 N/mm2. Water Absorption tests reveal that there is a 27.2% decrease in the water absorption of concrete at the end of 28 days due to the presence of bacteria in the concrete matrix, as compared to that of the original one (3.67%). There is a 69.7%decrease in the permeability of concrete of the conventional mix when there is an added amount of bacterial culture solution into the concrete matrix.

II. Conclusion:

Among all the paper, most of the paper shows that by the use of bacterial concrete name bacillus sphaericus for filling cracks in concrete is ecofriendly and can directly applied to the building cracks. It also helps the bacteria to increase in the compressive and flexural strength in concrete. There is also decrease in permeability, water absorption and corrosion of reinforcement when compared to conventional concrete.

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