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AN EXPERIMENTAL INVESTIGATION ON DIFFERENT TYPES OF BACTERIAL CONCRETE

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Abstract - 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. The usage of cement has been increased more over the world results in the air pollution which leads to the ozone depletion .To overcome these type of problem like crack formation and usage of cement content used for repair works can be reduced by using the self healing bacterial concrete. These are materials which heals the crack automatically when the cracks are formed. These self healing is achieved by means of using the Biological healing aspect by using the bacterial concrete. Bacteria are used during the mixing of concrete will cure the cracks the automatically by means of it screeds known as calcium carbonate precipitate.

In these study forces are applied to the concrete by means losd is applied in which the cracks are formed in the concrete. The Cracks leads to the penetration of oxygen inside the reinforcement area will forms the Corrosion. To avoid the formation of corrosion the cracks bacterial concrete along with cement are used which results in self healing process. These self healing which cure and arrest the cracks in the structure which gives the environment free pollution and sustainable structure.

Key Words: Auto- repairing, Bacterial concrete, Calcite, Bacillus family, Calcium carbonate

1. INTRODUCTION

1.1. General

Formed due to overloading, improper design, unskilled labours, quality of materials etc. The cracks that formed that allow unwanted pollutants to penetrate inside the concrete structure which leads to steel corrosion and also the production of cement emits equal tonnage of carbon-di-oxide (co2) into the atmosphere and leads to ozone depletion. In this study, we are going to reduce the production of cement which used for repair &maintenance work. Here we are going to introduce biological techniques moreover cement for the preparation of concrete which have some healing ability. Therefore the cement &bacteria will act as a healing agent in these biological concrete. In framed structure the cracks are formed at the Beam-Column joints, if there is an seismic force. Since the concrete is brittle and N no of cracks are formed at the structural element. The Cracks formed allow the oxygen to penetrate inside and starts the Multiplication of bacteria to heal the minor cracks .In these present study we are going to replace conventional concrete with biological concrete for casting of concrete. Then two different types of bacteria used in concrete. After healing the same test is repeated for the healed concrete.

1.2. OBJECTIVES

The main objectives of this system are,

1. The aim of the study is to augmentation of bacteria (Bacillus family) to improve the crack self-healing capacity of Bacterial concrete.
2. To study the performance analysis of automatically healed concrete made by Bacterial Concrete.
3. To assess the microscopic analysis in Bacterial Concrete specimens.
4. To shrink the production of cement and emission of Co_2 to the atmosphere by increasing the usage of bacterial concrete.
5. To develop guidelines and recommendations of bacterial concrete to implement in construction industry.

1.3. ADVATAGES OF BACTERIAL CONCRETE

- Self-repairing of cracks without any external aide.
- Significant increase in compressive strength and flexural strength when compared to normal concrete.
- Resistance towards freeze-thaw attacks.
- Reduction in permeability of concrete.

1.4. DISADVANTAGES OF BACTERIAL CONCRETE

- Cost of bacterial concrete is double than conventional concrete.
- Growth of bacteria is not good in any atmosphere and media.

2. LITERATURE REVIEW

C. Gavimath, B. M. Mali1, et .al.,[1] The objective of the present investigation is to study the potential application of bacterial species i.e. *B. sphaericus* to improve the strength of cement concrete. Water which enters the concrete will activate the dormant bacteria which in turn will give strength to the concrete through the process of metabolically mediated calcium carbonate precipitation. In this study we found that incorporation of spore forming bacteria of the speceies Bacillus will not negatively affect the compressive and split tensile strength of the cement concrete. Cracks in concrete occur due to various mechanisms such as shrinkage, freeze-thaw reactions and mechanical compressive and tensile forces. Cracking of the concrete surface may enhance the deterioration of embedded steel bars as ingression rate of corrosive chemicals such as water and chloride ions in to the concrete structure increased.

Darshak B. Raijwala, et.al., (2009) [2]It has discussed Concrete crack can be reduced by using micro bioloigalcally induced Calcite precipitation (CACO3).CACO3 is induced by means of the common soil bacterium known as the Bacterium known as the "BACILLUS PASTERII". Microbiologically entranced crack Remediation (MECR) was evaluated by comparing the compressive strength of treated mortar cubes with these of control specimens. Energy-Dispersive x-ray diffraction (XRD) analysis was used to qualify distribution in the regions of treated cubes. Basillus pasteuri confirms that the bacteria serve as the nucleation site for calcite crystals for precipitation. Concentrations of $9.0*10^8$ with different depth of cut like 10.0,20.0,25mm an increase in compressive strength of 15.0%,8.0%,·Bacteria near the surface of the mortar cubes are more active than bacteria away from the surface.

Henk M. Jonkers & Erik Schlangen(2012) [3] In this research project we develop a new type of self-healing concrete in which bacteria mediate the production of minerals which rapidly seal freshly formed cracks, a process that concomitantly decreases concrete permeability, and thus better protects embedded steel reinforcement from corrosion. Initial results show that the addition of specific organic mineral precursor compounds plus spore-forming alkaliphilic bacteria as self-healing agents produces up to 100-µm sized calcite particles which can potentially seal micro- to even larger-sized cracks. The mechanism of the self-healing process may actually differ, as it mainly depends on the composition of the concrete mixture. For example, crack-healing in mortar of centuries-old brick buildings in Amsterdam canals has been observed, and here the process was contributed to dissolution and re-precipitation of calcium carbonate within the mainly lime-based mortar matrix. The freshly produced minerals from the above stated reactions (1) and (2) and from dissolved and recrystallized calcite minerals, precipitated on the surface of cracks.

Jagadeesha Kumar B G, R Prabhakara, Pushpa H(2013) [4] In this paper results are presented on an experimental investigation carried out on mortar cubes which were subjected to bacterial precipitation by different bacterial strains and influence of bacterial calcite precipitation on the compressive strength of mortar cube on 7, 14 and 28 days of bacterial treatment. . Among the three strains of bacteria, Cubes treated with Bacillus flexus which is not reported as bacteria for calcite precipitation has shown maximum compressive strength than the other two bacterial strains and control cubes. Bacillus flexus which is capable of surviving at high pH, precipitate high calcite, and has less generation time can be used for bacterial calcite precipitation as concrete crack remediation and improvement of compressive strength of both mortar and concrete[4].

Jyothi Kumar K S, Seshagiri Rao M V, Sasikala Ch (2013) [5] Permeability is the most crucial internal factor in concrete durability. The durability of a concrete is closely related to its permeability. The permeability dictates the rate at which aggressive agents can penetrate to attack the concrete and the steel reinforcement. Water can be harmful for concrete, because of its ability to leach calcium hydroxide from the cement paste, to carry harmful dissolved species such as chlorides or acids into the concrete, to form ice in large pores in the paste, and to cause leaching of compounds from the concrete. A triaxial cell permeability apparatus and method for determining water permeability of concrete are presented in this paper.

J.Y. Wang1, 2, K. Van Tittelboom1, N. De Belie1 and W. Verstraete2(2007) [6] 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. Finally, self-healing of cracks in mortar specimens, by means of bacteria, was investigated. Glass tubes, containing the healing agent were provided inside the mortar matrix. Upon crack occurrence, the tubes break and the healing agent, consisting of a filler material and bacteria, is released into the crack and can cause crack repair. Strength regain up to 60% was thus observed due to self-healing. Therefore, it would be desirable if concrete cracks could be healed autonomously by releasing healing agents inside the matrix when cracks appear. In this research, an environment-friendly and autonomous crack repair technique is explored. Previous research has shown that *Bacillus sphaericus* bacteria are able to precipitate calcium carbonate (CaCO3) on their cell constituents and in their micro-environment by conversion of urea (CO(NH2)2) into ammonium (NH4+) and carbonate (CO32-). The bacterial degradation of urea locally increases the pH and promotes the microbial deposition of calcium carbonate in

a calcium rich environment. Through this process, the bacterial cell is coated with a layer of calcium carbonate.

Jacobsen. S, Sellevoid. E., (1996) [7] It has discussed the freeze and tha wingon concrete has been self healed by curing in water for2-3 months. Compressive strength, resonance frequency, weight, volume has been noted during the two phases i) Deterioration ii) self healing. 50% of the dynamic modulus loss during the deterioration is completely when it was cured in water for 2-3 months Reduction in compreesive strength of 22.9% on deterioration & 4.5% only self healing. Deterioration is governed by the ability to taken up water. It is seen that the all concretes were more or less deteriorated due to internal cracking with durability factors in the range of 9-79%."Self healing of high strength concrete after deterioration by freezing and thawing" CEMENT ANDCONCRETE RESEARCH VOL 26.ISSUE NO 1, 1996, PP 55-62.

Mayur Shantilal Vekariya1, Prof. Jayeshkumar Pitroda2,(2013)[8] Micro-cracks are the main causeto structural failure. One way to circumvent costly manual maintenance and repair is to incorporate an autonomous self -healing mechanism in concrete. . Therefore bacterial induced Calcium Carbonate (Calcite) precipitation has been proposed hence improvement of strength of building materials A novel technique is adopted in re-mediating cracks and fissures in concrete by utilizing Microbiologically Induced Calcite or Calcium Carbonate (CaCO3) Precipitation (MICP) is a technique that comes under a broader category of science called bio-mineralization. MICP is highly desirable because the Calcite as an alternative and environment friendly crack remediation and precipitation induced as a result of microbial activities is pollution free and natural. In the crack fixing process the anaerobic type bacteria which can be using along with concrete can be fix that crack by step by step. At first germination of germs by spores and swarming themselves and quorum sensing and growing from proper medium in large amount in particular time and from the metabolism process - levans glue is produce and making such type of filamentous cell formation and precipitation CaCO3. This both material combine with each other and making cementations material.

Navneet Chaha, Rafat Siddique. [9] Durability of concrete can be enhanced by using a novel technique which involves bacterial-induced calcite precipitation The initial objective of the research work involved the isolation of urease producing bacteria from alkaline soil. The bacteria were identified by the ability to sustain itself in alkaline environment of cement/concrete. The significant objective of the research work further involved the use of ureolytic bacteria (S. pasteurii) in concrete which would make it, self-healing. The bacteria present in the concrete rapidly sealed freshly formed cracks through calcite production. The bacterial concentrations were optimized to 10^3, 10^5 and 10^7 cells/ml. In concrete mix, cement was replaced with fly ash, and silica fume. The percentage replacement of fly ash and silica fume as by weight of cement. The percentage use of fly ash was 0%, 10%, 20% and 30%, and that silica fume were 0%, 5% and 10%. The experiments were carried out to evaluate the effect of S. pasteurii on the compressive strength, water absorption, water porosity and rapid chloride permeability of concrete made with fly ash and silica fume up to the age 91 days. The test results indicated that inclusion of S. pasteuri enhanced the compressive strength, reduced the porosity and permeability of the concrete with fly ash and silica fume. The improvement in compressive strength was due to deposition on the bacteria cell surfaces within the pores which was scanned by electron microscopy and confirmed by XRD which revealed calcium carbonate precipitation.

Santhosh, A.Kadapure, Ravindra, Anadini, M. Manjunath and Grish Kulkarni (2014) [10] It has the effects of Bacillus pasteruii bacteria on the strength properties of normal and fly ash concrete. In Fly ash concrete cement was replaced with three percentages (10%, 20%, 30%) with fly ash by weight. Different cell concentrations (0,10^3,10^5,10^7 cells/ ml of mixing water) of bacteria were used in making concrete mixes. Tests were performed for different strength properties at the age of 28 days. Test results indicated that inclusion of bacillus pasteuri in normal and fly ash concrete enhanced the different strength properties of concrete. Maximum increase in the different strength properties was observed with concentrations of 10^5 cells/ml of bacteria .This improvement in strength was due to deposition on the bacteria cell surface within the pores. The present work highlights the influence of bacteria on the strength properties of concrete made with supplementing cementing material such as like fly ash. Usage of bacteria like Bacillus pasteurii improves the strength of normal and fly ash concrete through self healing concrete

3. MATERIALS TO BE USED

3.1. INTRODUCTION

Material investigation is done to test the various materials that are used in making concrete cubes. According to these test results obtained we designed the mix ratios for the materials and prepared the concrete cubes, beams and cylinders. The information are given below,

3.2. CEMENT

PPC of 53 grades in one lot was procured and stored in air tight container. The cement used was fresh i.e. used within three months of manufacture. It should satisfy the requirement of IS12262. The properties of cement are determined as per IS4031:1968 & results are tabulated.

Table 1: Common properties of cement

S. No	PROPERTIES	VALUES
1	Fineness	10%
2	Initial setting time	28min
3	Specific gravity	3.15
4	Standard consistency	29%

3.3. AGGREGATES

A fine aggregate obtained from the river is used for experimental purpose. The less amount of clay and silt (<3% by weight). The hire from silt, clay, salt and organic material and it was clean and dry. It is of size retained in 1.19 micron sieve. The coarse aggregate is strongest and porous component of concrete. Presence of coarse aggregate reduces the drying shrinkage and other dimensional changes occurring on account of movement of moisture. The coarse aggregate used passes in 19 mm and retained in 11.4mm sieve. It is well graded (should of different particle size and maximum dry packing density and minimum voids) and cubical in shape.

3.4. WATER

Ordinary drinking water available in the construction laboratory was used for casting all specimens of this investigation. Water helps in dispersing the cement even, so that every particle of the aggregate is coated with it and brought into ultimate contact with the ingredients. It reacts chemically with cement and brings about setting and hardening of cement. It lubricates the mix and compact property. Potable water, free from impurities such as oil, alkali acids, salts, sugar and organic materials were used. The quality of water was found to satisfy the requirement if IS 456-2000.

The ordinary water consist of many micro-organisms which will leads to the change in pH value which does not effect the construction activity. pH of the tap water has been checked in our laboratory. The pH of the tap water tested is about **7.5**.

3.5. DIFFERENT TYPE OF CONCRETE BACTERIAS

Different types of bacteria are used in concrete.They are

- Bacillus pasteurii.
- Bacillus Pseudifirmus
- Bacillus.
- Lysinbacillus Sphaericus.
- Bacillus Megaterium.

4. TESTS TO BE CONDUCTED

Fresh concrete tests such as Slump cone test to be performed. Compressive strength test, Split tensile test and Flexural strength test are also proposed to be conducted. Mix designs are arrived by using IS 10262-2019.

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