AN ASSESSMENT STUDY ON BACTERIA CONCERN TO CONCRETE

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Abstract: *Historical Monuments and Structures were experienced with cracks due to shrinkage, chemical attack which leads to corrosion effect on embedded reinforced steel, spalling of concrete surface which affect the integrity and safety. Various remediations were taken at the later stage. An attempt was taken to heal the concrete by self by inducing aerobic, alkaliphilic bacterium inclusion in concrete. Various authors made an attempt by using different bacteria of various cell concentration thus minimizing the cracks but also improves the compressive strength to the considerably amount. Bacteria where chosen based on their non-pathogenic and eco-friendly nature.*

Key words: BOD, Water Quality, Chennai

I. INTRODUCTION

The main problem in construction field lies with corrosion of reinforcement due to the formation of cracks and the spalling of concrete surface. Corrosion effect takes place when crack is ingress with oxygen, forming iron oxides (electrochemical corrosion)

Numerous chemicals like Latex emulsion can be used to control corrosion effect but the drawback lies with its high cost and molecular structure. Synthetic materials such as epoxies coating were used widely in order to minimize the corrosion effect. Eventhough, the chemicals used were salt tolerant, its pH, temperature, costs are challenging parameters and maintenance should be done in regular basis. Use of chemicals also decreases the bonding effect of concrete and steel material when coated. This sense again creates the problem to construction field.

Modern technologies were introduced in Effective alternate crack Remediation Technique or self healing technique by microbiologically Induced calcite Precipitation (MICP). The non-pathogenic bacterium which is eco-friendly in nature was chosen for repairing the structural defects. This technique is adopted for repairing historical monuments.

Cement when mixed with water to make concrete has pH value of 11 to 13 which is alkaline in nature. Bacteria should withstand this alkaline nature, hence alkaliphilic (alkali resistant) bacteria is preferred. It should also withstand mechanical stresses while mixing and should retain for several years in concrete to lead the self healing process. Endolithic bacteria were collected from natural rocks which stand firm against the climatic conditions. When bacteria comes contact with water, the process of binary

fission takes place symmetrically where the spores were formed with thick plant cell wall. These spores start the self healing mechanism in concrete.

II. TYPES OF BACTERIA

a. Based on Shape, bacteria is classified as Spirilla, Bacilli and Cocci
b. Based on oxygen demand, it is classified as Aerobic and Anaerobic
c. Based on Gram strain, it is classified as Gram positive and Gram Negative

III. BACTERIA USED IN CONSTRUCTION FIELD

From various literatures, the following are different forms of bacteria used

MICROORGANISM	METABOLISM MECHANISM	APPLICATIONS
Bacillus Subtilis	Hydrolysis of Urea, Deamination of amino acids	Bacterial Concrete, Crack in concrete remediation
Bacillus Sphaericus	Hydrolysis of Urea	Crack in concrete remediation
Bacillus Cereus	Oxidative Deamination of amino acids	Biological mortar

Other than these bacteria, other forms like B. Lincheniformis, B. Megaterium, B. Flexus, Sporosarcina Pasteurii were used by some authors for its self-healing activities. Urease based calcite precipitation is used as crystal.

IV. METABOLISM ACTIVITY

Cracks of 0.2 mm to 0.5 mm width when comes in contact with water, hydration process takes place and results in forming the precipitate of Calcium Carbonate. The active metabolism takes place in concrete matrix on conversion of calcium nutrients from Urea to Ammonium and carbonate providing high alkaline environment.

$$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$$

The ammonia degradation of urea gives alkaline environment and enhances microbial deposition of carbonate.

V. LITERATURES ON ISOLATION OF BACTERIA

Jagadessha et.al (2013) prepared Isolate 1 in the nutrient agar plate with the composition of Beef extract 3g/lit, 5g/lit of Peptone and sodium chloride NaCl of 5 g/lit. As calcium carbonate precipitation was requires, two calcium sources such as Calicum Chloride Hydrate and Calicum Nitrate Penta Hydrate. The characterization of bacrteria was carried out as described in Bergey`s Manual of Systematic Bacteriology. The curing media was made up of 49 g /lit of calcium and urea of 20g/ lit.

Varenyam Achal et.al (2011) isolated the bacteria Bacillus sp. CT 5 from cement which is available commercially by enrichment culture technique. 1 g of cement sample was inoculated in 50 ml of nutrient broth which contains 2% urea. Incubation was done for 120 hrs at 37^{o}C by shaking method. The Serial dilution technique was used to enumerate the bacteria. The total plate count was determined and kept in Nutrient agar which is a mixture of 8 g of nutrient broth, 25 mM $CaCl_2$ and 2% urea.

VI. LITERATURES ON STRENGTH CRETERIA

Bhagyashri (2017) carried out the research with Bacillus Subtillus with chemical compound calcium lactate $C_6H_{10}CaO_6$. The concentration of bacterial cells was measured by Haemocytometer and Optical density and ingress into concrete. The cubes were casted for M25 grade and it was found 28% increases in compressive strength were obtained. The strength obtained as the process of precipitating converts soluble nutrients into insoluble $CaCO_3$ which solidifies on the crack surface and make it seal which is self healing process.

Monisha et.al., (2017) carried out the research with Bacillus Subtillus of cell concentration 10^4, 10^5 and 10^6 cells/ml and 0.4% polyethylene fibers were used to improve the tensile strength of concrete. Concrete was casted for M20 grade and cured properly in water. Testing was carried out on 7th and 28th day, in which compressive strength was done at the constant rate of 140 kg/cm^2/min and strength was found to be 13.2% more than Normal Concrete. The tensile strength and flexural strength were 21.4% and 16.04% respectively. On calculating, modulus of Rupture was found to be 12 to 20% of its compressive strength.

Chithra et.al (2016) investigated the concrete incorporated with bacteria of cell concentration of 10^3, 10^5 and 10^7 cells/ml and partial replacement of flyash in cement of 10%, 20% and 30% by weight. The cubes were designed for M30 mix proportion and casted cubes were tested for strength test such as compressive, tensile and flexural test and ultrasonic pulse velocity to determine the porosity on 28th and 56th days. The best results were obtained for 10% flyash, 10^5 bacterial cell concentrations in strength category which is 43 N/mm^2 and 47.66 N/mm^2 respectively is compared with conventional concrete of 41 N/mm^2. The Ultrasonic pulse velocity for flyash is found to be less on increase in flyash content implies that there are more void spaces. Bacterial concrete gives excellent result with value of 4.98 km/sec for 10^5 cell concentration.

Siddique et.al (2015) investigated the concrete mixed with cement bag house filter dust (CBFD) which is particulate matter derived from Air pollution control devices and bacterial strain AKKR5, which was the comparative study. The samples were prepared for conventional concrete, concrete with partial replacement of 10%, 20% and 30% CBFD and bacterial concrete of 10^{-5}cells/mh. Basic Isolation of ureolytic type of bacteria has been prepared from marble sludge. It was found that as the CBFD percentage increases, there is a decrease in compressive strength. The increase in bacterial content

reduces the water absorption. The formation of ettringite of pores increases which shows increases in CSH gel, a calcite formation was studied by SEM analysis. It was clear that $Ca(OH)_2$ at initial stages changed into $CaCO_3$ which is deposited on the bacteria, making it more denser and stronger, while CBFD concrete samples were formed with narrow ettringite. He concluded that bacterial concrete without CBFD increases the compressive strength of nearly 74% in which 34.96 N/mm^2 for 10% bacterial concrete and conventional concrete was designed for 20 N/mm^2

Jagadeesha et.al (2013) investigated the influence of bacteria in strength criteria on concrete cubes when cured by precipitation media. In this study, Bacillus Flexus (Isolate I), B.Pasturii and B.Sphaericus were chosen as the bacteria. All these bacteria were urease active, gram positive, endospore forming. Concrete cubes were prepared for 1:3 ratio by weight. Once moulding is done, except control cubes all other cubes are kept immersed in bacterial solution for a period of one day. Later, the concrete cubes were immersed in $CaCl_2$ and $CaNO_3$ precipitation media till testing to enhance the activity of bacteria. The compressive strength test has been found to be 57.2 N/mm^2 for cube immersed in Bacillus Flexus whereas 54.5 N/mm^2 for conventional concrete which is nearly 18% less. Nearly 5% difference was seen by using Isolator I bacteria with $CaCl_2$ Precipitate compared to $CaNO_3$ Precipitate.

Gandhimathi (2012) carried out the research on soil bacterium Bacterial Sphaerious with concrete. M25 grade of concrete were casted with 0.45 W/C ratio. The preparation of bacterium plays an important role. 10ml and 20ml of bacterial agar were mixed during casting of concrete. The compressive strength of normal concrete, 10 ml bacteria added concrete and 20ml bacteria added concrete were 30.52 N/mm^2, 30.84 N/mm^2 and 31.11 N/mm^2 respectively. It was also seen that tensile strength of bacterial concrete increased as 3.26 N/mm^2 for Normal Concrete, 3.32 N/mm^2 for 10ml bacterial added concrete and 3.35 N/mm^2 for 20ml bacterial added concrete.

VII. CONCLUSION

An eco-friendly bacteria need to be chosen to enhance the self-healing process of the concrete. The chosen bacteria should be cost effective and it should improve the strength and durability behaviour by reducing the permeability. Various researchers used different forms of bacteria in which Bacillus Genus have the ability to withstand high alkaline environment produced by concrete environment. Out of various literatures, B.Subtilis of cell concentration 10^5 cells / concentration gave best results compared to other bacteria.

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