REVIEW PAPER ON SELF HEALING CONCRETE

Nikhil Sanjay Gaikwad[1], Sakshi Chetan Bhalerao[2]

[1-2]*Dept. of Civil Engineering, MIT World Peace University, Pune, Maharashtra, India*

ABSTRACT : *Concrete is an irreplaceable ingredient in construction industry. We use different type of materials, procedures, methods to attain good, sustainable concrete. Even after proper precaution taken during mixing, casting and curing, we come across cracks. Eventually, crack formation in concrete has become inevitable phenomenon. There are various reasons which can cause cracks to our structure like temperature differences, application of heavy loads etc. Crack increases seepage which leads to corrosion of reinforcement, durability, life of the structure. Currently, we use epoxy system, acrylic resins to heal cracks which are not environmental friendly. Also, one cannot go physically to do the maintenance at such locations like high rise buildings, basements, underwater structures due to difficulty in accessibility, high threats of accidents. In such cases, self-healing concrete is effectively useful.*

Key Words: *inevitable phenomenon, self-healing, maintenance, cracks, sustainable concrete, environmental friendly*.

1. INTRODUCTION

Concrete is most widely used construction materials as it can resist high compressive loads and hence is used by every country for infrastructure development. concrete being a brittle material is subjected to cracking under shear and tension. Cracks in concrete are caused due to shrinkage, freeze-thaw, sustained loading. Due to formation of cracks water easily permeates into concrete and comes in contact with reinforcement which leads to corrosion. This eventually leads to decrease in strength and durability of concrete. Hence a convenient method of repairing cracks is required , which is a time consuming and expensive process. Conventional method of filling of cracks include applying of cement slurry or mortar, epoxy based fillers and grouting. But these methods are likely to thermally expand and have environmental issues. Hence a new method of bacterial healing of concrete is introduced[1].

A new technique in which bacteria producing calcium carbonate crystals which blocks cracks and pores in concrete is introduced. Bacterial induced calcium carbon precipitate has been suggested as an alternative and eco-friendly crack repair technique by many researchers. Various types of bacillus bacteria can be used to produce self healing concrete. Since water and cement mixture have a high pH , a bacteria which can adapt such High alkaline environment should be added. These bacteria can remain dormant for nearly 200 years. When cracks occur and water percolates these bacteria starts microbial activity which produces insoluble $CaCo_3$ and heals crack.

2. LITERATURE REVIEW

2.1. What is self-healing concrete?

It is a bacterial concrete which fills up cracks by producing calcium carbonate crystals with the help of bacterial reaction in the concrete. Bacteria which are embedded in the concrete while mixing precipitates calcite when comes in a contact with water. The process of self-healing cracks by the help of bacterial reaction in the concrete after hardening is known as Self-Healing Concrete.

2.2. Mechanism of self-healing concrete

Self-healing concrete is a result of biological reaction of limestone and calcium based nutrients with the help of bacteria. While preparation of concrete, bacteria are added in wet concrete when mixing is done. When water seeps through cracks in concrete, the pores of the bacteria germinate and start feeding on the calcium consuming oxygen. This soluble calcium lactate is converted to insoluble limestone, which starts to harden thus filling the crack automatically without external aide.

2.3. Why bacillus bacteria?

Bacillus bacteria has a positive effect on compressive strength of concrete. Water and cement mixture has high pH value around 13 in which most of micro-organisms die but these bacillus bacteria are alkaline resistant. They withstand the harsh environmental conditions. They are harmless to human life.

3. RESEARCH PAPER REVIEW

1. Kusuma K[1], Published a paper on detailed study of bio concrete with bacillus megaterium bacteria. They have replaced potable water with the bacterial water which has a concentration around 10^5 cells of bacillus megaterium per ml of water. It was observed that bacterial concrete performed better than a conventional concrete. It increased a compressive strength of bacterial concrete by 11.96% than conventional concrete. Because of the precipitation of calcite on the surface of specimen, bacterial concrete has improved surface. The decrease in water absorption was found to be 0.45%. It decreased water permeability because of filling the pores by calcite. It also improved durability of building materials. It showed that use of such bacteria has a positive

effect on water absorption, permeability, compressive strength.

2. Salmabanu Luhar[2], Published a paper on self-healing concrete using various bacteria like bacillus sphaericus, bacillus subtilis, bacillus pasteurii. In this study, they have prepared a specimen of concrete with 53 grade cement, fly ash, fine and coarse aggregates, bacillus subtilis was cultured and added to the water during mixing with different concentrations like 10^5 cells/lit, 10^6 cells/lit etc. and prepared a cube of size 150mm x 150mm x 150mm. For mechanical properties, cylindrical specimen having 150mm diameter and height 300mm were casted. It is found that using light weight aggregates of size 2 to 4 mm along with the bacteria helps in increasing compressive strength and improves healing capacity of concrete. It is observed that bacterial concrete gives better tensile strength than a conventional concrete. It reduced water permeability which is also an important factor. Bacillus subtilis improved compressive strength of concrete by 14% as compared to conventional concrete. Bacillus sphaericus improved compressive strength by 32% in 28 days as compared to a conventional concrete.

3. Bharanedharan G[3], Published a paper which has a comparison of bacillus subtilis with bacillus cohnii. M30 grade of concrete was prepared to study mechanical properties of microbial concrete. Results of this study has shown that bacillus subtilis were more effective than bacillus cohnii in crack healing. Compressive strength of bacterial concrete having bacillus subtilis has increased compressive strength by 11% whereas bacterial concrete with bacillus cohnii has increased compressive strength by 9%. It has shown that selected bacteria healed the cracks successfully by producing calcium carbonate as a filler material. Bacillus subtilis turned out to be efficient than bacillus cohnii

4. Eveena Stephen[4], Published a paper having main objective to check and compare durability and properties of bio and conventional concrete. To make a concrete Pozzolana Portland Cement, fine and coarse aggregate, water, bacillus subtilis, chemical admixtures like super plasticizer, water reducing agents are used. Pozzolana Portland Cement produces less heat of hydration. Low sand content enhances every aspect of concrete. Concrete cubes of dimension 15cm x 15cm x 15cm were prepared and cured for 7,14,28 day. There was increase in compressive strength for every 10ml bacterial sample. After 28 days, compressive strength increased by 1.33% for 10ml bacterial sample compared to conventional concrete. Split tensile strength increased by 10% for 10ml bacterial sample. Flexural strength increased by 5.2% for 15ml bacterial concrete. In water absorption test, it showed lower rate of water absorption for bacterial concrete than conventional concrete due to layer of calcium deposited into pores.

5. G. Mohan Ganesh[5], studied concrete durability using Bacillus cohnii bacteria and rice husk.Mix proportion for cement of 360kg/m^3 was designed.Mix was designed keeping density 2400kg/m^3 and w/c ratio 0.4 constant. Mix grade of 1:2.1:3.16:0.40 is used throughout the study. The study was performed with four mixes M1=control, M2=5% of husk, M3=control concrete with 100ml bacteria, M4=100ml bacteria with 5% husk. Performed experiment showed that rice husk enhances the growth of bacteria and reduces self-weight of concrete. Presence of layer of carbonate crystals on the surface has potential to improve resistance of cementations materials towards degradation process. Compressive strength gained by M3 mix was optimum at 49.55 N/mm^2 and the tensile strength gained was 3.34N/mm^2, flexural strength at 6.87N/mm^2. The M4 mix also had the least water absorption at 3.4%

6. C. Venkata Siva Rama Prasad[6], studied the effect of bacillus subtitles on mechanical behavior of bacterial concrete. The mix proportions for M20 and M40 concrete were designed as per IS 10262-2009. Ordinary Portland cement of grade 53 was tested and used, Local available river sand with specific gravity 2.68 and Crushed granite broken stone of 20mm size was used for experiment. Bacillus subtitles cultured at DVS Bio life Pvt Ltd lab and Calcium lactate was used with bacteria as a nutrient broth. Concrete mix was produced with bacterial percent of 5, 10 and 15. Optimum strength of concrete was obtained at 10%bacteria. Which increased the compressive strength by16.8% for M20 and 17.02 for M40, the flexural strength was increased by 7.9% for M20 and 9.47% for M40. The increase in strength of concrete was observed due to formation of calcium carbonate crystals and it's precipitation in gel matrix.

4. CONCLUSIONS

Addition of bacteria into a concrete makes it beneficial. Self-healing concrete can be a great concrete sealant. It improves durability of concrete, life of the structure. It reduces need of regular maintenance and inspection. It produces calcium carbonate which blocks and seals the crack which reduces water permeability. It increases compressive strength tensile strength and decreases water absorption and acid attacks. From above study, bacterial concrete increases approximately at least 10% of compressive strength and reduces water permeability up to 0.45%.

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