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A REVIEW ON ADVANTAGES OF SELF HEALING CONCRETE

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ABSTRACT

Self-healing concretes are being widely recognized as a remedial technique to improve the durability of concrete. Although, few review papers on self-healing concrete were published, a strong review on advantages of self-healing concrete cannot be found.. In fact, the interest on concrete's self-healing process is increasing, due to the rapidly deterioration of that material which tends to crack and thus quickly deteriorate.

In this paper, a review on advantages of self healing concrete and detail about self healing concrete. In Concrete, cracking is a common phenomenon developed due to relatively low tensile strength. High tensile stresses may be developed inconcrete due to external loads, imposed deformations, plastic shrinkage, plastic settlement and expansive reactions. Proper and immediate treatment should be done in order to prevent expansion of cracks which may eventually be of higher cost. Bacterially induced calcium carbonate precipitation has been proposed as an alternative and environmental friendly crack repair technique. It is expected that further development of this techniques will result in a more durable, sustainable and crack free concrete that can be used effectively for constructions. Thus this paper is an attempt to define self healing concrete, its classification and types, advantages and its application

Keywords- *Clustering, automatic, bisecting, intra-cluster, inter-cluster, accuracy, delay.*

I. INTRODUCTION

Concrete is the most commonly used building material which is recyclable. It is strong, durable, locally available and versatile. It is capable to resist the compressive load to a limit but if the load applied on the concrete is more than their limit but if the load applied on the concrete is more than their limit of resisting load, it causes the strength reduction of concrete by producing the cracks inconcrete and the treatment of cracks is very expensive. Cracks in concrete affects the service ability limit of concrete.The ingress of sulphates and chlorides in concrete results in decrease of durability. These effects in concrete structures by cracking might be overcome by utilizing self healing technology which has high potential to repair cracks in concrete and enhance the service life of concrete structures with a reduction of demand for repair and maintenance. Self healing agents such as epoxy resin, bacteria, fiber, etc., are used to heal cracks in concrete. Among these bacteria is used commonly and is found to be effective. When the bacteria is mixed with concrete the calcium carbonate precipitates forms and these precipitates fills the cracks and makes the concrete free from cracks.

Self-healing concrete is a product which biologically produces limestone by which cracks on the surface of concrete surface heal. Selected types of the bacteria genus Bacillus, along with calcium-based nutrient known as calcium lactate, and nitrogen and phosphorous are added to the concrete when it is being mixed. The self-healing agents can lie dormant within the concrete for up totwo hundred years. When a concrete structure damages and water starts to penetrate in the cracks present in it the bacteria starts to feed on the calcium lactate consuming oxygen and converts the soluble calcium lactate into insoluble limestone. The limestone formed thus seals the cracks present. It is similar to the process of how a fractured bone gets naturally healed by osteoblast cells that mineralize to reform bone. Consumption of oxygenic the bacterial conversion has an additional advantage. Oxygen which becomes an essential element for the corrosion of steel to take place is being used in the bacterial conversion. Hence the durability of steel in construction becomes higher. The process of bacterial conversion takes place either in the interior or exterior of the microbial cellor even some distance away within the concrete. Often the bacterial activities trigger a change in the chemical process that leads to over saturation and mineral precipitation. Utilization of concepts of biomineralogy in concrete lead to invention of a new material termed as Bacterial Concrete. Bacterial concrete refers to a new

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generation concrete in which selective cementation by microbiologicallyinducedCaCO3 precipitation has been introduced for remediation of micro-cracks.

II. METHOD OF SELFHEALING CONCRETE.

Following are the method of self healing in concretes:

1. Natural self healing processes
2. Biological self healing processes
3. Chemical self healing processes

2.1 Natural self healing processes

There are different natural self healing process- (a) Calcium carbonate or calcium hydroxide formation, (b)Blocking cracks by impurities in the water, (c) Further hydration of the unreacted cement or cementitious materials(d) Expansion of the hydrated cementitious matrix in the crack flanks (swelling of C–S–H).In many cases, more than one of these process or mechanisms can happen simultaneously. In fact, most of these mechanisms can only partially fill the entrance of some cracks and cannot completely fill the cracks. This will be useful to prevent the development of cracks or prevention of deep penetration of harmful chemicals such as acids into the crack. Among the proposed self-healing mechanisms in the natural process, formation of calcium carbonate and calcium hydroxide are the most effective methods to heal concrete naturally. This view is supported by the fact that some white residue can be found on the outer surface of the concrete cracks. This white residue is found to be calcium carbonate and has been widely reported including Wu etal. At the first step, carbon dioxide is dissolved in water.

2.2 Biological self healing processes.

Bacteria Used in Bio Concrete- In suspension state, concrete mix is added with bacteria. Concrete being extremely alkaline in nature, the bacteria added should fit in some special norms. The added bacteria should be able to withstand the harsh environmental conditions of concrete. Concrete is a dry material and the pH value of cement and water when mixed is up to 13 which makes it confrontational as most of the organisms cannot survive in an environment having pH value higher than 10.

2.2.1 Types of Bacteria

Bacteria naturally occur in nature in various forms. They are present not only on the surface but also beneath the surface of the earth. The various bacteria that can be used in concrete are:

2.2.1.1 Anaerobic Bacteria

If anaerobic bacteria like closely related specie of shewanella are added to concrete, the compressive strength increases from 25-30%.

2.2.1.2AerobicBacteria

It has been observed after 7 days strength the S. soli and L. fusiformis showed better compressive strength while as B. massiliensis and A. crystallopoietes no strength improvement was observed. A.crystallopoietes showed the maximum strength after 28 days.

2.3 Viable bacteria as self healing agent

The bacteria to be used as self healing agent in concrete should be fit for the job, i.e. theyshould be able to perform long-term effective crack sealing, preferably during the total constructions life time. The principle mechanism of bacterial crack healing is that the bacteria themselves act largely as a catalyst, and transform a precursor compound to a suitable filler material. The newly produced compounds such as calcium carbonate-based mineral precipitates should than act as a type of bio-cement what effectively seals newly formed cracks. Thus for effective self healing, both bacteria and a bio-cement precursor compound should be integrated in the material matrix. However, the presence of the matrix-embedded bacteria and precursor compounds should not negatively affect other wanted concrete characteristics. Bacteria that can resist concrete matrix incorporation exist in nature, and these appear

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related to a specialized group of alkali-resistant spore-forming bacteria. Interesting feature of these bacteria is that they are able to form spores, which are specialized spherical thick-walled cells somewhat homologous to plant seeds. These spores are viable but dormant cells and can withstand mechanical and chemical stresses and remain in dry state viable for periods over 50 years.

However, when bacterial spores were directly added to the concrete mixture, their lifetime appeared to be limited to one-two months. The decrease in life-time of the bacterial spores from several decades when in dry state to only a few months when embedded in the concrete matrix may be due to continuing cement hydration resulting inmatrix pore-diameter widths typically much smaller than the 1-µm sized bacterial spores. Another concern is whether direct addition of organic bio-mineral precursor compounds to the concrete mixture will not result in unwanted loss of other concrete properties. In the preceding study it was indeed found that various organic bio-cementprecursor compounds such as yeast extract, peptone and calcium acetate resulted in a dramatic decrease of compressive strength. The only exception appeared to be calcium actate what actually resulted in a 10% increase in compressive strength compared to control specimens.

In order to substantially increase the lifetime and associated functionality of concrete incorporated bacteria, the effect of bacterial spore and simultaneously needed organic biomineral precursor compound (calcium lactate) immobilization in porous expanded clay particles was tested in this study. It was found that protection of the bacterial spores by immobilization inside porous expanded clay particles before addition to the concrete mixture (Fig. 1) indeed substantially prolonged their life-time. Currently running viability experiments show that still after 6 months concrete incorporation no loss of viability is observed, suggesting that their long term viability as observed in dried state when not embedded in concrete is maintained. In subsequent experiments the expanded clay particles loaded with the two-component bio-chemical healing agent were applied as additive to the concrete mixture to test self healingpotential of bacterial concrete.

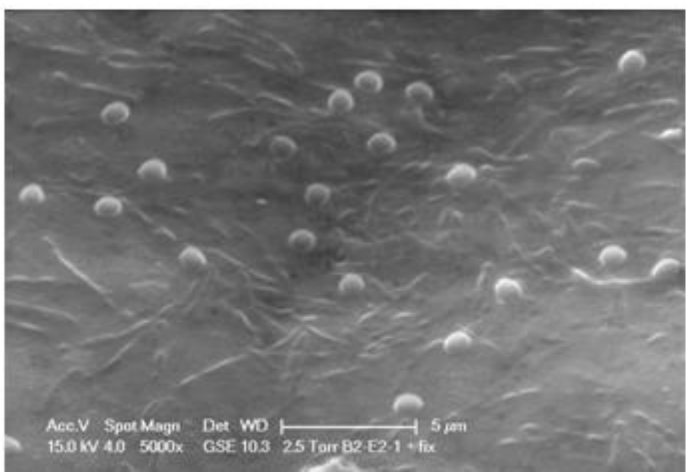

Figure 1. ESEM photomicrograph (5000x magnification) of alkali-resistant spore forming bacterium (Bacillus strain B2-E2-1). Visible are active vegetative bacteria (rods) and spores (spheres), showing that spore diameter sizes are in the order of one micrometer.

III. MATERIALS USED FOR CONCRETE MAKING

The following are the particulars of the materials used for concrete making.

3.1 Cement

Portland Pozzolana fly ash based cement is used in the investigation. The cement used has been tested for various properties as per IS:4031-1988 and found to be confirming to various specifications of IS:12269-1987. The cement has a specific gravity of 3.15, 38% of water content for standard consistency and 3% fineness.

3.2 Coarse Aggregate
The coarse aggregate of 20mm and down size, having a specific gravity of 2.83 and a fineness modulus of 4.12, tested as per IS:2386-1963 is used.

3.3 Fine Aggregate
Natural river sand with specific gravity of 2.63 and confirming to IS:383 zone II is used. The sand was tested as per IS:2386 (Part III) -1963. The sand is having percentage of water content at maximum bulking equal to 7%.

3.4 Water
Locally available portable water confirming to standards specified in IS:456-2000 is used.

3.5 Bacteria
Bacteria based system involves the use of ureolytic bacteria of genus Bacillus for the production of Calcium Carbonate minerals. The metabolism of this genus of bacteria involves the enzymatic hydrolysis of urea to ammonia and carbon dioxide. The reaction also causes an increase of pH from neutral to alkaline conditions forming bicarbonate and carbonate ions, which precipitate with the Calcium ions in the concrete to form Calcium Carbonate minerals. The further crystalisation of the Calcium Carbonate minerals heals the pores and cracks in the concrete.

IV. ADVANTAGES

- Microbial concrete in crack remediation.
- Improvement in compressive strength of concrete.
- Better resistance to freeze-thaw cycle.
- Reduction in permeability of concrete.
- Reduction in corrosion of reinforced concrete.
- The use of bio concrete significantly influences the strength of concrete.
- It has lower permeability than conventional concrete.
- It offers great resistance to freeze-thaw attacks.
- The chances of corrosion in reinforcement are reduced.
- Remedying of cracks can be done efficiently.
- Maintenance cost of this concrete is low.
- It is pollution free, eco-friendly and natural
- Decreased production of concrete
- Lower repair & maintenance cost
- Applicable to existing buildings in form of spray
- Curbed carbon dioxide emission from concrete production
- Remediates cracks quickly
- Improvement the compressive strength of 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.
- Reduces the corrosion of steel due to the cracks formation and improves the durability of steel reinforced concrete.
- Bacillus bacteria are harmless to human life and hence it can be used effectively.

V. CONCLUSION

The outcome of this study shows that crack healing of bacterial concrete based on expanded porous clay particles loaded with bacteria and calcium lactate, i.e. an organic bio-mineral precursor compound, is much more efficient than of concrete of the same composition however with empty expanded clay particles.

Non-hydrated cement particles exposed at the crack surface of concrete will undergo secondary hydration and in addition in control specimens carbon dioxide present in the bulk water will react with present portland (calcium hydroxide) particles to produce calcium carbonate-based mineral precipitates. Latter mineral precipitates will particularly form near the crack rim due to the relatively high solubility of calcium hydroxide.

A novel technique for the production of self-healing concrete was proposed: glass small spheres and pharmaceutical capsules were filled with sodium silicate as a healing agent. The use of bio concrete significantly influences the strength of concrete.

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