EXPERIMENTAL STUDY ON SELE HEALING CONCRETE

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Abstract – Self Healing Concrete is a term that is used for cement-based materials that repair themselves after the material or structure gets damaged due to some sort of deterioration mechanism. Possible causes of self-healing are formation of calcium carbonate or calcium hydroxide, sedimentation of particles, continued hydration and swelling of the cement matrix.

Usually SHC consists of Portland cement, water and other filling materials, like sand and grit. Calcium hydroxide is a reaction product of the hydration of concrete. For calcium carbonate, the water in the crack has to contain dissolved carbon dioxide.

The hydrated cement in the vicinity of the crack hydrates and the hydration product fill the crack. There is increasing interest in the phenomenon of mechanical property recovery in self-healed concrete materials because self-healing concrete could solve the problem of concrete structures deteriorating before the end of their service life

1. INTRODUCTION

As Reclamation's infrastructures continue to age, many structures have surpassed their expected service life. The increased demands on these systems further strain their capacity to maintain normal operations. Limited resources for maintenance and repair at all levels also contribute to limiting repairs. Concrete cracks are an important indicator for determining the overall condition of a structure. While no tall concrete cracking is detrimental to a structure, the size, location and severity can dictate the importance of repairs. Large cracks can indicate the existence of structural overloading or severer deterioration. Smaller cracks can also provide evidence of damage, including those related to poor substrate preparation, poor curing, deterioration from a number of causes, and use of poor quality materials.

Concrete cracks can be hard to control and prevent and can lead to durability-related issues with concrete. Reclamation and others have published numerous studies analyzing the factors that cause concrete cracks and mitigation strategies with the goal of extending the service life of concrete and concrete repairs. .Such publications have examined factors such as poor substrate preparation prior to new concrete placements, concrete shrinkage reducing additives (Prevent-C), effects of bond strength between existing and new concrete, and durability issues

Due to materials. These studies indicate that while some progress has been made by the concrete repair industry there are still durability problems with many repair projects. Obviously, performing repeat repairs after only a few years of service is very costly.

2. Literature survey

Suthar Gourav:- *Concrete is very good material to resist the compressive load to a 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 in the concrete and the treatment of the cracks in very expensive. Some of the property like durability, permeability ad strength of the concrete structure is also decreases. Due to increase in the permeability of the concrete the water easily pass through the concrete and come in the contact with the reinforcement of the concrete structure and after some time corrosion start due to this strength of the concrete structure will decreases so it will be necessary to repair the cracks.*

By introduce the bacteria in concrete it producing calcium carbonate crystals which block the micro cracks and pores in the concrete. In concrete micro cracks are always avoided but to some extent they are responsible to their failure in strength.

The selection of the bacteria is depend on the survive capability of bacteria in the alkaline environment. **S.Dinesh**:- *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 in concrete and the treatment of cracks is very expensive. Cracks in concrete affects the serviceability limit of concrete. The ingress of moisture and other harmful chemicals into the concrete may result in decrement of strength and life. 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 are mixed with concrete the calcium carbonate precipitates forms and these precipitates fills the cracks and makes the concrete free from cracks.*

A.S. Santhi:- *Concrete must be relatively impervious to withstand the service conditions for which it has been designed, without serious deterioration over the lifespan of the structure. The loss of concrete durability may be caused by the severity of the environment to which it is exposed or by internal changes within the matured concrete itself. The external causes may be physical, chemical or mechanical and may be due to attack by natural or industrial aggressive liquids and gases. The impact of durability-related problems, particularly, cracking of the surface layer of concrete reduces material durability as ingress water and detrimental chemicals cause a range of matrix degradation processes as well as corrosion of the embedded steel reinforcement. One of the recent methods to improve the durability and strength of concrete is by the addition of bacteria into the concrete which protects the concrete by natural calcite deposition.*

Amirreza Talaiekhozan:- *Self-healing concrete is mostly defined as the ability of concrete to repair its small cracks autonomously. The idea of self-healing concrete was inspired from the natural phenomenon by organisms such as trees or animals. Damaged skin of trees and animals can be repaired autonomously. Remediating cracks in concrete structure is important for its service durability and structural safety. The main keyword of this article is self-healing concrete. However, other similar keywords in this area are self-healing, self repair, autonomous healing, automatic healing, auto-treatment, self-treatment, bio concrete, bio-inspired, biological concrete, calcite bio mineralization, and calcite precipitation. Recently, developing self-healing concrete technology has become an important objective for researchers in biotechnology and civil engineering sciences. During the 1980s, only very few articles can be found related to self-healing concrete, more over serious studies in this area were not established until late 1990's. Among the self-healing designing methods, biological methods are the latest ones. Several processes are proposed for the design of self-healing concrete.*

3. METHODOLOGY

3.1 MATERIALS USED

Cement

Ordinary Portland cement of 53 grade available in local market 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 having specific gravity of 3.0

Fine Aggregate

Locally available clean, well-graded, natural river sand having fineness modulus of 2.89 conforming to IS 383-1970 was used as fine aggregate. **Coarse Aggregate**

Crushed granite angular aggregate of size 20 monomial size from local source with specific gravity of 2.7 was used as coarse aggregate.

Water

Locally available potable water conforming to IS 456 issued.

Microorganisms

*Bacillus subtitles' JC3***,** *a model laboratory Soil bacterium which is cultured and grown at JNTUH Biotech Laboratory was used.*

3.2 HOW DOES BACTERIAREMIDIATE CRACKS

- *When the concrete is mixed with bacteria (bacillussubtilus), the bacteria go into a dormant state, a lot like seeds.*
- *All the bacteria need is exposure to the air to activate their functions. Any cracks that should occur provide the necessary exposure.*

- *When the cracks form, bacteria very close proximity to the crack, starts precipitating calcite crystals. When a concrete structure is damaged and water starts to seep through the cracks that appear in the concrete, the spores of the bacteria germinate on contact with the water and nutrients.*
- *Having been activated, the bacteria start to feed on the calcium lactate nutrient. Such spores have extremely thick cell walls that enable them to remain intact for up to 200 years while waiting for a better environment to germinate.*
- *As the bacteria feeds oxygen is consumed and the soluble calcium lactate is converted to insoluble limestone. The limestone solidifies on the cracked surface, thereby sealing it up.*
- *Oxygen is an essential element in the process of corrosion of steel and when the bacterial activity has consumed it all it increases the durability of steel reinforced concrete constructions.*
- *Tests all show that bacteria embedded concrete has lower water and chloride permeability and higher strength regain than the surface application of bacteria.*
- *The last, but certainly not least, key component of the self-healing concrete formula is the bacteria themselves. The most promising bacteria to use for self-healing purposes are alkaliphilic (alkaliresistant) spore-forming bacteria.*
- *The bacterium, from the genus Bacillus subtitles is adopted for present study. It is of great concern to the construction industry whether or not these Bacteria are "smart" enough to know when their task is complete because of safety concerns.*
- *Bacillus Subtitles which is a soil bacterium is harmless to humans as it is non-pathogenic microorganism.*

3.3 CHEMISTRY OF THE PROCESS

- *Microorganisms (cell surface charge is negative) draw captions including Ca2+from the environment to deposit on the cell surface. The following equations summarize the role of bacterial cell as a nucleation site*
- *The bacteria can thus act as a nucleation site which facilitates in the precipitation of calcite which can eventually plug the pores and cracks in the concrete. This microbiologically induced calcium car bonate precipitation (MICCP) comprises of a series of complex biochemical reactions.*
- *As part of metabolism, B.Subtilus produces urease, which catalyzes urea to produce CO2 and ammonia, resulting in an increase of pH in the surroundings where Ca^{2+} & CO_3^{2-}precipitate as $CaCo_3$* $Ca^2+CELL \rightarrow CELL\text{-}Ca^{2+}$

  $CELL\text{-}Ca^2 + CO_3^2 \rightarrow CaCo_3$

- *These create calcium carbonate crystals that further expand and grow as the bacteria devour the calcium lactate food. The crystals expand until the entire gapis filled. In any place where standard concrete is currently being used, there is potential for the use of bacterial self- healing concrete instead.*
- *The advantage of having self-healing properties is that the perpetual and expected cracking that occurs in every concrete structure due to its brittle nature can be controlled, reduced, and repaired without a human work crew.*
- *Bacterial self-healing concrete also prevents the exposure of the internal reinforcements. This form of self-healing concrete was created to continuously heal any damage done on or in the concrete structure.*
- *It was made to extend the life span of a concrete structure of any size, shape, or project and to add extra protection to the steel reinforcements from the elements.*
- *With this process, money can be saved, structures will last far longer, and the concrete industry as a whole will be turning out a far more sustainable product, effectively reducing its CO2 contribution*

3.4 EXPERIMENTALPROGRAM

The main aim of the present experimental program is to obtain specific experimental data, which helps to understand the crack healing ability of Bacterial concrete and its characteristics (Strength and Durability).This experimental program is categorized into three phases:

Phase1: Culture and Growth of Bacillus subtilus

Phase2: Evaluation of compressive strength enhancement in Bacterial concrete specimens

Phase3: Evaluation of Durability enhancement in Bacterial concrete specimens

4. CONCLUSIONS

Experimental investigations were conducted to determine the characteristics and strength of concrete by addition of bacteria with water. Concrete specimens were casted and tested to determine the compressive strength and flexural strength .based on the test results than the conventional concrete with respect to 7,14,28 days compressive strength ,split tensile strength and flexural strength when added bacteria.

According to the compressive studies undertaken it is clear that with 10ml, 20ml, and 30mladdition of bacteria a maximum compressive strength of 26.44N/mm2, 29.33N/mm2, and 32N/mm2 which is more than the conventional concrete was obtained.

- Further increment of concentration of bacillus subtills to the percentages could further increase the strength on concrete
- Microbial concrete technology have proved to be better than conventional technologies because of its eco-friendly nature ,self-healing abilities and very convenient for usage
- The optimum percentages obtained is 0.9%

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