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Smart Concrete – A New Technology

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Abstract – Due to temperature gradients, surface cracks can occur at very early ages in concrete structures. Because the hydration has just started it is possible that these cracks can heal with continuing hydration. The aim of this research was to investigate if cracks that arise at early ages can heal and under what conditions. Primarily the strength of healed cracks was considered. When water flows through cracks smaller than 0.2 mm, the flow will decrease and can stop completely. This is called self healing. Precipitation of calcium carbonate and clogging by loose particles are the most mentioned causes.

Keywords—Bacillus Sphaericus, Filling of cracks, Peptone, Self healing, Calcium carbonate, Corrosion resistance, Compressive strength

INTRODUCTION:

Concrete is the most widely used construction material because of its high compressive strength, relatively low cost etc. One adverse property of concrete is its sensitivity to crack formation as a consequence of its limited tensile strength. For that reason, concrete is mostly combined with steel reinforcement to carry the tensile loads. Although these rebars restrict the crack width, they are mostly not designed to completely prevent crack formation. Cracks endanger the durability of concrete structures as aggressive liquids and gasses may penetrate into the matrix along these cracks and cause damage. Consequently, cracks may grow wider and the reinforcement may be exposed to the environment. Once the reinforcement starts to corrode, total collapse of the structure may occur. Therefore, it seems obvious that inspection, maintenance and repair of concrete cracks are all indispensable. However, crack repair becomes difficult when cracks are not visible or accessible. Moreover, in Europe, costs related to repair works amount to half of the annual construction budget. In addition to the direct costs, also the indirect costs due to loss in productivity and occurrence of traffic jams carry a severe economic penalty. Accordingly, self-healing of cracked concrete would be highly beneficial. Self-healing is actually an old and well known phenomenon for concrete as it possesses some natural autogenous healing properties.

However, autogenous healing is limited to small cracks, is only effective when water is available and is difficult to control. In 1969, self-healing properties were for the first time built-in inside polymeric materials.

PRINCIPLE:

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. It is a well-known fact that concrete structures are very susceptible to cracking which allows chemicals and water to enter and degrade the concrete, reducing the performance of the structure and also requires expensive maintenance in the form of repairs. In this paper, the following notable points regarding classification of bacteria, self-healing of cracks in concrete, chemical process for crack remediation, self-healing mechanism of bacteria, application of bacteria in construction field, Advantages and disadvantages of bacterial concrete etc., are observed and identified from the other research works. Cracking in the surface layer of concrete mainly reduces its durability, since cracks are responsible for the transport of liquids and gases that could potentially contain deleterious substances. On the other hand the concrete structures show some self- healing capacity, i.e. the ability to heal or seal freshly formed micro-cracks.

LITERATURE REVIEW:

Bacterial Concrete: New Era for Construction Industry
International Journal of Engineering Trends and Technology (IJETT) – Volume 4 Issue 9- Sep 2013

Concrete which forms major component in the construction Industry as it is cheap, easily available and convenient to cast. But drawback of these materials is it is weak in tension so, it cracks under sustained loading and due to aggressive environmental agents which ultimately reduce the life of the structure which are built using these materials. This process of damage occurs in the early life of the building structure and also during its life time. Synthetic materials like epoxies are used for remediation. But, they are not compatible, costly, reduce aesthetic appearance and need constant maintenance. Therefore bacterial induced Calcium Carbonate (Calcite) precipitation has been proposed as an alternative and environment friendly crack remediation and hence improvement of strength of building materials. The concept was first introduced by Ramakrishna, Journal publication on self-healing concrete over the last decade. A novel technique is adopted in re-mediating cracks and fissures in concrete by utilizing Microbiologically Induced Calcite or Calcium Carbonate ($CaCO_3$) Precipitation (MICP) is a technique that comes under a broader category of science called bio-mineralization. MICP is highly desirable because the Calcite precipitation induced as a result of microbial activities is pollution free and natural. The technique can be used to improve the compressive strength and stiffness of cracked concrete specimens. Research leading to microbial Calcium Carbonate precipitation and its ability to heal cracks of construction materials has led to many applications like crack remediation of concrete, sand consolidation, restoration of historical monuments.

MATERIALS:

1. **Cement –**

Ordinary Portland cement of grade 53 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.

2. **Coarse Aggregate –**

Crushed granite angular aggregate of size 20 mm nominal size from local source having specific gravity of 2.71 is used as coarse aggregate.

3. **Fine Aggregate –**

Natural river sand having specific gravity of 2.60 and confirming to IS-383 zone II is used.

4. **Water –**

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

5. **Microorganisms –**

Any of the following bacteria may be used for the process:

- Bacillus sphaericus
- Bacillus cohnii
- Bacillus halodurans
- Bacillus pseudofirmus
- Bacillus subtilis

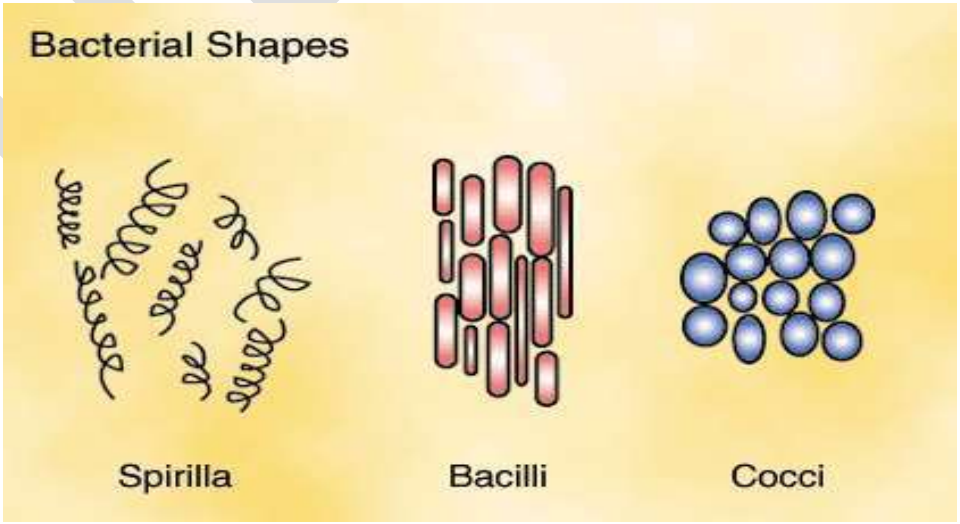

Fig.1 Shapes of Bacteria

METHODOLOGY –

The following steps are involved in the implementation of the project and are not limited to

- Literature Survey
- Collection of Required RAW materials
- Designing of concrete M20 Grade mix as per IS 10262-2009
- Culturing of Calcite Depositing Bacteria
- Casting and curing of controlled concrete cubes, beams and cylinders
- Creating a fault plane for bacterial concrete application
- Application of cultured bacteria for cracked Surface
- Strength and durability tests on healed concrete
- Comparison of strength and durability characteristics of controlled M20 grade concrete and bacteria healed concrete
- Discussions and conclusions to be done on the results obtained.

Fig. 2 Bacteria

Fig. 3 Nutrient Agar

Fig.4 UV rays machine

ADVANTAGES:

- Helpful in filling of cracks in concrete.
- Helpful to reduce leakage of residential building.
- Helps to reduce permeability in concrete.
- Helpful to reduce corrosion of reinforced concrete.
- It increases durability of concrete.

DISADVANTAGES:

- It is quite costly than normal concrete so becomes uneconomical.
- It is not suitable for Indian atmospheric condition.
- It gives better results only if comes in contact with water.
- Process of activation of bacteria is tedious.
- It takes more time for working of bacteria in concrete.

CONCLUSION:

The microbial induced calcite precipitation reaction may cause lower amount of capillary pores and clogging of the pores, which reduces chloride ion transport in concrete. The use of bacterial cells has thus become a viable solution not only to some durability problems but also as an environmentally responsible course of action. The new method of self healing design to repair cracks in cracked concrete was suggested, and self healing properties of cracked concrete using various mineral admixture were investigated. This microbe proved to be efficient in enhancing the properties of concrete by achieving a very high initial strength increased and thus we can conclude that the produced calcium carbonate has filled some percentage of void volume thereby making the texture more compact and resistive to seepage.

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