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EXPERIMENTAL STUDY OF CONCRETE BY USING BIO-MINERALIZATION PROCESS

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ABSTRACT

Micro-cracks are the main cause to structural failure. One way to circumvent costly manual maintenance and repair is to incorporate an autonomous self -healing mechanism in concrete. One such an alternative repair mechanism is currently being studied, i.e. a novel technique based on the application of bio-mineralization of bacteria in concrete. The applicability of specifically calcite mineral precipitating bacteria for concrete repair and plugging of pores and cracks in concrete has been recently investigated and studies on the possibility of using specific bacteria as a sustainable and concrete -embedded self-healing agent was studied and results from ongoing studies are discussed. Synthetic polymers such as epoxy treatment etc, are currently being used for repair of concrete are harmful to the environment, hence the use of a biological repair technique in concrete is focused. Recently, it is found that microbial mineral precipitation resulting from metabolic activities of favorable microorganisms in concrete improved the overall behavior of concrete. In our project we are using these bacteria (Bacillus subtilis).

Keywords : self healing , micro cracks, carbonate precipitation, crack healing properties.

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INTRODUCTION

SELF- HEALING APPROACH

Self-healing approaches are promising techniques for the remediation of micro-cracks in concrete. The autogenously self-healing techniques show better results in healing of micro cracks on the surface of the concrete. The formation of pervious layer on the existing layer of concrete shows precipitation of Calcite. As concrete is a high alkaline building material the bacteria is added should be alkali-resistant to withstand in high alkali environment .The experiments showed cracks can be healed up to 0.46 mm wide cracks of bacterial specimens after 100 days of curing . The CSH gel is increased by treatment of bacteria in concrete specimens to precipitate calcite which affects the healing capacity by bacterial concentration. The presence of silicate substances in concrete matrix makes porous and reduce ingress of water into concrete . Calcium carbonate can be formed on the surface of the concrete by reacting with CO2 present in the calcium hydroxide by following reactions

$$CO2 + Ca (OH) 2 \rightarrow Ca CO3 + H2O \quad (1)$$

$$Ca (C3H5O2) 2 + 7 O2 \rightarrow CaCO3 + 5 CO2 + 5 H2O \quad (2)$$

The Ca(OH)2 is a soluble mineral will be dissolved in water, ingress into the crack and will be out at the time of leaching. This process is more efficient because of active metabolic conversions of calcium nutrient sand bacteria present in the concrete . Several studies investigated that the bio-mineralization in cement materials shows possibility to show self-healing characteristics in concrete. The influence of urea producing bacterial cells shows precipitation of Ca CO3in urea extract medium (UYE medium). The compressive strength that was similar or higher than the neat mortar was observed . The increment in

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compressive strength was observed up to 15 % and the decrease in porosity at 28 days was observed. The efficiency of the concrete may be defined as performing permeability tests on low pressure environments. Visual examination of the crack filling may be adopted to check the better performance of crack filling improvement.

MATERIALS AND METHOD

A.*Cement*

Portland Pozzolana Cement of " 43 grade.

B. Fine Aggregate

Sand sample conforming to Zone-III as per the test from IS:383-1970 with specific gravity of 2.54 was used.

C. Coarse Aggregate

Coarse aggregate of specific gravity 2.6 and of maximum size 20.0 mm single sized aggregate were taken.

D. Water

Water confirming to the requirements of IS456-2000 was taken with the pH value 7.1 at zero turbidity.

E. Bacteria

Bacillus subtilis strain 121 was obtained and used in this study from Microbial Type Culture Collection

F. Mix Proportion

For a concrete mix design of M20 as per IS10262-1982 the ratio of cement, fine aggregate and coarse aggregate was derived to be 1.0 : 1.43 : 3.10 for a water cement ratio of 0.5 by mass for conventional concrete and a water cement ratio of 0.25 and bacterial culture of 0.25 for bacterial concrete by mass.

Samples were prepared in sets of three in a standard cube mould of 15x15x15 cm . The cement concrete cubes were demoulded after 24 h and placed in water for curing process. After removal from water, the surfaced of the cubes were completely dried prior to tests like physical properties, compressive strength and SEM

WORKING PROCESS OF BACTERIA IN CONCRETE

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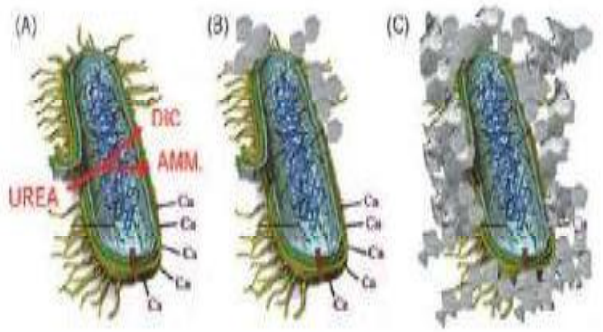
Self-healing concrete is a product that will biologically produce limestone to heal cracks that appear on the surface of concrete structures. Specially selected types of the bacteria genus *Bacillus, along with a calcium-based nutrient* known as calcium lactate, and nitrogen and phosphorus, are added to the ingredients of the concrete when it is being mixed. These self-healing agents can lie dormant within the concrete for up to 200 years. 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.



(a)Release of lactate to bacteria
(b)Precipitation of calcium cart
(c)Capsulation of bacterial cell
(d)Imprints of bacterial cell

ADVANTAGES

- Improvement in compressive strength of concrete.
- Better resistance towards freeze and thawing attack.
- Reduction in corrosion of reinforcement in concrete.
- Reduction in permeability of concrete.
- The consumption of oxygen during the bacterial conversion of calcium lactate to limestone has an additional advantage.

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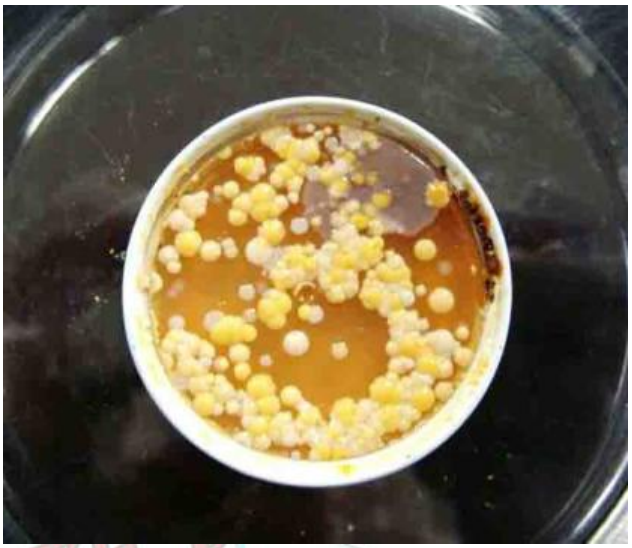
Oxygen is an essential element in the process of corrosion of steel and when the bacterial activity has consumed it all it increases the durability of steel reinforced concrete constructions.

- Increases the durability of steel structure(upto200 YEARS).
- Increases the life of the building(up to 400 years).
- Saves humans life by reducing the risking of human life in dangerous areas.
- Durability of cementations materials to improvement in sand properties, from repair of limestone monuments, sealing of concrete cracks to highly durable bricks, microbial concrete has been successful in one and all.

- In production of brick
- Used as a crack filling material.
- To give a cover to pervious member



Bacteria plate

APPLICATION

- In cement mortar
- In precast concrete member

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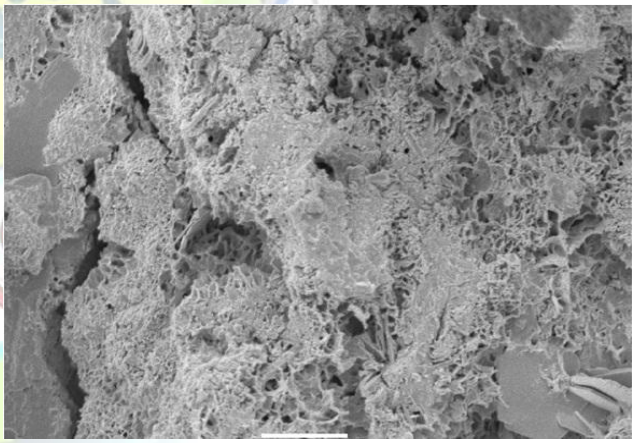
Bacterial solution

Concrete piece for SEM analysis

TEST AND RESULTS

SEM ANALYIS

The SEM procedures and scans a finely focused beam of electrons across the specimen and measures signals resulting from the electrons beam interaction. Commonly signals employed in SEM analysis include secondary electrons for imaging surface topography.



Conventional concrete show more voids in micro structure

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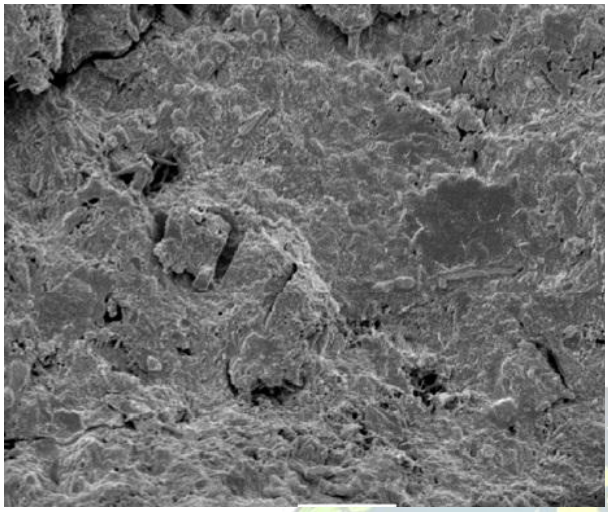

SEM for bio concrete shows that more dense in micro structures

COMPRESSIVE STRENGTH

The compressive test is carried out according to determine the characteristic strength of the concrete. In the test , 150mm x 150mm x 150mm standard cube mould is used for concrete mix. The apparatus cube mould is used for concrete mix. The apparatus should be clean and free from hardened concrete and superfluous water before testing. The test is carried out for each cube. The reported compressive strength of 3 ml (50 ml,100ml, 150ml) tested at the age of 7,14,21 &28 days.

In the project determine the mixing of bacterial solution in the concrete and it increase the strength of the bacteria.

Test days	Conventional Concrete N/mm^2	50 ml	100 ml	150 ml
7	10.5	10.9	11.2	11.9
14	17.2	17.7	18.1	19
21	19	24.3	25.9	27.4
28	23.7	29	31.3	33.65

Compressive strength result for bacterial concrete and conventional concrete.

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CONCLUSION

Microbial concrete technology has proved to be better than many conventional technologies because of its eco- friendly nature, self-healing abilities and increase in durability of various building materials. Enhancement of compressive strength, reduction in permeability, water absorption, and reinforced corrosion has been seen in various cementituous and stone materials. Bacterial concrete is a potential self-healing remediation technique for cracks in concrete due to its high impermeable nature.

Bacillus subtilis of MTCC NO.113 is a soil bacterium which can utilize the urea and continuously precipitate calcite which prevent the presence of air molecules in the concrete. In M20 grade concrete, with the addition of bacteria the percentage of improvement in the compressive strength is in the order of by 12.32%, to 30.05% at different ages.

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