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Experimental Study on Bacterial Concrete

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Abstract
This paper explains about the overview of bacterial concrete There are many papers which discussed about the various strains of bacteria. Self healing agents such as epoxy resins, bacteria, fiber are used to heal cracks in concrete. Among these, bacteria used in concrete are effective. When the bacteria is mixed with concrete the calcium carbonate precipitates forms and these precipitates filling the cracks and makes the crack free concrete. The state of art results in all projects show that material designed as self healing agents.

Keywords: *Bacterial concrete, Calcium carbonate, Epoxy resins, Self healing agent.*

1. Introduction

Last few years several investigation are made in bacterial concrete. H.M.Jonkers(2011) gives an overview of durability of bacterial concrete. His paper deals with the self healing repair mechanism. He concludes that the bacterial concrete heals sub millimeters crack size of 0.15mm. This concrete is very effective in wet environment and controls the corrosion of steel reinforcement. Nithin kumar et al (2012) studied about the fracture of bacterial concrete. He considered the fracture parameters such as stress Intensity Factor(K), Fracture Energy(G_f), crack mouth opening displacement and brittleness number(S). His analytical and experimental investigation concludes that the fracture in bacterial concrete is less compared to conventional due to high stress intensity factor, low deflection ands less fracture energy. Jagadeesh Kumar et.al(2013) compared three species of bacillus such as Bacillus flexus, Bacillus Sphaericus and Bacillus pasteuri. From this he concluded that the bacillus flexus is an best option in MICP(Microbially Induced Calcite Percipitation).

Srinivas Reddy et al (2012) has shown the results of durability properties of bacterial concrete. He made investigation in Bacillus substilis and also performed acid test for the bacterial concrete .The results shows that the bacterial concrete is an excellent reistance to acid attack. Ter Heide (2005) gives an overview of different causes of autogenic healing. (Fig. 1) in which a materials has already by nature the ability to heal itself.

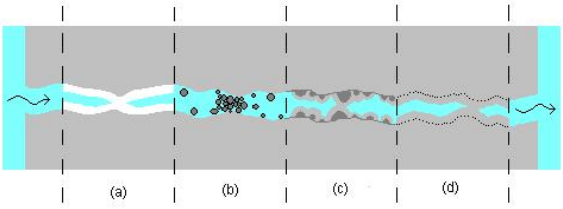

Figure 1. Possible causes of self healing: (a) formation of calcium carbonate or calcium hydroxide, (b) sedimentation of particles, (c) continued hydration, (d) swelling of the cementmatrix, (Ter Heide , 2005).

S.Maheswaran et.al(2014) compared the compressive strength of new type of wild strain Bacillus Cereus and Bacillus pasteuri. In his literarture review, the compreesive strength of Bacillus Cereus is higher than the Bacillus pasteuri and conventional concrete. It is good in marine environment.

2. **Bacterial Concrete:**

Bacterial concrete is the new innovative technique, in which the bacteria are added to the concrete mix to enhance the strength and also it act as a excellent self healing agent.

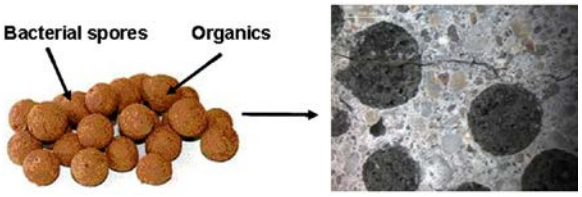

Figure 2: Bacterial spores(left), bacterial spores embedded in concrete mix(right).

3. Advantages Of Microbial Concrete :

1) Improvement in compressive strength of concrete
2) Better resistant towards freeze thaw attack
3) Reduction in permeability of concrete
4) Reduction in corrosion of reinforced concrete
5) Eco friendly

Figure 3: healing of cracks

4. Need for bacterial concrete:

Concrete is the mixture of cement, fine aggregate, coarse aggregate and water. It is an excellent building material but it is imperfect because Micro cracks form in concrete makes the structure damage. Repair in conventional concrete is time consuming and expensive.

Bacterial concrete is one of the solution to problems in the concrete. It successfully remediate cracks in concrete.

5. Types Of Bacteria:

The above mentioned bacteria are used in concrete.

6. Healing Of Cracks:

If the crack occur in the structure, water enters into the cracks and makes the structure damage. But in bacterial concrete when the water penetrates into the crack the bacteria germinates and produces the calcium carbonate precipitate which heals the cracks.

The calcium carbonate is formed by the following reaction,

$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$.

7. Test for Bacterial Concrete:

Jagadeesha Kumar B G et.al suggested the following test for bacterial concrete

1) Calcium carbonate estimation
2) X-ray diffraction (XRD)
3) Scanning Electron Microscope (SEM)

7.1 Calcium Carbonate Estimation:

They evaluated the calcium carbonate by the following procedure

1ml of bacterial solution was titrated with Erichrome Black Indicator(EBT) gives wine red colour which when added with EDTA changes the wine red colour into blue colour at the endpoint.

[Ca-EBT]+ EDTA $\rightarrow$ [Ca-EDTA]+ EBT (Wine red) (Blue)

7.2 X-Ray Diffraction:

In their XRD analysis the chemical composition of the precipitate that occurred due to bacterial mineralization was determined.

7.3 Scanning Electron Microscope:

The deposition of calcite inside the micro cracks of concrete by bacteria were analyzed under SEM.

8. Strength Aspect:

The compressive and tensile strength of bacterial concrete is higher than the conventional concrete and it is more durable.

9. Numerical Analysis:

Nithin Kumar et.al discussed about the ANSYS modeling and explained about the aspects given below

1) Modeling of crack region
2) Analytical investigation

9.1 Modeling Of Crack Region:

The crack region was determined by ANSYS. The model was meshed as triangular mapped elements.The crack region which is referred as crack tip in 2D and crack front in 3D model.

9.2 Analytical Investigation:

The beam was analysed by ANSYS to determine the ultimate load and deflection. The experimental and analytical deflection results are compared.

10. Conclusion

From the above discussion the bacteria such as Bacillus Pasteuri, Bacillus megaterium, Bacillus subtilis are having some disadvantages and also Pseudomonas aeruginosa are undoubtedly pathogen and cannot be directly applied in building structures like houses and offices because of health concerns.Finally we conclude that the Bacillus Sphaericus and Eschericheria Coli have some advantageous than above bacteria

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