STUDY PARAMETERS OF CRACK ON CONCRETE DUE TO BACTERIAL AFFECT

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Abstract : . In this research we have developed bacterial concrete. Here, the cementation by microbiologically induced calcium carbonate rain has been introduced for the remedies of micro cracks, where the bacteria is induced in themortarand concrete to seal the cracks. Cracking is a ordinary problem developed due to reasonably low tensile strength in concrete. A typical durability related occurrence in many concrete construction is crack formation. Besides durability, Cracks in concretesoccur due to other implements such as shrinkage, freeze-thaw reactions, and mechanical compressive and tensile forces. Cracks play a vital role for the reduced service life of concrete structure. Regular manual maintenance and repair of concrete construction is costly and in some cases not possible, but autogenous repair would save a considerable amount of resources. Concrete structures have the potential to seal freshlyformed micro-cracks. This property is due to the presence of non-hydrated excess cement particles within the materials matrix, which undergo delayed or secondary hydration upon reaction with the access of water. So a reliable self-healing technique forconcrete would not only result in more durable structures, but also favorable for the globaleconomy.

Index Terms - Self-healing, micro-cracks, CaCO3 precipitation, bacteria, autogenous repair

I. INTRODUCTION

As a structural material, concrete receive extensive use everywhere in the planet. The common problem is the higher possibility of cracking caused by low tensile strength in concrete structure. Crack formation in concretestructuresisa occurrence that can rarely be avoided due to shrinkage and tensile stresses. While larger cracks can potentially hamper a structure's integrity, smaller cracks typically with a crack width smaller than 0.2 mm do not create problems. Although micro-cracks do not necessarilyresult in losses of strength but helps in material porosity and permeability, the ingress of water and other reactive chemicals such as chloride, sulphates and acid may hamper the steel reinforcement as these strongly enhance its erosion rate and durability for a long term. Autogenous cracks are developed in concrete by adding the microbialself-healing agentwhichhasthe potentialto improveself healing capacity mainly achieved by bacteria influenced mineral precipitation by direct method or encapsulation way. In this study, the properties of normal concrete and bacterial concrete are studied by conducting various tests such as compressive strength, tensile strength, flexural test with different grades as M20, M25, M30.When bacteria is used to work for the healing of cracks in concrete, the most important point is the high alkalinity available in environment, which helps the growthof the bacteria.

II. SELF HEALINGAGENT

The bacteria which behaves as self healing agent in concrete should be able to perform long-term effect in crack sealing, throughout the life time of the construction. Self-healing concrete is a product which produces limestone by which cracks on the surface of concrete structure heals. Selected categories of the bacteria Bacillus with calcium-based nutrient referred to as salt, nitrogen and phosphorous are mixed to the concrete when it is being mixed. The principal mechanism of self crack healing is that the bacteria act as a catalyst, and transform a parent compound to a suitable filler material. The utilization of bio mineralogy in concrete isinvented a new material known as bacterial concrete.

Figure -1:- Image of before and after crack by using self healing concrete

III. OBJECTIVES

The main purpose of self healing concrete is to enhance the service time and durability of the concrete work.

1. This concrete ease the loss of materials and also to build eco friendly civilworks.
2. Self healing techniques permit the concrete to get back liquid tightness by using of micro-organisms andhydrogels.
3. In self healing techniques, using of encapsulated polymers prevent future durability problems when cracks in concrete occur under dynamicloading.
4. Monitoring techniques and non-destructive testing designate the effect of various self-healing mechanisms in small and full-sizespecimens.
5. It develops construction detail and structure within the project by using self healingproduct.

IV. MATERIALS USED INWORK

1. Ordinary portland cement: The cement test confirms to IQS:5/1984.
2. Fine aggregate: The grade size of sand is within the limits prescribed by IQS: 45/1984 and lies in Zone 3. ex- Natural sand(Al-Ekhadir)
3. Coarse Aggregate: The grade size of aggregate and its properties (physical and chemical) confirm to IQS: 45/1984. ex- Natural gravel (Al- Nibaee) with a standard aggregate size of (5-20mm)
4. Mixing water: Ordinary drinkingwater
5. Calcium Hydro-oxide(Ca(OH)2)
6. Crystallization Material(Na2CO3)

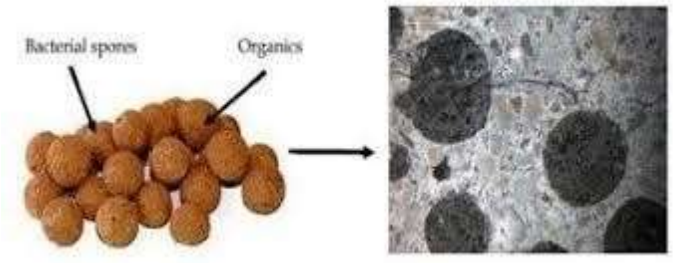

Figure -2:- (In the left side) self healing admixture collected of expanded clay particles packed with bacterial spores and calcium lactate. (In the right side)when this admixture soaked in the concrete matrix which containing the two-component healing agent consisting of bacterial spores and a suitable bio-mineral parent compound.

2.1 Testing of hardenedconcrete

Following tests are conducted to check the strength of concrete structure

1.Compressive Strength Test
2.Flexural Strength Test
3.Splitting Tensile StrengthTest
4. Ultrasonic Pulse VelocityTest

2.2 MixDesign

The proportion of concrete mixture is made according to ACI 211-91 .The compressive strength and unit mass of concrete is 35 N/mm^2 and 2280 kg/m^3 respectively. Beside that, the slump value of concrete lies in 75 to 100 mm.

Table-1: Mix proportion by weight of concrete materials according to ACI 211-91

Material	Cement	Sand	Gravel	Water
Mix proportion by weight(kg/m^3)	456	555	1040	205
Mix proportion	1	1.71	2.256	0.42

2.3 Methodology

Self healing concrete is a biological reaction of non-reacted limestone and a calcium based nutrient. The bacteria which seal the cracks appeared on the concrete structure, is of Bacillus family. The special categories of bacteria are used together with calcium nutrient known as calcium lactate. During the preparation of the concrete, these products are mixed in the wet concrete. Self healing concrete can be prepared in differentmethods

1. Directapplication
2. Encapsulation in lightweightconcrete

3 Mineral admixtures.

4. Chemical in glasstubing.
5. Self- healing with self-controlled tight crackwidth

2.3.1 Directapplication

In this process, bacterial spores and calcium nutrients are included in the concrete directly, when it is mixed. The amount of Bacillus bacteria and calcium nutrients don't change the normal proposition of the concrete. The bacteria are uncovered to the climatic changes when the cracks formation appear in the structure. The seepage of water comes in contact with this bacteria,then they spread and consume calcium lactate producing limestone. In this way the cracks aresealed.

2.3.2 Encapsulation method

Normally Encapsulation method is two types:

1. Chemicalencapsulation
2. Bacterial encapsulation.

In this process, the bacteria and its nutrients are placed inside the clay compound and concrete is prepared. Around 6.1% of the clay prills are mixed for preparing the bacterial concrete. When the crack occurs in the concrete structure the clay compounds are broken and the bacteria spread and eat down the calcium lactate and create limestone, which hardens and seal the cracks. The mixture of compressed nutrients and bacterial spores can be mixed directly to the concrete mixture and the coating shouldform a strong bond withtheconcretematrixsothatcracksgothroughtheparticles.

The technique of the self healing process may differ and depend on the formation of the concrete mixture. Crack-penetrating waterwoulddissolvecalciteparticles($CaCO_3$)presentinthemortarpatternandalsoreacttogetherwithatmosphericcarbondioxide.

3.**I. Selected categories of bacteria used inconcrete**:

Selected categories of bacteria are used as construction materials. Bacillus bacteria are used for the precipitation of calcite on the surface of the concrete. From calcium sources, phosphorous and nitrogen sources, the nutrients for the bacteria is available in calcite form. These bacterial constituents remain in concrete, when the seepage of water take place the bacterial constituent react with nutrient to precipitate calcite i.e. $CaCO_3$. These are the following categories of the Bacillusbacteria:-

- Bacilluspasteurizing
- Bacillussphaericus
- Escherichiacoli
- Bacillussubtilis
- Bacilluscohnii
- Bacillusbalodurans
- Bacilluspseudofirmus.

3.2 Advantages

- Theselfhealingbacteriareducesmaintenanceandrepaircostsinreinforcedconcretestructures.
- It minimizes the permeability ofconcrete.
- Theerosionofsteeldecreases,duetotheformationofcrackandhelpsinimprovingthedurabilityofsteelreinforcedconcrete.
- It helps in increasing compressive and flexural strength of the concrete ascompared to the normal concrete.
- It minimizes the risk factor of human lives in hazardous area and also enhances the durability of the variousstructure.

3.3 Disadvantages

- The self healing concrete is more expensive than the normalconcrete.
- Thegrowthofbacteriainconcreteisfasterthannormalconcreteinatmosphere.
- Neither any IS code nor any other code has mentioned about the design of mix concrete with bacteria.

4. Results

Compressive and flexural strength tests were conducted on normal and self healing concrete cube for 7 and 28 days. The results are givenbelow:-

Table 4.1: Compressive strength for 7 and 28 days

Sl. No	Days	Normal concrete (N/mm^2)	Self healing concrete(N/mm^2)
1	7	20.85	26.35
2	28	30	39.25

Table 4.2: Flexural strength for 7 and 28 days

Sl. No	Days	Normal concrete (N/mm^2)	Self healing concrete(N/mm^2)
1	7	3.90	4.32
2	28	7.05	7.60

Figure-3: Image of bacterial concrete

5. DISCUSSION

The objective of this paper is to introduce bacteria-based self-healing concrete. The application of bacteria to rain calcite in the cracks of concrete .By the use of this technique, rather large cracks in ferroconcrete are often filled. Due to its eco-friendly and self- healing capacity, bacterial concrete is better than the normal concrete. It has been found that the use of bacteria can increase the durability, mechanical and chemical aspect of concrete, compressive strength, reduction in permeability, water absorption, reinforced corrosion in various cement and stone materials. This study shows that bacteria combined in the concrete matrix can actively precipitate calcium carbonate minerals. Water, needed for the activation of endospores can enter the concrete structure through freshly formed cracks. For mineral precipitation, active cells need an organic extract which will be changed to inorganic carbon what can subsequently precipitated with free calcium to carbonate. Free calcium is normally present within the concrete matrix, but there is no organic carbon. In the present observation organic carbon was applied externally as a part of the incubation medium, while it should also be the part of concrete matrix. In that case only external water is needed to activate the deactivated bacteria of concrete, which can convert organic carbon present in the concrete matrix to calcium carbonate and seal freshly formedcracks.

From the above analysis, the process of mixing the bacteria in concrete is somehow complicated, so it requires skilled labour. To conclude from the bacterial point of view, we will state that it has the potential to contribute to the self-healing capacity of concrete. It shows that bacteria included in high numbers (109 cm^{-3}) don't affect concrete strength , that a substantial number of mixed bacteria remain workable and these feasible bacteria can precipitate calcium carbonate needed to seal freshly formedcracks.

REFERENCES

[1] Bang S.S., Galinat J.K., & Ramakrishnan V., (2001).“*Calcite precipitation induced by polyurethane-immobilized Bacillus pasteurii*” , Enzyme Microb Tech 28:404-409.

[2] Clegg, J.S., 2001. Cryptobiosis – a peculiar state of biological organization. “*Comparative Biochemistry and Physiology Part B*” 128(8): 613–624.

[3] De Muynck W., De Belie N. &Verstraete W., 2007. “*Improvement of concrete durability with the aid of bacteria*”. Proc of the 1st conference on self healing materials 18–20 April 2007, Noordwij kaan Zee, The Netherlands; p:1–11.

[4] Dorn R.I. & Oberlander T.M., 1981. “*Microbial origin of Desert Varnish Science*”213:1245-1247.

[5] Edvardsen C., (1999). “*Water permeability and autogenous healing of cracks in concrete*”. ACI Materials Journal 96(4):448-454.

[6] Ghosh P., Mandal S., Chattopadhyay B.D., and Pal S., (2005). “*Use of microorganisms to improve the strength of cement mortar*”. Cement Concrete Res35:1980-1983.

[7] H. M. Jonkers, “*Bacteria-based self-healing concrete*”, Delft University ofTechnology.

[8] Kunamineni Vijay, Meena Murmu, Shirish V. Deo, “*Bacteria based self-healing concrete Construction and Building Materials*” 152 (2017) 1008–1014.

[9] K. Van Tittelboom, N. De Belie, “*Self-Healing in Cementitious Materials - A Review*”, Materials 6 (2013)2182-2217.

[10] Neville A.M., (1996) .“*Properties of concrete (4th edition)”.* Pearson Higher Education, Prentice Hall, New Jersey. [11.] Neville A.M.,(2002). “*Autogenous healing – A concrete miracle?”*Concrete Int24(11):76–82.

[12] Ramachandran S.K., Ramakrishnan V. and Bang S.S., “*Remediation of concrete using microorganisms*”, ACI Materials Journal 98 (1) (2001)3-9.

[13] Sagripanti J.L., and Bonifacino A., “Comparative sporicidal effects of liquid chemical agents”, Applied and Environmental Microbiology 62 (2) (1996)545.

[14] Schlegel H.G., 1993. “*General microbiology*” (7th edition). Cambridge UniversityPress.

[15] Stocks-Fischer S., Galinat J. K., & Bang S.S., 1999. Microbiological precipitation of CaCO3 . “*Soil Biology and Biochemistry*” 31:1563– 1571.

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