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REVIEW ON EFFECT OF BACILLUS SUBTILIS STRENGTHENING OF CRACKED CONCRETE

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Abstract: Cracks are the common type of failure in concrete which are irreversible in process [1, 2] Bacillus Pastuerii, Bacillus Cohni, Bacillus Sphearicus are common soil bacterium induce the precipitation of calcite exhibited its positive potential in selectively consolidating simulated fractures in the consolidation of sand. [1, 3, 4, 5] In this study we tried to find the effect of Bacillus Subtilis on strengthening of cracked concrete. It was found that all the increase in depth of crack reduce the strength of cubes and beams.

Keywords: Bacterial Concrete, Self-Healing, Cracks, Concrete, Repair

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INTRODUCTION

In concrete, cracking is a regular observable fact due to the comparatively low tensile strength. Many factors are affecting the durability and strength of concrete. High tensile stresses can result from external loads which lead to failure of concrete. Many methods and material are available in market to repair concrete cracks. But most of materials are not eco-friendly and cause environment pollution and due to these many are banned in many countries. Bacterial induced calcium precipitation type repairing technique is eco-friendly and has been proposed as an alternative and environmental friendly crack repair technique. B. Pastuerii produces urease, which catalyzes urea to produce CO_2 and ammonia, resulting in an increase of pH in the surroundings where ions Ca_2^+ and CO_3^{2-} precipitate as $CaCO_3$. Possible biochemical reactions in medium to precipitate $CaCO_3$ at the cell surface that provides a nucleation site. The microbial urease catalyzes the hydrolysis of urea into ammonium and carbonate.[9] One mole of urea is hydrolyzed intracellularly to 1 mol of ammonia and 1 mole of Carbamic acid (1), which spontaneously hydrolyzes to form an additional 1 mole of ammonia and carbonic acid (2).[3, 4, 5, 6, 7, 8, 9, 10]

$CO(NH_2)^2 + H_2O$ ---> $NH_2COOH + NH_3$ (1)
$NH_2COOH + H_2O$ ---> $NH_3 + H_2CO_3$ (2)

Ammonium and carbonic acid form bicarbonate and 2 moles of ammonium and hydroxide ions in water (3 &4).

$2NH_3 + 2H_2O$ <---> $2NH^{+4} + 2OH^-$ (3)
H_2CO_3 <---> $HCO^{-3} + H^+$ (4)

The production of hydroxide ions results in the increase of pH, which in turn can shift the bicarbonate equilibrium, resulting in the formation of carbonate ions (5)

$HCO^{-3} + H^+ + 2NH^{+4} + 2OH^-$ <---> $CO_3^{-2} + 2NH^{+4} + 2H_2O$ (5)

The produced carbonate ions precipitate in the presence of calcium ions as calcium carbonate crystals (6).

$Ca^{+2} + CO_3^{-2}$ <---> $CaCO_3$ (6)

The formation of a monolayer of calcite further increases the affinity of the bacteria to the soil surface, resulting in the production of multiple layers of calcite.

Bacteria such as Bacillus Pastuerii, Bacillus pseudofirmus, Bacillus cohnii, Sporosarcina Pastuerii, and Arthrobacter crystallopoietes increase the compression strength of concrete through their

biomass. Not all bacteria increase the strength of concrete significantly with their biomass [11]. Bacillus sp. CT-5. can reduce corrosion of reinforcement in reinforced concrete by up to four times. Sporosarcina Pastuerii reduces water and chloride permeability. B. Pastuerii increases resistance to acid [11].146 Bacillus Pastuerii and B. sphaericuscan induce calcium carbonate precipitation in the surface of cracks, adding compression strength.[11]

LITERATURE REVIEW

Koustubh A. Joshi et. al. In this study Bacillus Subtilis are added in concrete at time of mixing to avoid micro-cracks in concrete. In this technique bacteria from bacillus family are impregnated in concrete which are having calcium as their food from concrete and when these bacteria gets in contact with atmosphere they use water and carbon dioxide from surrounding environment and its Rita produces the precipitate of calcium carbonate (lime stone) which ultimately seals the cracks and enhances compressive strength of concrete. As pores from concrete gets reduced and filled with calcium carbonate. Bacillus subtilis has positive impact on concrete's compressive strength. Change in compressive strength as bacterial count changes. [12]

Neha Singla et. al. This paper focuses on the basic process involved in formation of bacterial concrete and outlines the experimental studies carried out for investigation in the enhancement of the strength parameters of bacterial concrete. The microstructure analysis of bacterial concrete was done using SEM which revealed distinct calcite crystals formed in concrete and thus indicated that the bacteria served as the nucleation sites for the mineralization process. It is observed that Following are the results and conclusions drawn: At an optimum cell concentration of bacteria, the strength achieved is maximum stage. Compressive strength of concrete at 7 days increases about 22.7% for urea medium and 9.2% for NB medium. Compressive strength of concrete at 28 days increases about 10.4% for urea medium and 27% for NB medium. Tensile strength of concrete at 7 days increases about 14.54% for urea medium and 8.36% for NB medium.[13]

Dr. K.V. Ramana Reddy et. al., In this study, M30 grade bio concrete was prepared and was tested for healing cracks successfully. The hardened state characteristics include Compressive Strength, split tensile strengths, durability aspects such as R.C.P.T and Water Absorption. The results show that the replacement of water with bacterial solution gives additional strength to the concrete. The cube compressive strength of concrete at the age of 28 days has been increased by 31.2% .There is a 19.2% increase in the split tensile strength. Water absorption tests reveal that there is a 27.2% decrease in the water absorption of concrete.[14]

PradeepKumar.A et. al., The present investigation is to obtain the performance of the concrete by the microbiologically induced special growth. One such has led to the development of a very special concrete known as bacterial concrete where bacteria is induced in the mortars and concrete to heal up the faults. Researchers with different bacteria proposed different concretes. Here an attempt was made by using the bacteria "Bacillus subtilis strain no jc3". This

study showed a significant increase in the compressive strength due to the addition of bacteria. When 30 ml of "Bacillus Subtilis" is added in M20 grade concrete it attains maximum compressive strength. In concrete selfhealing property is successfully achieved due to addition of bacteria. [15]

CONCLUSIONS

• From the study of various papers on Bacillus Subtilis, concluded that Compression test and Flexural test on repaired cracked concrete with Bacillus type bacteria can be re-strengthen up to almost its original strength in case of smaller depth cracks. But in case of larger depth than 15 mm improvement in compressive strength reduces as the depth of crack increases. Because for calcite precipitation process Bacillus type bacteria needs more oxygen. Due to larger depth Bacteria didn't get enough amount of Oxygen from atmosphere.

• The use of this biological repair technique is highly desirable because the mineral precipitation induced as a result of microbial activities is pollution free and natural.

REFERENCES

1. Abhijitsinh Parmar, Ankit Patel, Priyank Shah, "IMPROVEMENT OF THE CONCRETE CRACKS BY USING BACILLUS SPHAERICUS", International Journal of Engineering Development and Research (IJEDR), ISSN:2321-9939, Volume.1, Issue 2, pp.82 - 84, Sept 2014
2. Abhijitsinh Parmar, Ankit Patel, Vismay Shah, Sandeep Khorasiya, Dipan Patel. (2013). "Improvement on the concrete cracks by using Bacillus pastuerii." International Journal for Scientific Research & Development (IJSRD) | Vol. 1, Issue 1, 2013
3. H. M. Jonkers, "Bacteria-Based Self-Healing Concrete", vol .56, 2011, pp.1-12.
4. Henk Jonkers, "Development And Application Of Bacteria-Based Self-Healing Materials",2012
5. Srinivasa Reddy. V, Achyutha Satya. K, Seshagiri Rao .M. V, Azmatunnisa. M, "A Biological Approach To Enhance Strength And Durability In Concrete Structures", vol. 4, 2012, pp. 392-399.
6. Ramakrishnan, V., Bang, S.S., Ramesh, K.P., and Mulukutla, S., "Performance of Bacterial Cement", Proceedings of 24th International Conference of Cement Microscopy, San Diego, California, April 2002, pp. 336-354.
7. Ramakrishnan, V., Bang, S.S., Srinivasan Neelamegam., and Ramesh, K.P., "Durability of Cement Mortar Made With Different Concentrations of Bacteria", Proceedings of 25th International Conference of Cement Microscopy, Richmond, Virginia, April 2003.
8. Ramachandran, S.K., Ramakrishnan, V., and Bang, S.S., "Remediation of Concrete using Microorganisms", ACI Materials Journal, v.98, Jan-Feb 2001, No.1, pp. 3-9.
9. DeJong, J.T.; Fritzges, M.B.; Nüsslein, K. (2006). "Microbial Induced Cementation to Control Sand Response to Undrained Shear". Journal of Geotechnical and Geoenvironmental Engineering. 132 (11): 1381–1392
10. DeJong, J.T.; Morenson, B.M.; Martinez, B.C.; Nelson, D.C. (2010). "Bio-mediated soil improvement". Ecol. Eng. 36 (2): 197–210.

11. Navdeep Kaur Dhami; Sudhakara M. Reddy; Abhijit Mukherjee (2012). "Biofilm and Microbial Applications in Biomineralized Concrete". Archived from the original on 19 December 2013.
12. Koustubh A. Joshi, Madhav B. Kumthekar, Vishal P Ghodake, “Bacillus Subtilis Bacteria Impregnation in Concrete for Enhancement in Compressive Strength”, International Research Journal of Engineering and Technology, Volume: 03 Issue: 05, May-2016
13. Neha Singla, Sanjay K. Sharma, Jasvir Singh Rattan, ‘An Experimental Investigation on Properties of High Strength Bacterial Concrete (Bacillus Subtilis)”, International Research Journal of Engineering and Technology (IRJET), Volume: 03 Issue: 08, Aug-2016
14. Dr. K.V. Ramana Reddy, M. Padmaja , P.Sankar Kumar Reddy, “AN EXPERIMENTAL INVESTIGATION ON BACILLUS SUBTILIS IN HEALING MICRO-CRACKS IN CONCRETE”, International Journal of Advance Research and Innovative Ideas in Education, Vol-3 Issue-3 2017.
15. PradeepKumar.A, Akila Dev, Anestraj. S, Arun. S, Santhoshkumar. A, “An Experimental Work on Concrete by Adding Bacillus Subtilis”, International Journal of Emerging Technologies and Engineering, Volume 2 Issue 4, April 2015.