

EXPERIMENTAL STUDY ON SELF HEALING WITH BACTERIAL CONCRETE

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Abstract – concrete cracks are the common phenomenon that has no immediate and proper treatment; these cracks lead to significant reduction in concrete structure life and require costly repairs. Although it is not possible to reduce the formation of crack, remediation of cracks in concrete has been possible in many ways. It has been shown that technique in fitting cracks with environmentally friendly biologically process; that is continuous self – remediating process. In this paper an attempt has been made to use different microorganisms, i.e.; bacillus sphaericus so as to observe the strength gain and also healing property as a result of mixing those bacteria in concrete with water. From the tests conducted on various specimens of bacterial concrete using different concentrations, a clear comparison is made for strengths of different specimens of bio concrete using different concentrations and convention concrete the results obtained from the experiment concludes that when water enter in the concrete after the formation of cracks activates the dormant bacteria (inactive) the process of metabolically mediated calcium carbonate precipitation and it increased the strength of bio concrete as compared to the conventional concrete.

Key words: - self – remediating, microorganisms, Bacillus Sphaericus, dormant bacteria, Calcium carbonate.

I. INTRODUCTION

The most important and plenteously used building material is concrete. In constructions mostly it is used because of its strength and durability. Although we give a perfect mix, cracks are common issue for concrete structure. So that structure tends to fail. To reduce the cracks; structure requires costly repairs and regular maintenance. Not only concrete but also reinforcement is effected due to cracks by corrosion. The only possible way to reduce these cracks is self healing method. This method depends on biological process, in this process not only the concrete structure heals but also the durability and strength will increases. Using bio concrete for self healing process is not harmful to the environment and also health.

Living concrete (or) bio concrete is known as “ it is a concrete which mix nature with construction.” As the normal concrete and bio concrete mix is same procedure; bio concrete is having more properties than normal concrete. When the crack occurs on the concrete structure, the bacteria which are in inactive position gets active when it comes contact with oxygen and water then it releases calcium lactate thereby the cracks get healed.

In this thesis, Bacillus sphaericus and bacillus cereus is used as biological agents. These are aerobic bacteria's.

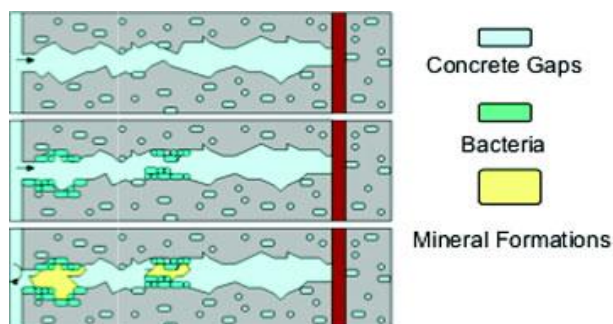
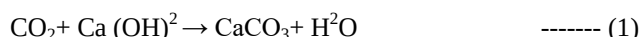


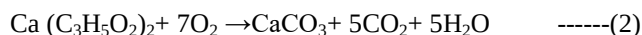
Fig 1 View of the formation of minerals in the gaps

1) METHOD OF USING SELF-HEALING BACTERIA

When bacterial concrete is made up of microbes then such process is known as Microbial induced calcium carbonate precipitation (MICCP) or bio mineralization. When photosynthesis and urea hydrolysis is mixed up then it releases CaCO_3 . The presence of CO_2 and calcium hydroxide forms calcium carbonate



Due to the presence of Carbon dioxide; calcium hydroxide is getting soluble in nature and liquefied in water and then comes out through cracks to heal them.



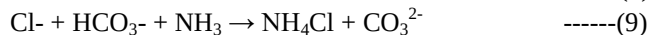
When one mol of urea forms one mol of ammonia and one mol of carbonate by intracellular hydalization; which forms one mol of ammonia and carbonic acid.



PH can rises due to one mol of ammonium and hydroxide ions.



Now the bio chemical reaction can be summed up in possible way as:



II. MATERIALS AND METHODS

MATERIALS:

The materials which are used for this project work are ordinary Portland cement of 53 grade, coarse aggregate of 20 mm and 12.5 mm size, fine aggregate as river sand, bacillus sphaericus and bacillus cereus as bacteria solutions.

PREPARATION OF SPECIMENS:

Concrete mix of M40 grade is used for casting the specimens. Conventional specimens were casted, and then specimens by using bacillus sphaericus and bacillus cereus, where the solution is taken 0.06ml per cube for both bacteria's of three different concentrations i.e., 10^4 , 10^5 and 10^6 respectively. Now the specimens were kept in curing tank and tested for 7days and 28 days.



Fig 2 Bacterial Solution

PREPARATION OF BACTERIA:

In 500ml of water; take 12.5 grams of nutrient broth (medium) in conical flask; then it is sterilized by using a cooker for 10-20 minutes. Now the solution is in orange color. Later flasks are open then add exactly 1ml of bacterium and is kept in a shaker at a speed of 150-200 rpm for 24 hours. Now the solution is in yellow turmid color. After that serial dilution and plate count method is done for getting required concentrations i.e., 10^4 , 10^5 , 10^6 respectively.

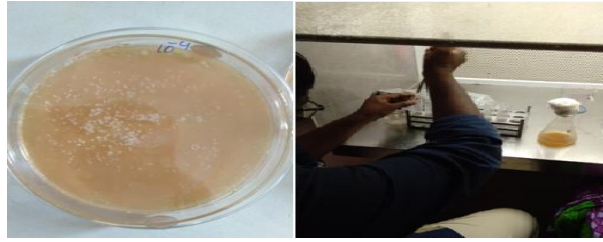


Fig 3 Serial dilution and Plate count method

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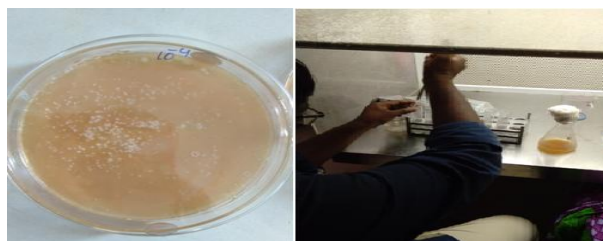


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IV TESTS ON CONCRETE

1) Compressive Strength Test:

The casted controlled specimens and bacterial specimens of size 150mm* 150mm* 150mm cubes were tested for compressive strength for 7 days and 28 days.

V RESULTS AND DISCUSSION

From compressive strength test various results were obtained. The graph charts also represented for each table of results. The table 1 and chart1 indicates the compressive strength test results of controlled specimens of M40 grade concrete. The table 2 and chart 2 indicates the test results of Bacillus sphaericus of 10^4 , 10^5 , 10^6 concentrations.

Table I
Compressive test results of Control Specimens

<i>NO.OF CUBE</i>	<i>7 DAYS (N/MM²)</i>	<i>28 DAYS (N/MM²)</i>
1	32.88	42.86
2	17.78	39.02
3.	30.14	41.96
AVERAGE	26.93	41.28

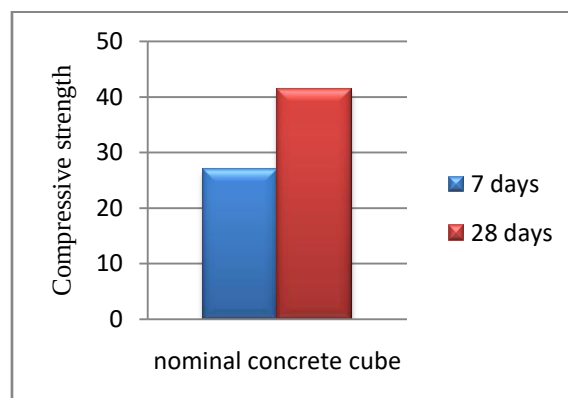


Fig 3 Compression test results of Control Specimens

Table II
Compression test results of Bacillus Sphaericus

<i>SL.NO</i>	<i>7 DAYS</i>	<i>28 DAYS</i>
<i>10⁴ CELLS/ML (N/MM²)</i>	22.59	35.99
<i>10⁵ CELLS/ML (N/MM²)</i>	25.04	36.44
<i>10⁶ CELLS/ML (N/MM²)</i>	26.93	38.51

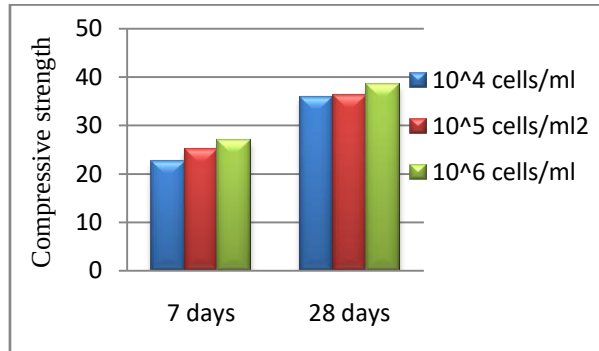


Fig 4 Compression test results of Bacillus Sphaericus

VI CONCLUSION

The results presented in this study show that the microbial self-healing mechanism can be used to achieve the goal of concrete crack self-healing. Bacterial solution which is used is cost effective and also safe. The maximum compressive strength of concrete cube is with addition of bacillus sphaericus with 10^6 cells/ml i.e, 38.51 N/mm². So, bacteria with a cell concentration of order 10^6 cells/ml for bacillus sphaericus is an optimum dosage for present investigation. Because of bacteria added in concrete, there is an increase in compressive strength. From the results we get it is concluded that bacillus sphaericus can be used in concrete and it is safe. And also these bacteria are used to heal the cracks. The bacteria is working effectively and the self-healing process has been done for three weeks.



Fig 5 The concrete cube before and after the self healing process

VII FUTURE SCOPE OF WORK

- In order to change the compressive strength there is a chance to add fibers and bacterial solution in a concrete cube and can increase the strength as well as self-healing property.
- When the super plasticizer is added for workability there is a need to study the internal reaction of bacterial solution and plasticizer.
- The effect of higher concentrations of Bacillus Sphaericus on the design strength of concrete is to be studied in addition to the concentrations chosen in the present study.
- The durable nature of the concrete is to be studied for complete understanding of behaviour of the mix.
- Study on influence of additional agents during the crack healing process is to be carried out.
- The above points can help in making the project to other leads.

REFERENCES

- [1] Jasira bashir, ifrahKathwari, Aditya Tiwary and Khushpreet Singh (2016), “*Bio concrete- the self healing concrete*” Indian Journal of Science and technology, Vol9(47), DOI:10.17485/ijst/2016/v9i47/105252, December 2016.
- [2] Harshali J , Mitli S , Prgathi B (2016), “*Bio concrete and bacteria based selfhealing concrete*” ,International Journal of Research in Engineering and Technology eISSN: 2319-1163/ pISSN: 2321-7308Maharashtra , India, May 2016 .
- [3] Abhishek Thakur , Akshay Phogat ,Khushpreet singh (2016), “*Bacterial concrete and effect of different bacteria on the strength and water absorption characteristics of concrete*” International Journal of Research in Engineering and Technology , volume7 Issue5, pp.43-56 2016 september, Punjab, India
- [4] KanthaD.Arunachalam,K.S. Sathyanarayanan ,B.S. Darshan, R. Balaji Raja. “Studies on the characterisation of Biosealant properties of Bacillus sphaericus”
- [5] Bang SS, Galinat JK, Ramakrishnan V (2001) “*Calcite precipitation induced by polyurethane-immobilized Bacillus cereus.*” Enzyme and Microbial Technology28:404–409.
- [6] W.DeMuynck,KCox,N.DeBelie,W.Verstraete.“*Bacterial carbonate Precipitation as an alternative surface treatment for concrete,*” Constr. Build. Mater. 22 (2008) 875–885.
- [7] S.K. Ramachandran, V. Ramakrishnan, S.S. Bang, “*Remediation of concrete using micro-organisms*”, ACI Mater. J. 98 (2001) 3–9.
- [8] J.D. Rule, N.R. Sottos, S.R. White, “*Effect of microcapsule size on the performance of self-healing polymers*”, Polymer 48 (2007) 3520–3529.
- [9] Mian Luo, Chun-xiang Qian , Rui-yang Li (2015) “*Factors affecting crack repairing capacity of bacteria-based self-healing concrete*” ,China
- [10] J.K. Lee, S.J. Hong, X. Liu, S.H. Yoon (2004)“*Characterization of dicyclopentadiene and 5-ethylidene-2-norbornene as self-healing agents for polymer composite and its microcapsules*”, Macromol. Res. 12 (2004) 478–483.
- [11] M.V. Seshagiri Rao, V. Srinivasa Reddy, M. Hafsa,P.VeenaandP.Anusha(2013)”*Bioengineered Concrete A Sustainable Self-Healing Construction Material*” India.
- [12] Reinhardt HW, Jooss M (2003) “*Permeability and Self-healing of cracked concrete as a function of temperature and crack width*”. Cement and Concrete Res 33:981–985. Schlegel HG (1993) General microbiology, 7th edition, Cambridge University Press.
- [13] Neville AM (2002) “*Autogenously healing—A concrete miracle?*” Concrete Int 24(11):7682.