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Study of Durable Properties of Bacterial Concrete

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ABSTRACT: A typical durability-related phenomenon in many concrete constructions is crack formation. While larger cracks hamper structural integrity, also smaller sub-millimeter sized cracks may result in durability problems as particularly connected cracks increase matrix permeability. Ingress water and chemicals can causes premature matrix degradation and corrosion of embedded steel reinforcement. As regular manual maintenance and repair of concrete constructions is costly and in some cases not at all possible, inclusion of an autonomous self healing repair mechanism would be highly beneficial as it could both reduce maintenance and increase material durability. Therefore, within the Delft Centre for Materials at the Delft University of Technology, the functionality of various self healing additives is investigated in order to develop a new generation of self-healing concretes.

In the present study the crack healing capacity of a specific bio-chemical additive. consisting of a mixture of viable but dormant bacteria and organic compounds packed in porous expanded clay particles, was investigated. Microscopic techniques in combination with permeability tests revealed that complete healing of cracks occurred in bacterial concrete and only partly in control concrete. The mechanism of crack healing in bacterial concrete presumably occurs through metabolic conversion of calcium lactate to calcium carbonate what results in crack-sealing. This biochemically mediated process resulted in efficient sealing of sub millimeter sized (0.15 mm width) cracks. It is expected that further development of this new type of self-healing concrete will result in a more durable and moreover sustainable concrete which will be particularly suited for applications in wet environments where reinforcement corrosion tends to impede durability of traditional concrete constructions.

KEYWORDS: Bacteria, testing.

I. INTRODUCTION

A typical durability-related phenomenon in many concrete constructions is crack formation. While larger cracks hamper structural integrity, also smaller sub-millimeter sized cracks may result in durability problems as particularly connected cracks increase matrix permeability. Ingress water and chemicals can causes premature matrix degradation and corrosion of embedded steel reinforcement. As regular manual maintenance and repair of concrete constructions is costly and in some cases not at all possible, inclusion of an autonomous self-healing repair mechanism would be highly beneficial as it could both reduce maintenance and increase material durability. Therefore, within the Delft Centre for Materials at the Delft University of Technology, the functionality of various self healing additives is investigated in order to develop a new generation of self-healing concretes. In the present study the crack healing capacity of a specific bio-chemical additive, consisting of a mixture of viable but dormant bacteria and organic compounds packed in porous expanded clay particles, was investigated. Microscopic techniques in combination with permeability tests revealed that complete healing of cracks occurred in bacterial concrete and only partly in control concrete. The mechanism of crack healing in bacterial concrete presumably occurs through metabolic conversion of calcium lactate to calcium carbonate what results in crack-sealing. This biochemically mediated process resulted in efficient sealing of sub-millimeter sized (0.15 mm width) cracks. It is expected that further development of this new type of self- healing concrete will result in a more durable and moreover sustainable concrete which will be particularly suited for applications in wet environments where reinforcement corrosion tends to impede durability of traditional concrete constructions.

Concrete is most widely used construction material because Of its high compressive strength, relatively low cost etc. One Adverse property of concrete is its sensitivity to crack formation as a consequence of its limited tensile strength. For that reason concrete is mostly combined with steel reinforcement to carry the tensile loads. Although these rebars restrict the cracks width they are mostly not designed to completely prevent cracks formation. Cracks

endanger the durability of concrete structure as aggressive liquid and gases may penetrate in to these cracks and may cause damage. When cracks appear in concrete structure and water start to seep in through, the spores of the bacteria starts microbial activities on contact with water and oxygen. In the process of precipitating calcite crystals through nitrogen cycle the soluble nutrients are converted in to insoluble CaCO_3 . CaCO_3 solidifies on the cracks surface there by sealing it up. The consumption of oxygen during metabolic biochemical reaction to form CaCO_3 help in arresting corrosion of steel because the oxygen is responsible to initiate the process of corrosion there by increasing the durability of steel reinforced concrete structures.

OBJECTIVES

1.1 Objectives of Bacterial Concrete

1. Develop bacterial concrete by introducing the bacteria's of bacillus family.
2. To find optimum dosage of bacteria required for bacterial concrete.
3. To increase compressive strength of concrete.

1.2 Scope Of The Work:

1. To study the durability of concrete under various weathering conditions.
2. To check the performance of bacillus subtilis by durability test.
3. To verify the performance of bacillus subtilis with 1mm and 2mm crack width and 15mm, 20mm, 25mm, and 30mm crack depth.

ADVANTAGES

- The use of bio concrete significantly influences the strength of concrete.
- It has lower permeability than conventional concrete.
- It offers great resistance to freeze-thaw attacks.
- Remedying of cracks can be done efficiently.
- The chances of corrosion in reinforcement are reduced.
- Maintenance cost of this concrete is low.

Disadvantages

- Design of bacterial concrete is not mentioned in IS codes or any other codes.
- Cost of this concrete is comparatively higher than conventional concrete i.e. about 7- 28%
- More than conventional concrete.
- The investigations involved in calcite precipitation are costly.
- Bacteria that grow in concrete are not good for human health and atmosphere.
- Usage should be limited to the structure.

II. METHODOLOGY

Materials :

Following materials are used for making Concrete:

- a) Cement – Ordinary Portland cement of 53 grade is used. The cement has been tested for various properties has been tested for various properties as per IS 4031-1988 & found to be confirming to various specification of IS:12269-1987 having specific gravity of 3.0.
- b) Sand – Sand size less than 4.75mm size were used as fine aggregate (sp.gravity 2.69).
- c) Coarse Aggregate – Hard granite broken stones of size 20mm were used as coarse agg. (Sp.gravity-2.75).
- d) Water – Locally available potable water confirming to IS 456 is used.
- e) Micro-organism: Bacillus subtilis

• 3.2 Methodology

The methodology for producing a self-healing concrete involves the following steps:

1. Selection and cultivation of bacteria.
2. Preparation of test specimens.
3. Characterization studies

Compression Test

Table for 7 Days Compressive Strength of Concrete

Description	Cube Notation	Weight of cube (Kg)	Load Taken (KN)	Compressive Strength (N/mm ²)	Average Compressive Strength (N/mm ²)
Conventional Concrete Cube	CC1	8.910	420	18.667	21.99
	CC2	8.790	505	22.44	
	CC3	9.360	560	24.88	
Bacterial Concrete Cube with 2.5% Bacterial Solution	BC1	9.075	585	26	24.44
	BC2	9.225	540	24	
	BC3	9.275	525	23.33	
Bacterial Concrete Cube with 5% Bacterial Solution	BC7	9.115	575	25.55	24.59
	BC8	8.925	535	23.77	
	BC9	9.120	550	24.44	

Table for 28 Days Compressive Strength of Concrete

Description	Cube Notation	Weight of cube (Kg)	Load Taken (KN)	Compressive Strength (N/mm ²)	Average Compressive Strength (N/mm ²)
Conventional Concrete Cube	CC4	9.085	830	36.88	36.81
	CC5	8.875	835	37.11	
	CC6	9.060	820	36.44	
Bacterial Concrete Cube with 2.5% Bacterial Solution	BC4	9.170	930	41.33	40.145
	BC5	8.755	820	36.44	
	BC6	9.030	960	42.67	
Bacterial Concrete Cube with 5% Bacterial Solution	BC10	9.075	1000	44.44	42.22
	BC11	9.160	960	42.67	
	BC12	9.025	890	39.55	

The results in above tables satisfies the IS requirement i.e. compressive strength is greater than 30MPa at 28 days. It is observed that compressive strength of bacterial concrete increased with increase in bacterial solution up to 5%. For 2.5% bacterial solution concrete there is increase in strength by 8.30% compared to compressive strength of conventional concrete. Increase in bacterial solution upto 5% it is observed that strength increase by 14.69% as compared to compressive strength of conventional concrete.

IV. CONCLUSIONS

Based on the experimental work, the following conclusion is drawn:

1. For strength assessments cubes were tested for different bacterial solution volumes. It was observed that the compressive strength of bacterial concrete shows significant increase with addition of bacteria. 5% of total volume, bacterial solution of *Bacillus Subtilis* in concrete mix M30 shows maximum improvement in compressive strength as compared with the conventional concrete's strength.
2. Addition of *Bacillus subtilis* plays a significant role in increasing the flexural strength of bacterial concrete as compared to conventional concrete.
3. From the observation 5% added bacterial solution that concrete gives better results for compressive strength and flexural strength as compared to 2.5% bacterial solution added concrete.
4. The increase in compressive strength, and flexural strength is mainly due to consolidation of the pores inside the concrete with bacteria induced calcium carbonate precipitation.
5. *Bacillus Subtilis* can be produced in the laboratory which is proved to be safe and cost effective.

REFERENCES

1. Stocks-Fischer, S., Galinat, J.K., and Bang, S.S., "Microbiological precipitation of CaCO_3 ", *Soil Biology and Biochemistry*, v. 31, pp. 1563-1571, 1999.
2. 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, pp. 336-354, April 2002.
3. 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.
4. Ramachandran, S.K., Ramakrishnan, V., and Bang, S.S., "Remediation of Concrete using Microorganisms", *ACI Materials Journal*, v.98, No.1, pp. 3-9, Jan-Feb 2001.
5. Kantzas, A., Ferris, F.G., Jha, K.N., and Mourits, F.M., "A Novel Method of Sand Consolidation through Bacteriogenic Mineral Plugging", paper presented at the CIM Annual Technical Conference, Calgary, June 7-10, 1992.
6. Gollapudi, U.K., Knutson, C.L., Bang, S.S., and Islam, M.R., "A New method for Controlling Leaching through Permeable Channels", *Chemosphere*, v. 30, No. 4, pp. 695- 705, 1995.
7. Zhong, L., And Islam, M.R., "A New Microbial Process and its Impact on Fracture Remediation", paper presented at the 70th Annual Technical Conference and Exhibition of the Society of Petroleum Engineers, Dallas, Texas, Oct 22-25, 1995.
8. Ramakrishnan, V., Ramesh Panchalan., and Bang, S.S., "Bacterial Concrete" *Proceedings of SPIE-International Society for Optical Engineering on Smart Materials*, Australia, Vol. 4234 (2001), pp. 168-176, 13-15 December 2000.
9. Ramakrishnan, V., Ramesh Panchalan., and Bang, S.S., "Bacterial Concrete- A Self Remediating Biomaterial" *Proceedings of 10th International Congress on the Polymers in Concrete*, Hawaii, May 2001.
10. DeMuynck, W., DeBelie, N. and Verstraete, W. (2010) "Microbial carbonate precipitation in construction materials." *Ecological Engineering*, 6(2) pp.118-136.
11. Neville, A.M., (1996). *Properties of Concrete*. Pearson Higher Education, 4th edition. Prentice Hall, New Jersey.
12. Wasim Khaliq, Muhammad Basit Ehsan (2015), *Crack healing in concrete using various bio influenced self-healing techniques*. *Construction and Building Materials*, p.349-357.
13. Meera .C.M., Lakshmi.L , Eldhose Cheriyan, (2016). *Durability and Self- Healing Behaviour of Bacterial Impregnated Concrete*. *International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297:2007 Certified Organization)* Vol. 5, Issue 8, August 2016.
14. Klaas van Breugel "Self-healing material concepts as solution for aging infrastructure" *Delft University of Technology Stevinweg 37th Conference on Our World in Concrete & Structures* 29-31 August 2012, Singapore.
15. Mohini P. Samudre, M. N. Mangulkar, S. D. Saptarshi "A review of Emerging Way to Enhance the Durability and Strength of Concrete Structures : Microbial Concrete " at *International Journal of Innovative Research in Science, Engineering and Technology* Vol. 3, Feb. 2014 pp.456-458.



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