ISSN: 2348 9510
International Journal of Core Engineering & Management (IJCEM)
Volume 2, Issue 9, December 2015

AN EXPERIMENTAL STUDY ON STRENGTHENING OF CONCRETE BY USING BACTERIAL MINERAL PRECIPITATION

L.Soundari
Associate Professor
Department of civil Engineering, IFET college of Engineering, villupuram
soundaricruz@gmail.com, 9952097227

C.S.Maneesh Kumar
Senior Assistant professor
Department of civil Engineering, IFET college of Engineering, villupuram
maneesh4jou@gmail.com,. 8883147456

S.Anthoniraj
UG graduate
Department of civil Engineering, IFET college of Engineering, villupuram

E.Karthikeyan
UG graduate
Department of civil Engineering, IFET college of Engineering, villupuram,

ABSTRACT

A new technique in remediating cracks and fissures in concrete by utilizing microbiologically induced calcite (CaCo3) precipitation is discussed. Microbiologically induced calcite precipitation (MICP) is a technique that comes under a broader category of science called Bio Mineralization. It is a process by which living organisms form inorganic solids. Bacillus subtilis, a common soil bacterium can induce the precipitation of calcite. The objective of the present investigation is to study the potential application of bacterial species i.e. Bacillus subtilis to improve the strength of cement concrete. Here we have made an attempt to incorporate dormant but viable bacteria in the concrete matrix which will contribute to the strength of the concrete. In this project, bacterial concrete is prepared under grade of concrete M25.The design mix proportioning also carried under IS code provision. Testing of specimens are carried at 7 days ,14 days and

28 days of curing by Compression Testing Machine and Universal Testing Machine for corresponding specimens. The Compressive Strength, Split Tensile Strength and Flexural Strength of Bacterial Concrete are to be found and it compared with conventional Concrete.

Key words: inorganic solids, Bacillus subtilis, calcite, bacterial concrete and Strengths.

I. INTRODUCTION

Concrete is the most widely used construction material. Despite its versatility in construction, it is known to have several limitations. It is weak in tension, has limited ductility and little resistance to cracking. Based on the continuous research carried out around the globe, various modifications have been made from time to time to overcome the deficiencies of cement concrete. The ongoing research in the field of concrete technology has lead to the development of special concrete considering the speed of construction, the strength of concrete, the durability of concrete and the environmental friendliness with industrial material like Fly Ash, Blast Furnace Slag, Silica Fume, Metakeolin etc. Recently, it is found that microbial mineral precipitation resulting from metabolic activities of favorable microorganisms in concrete improved the overall behavior of concrete. The process can occur inside or outside the microbial cell or even some distance away within the concrete. Often bacterial activities simply trigger a change in solution chemistry that leads to over saturation and mineral precipitation. Use of these Bio mineralogy concepts in concrete leads to potential invention of new material called Bacterial Concrete.

Classification of bacteria

Classification on the Basis of Shapes

Bacteria are usually classified on the basis of their shapes. Broadly, they can be divided into Rod-shaped bacteria (Bacilli), Sphere-shaped bacteria (Cocci) and Spiral-shaped bacteria (Spirilla).

Classification on the Basis of Gram Strain

This classification is based on the results of Gram Staining Method, in which an agent is used to bind to the cell wall of the bacteria, they are Gram-positive and Gram-negative.

Classification on the Basis of Oxygen Requirement

This classification is based on the requirement of oxygen for the survival of the bacterium. They are Aerobic (Use molecular oxygen as terminal electron acceptor) and Anaerobic (Do not use molecular oxygen as terminal electron acceptor).

Various bacteria used in the concrete

The bacteria are,

i) Bacillus pasteurii

ii) Bacillue sphaericus iii) Escherichia coli
iv) Bacillus subtilis (used in the present study)

Bacterial concrete

Bacterial concrete refers to a new generation of concrete in which selective cementation by microbiologically-induced CaCO3 precipitation has been introduced for remediation of micro cracks. Considerable research on carbonate precipitation is done by selecting ureolytic bacteria but very limited work has been reported on the application part of it.

Bacterial urease enzymes degrade urea into ammonia and carbon dioxide, which lead to increase in pH of the media and carbonate precipitation. Various researchers have confirmed the persistence of organic CaCO3 precipitate in the environment for an extended period of time using Bacillus subtilis.

Chemistry of the process

Microbiologically induced calcite precipitation utilizes a biological by-product, CaCO3. In aqueous environments, the overall chemical equilibrium reaction of calcite precipitation can be described as:

$$Ca^{2+} + Cell \rightarrow Cell\text{-}Ca^{2+} \ldots (1)$$

$$Cl^{-} + HCO_3^{-} + NH_3 \rightarrow NH_4Cl + CO_3^{2-} \ldots (2)$$

$$Cell\text{-}Ca^{2+} + CO_3^{2-} \rightarrow Cell\text{-}CaCO_3\downarrow \ldots (3)$$

II. MATERIAL USED

The required materials are,

- Cement
- Coarse aggregate
- Fine aggregate
- Water
- Bacteria
- Aluminum Foil

Chemicals used

- Potassium permanganate
- Nutrient Broth
- Urea
- sodium bicarbonate (NaHCO3)
- calcium carbonate (CaCl2)
- ammonium chloride (NH4Cl)

fig 1

fig 1.Process Flow Diagram for Production of Bacterial Water

III.PRODUCTION OF BACTERIAL WATER

The nutrient broth and other chemicals are mixed with required water. After that the mixed water is boiled for autoclaving process. The boiled water should have the reddish color due to nutrient broth and other chemicals. After the atmospheric cooling the required bacterial cell is transferred from nutrient agar plate to that prepared liquid media. Then the liquid media should be covered with aluminum soil and shake periodically

The reddish color should be changed into light yellow color after 36 – 48 hours which shows the presence of bacillus subtilis in the liquid media. Before mixing into the concrete, concentration of bacterial cell is tested.

Table1. Composition of Culture media

SI NO	COMPONENTS	GRAMS (PER LITRE)
1	Nutrient Broth	2.10 gm
2	NaHCo3	1.50 gm
3	NH4Cl	7.00 gm
4	Urea	7.00 gm
5	CaCl2	5.00 gm

Mixing of concrete

The mixing process is carried out in electrically operated mixer. The materials are laid in uniform layers, one on the other in the order – coarse aggregate, fine aggregate and cement. Dry mixing is done to obtain a uniform color. Required amount of bacterial water is added. The workability tests are carried out immediately after mixing of concrete using the compaction factor testing apparatus in accordance with IS: 10510-1983

Mix design

MATERIAL	CODE PROVISI ON	PROPERTIES
Mix proportion (M25)	IS 10262-1982&IS10262-2009	1 : 1.28 : 2.86 (w/c =0.45)

IV. RESULT AND DISCUSSION

COMPRESSIVE STRENGTH OF CONCRETE

The investigation is carried out to study the compressive strength concrete. The results of the Compressive strength of controlled and bacterial concrete at 7 days, 14 days and 28 days for M25 grade concrete are tabulated in Table 2

No. of Days	Compressive Strength of Conventional Concrete N/mm2	Compressive Strength of Bacterial Concrete N/mm2
7	**21.52**	**24.17**
14	**25.36**	**30.05**
28	**32.24**	**41.93**

Table 2 Results of the Compressive Strength test with and without addition of bacteria for M25 Grade of concrete

In M25 grade of concrete the compressive strength at 7 days, 14 days and 28 days are given in Table2. It is observed that with the addition of bacteria the compressive strength of concrete showed significant increase by 12.32% ,18.49% and 30.05% at 7 days, 14 days and 28 days respectively.

Table 3 Results of the Split Tensile Test with and without addition of bacteria for M25 grade of concrete

No. Of	Spilt Tensile Strength of Conventional Concrete (N/mm^2)	Spilt Tensile Strength of Bacterial
7	2.78	3.16
14	3.62	4.14
28	3.85	4.56

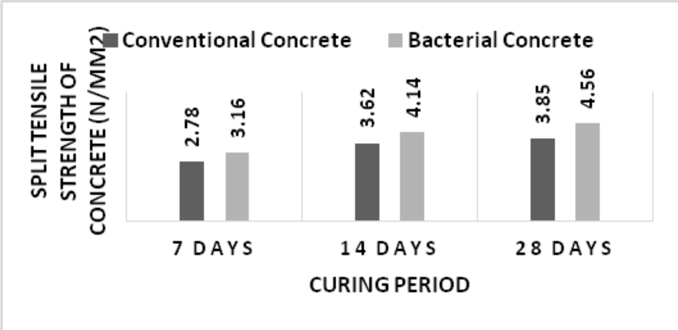


FIG 2 SPLIT TENSILE STRENGTH

In M25 grade concrete the Split Tensile Strength on standard cylindrical specimens at 7 days, 14 days and 28 days are given in Table 3 It is observed that with the addition of bacteria there is a significant increase in the spilt tensile strength by 13.80%, 14.38% and 18.45% at 7 days, 14 days and 28 days respectively.

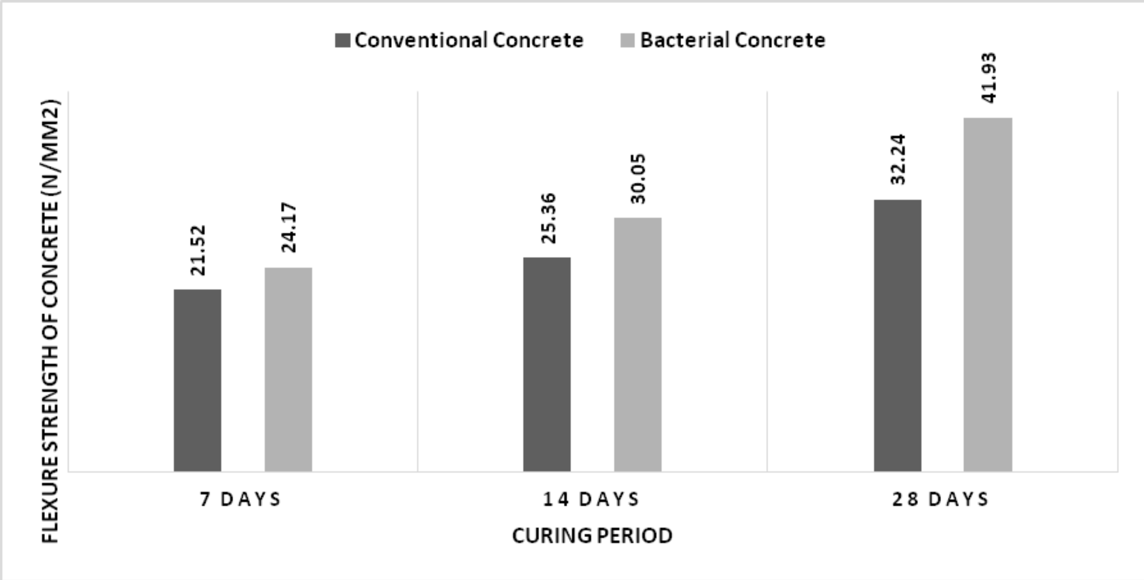
Flexural tensile strength of concrete

The investigation is carried to study the flexural behavior of concrete. 3 simply supported beams consisting of balanced section are cast and tested. The cross section of the beam specimen is 150mm x 150mm x 700mm. The beams are cast using with bacteria and without bacteria in M25 grade concrete. The flexural strength of both controlled and bacterial concrete is calculated and the result is tabulated in Table 4

Table 4 Results of the Flexural Tensile Strength test with and without addition of Bacteria for M25 grade of concrete

No. Of Days	Flexural Tensile Strength of Conventional Concrete	Flexural Tensile Strength of Bacterial Concrete (N/mm2)
7	2.88	3.26
14	3.73	4.28
28	3.92	4.53

Based on the experimental results the Flexural Tensile Strength is as shown in Table 5.3. It is observed that with the addition of bacteria there is a significant increase in the Flexural Strength by 13.19%, 14.74% and 15.56% at 7 days, 14 days and 28 days respectively



V. CONCLUSION

The following conclusions are drawn from the detailed experimental investigations conducted on the comparative behavior of M25 grade conventional and bacterial concrete.

- Bacillus subtilis of MTCC NO.113 is a soil bacterium which can utilize the urea and continuously precipitate calcite which prevent the presence of air molecules in the concrete.
- In M25 grade concrete, with the addition of bacteria the percentage of improvement in the compressive strength is in the order of by 12.32%, to 30.05 % at different ages.
- In M25 grade concrete, with the addition of bacteria the percentage of improvement in the spilt tensile strength is in the order of 13.80% to 18.45% at different ages.
- In M25 grade concrete, with the addition of bacteria the percentage of improvement in the flexural tensile strength is in the order of 13.19% to 15.56% at different ages.
- Cost of the bacterial concrete is 15% increased to that of conventional concrete. But compare to other type of special concrete it should be very economical.

REFERENCES

- Abigail S. Haka, Karen E et al. 2002, “Identifying Micro calcifications in Benign and Malignant Breast Lesions by Probing Differences in Their Chemical Composition Using Raman Spectroscopy” in Cancer Research 62, 5375–5380, September 15.
- B. M. Mali “Potential application of bacteria to improve the Strength of cement concrete” “International Journal of Advanced Biotechnology and Research” ISSN 0976-2612, Vol 3, Issue 1, 2012, pp
- 541-544

- Bang SS, Galinat JK, Ramakrishnan V. 2001 "Calcite precipitation induced by polyurethane-immobilized Bacillus pasteurii". Enzyme Microb Technol Vol.
- 28(4-5): 404-409.
- De Muynck, W. "improvement of concrete durability with The aid of bacteria" Proceedings of the First International Conference on Self Healing Materials 18-20 April 2007, Noordwijk aan Zee, The Netherlands
- Dick J, De Windt W, De Graef B, Saveyn H, Van der Meeren P, De Belie N, Verstraete W. 2006, "Bio-deposition of a calcium carbonate layer on degraded limestone by Bacillus species". Biodegradation, Vol. 17(4): 357-367.
- Hammes F, Boon N, de Villiers J, Verstraete W & Siciliano SD. 2003
- "Strain-specific ureolytic microbial carbonate precipitation". App. Environ. Microbial. 69(8): 4901–4909.
- Henk M. Jonkers & Erik Schlangen "Development of a bacteria-based self healing concrete" Tailor Made Concrete Structures – Walraven & Stoelhorst (eds)© 2008 Taylor & Francis Group, London, ISBN 978-0-415-47535-8
- Keri bachmeir et al. 2002, "Urease activity in microbiologically induced calcite precipitation". Journal of biotechnology, vol. p171-181.

- Nolan E, Basheer PAM, Long AE. 1995 "Effects of three durability enhancing products on some physical properties of near surface concrete". Construction Build Mater. 9(5): 267-272.
- Ramakrishnan V. 2001, "Calcite precipitation induced by polyurethane-immobilized Bacillus pasteurii". Enzyme Microb Technol, Vol. 28(4-5): 404-409.
- S. Sunil Pratap Reddy "performance of standard grade bacterial (Bacillus subtilis) concrete" "Asian journal of civil engineering (building and housing)" vol.11, No. 1 (2010).
- Shang-Lin Gao et al. 2007, "Surface Defect Repairing by polymer coating with low fraction of nano reinforcement". Vol. 334-335, pp757-760.
- Sookie Bang et al. 2004, the present and future of biosealent in crack remediation, proceeding ICFRC international Conference on Fiber Composites, "High performance concrete and smart materials", Chennai. pp 991-1001.
- Srinivasa Reddy V "A Biological Approach to Enhance Strength and durability In Concrete Structures" "International Journal of Advances in Engineering & Technology, Sept 2012.©IJAET" .ISSN: 2231-1963
- Maneeshkumar C S et al. Int. Journal of Engineering Research and Applications www.ijera.com ISSN : 2248-9622, Vol. 5, Issue 5, (Part -1) May 2015, pp.91-95
- International Journal Of Core Engineering & Management (IJCEM) Volume 2, Issue 5, August 2015 Strength And Durability Studies On Fly Ash Concrete In Sea Environment Arul Kumaran.S1 Maneesh Kumar Cs 2 Arivazhagan.K3, Daryl Jeffry Roy4
- North Asian International Research Journal Of Sciences, Engineering & I.T. ISSN: 2454 - 7514 Vol. 2, Issue 1 January 2016 Fiber Reinforced Concrete By Using CARPET Industerial Waste Maneesh Kumar Cs1, U.Umapathy2, S.A.Sayed Abuthahir3, K.Gunasekar4