Vandana Publications
IJEMR

Volume-8, Issue-6, December 2018
International Journal of Engineering and Management Research
Page Number: 161-170
DOI: doi.org/10.31033/ijemr.8.6.15

Experimental Study on Microbial Fibre Concrete

V.Tamilselvan[1], M.Shyamkumar[2], B.Kondababu[3] and V.Bharathi[4]
[1]Assistant professor, Department of Civil Engineering, Aditya College of Engineering, Surampalem, Kakinada, INDIA
[2]Assistant professor, Department of Civil Engineering, Aditya College of Engineering, Surampalem, Kakinada, INDIA
[3]Assistant professor, Department of Civil Engineering, Aditya College of Engineering, Surampalem, Kakinada, INDIA
[4]Assistant professor, Department of Civil Engineering, Aditya College of Engineering, Surampalem, Kakinada, INDIA

[1]Corresponding Author: civiltamilstructural@gmail.com

ABSTRACT

The usage of cement has been increased throughout the world which has severe effect on the environment. replacement of cement in concrete is in very much need, for which several materials came into existence like flyash, silicafume GGBS and geopolymers etc.one such material which will act as cementinious materials is used in the study which will reduce cracks and fissures in concrete by utilizing microbiologically induced calcite ($CaCo_3$) precipitation called Bio Mineralization produced by Bacillus subtilis in the presence of chemicals. In this project, bacterial concrete is prepared under grade of concrete M_{25} and Natural fiber is added in total volume of concrete in desired level which will cure the cracks automatically by forming calcium carbonate precipitate as well as to achieve more Compressive strength and Flexural strength. To avoid corrosion, the bacterial concrete along with natural fibers is used which results in self healing process.

In this study, the behavior of bacterial fibre concrete was investigated experimentally. Various parameters like compressive strength, flexural strength and splitting tensile strength of specimens for bacterial fibres concrete have been studied. Then these values for bacterial and bacterial fibre concrete are compared with the conventional concrete.

Keywords— Reed Fibre, Calcite, Compressive Strength, Flexural Strength, Split Tensile Strength

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 led 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, and Metakaolin etc. Recently, it is found that microbial mineral precipitation resulting from metabolic activities of favourable microorganisms in concrete improved the overall behaviour 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 and also by adding some percentage of fiber (REED FIBER) to get additional strength of concrete.

Various bacteria used in the concrete

The bacteria used 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 $CaCO_3$ 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 $CaCO_3$ precipitate in the environment for an extended period of time using Bacillus pasteurii.

Considerable research on carbonate precipitation by bacteria has been performed using ureolytic bacteria. These bacteria are able to influence the precipitation of calcium carbonate by the production of a Urease enzyme. This enzyme catalyzes the hydrolysis of urea to CO_2 and

ISSN (ONLINE): 2250-0758, ISSN (PRINT): 2394-6962

ammonia, resulting in an increase of the pH and carbonate concentration in the bacterial environment. Once super saturation is achieved precipitation of calcium carbonate crystals occurs by heterogeneous nucleation on bacterial cell walls.

Research has indicated that a concrete which is low in permeation properties lasts longer without exhibiting signs of distress and deterioration. Bacillus Subtilis yet other ureolytic bacteria which showed strong potential in precipitating the insoluble calcium carbonate were selected as a test organism.

Chemical 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:

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

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

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

A. REED FIBRE (NATURAL FIBRE)

Reed fibre is used in the present work which is shown in figure1 and the properties of Reed fibre are shown in table1.

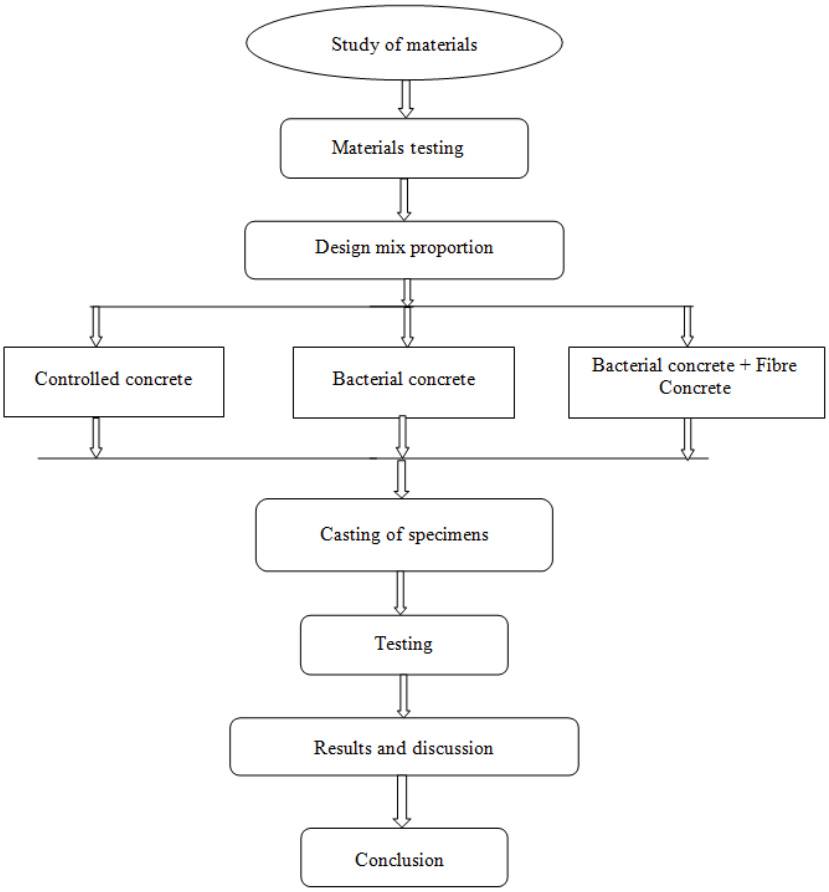
Figure1. Reed Fibre

Table-1 Properties of Reed Fibre (Natural fibre)

Sl. No.	Properties	Test Results
1	Density of fibre	490 kg/m^3
2	Modulus of Elasticity	37 Gpa
3	Tensile strength	70 – 140 Mpa
4	Fibre Length	1.5 mm
5	Diameter of Fibre	13 µm

II. METHODOLOGY

The methodology of the present project work is shown in the following flowchart.



Flowchart 1. Methodology of present Work

A. Preliminary Tests

The preliminary tests were conducted for the following materials which are given in the below tables.

Table -2 Preliminary test for the cement material.

Sl. No.	Properties	Test Results	Requirements as per IS :12269-1987
1	Normal consistency	32%	--
2	Specific gravity	3.15	--
3	Initial setting time	34 minutes	Not less than 30 minutes
4	Final setting time	592 minutes	Not more than 600 minutes

Table-3 Preliminary test for the Fine Aggregate

Sl. No.	Properties	Test Results	Requirements as per IS :12269-1987
1	Sieve Analysis	2.796	
2	Grading zone	III	IS 383-1970 & IS 2386(Part III) -1963
3	Specific gravity	2.83	
4	Water Absorption	1.0%	
5	Free Surface Moisture	0.2%	
6	Bulk Density	1700.15 Kg/cu.m	

Table-4 Preliminary test for the Fine Aggregate

Sl. No.	Properties	Test Results	Requirements as per IS :12269-1987
1	Sieve Analysis	2.83	
2	Specific gravity	2.73	IS 383-1970 & IS 2386-1963
3	Water Absorption	0.12%	
4	Bulk Density	1642.07 Kg/cu.m	

B. Casting of Cubes, Cylinders and Beams

The cubes, cylinders and beams were cast for controlled concrete, bacterial concrete and bacterial with fibre concrete in the days of 7, 14 and 28 respectively.

Table-5 Casting of specimens

S. No.	Name of Specimen	Curing Period	Controlled Concrete	Bacterial Concrete	Bacterial Fibre concrete	Total Specimen
1	Cubes	7	5	5	5	15
		14	5	5	5	15
		28	5	5	5	15
2	Cylinder	7	5	5	5	15
		14	5	5	5	15
		28	5	5	5	15
3	Beam	28	1	1	1	3

III. RESULTS AND DISCUSSIONS

The compressive strength test was conducted on conventional concrete, Bacterial concrete and bacterial with fibre concrete with PPC & OPC cement in the days of 7, 14 and 28 respectively which were compared and high strength was taken. As well as split tensile and Flexural strength was done.

Table 6 Results of the Compressive Strength test with and without addition of bacteria for M25 grade of concrete (PPC CEMENT)

No. Of Days	Compressive Strength of Conventional Concrete N/mm^2	Compressive Strength of Bacterial Concrete N/mm^2	Compressive Strength of Bacterial Concrete + fiber N/mm^2
7	24.6	27.73	27.20
14	30.04	32.53	32.26
28	35.24	38.75	38.35

Table 7 Results of the Compressive Strength test with and without addition of bacteria for M25 grade of concrete (OPC 53 Grade Cement)

No. Of Days	Compressive Strength of Conventional Concrete N/mm^2	Compressive Strength of Bacterial Concrete N/mm^2	Compressive Strength of Bacterial Concrete + fiber N/mm^2
7	22.0	30.80	31.10
14	32.3	38.50	36.80
28	37.9	42.30	39.50

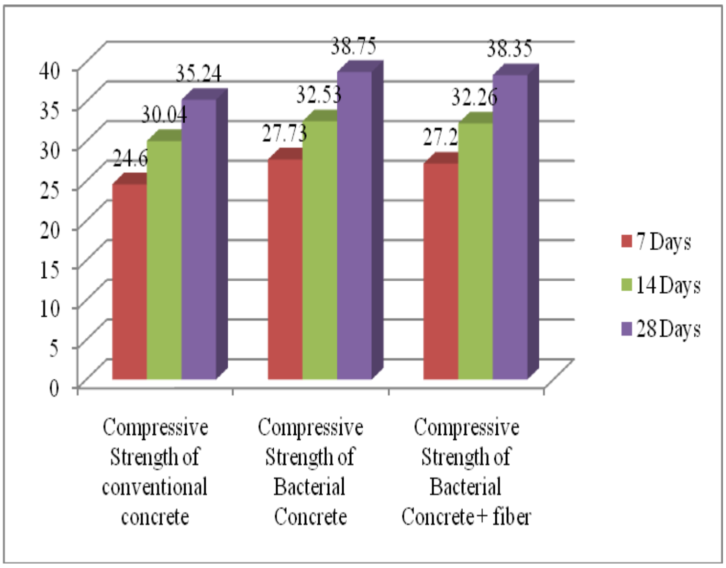


Figure 2 Compressive Strength with and without addition of bacteria for M25 grade of concrete (PPC CEMENT)

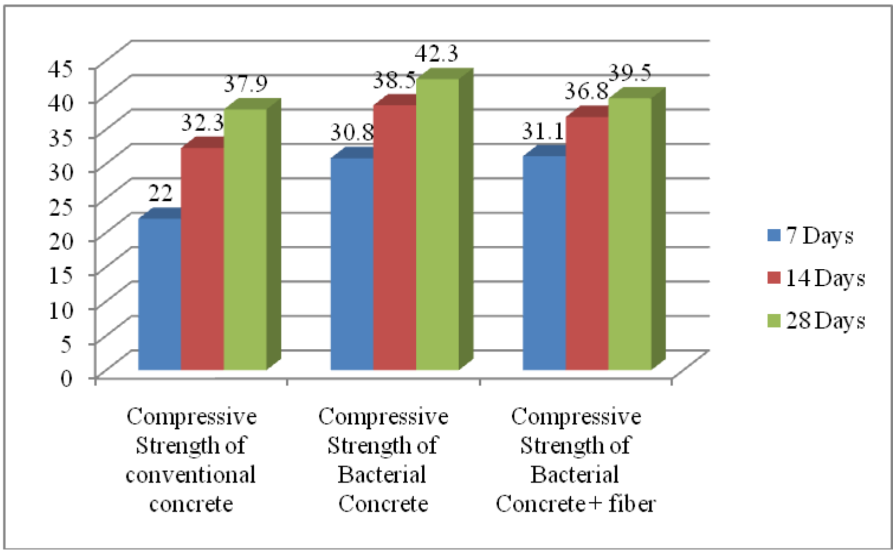


Figure 3 Compressive Strength with and without addition of bacteria for M25 grade of concrete (OPC CEMENT)

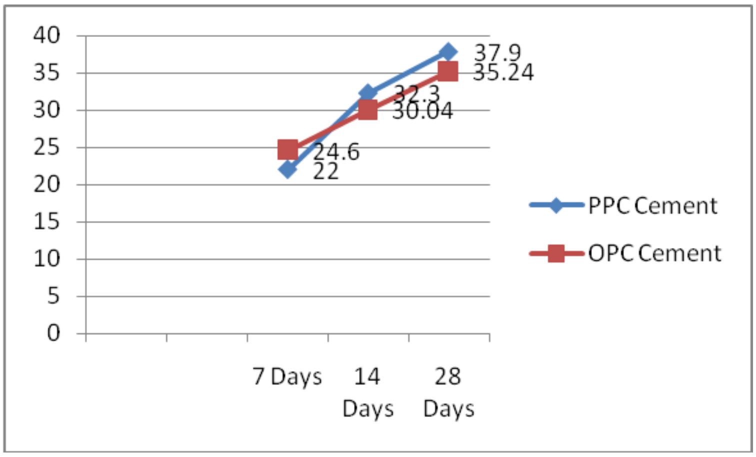


Figure 4 Comparison of compression strength of conventional concrete with PPC and OPC

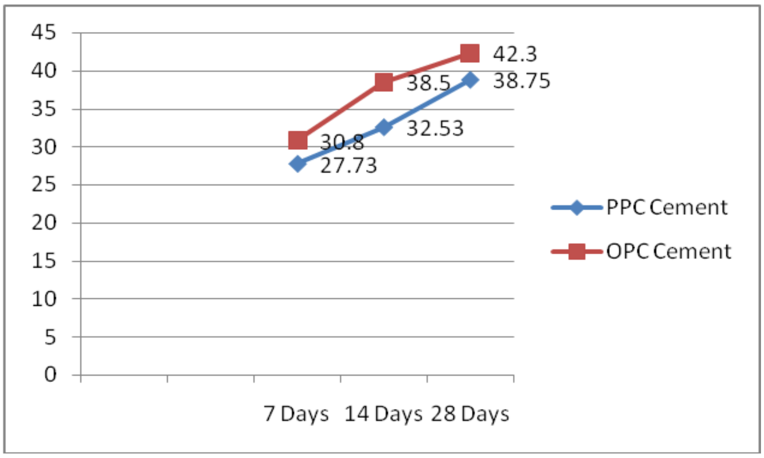


Figure 5 Comparison of compression strength of Bacterial concrete with PPC and OPC

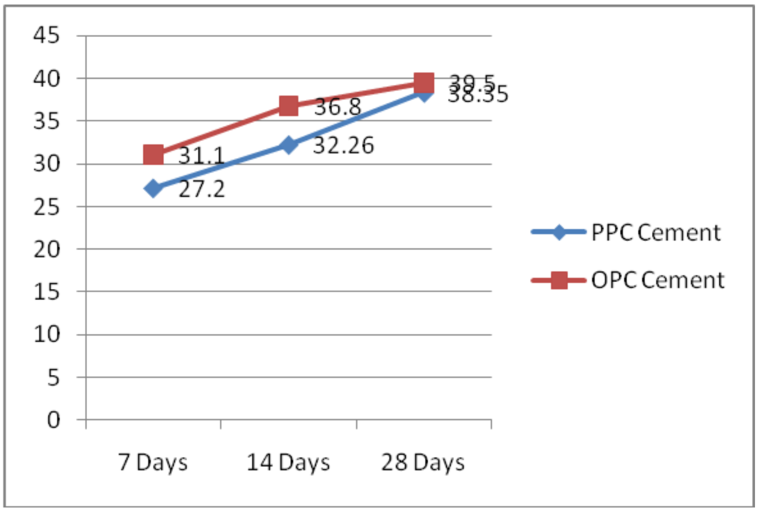


Figure 6 Comparison of compression strength of Bacterial concrete+ Fibre with PPC and OPC

It is observed that from the figure 4, 5 and 6 the compressive strength of concrete is increased in Bacterial concrete with the combination of Ordinary Portland cement (OPC) compared to Portland pozzolana cement (PPC).

No. Of Days	Spilt Tensile Strength of Conventional Concrete (N/mm2)	Spilt Tensile Strength of Bacterial Concrete (N/mm2)	Spilt Tensile Strength of Bacterial Concrete +fiber (N/mm2)
7	2.19	2.80	3.53
14	2.48	2.89	3.78
28	2.80	3.56	4.36

Table 8 Results of the Split Tensile Test with and without addition of bacteria for M25 grade of concrete (PPC cement)

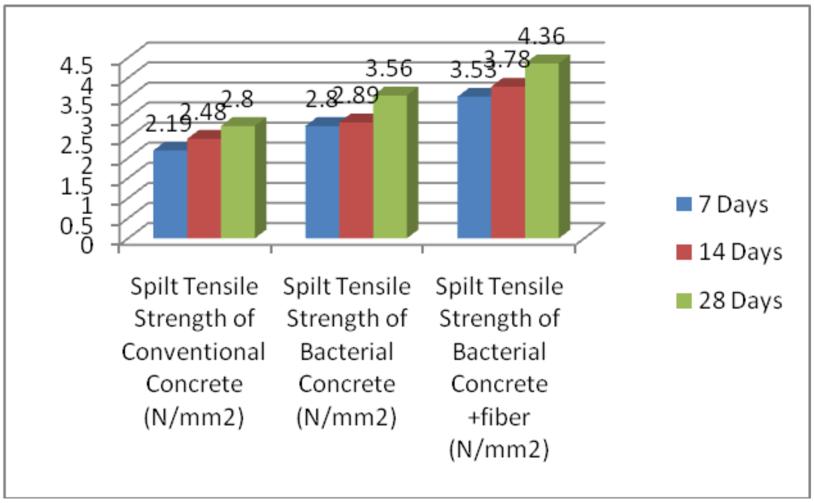


Figure 7 Split Tensile Strength with and without addition of bacteria (PPC Cement)

Table 9 Results of the Split Tensile Test with and without addition of bacteria for M25 grade of concrete (OPC 53 grade cement)

No. Of Days	Spilt Tensile Strength of Conventional Concrete (N/mm2)	Spilt Tensile Strength of Bacterial Concrete (N/mm2)	Spilt Tensile Strength of Bacterial Concrete +fiber (N/mm2)
7	2.38	2.67	2.96
14	3.05	3.31	3.78
28	3.80	4.10	4.62

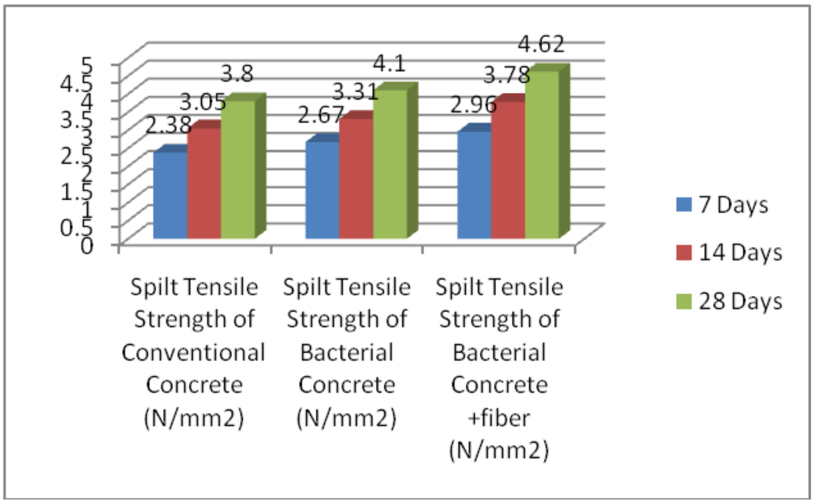


Figure 8 Split Tensile Strength with and without addition of bacteria (OPC Cement)

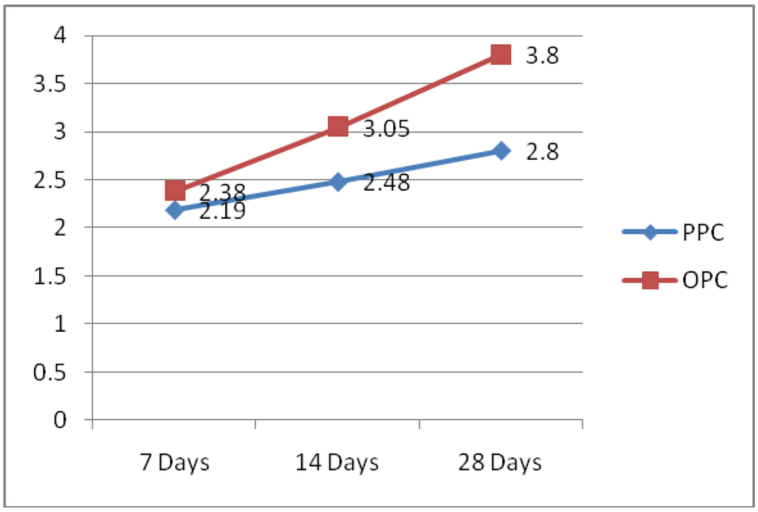


Figure 9 Comparison of conventional Split Tensile Strength with PPC and OPC

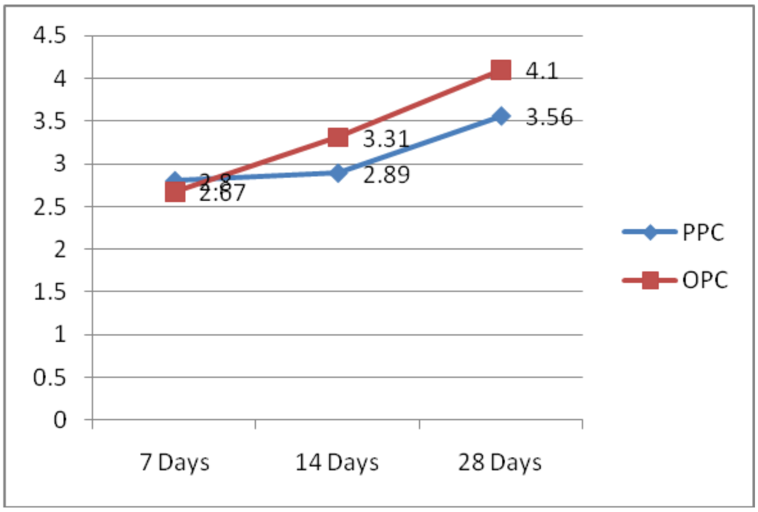


Figure 10 Comparison of Bacterial Split Tensile Strength with PPC and OPC

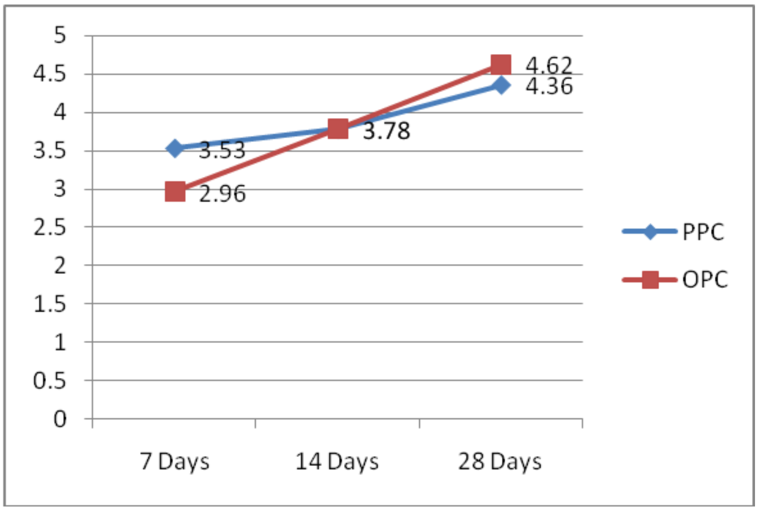


Figure 11 Comparison of Bacterial+ Fibre Split Tensile Strength with PPC and OPC

It is noticed from the figure 9, 10 and 11 the split tensile strength of concrete is increased in Bacterial with Fibre concrete with the combination of OPC cement compared to PPC cement.

Table 10 Results of the Flexural Tensile Strength test with and without addition of Bacteria for M25 grade of Concrete (OPC 53 Grade Cement)

No. Of Days	**Flexural Tensile Strength of Conventional Concrete (N/mm2)**	**Flexural Tensile Strength of Bacterial Concrete (N/mm2)**	**Flexural Tensile Strength of Bacterial Concrete + Fiber (N/mm2)**
28	10.75	16.66	23.11

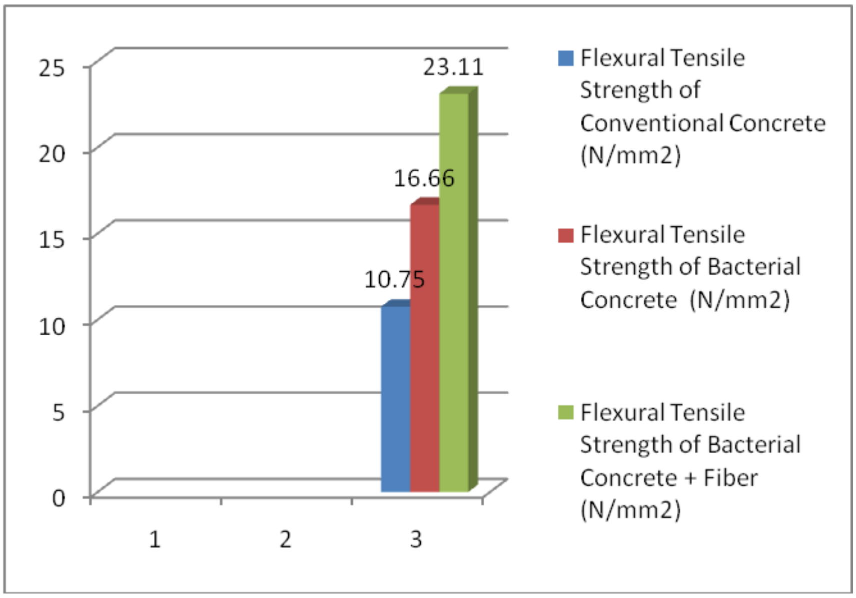


Figure 12 Comparison of Flexural Strength of concrete

The flexural strength of bacterial with fibre concrete from the above figure 12 is increased compared to other two types of concrete with the combination of Ordinary Portland cement.

IV. CONCLUSIONS

Based on experimental observation of the behavior of specimens, the influence of several parameters including measurement methods of various strengths of microbial fiber concrete and comparison showed by conventional concrete was investigated. The following conclusion may be drawn:

- Bacillus subtilis is a soil bacterium which utilizes the urea continuously, produces calcite precipitate and prevents the presence of air molecules in the concrete.
- An Experimental model for microbial concrete was developed and compared with OPC and PPC results.
- The compressive strength was found to increase from 10.83% to 14.45% for PPC and OPC grade respectively.
- In M25 grade concrete with addition of bacteria, the percentage of improvement in split tensile strength in the order of 10.32% to 12% for OPC and PPC at different stages was observed.
- In RCC beam with addition of bacteria and fiber, the percentage of improvement in Flexural strength is in the order of 13% for OPC at different stages.
- Cost of bacterial concrete is 15% more than the conventional concrete. But comparing other type of concrete it is economical.
- Experimental results indicate that the microbial Fiber concrete have more flexural strength than the ordinary and bacterial concrete and it increases the flexural load capacity of beam.

ACKNOWLEDGMENT

Let me take this opportunity to thank Chairman Sir, **N. Sesha reddy** and Vice Chairman sir, **N.Satish Reddy**, ADITYA College of Engineering for the whole hearted support extended to us throughout the conduct of the research.

We would like to thank Principal Sir, **Dr. A.Ramesh**, ADITYA College of Engineering, for giving me an opportunity to carry out the research work through the esteemed institution.

REFERENCES

[1] 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*. Available at: http://cancerres.aacrjournals.org/content/62/18/5375.long.

[2] B.M. Mali. (2012). Potential application of bacteria to improve the Strength of cement concrete. *International Journal of Advanced Biotechnology and Research, 3*(1), 541-544.

[3] Bang SS, Galinat JK, & Ramakrishnan V. (2001). Calcite precipitation induced by polyurethane-immobilized Bacillus pasteurii. *Enzyme and Microbiology Technology, 28*(4-5), 404-409.

[4] De Muynck, W. (2007). Improvement of concrete durability with The aid of bacteria. *Proceedings of the First International Conference on Self-Healing Materials*. Noordwijk aan Zee, The Netherlands.

[5] 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, 17*(4), 357-367.

[6] Hammes F, Boon N, de Villiers J, Verstraete W, & Siciliano SD. (2003). Strain-specific ureolytic microbial

carbonate precipitation. *Applied and Environmental Microbiology*, *69*(8), 4901–4909.

[7] Henk M. Jonkers & Erik Schlangen. (2008). *Development of a bacteria-based self-healing concrete*. Available at: http://www.abece.com.br/web/restrito/restrito/Pdf/CH062.pdf.

[8] Keri bachmeir et al. (2002). Urease activity in microbiologically induced calcite precipitation. *Journal of Biotechnology*, *93*(2), 171-181.

[9] Nolan E, Basheer PAM, & Long AE. (1995). Effects of three durability enhancing products on some physical properties of near surface concrete. *Construction and Building Materials*, *9*(5), 267-272.

[10] Ramakrishnan V. (2001). Calcite precipitation induced by polyurethane-immobilized Bacillus pasteurii. *Enzyme and Microbiology Technology*, *28*(4-5), 404-409.

[11] S. Sunil Pratap Reddy. (2010). Performance of standard grade bacterial (Bacillus subtilis) concrete. *Asian Journal of Civil Engineering (Building and Housing)*, *11*(1), 43-55.

[12] Shang-Lin Gao et al. (2007). Surface defect repairing by polymer coating with low fraction of nano reinforcement. *Scientific Net, 334-335,* 757-760.

[13] 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*. 991-1001.

[14] Srinivasa Reddy V. (2012). A biological approach to enhance strength and durability in concrete structures. *International Journal of Advances in Engineering & Technology*, *4*(2), 392-399.