iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** X **Month of publication:** October 2021

DOI: https://doi.org/10.22214/ijraset.2021.38542

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue X Oct 2021- Available at www.ijraset.com

An Experimental Study on Concrete by Bacterial Mineral Precipitation

A. Narendiran
Hayagriva polytechnic College, Sooramangalam, Puducherry – 605107

Abstract: ***A new technique in remediating cracks and fissures in concrete by utilizing microbiologically induced Calcite ($CaCo_3$) 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 M_{30}.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.***

I. REVIEW OF LITERATURE

B. M. Mali (2012) Investigated the potential application of bacterial species i.e. B.sphaericus to improve the strength of cement concrete. Here an attempt to incorporate dormant but viable bacteria in the concrete matrix which will contribute to the strength of the concrete. Water which enters the concrete will activate the dormant bacteria which in turn will give strength to the concrete through the process of metabolically mediated calcium carbonate precipitation.

Srinivasa Reddy, (2012)A novel eco-friendly self-healing technique called Bio calcification is one such approach on which studies were carried out to investigate the crack healing mechanism in enhancing the strength and durability of concrete. Microbiologically induced calcite precipitation (MICP), a highly impermeable calcite layer formed over the surface of an already existing concrete layer, due to microbial activities of the bacteria (Bacillus subtilis JC3) seals the cracks in the concrete structure and also has excellent resistance to corrosion.

S. Sunil Pratap Reddy, (2010) Researchers with different bacteria have proposed different bacterial concrete's. Here an attempt was made by using the bacteria "Bacillus subtilis". Calcite formation by Bacillus subtilis is a model laboratory bacterium, which can produce calcite precipitates on suitable media supplemented with a calcium source. This study showed a significant increase in the compressive strength was observed due to the addition of bacteria for a cell concentration of 10^5 cells per ml of mixing water. From Scanning Electron Micrography analysis, it is noted that pores were partially filled up by material growth with the addition of the bacteria. From the durability studies, the percentage weight loss and percentage strength loss with 5% H_2SO_4 revealed that Bacterial concrete has less weight and strength losses than the conventional concrete and it also revealed that bacterial concrete is more durable in terms of "Acid Durability Factor" and "Acid Attack Factor" than conventional concrete.

De Muynck W. Et Al.,(2007)In our research groups, first the criteria for the selection of calcium precipitating Bacillus strains were established. Bacillus sphaericus strains capable of the remediation of Euville limestone, by precipitating a dense and coherent calcium carbonate layer and concomitantly inducing a reduction of capillary water absorption, were characterized by a high urease activity, abundant EPS-production, a good biofilm production and a very negative ζ-potential.

II. MATERIALS AND TESTING

A. Cement

In market various types of cements are available but our present investigation ordinary Portland cement of 53 grade is used. OPC is the most commonly produced and used cement. The properties of cement tested as per IS: 4031-1988 and found to be conforming to various specifications of IS: 12269-2009.

B. Metakaolin

Metakaoiln is a dehydroxylated form of the clay mineral kaolinite. Stone that are rich in kaolinite are known as china clay or kaolin, traditionally used in the manufacture of porcelain. The particle size of metakaolin is smaller than cement particles, but not fine as silica fume.

©IJRASET: All Rights are Reserved

C. Water

Water used for mixing and curing is fresh potable water, conforming to IS: 3025 – 1964 part 22, part 23 and IS: 456 – 2000.

D. Bacteria

Researchers with different bacteria proposed different bacterial concretes. The various bacteria used in the concrete are Bacillus pasteurii, Bacillus sphaericus, E.coli etc. In the present study an attempt was made by using the bacteria Bacillus subtilis strain no.113 (MTCC). The main advantage of embedding bacteria in the concrete is that it can constantly precipitate calcite. This phenomenon is called Microbiologically Induced Calcite Precipitation (MICP).

Nutrient Broth is used for the general cultivation of bacterial microorganisms, can be enriched with blood or other biological fluids.

Table1 Nutrient Broth

S.No	Ingredients	Gms / Litre
1	Peptic digest of animal tissue	5.000
2	Sodium chloride	5.000
3	Beef extract	1.500
4	Yeast extract	1.500
5	Final pH (at 25°C)	7.4±0.2



Figure 1 Nutrient Broth

Table2. Mix proportioning for a M30 grade concrete

WATER	CEMENT	FINE AGGREGATE	COARSE AGGREGATE
197.16	492.9	610.25	1126.29

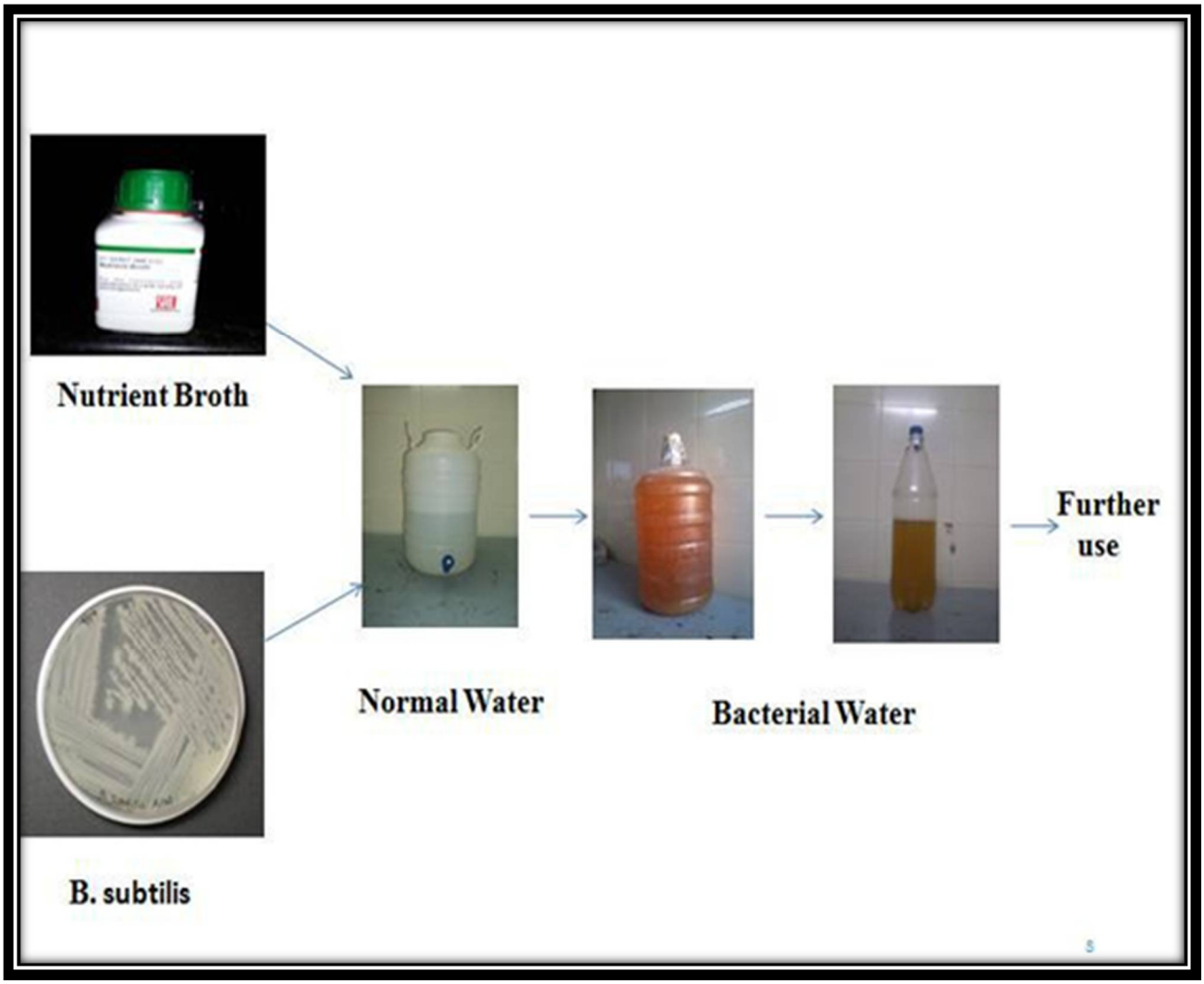
©IJRASET: All Rights are Reserved

III. EXPERIMENTAL INVESTIGATION

A. 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 foil 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.

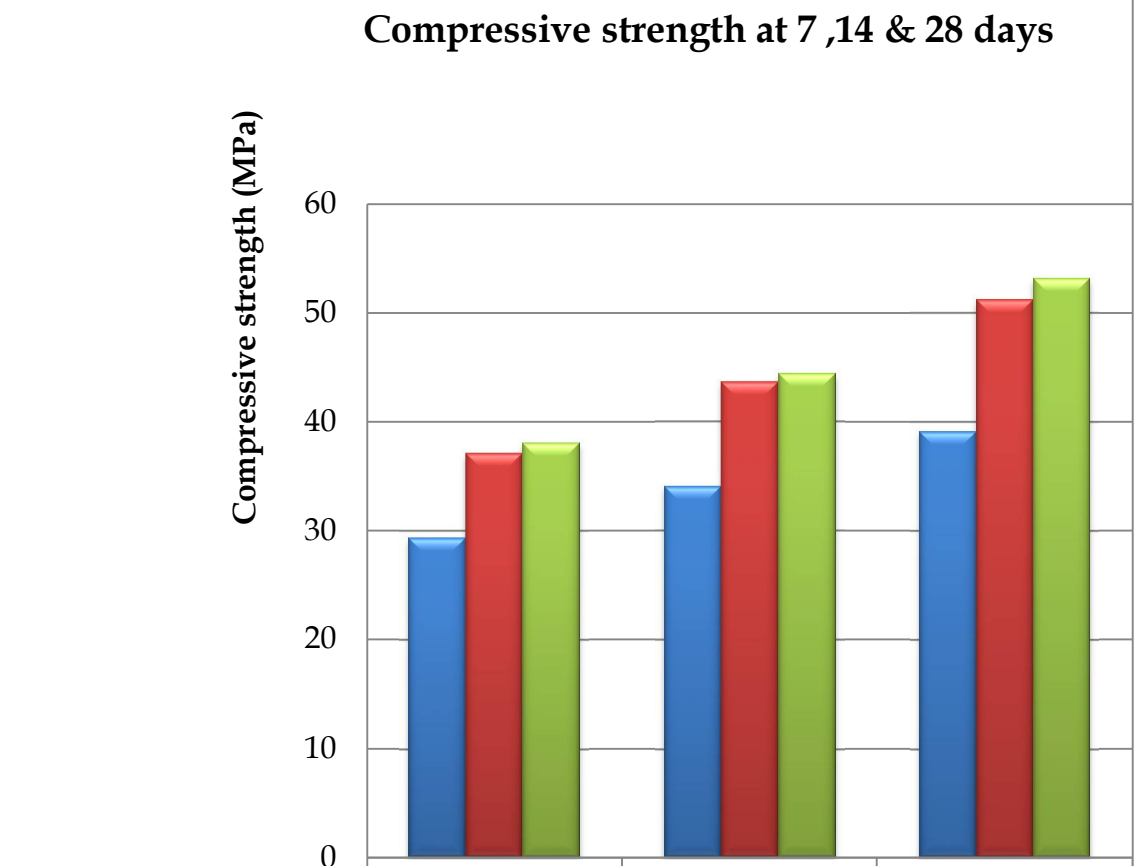


IV. EXPERIMENTAL STUDY ON COMPRESSIVE STRENGTH OF CONCRETE

A. Compressive Strength of Concrete

The investigation is carried out to study the compressive strength concrete. The results of the compressive strength of controlled, bacterial concrete and bacterial metakaolin concrete at 7 days, 14 days and 28 days for M30 grade concrete are tabulated in Table 4.1In M30 grade of concrete the compressive strength at 7 days, 14 days and 28 days are given in Table 4.1. It is observed that with the addition of bacteria and metakaolin increases the compressive strength of concrete showed significant by adding bacteria 26.52%, 28 % and 30.90 % at 7 days, 14 days and 28 days and with replacement of cement with metakaolin increase the compressive strength 29.73%, 30.20 % and 35.78 % at 7 days, 14 days and 28 days respectively.

©IJRASET: All Rights are Reserved



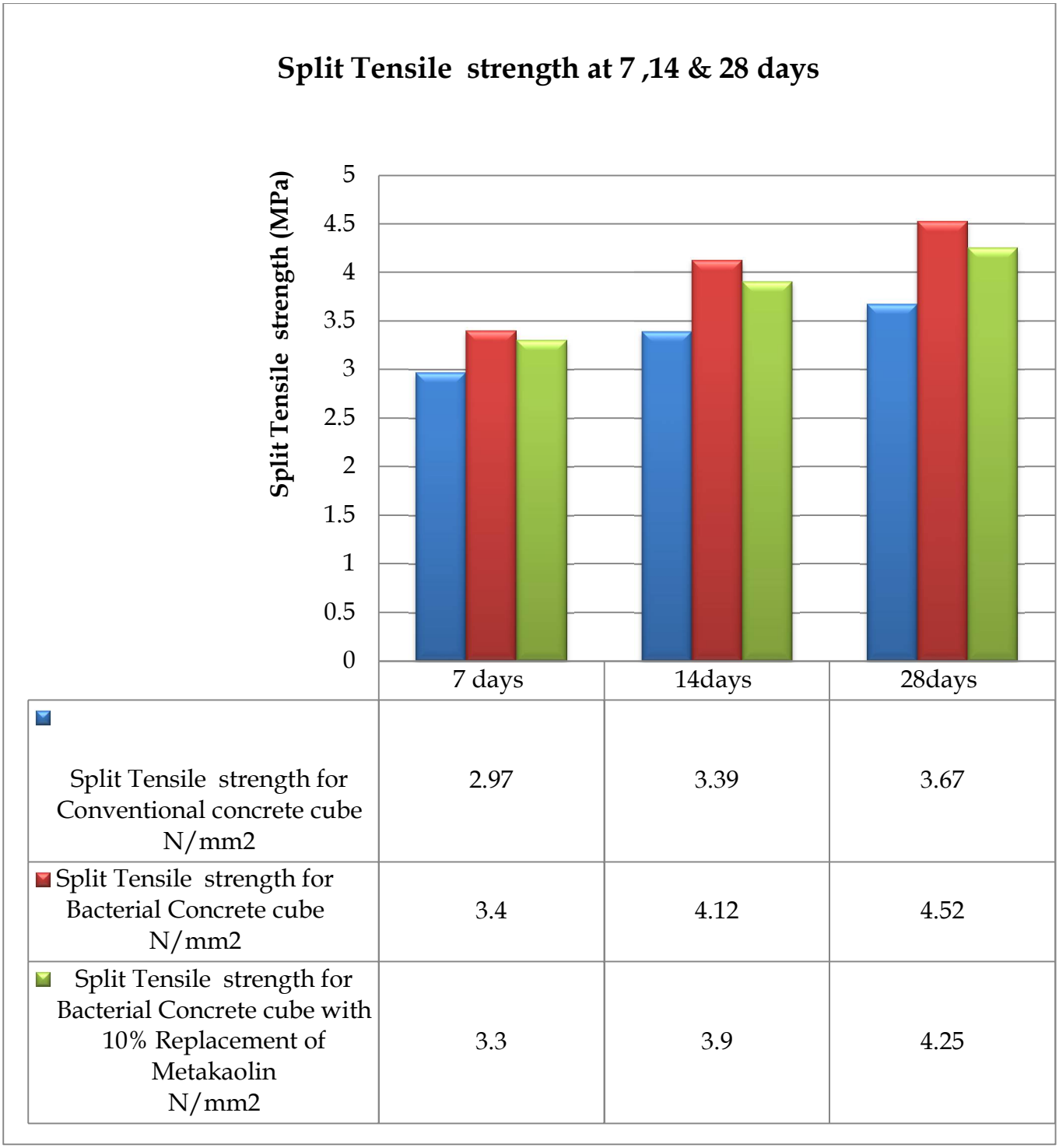
	7 days	14days	28days
Compressive strength for Conventional concrete cube N/mm2	29.33	34.07	39.12
Compressive strength for Bacterial Concrete cube N/mm2	37.11	43.61	51.21
Compressive strength for Bacterial Concrete cube with 10% Replacement of Metakaolin N/mm2	38.05	44.36	53.12

Figure 4.1 Comparison of Compressive Strength between Controlled and Bacterial Concrete with Age

©IJRASET: All Rights are Reserved

B. Split Tensile Strength of Concrete

In M30 grade concrete the Split Tensile Strength on standard cylindrical specimens at 7 days, 14 days and 28 days are given in Table 7.2. It is observed that with the addition of bacteria there is a significant increase in the spilt tensile strength by 14.47%, 21.53 % and 23.16% at 7 days, 14 days and 28 days and with replacement of cement with metakaolin decrease the split tensile strength 11.11%, 14.70 % and 15.80 % at 7 days, 14 days and 28 days respectively.



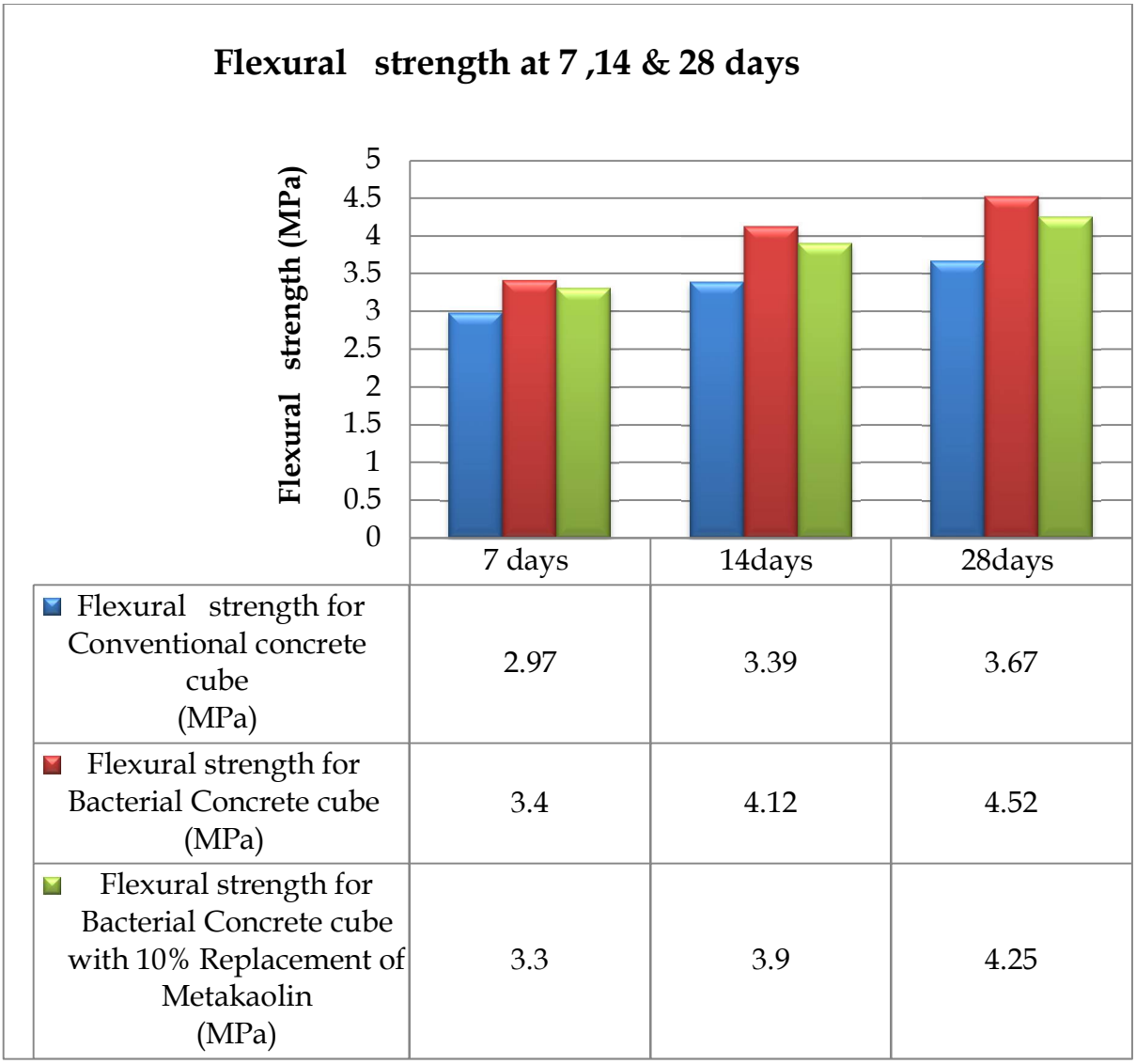
	7 days	14days	28days
Split Tensile strength for Conventional concrete cube N/mm2	2.97	3.39	3.67
Split Tensile strength for Bacterial Concrete cube N/mm2	3.4	4.12	4.52
Split Tensile strength for Bacterial Concrete cube with 10% Replacement of Metakaolin N/mm2	3.3	3.9	4.25

Figure 6.2 Comparison of Split Tensile Strength between Controlled and Bacterial Concrete with Age

©IJRASET: All Rights are Reserved

C. Flexural Strength of Concrete

The investigation is carried to study the flexural behavior of concrete. 27 simply supported beams consisting of balanced section are cast and tested. The cross section of the beam specimen is 100mm x 100mm x 500mm. The beams are cast using with bacteria and without bacteria in M30 grade concrete. The flexural strength of both controlled and bacterial concrete is calculated and the result is tabulated in Table 6.3



	7 days	14days	28days
Flexural strength for Conventional concrete cube (MPa)	2.97	3.39	3.67
Flexural strength for Bacterial Concrete cube (MPa)	3.4	4.12	4.52
Flexural strength for Bacterial Concrete cube with 10% Replacement of Metakaolin (MPa)	3.3	3.9	4.25

Figure 4.3 Comparison of Flexural Strength between Controlled and Bacterial Concrete with Age

V. CONCLUSIONS

A. Bacillus subtilis can be produced in the laboratory which is proved to be safe and cost effective.

B. In M30 grade concrete, with the addition of bacteria and metakaolin the percentage of improvement in the compressive strength is in the order of by 26.52% to 30.90 % and 29.73% to 35.78%at different ages. [2]

C. In M30 grade concrete, with the addition of bacteria the percentage of improvement in the spilt tensile strength is in the order of 14.47% to 23.16% at different ages and the percentage is reduced by replacement of metakaolin in bacterial concrete.

D. In M30 grade concrete, with the addition of bacteria the percentage of improvement in the flexural strength is in the order of 13.05% to 30.09% at different ages the percentage is reduced by replacement of metakaolin in bacterial concrete.

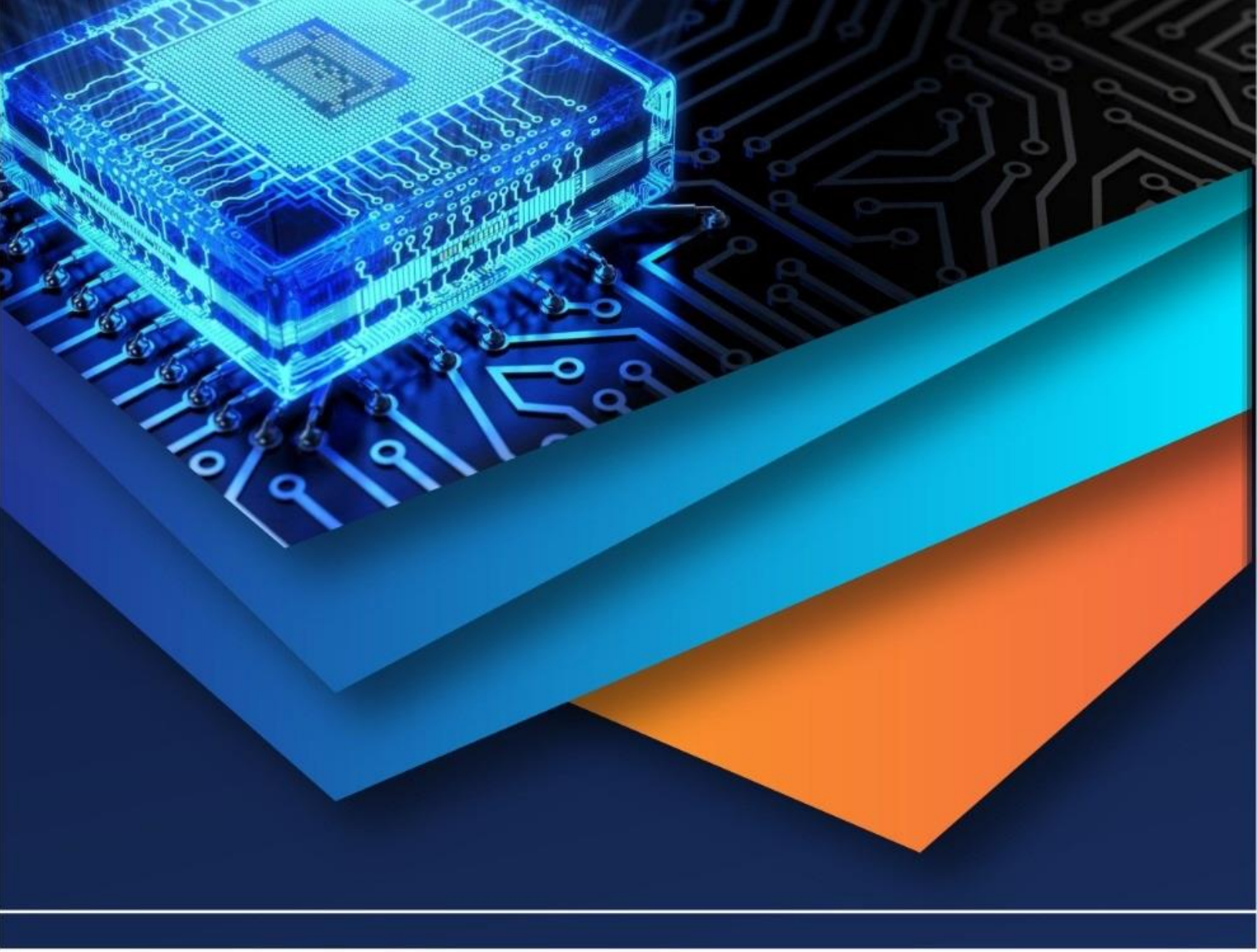
E. Cost of the bacterial concrete is increased to that of conventional concrete. But compare to other type of special concrete it should be very economical.

©IJRASET: All Rights are Reserved

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" in Cancer Research 62, 5375–5380, September 15.
[2] I.S 10262-2009 "Concrete Mix Proportioning – Guidelines (First Revision)"
[3] I.S 456-2000 "Indian code of practice for plain and reinforced concrete(Fourth Revision)"
[4] I.S 516-1959 "Indian code for method of tests for concrete".
[5] 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
[6] Bang SS, Galinat JK, Ramakrishnan V. 2001 "Calcite precipitation induced by polyurethane-immobilized Bacillus pasteurii". Enzyme Microb Technol Vol. 28(4-5): 404-409.
[7] 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
[8] 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.
[9] 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.
[10] 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
[11] Keri bachmeir et al. 2002, "Urease activity in microbiologically induced calcite precipitation". Journal of biotechnology, vol. p171-181.
[12] 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.
[13] Ramakrishnan V. 2001, "Calcite precipitation induced by polyurethane-immobilized Bacillus pasteurii". Enzyme Microb Technol, Vol. 28(4-5): 404-409.
[14] 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).
[15] Shang-Lin Gao et al. 2007, "Surface Defect Repairing by polymer coating with low fraction of nano reinforcement". Vol. 334-335, pp757-760.
[16] 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.
[17] 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.
[18] Vengadesh Marshall Raman, J. & Ramasamy, V. (2020). Various treatment techniques involved to enhance the recycled the recycled coarse aggregate in concrete: A review. Material today proceedings. Volume 45, Part 7, 2021, Pages 6356-6363. https://doi.org/10.1016/j.matpr.2020.10.935
[19] Vengadesh Marshall Raman, J. & Ramasamy, V. (2021). Augmentation of dissimilar techniques for enhancing the concrete properties with recycled coarse aggregate and manufactured sand Journal of Materials Research and Technology Volume 14, September–October 2021, Pages 1180-1190 . .https://doi.org/10.1016/j.jmrt.2021.06.094
[20] J. Vengadesh Marshall Raman, R. Aswini."Studies on Self Compacting Fuel Dispenser Hose Pipe Rubber in Concrete", Volume 4, Issue XII, International Journal for Research in Applied Science and Engineering Technology (IJRASET) Page No: , ISSN : 2321-9653,www.ijraset.com
[21] J.Vengadesh Marshall Raman, M. Sriram ."Experimental Investigation on Fully Replacement of Steel Slag as Course Aggregate in M30 Grade Concrete", Volume 5, Issue II, International Journal for Research in Applied Science and Engineering Technology (IJRASET) Page No: , ISSN : 2321-9653, www.ijraset.com
[22] J. Vengadesh Marshall Raman, R. Senthil Raj."Mechanical Studies of Self Compacting Concrete Using Plastic Aggregate", Volume 5, Issue II, International Journal for Research in Applied Science and Engineering Technology (IJRASET) Page No: , ISSN : 2321-9653,www.ijraset.com
[23] J. Vengadesh Marshall Raman, R. Kirubakaran."Experimental Investigation of Partial Replacement of Sand by Laterite Soil in Concrete", Volume 5, Issue II, International Journal for Research in Applied Science and Engineering Technology (IJRASET) Page No: , ISSN : 2321-9653, www.ijraset.com
[24] J.Vengadesh Marshall Raman, M. Sriram."Study on Replacement Level of Concrete Waste as Fine Aggregate in Concrete", Volume 5, Issue II, International Journal for Research in Applied Science and Engineering Technology (IJRASET) Page No: , ISSN : 2321-9653,www.ijraset.com
[25] J.Vengadesh Marshall Raman , K.Jaiganesan , "Durability Study on Replacement Level of Concrete Waste as Fine Aggregate in Concrete" Vol. 2 - Issue 2 (January - February 2017), International Journal of Research in Engineering Technologys (IJRET) , ISSN: 2455- 1341 , www.ijretjournal.org
[26] J.Vengadesh Marshall Raman and K Ajeeth Kumar , "Studies on Partially Replacement of Municipal Solid Waste Ash as Cement in Concrete" Vol. 2, No. 2, April 2017, International Journal of civil engineering and construction structures (IJCECS), ISSN: 2455-7714, www.trpubonline.com
[27] J.Vengadesh Marshall Raman, V.Murali Krishnan "Partial Replacement of Cement with GGBS in Self Compacting Concrete for Sustainable Construction", SSRG International Journal of Civil Engineering(SSRG-IJCE),V4(3),24-28March2017.ISSN:2348–8352. www.internationaljournalssrg.org/IJCE/index.html. Published by: Seventh Sense Research Group
[28] J.Vengadesh Marshall Raman and P.Soundarya "An Experimental Study On Rapid Hardening Cement Concrete Paver Blocks By Using Corundum As A Mineral Admixture" Volume 16, Issue 3 Ser. I (May. - June. 2019),IOSR- Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, , PP 01-09 www.iosrjournals.org
[29] J.Vengadesh Marshall Raman, V.Gnanadevi and V.Anitha "Experimental Investigation on Quarry Dust and Recycled Aggregates in Concrete", International Journal of Civil Engineering and Applications. ISSN 2249-426X Volume 9, Number 1 (2019), pp. 1-9 © Research India Publications http:// www.ripublication.com
[30] J.Vengadesh Marshall Raman, R.Rajesh and P.Sabari Velswaran "Study on Strength of High Performance Concrete by Partial Replacement of Fine Aggregate by Copper Slag" International Journal of Applied Engineering Research ISSN 0973-4562 Volume 14, Number 11 (2019) pp. 2795-2798 © Research India Publications. http://www.ripublication.com

©IJRASET: All Rights are Reserved



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)