International Journal of Advanced Structures and Geotechnical Engineering
ISSN 2319-5347, Vol. 04, No. 03, July 2015

Effect of Bacteria on Strength of Concrete

RAVINDRANATHA, LIKHITH, UDAYA SHANKAR H. N., SUHAS S.VOKUNNAYA
Department of Civil Engineering, Manipal Institute of Technology, Manipal, Karnataka, India
Email: ravi_mit@yahoo.com, likhit.ml@gmail.com, udaya.shankar@manipal.edu
suhasvokunnaya@gmail.com

Abstract: The infrastructure is a very basic need of any industry. The necessity for such infrastructure is high level of service and performance, high durability and minimum negative ecological impact. In all concrete structures, crack is one of the main concern .Cracks form an open pathway to the reinforcement and can lead to durability problems like corrosion of the steel bars. These cracks should be repaired because they can reduce the service life of the structure. Here an Overview is given of new developments obtained in research on self healing of cracks in cement based materials .Bacterial concrete, as the name indicates is an improvisation provided to cement using living microbes which are capable of doing so. Using microbes such as Bacillus pasteurii, which has properties of bio calcification, can secrete calcium carbonate as an extra cellular product thus filling the pores and the cracks internally making the structure more compact and resistance to seepages. As the texture becomes more compact the compressive strength, flexural strength &split tensile strength is considerably increased. The process can reduce the seepage.

The laboratory tests are conducted on 43 grade ordinary Portland cement (OPC).the physical tests of ingredient materials are conducted according to IS specifications .For laboratory tests M25 concrete is adopted. On hardened concrete the strength related test such as Compression, Split tensile and flexural tests on cubes, cylinder and beams are conducted as per IS specifications. It is found out that increase in compressive strength is as much as 30% for all cubes after 3, 7, 14, 28 days of curing .The increase in split tensile is found out to be more than 35%.The increase in flexural strength is found out to be more than 11%.

Keywords: *Bacillus pasteurii, compressive strength, flexural strength, and Bio-calcification*

1. Introduction:

1.1. Preamble:

Concrete is the most widely used construction material in the world. Despite its different qualities in construction, it is known to have several limitations. It is weak in tension and has limited ductility and less resistance to cracking. Since the beginning there has been continuous research carried out around the world, various modifications has been made over the years to overcome the insufficiency in cement concrete. The continuing research in the field of concrete technology has led to the development of special type of concrete considering various parameters such as the speed of construction, the strength of concrete, the durability of concrete and the environmental friendliness with use of industrial waste material such as fly ash, ground granulated blast-furnaces. Cement concrete in terms of weight it stands second only to water. In terms of cost, generally it accounts for about 25 to 30 % of the national budget. Concrete is the main material used for the infrastructure development in every country around the world. As far as India is concerned, our infrastructure development as just started. In the upcoming years there will be a sudden advancement in the production and use of cement and concrete. Cement is a binder; a substance that sets and hardens independently, and can bind other materials as well. Cements are generally graded according to a few set of specifications defined, (Refer - IS 269(2013) [7], IS-8112(2013)[8], IS 12269(1987)[9]) which differentiate the various grades of cements.

Cement is one of the most important ingredient materials of concrete; generally the Ordinary Portland Cement (OPC). CO_2 emission is responsible for global warming and ecological imbalance. Recently, it is found that metabolic activities of favourable microorganisms led to the mineral precipitation in concrete improved the overall behaviour of concrete. This process occurs inside or outside the microbial cell and within the concrete. Often bacterial activities simply trigger a change in chemistry that leads to the mineral precipitation. Use of these mineralogy concepts in concrete has lead to potential invention of new material called "Bacterial Concrete''

1.2. Objective:

The Structural members are porous in texture up to a microscopic level. This porosity of building material allows moisture and water to seep into the concrete members. Due to this cracks are developed and this leads to corrosion of steel reinforcements, thus reducing the service life of the structure which leads to failure of the structure. An additive that seals the pores and cracks can reduce the permeability of the structure and improve its service life. In accordance there exists a variety of waterproofing agents and surface treatments like the water repellents such as silanes or siloxanes are used to enhance the durability of the concrete structures today. However, they suffer from various limitations like the incompatibility with interfaces, susceptible to ultraviolet radiations, unstable molecular structure and are expensive.

1.3. Bacteria:

A bacterium is relatively simple, single celled organism. The bacterium used in this process is formerly known as Bacillus pasteurii. This bacterium has the ability to precipitate minerals (calcium carbonate) in the presence of any carbonate source. It is also said that it contributes for significant improvement in strength in concrete by producing inorganic rod shaped calcite crystals at empty spaces hence avoiding voids like how we humans produce teeth and bones. These microbes are of bacillus species and are not harmful for the human beings, as this bacterium is in human saliva as well. The main advantage of embedding bacteria in the concrete is that it can constantly precipitate calcite and this phenomenon is called Microbiologically Induced Calcite Precipitation (MICP). Bacillius Pasteuri strain No MTCC 1761(Microbial Type culture collection and Gene Bank) is a laboratory located in chandigarh ,INDIA. It is a soil Bacterium and the cost of one Bacterium was Rs.450/- Only which was cultured and used. An attempt is made to study its effect on the strength and remediation of cracks in Concrete.

Fig 1: *Bacterial Specimen*

2. Procedure:

2.1 Preparation of bacterial solution

Primarily 12.5g [5] of Nutrient broth (media) is added to a 500ml conical flask containing distilled water. It is then covered with a thick cotton plug and is made air tight with paper and rubber band. It is then sterilized using a cooker for about 10-20 minutes. Now the solution is free from any contaminants and the solution is clear orange in colour before the addition of the bacteria. Later the flasks are opened up and an exactly 1ml of the bacterium is added to the sterilized flask and is kept in a shaker at a speed of 150-200 rpm overnight. After 24 hours the bacterial solution was found to be whitish yellow turbid solution.

2.2 Preparation of M-25 Concrete

OPC Cement is used with nominal size of aggregate as 20mm. Specific gravity of cement is 3.15 and that of Coarse aggregates and Fine Aggregates are 2.7 each. Water Absorption of Coarse Aggregates is 0.5 and Fine Aggregates is 1%.The target mean Strength was taken as 31.6 N/mm^2.Water Cement Ratio was found to be 0.45.Finally we ended up with Mix of **1:1.824:2.323** .

2.2 Compression strength test :

The cubical Moulds of size 150mm x 150mm x 150mm were used and tested as per IS 516:1959[11]. The required quantities of cement, along with fine aggregate and coarse for the M-25 mix are weighed accurately for concreting .The wet concrete is now poured into the Moulds and for every one third layers the mix in the Moulds is compacted manually. Three Cubes of 3, 7, 14, 28 and 56 day's age were tested in a compressive strength testing machine.

2.3 Flexural strength test:

Moulds of 10cm x 10cm x 50cm is used and the Moulds are tested as per IS:516-(1959)[11]. The required quantities of cement, fine aggregate and corresponding coarse aggregate for the particular mix are weighed accurately for concreting. After the concreting operations, the upper surface is leveled and finished with a mason's trowel. The corresponding identification marks were labeled over the finished surface and 3 beams were tested for every 3,7,14, 28 and 56 days .

2.4. Split Tensile Strength Test:

The cylindrical moulds of diameter 150 mm and height 300 mm are casted and tested as per IS:5816-(1999)[10]. . The corresponding identification marks were labeled over the finished surface and 3 cylinders were tested for every 3,7,14, 28 and 56 days.

Table -1: Compressive strength test results for 3,7,14, 28 and 56 days

Sl. No	Days	Normal concrete (N/mm^2)	Bacterial Concrete (N/mm2)
1	3	3.69	3.99
2	7	3.92	4.60
3	14	4.31	5.20
4	28	7.06	7.85
5	56	7.14	7.94

3. Results and Conclusions:

The test results showed a 30% increase in Compressive Strength of Bacterial Concrete Cubes, compared to Normal Concrete ones of 3,7,14,28 days age , except for 56 days aged Cubes.The Increase in Flexural Strength was varying from 8 % to 20% .The Increase in Split Tensile Strength was varying between 34% to 70 % which is evident from the test results

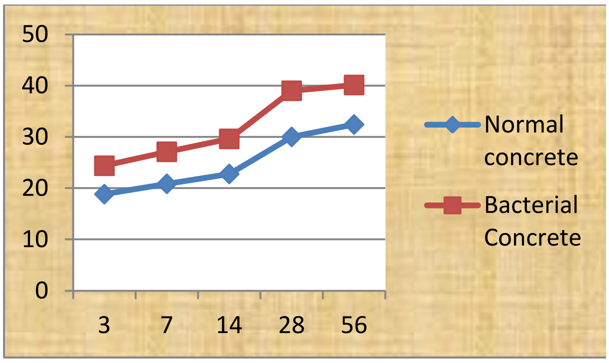

Fig 2: *Plot of Compressive Strength vs Age (Days).*

Table -2: Flexural Strength Test results for 3, 7, 14, 28, 56 days.

Sl. No.	Days	Normal Concrete (N/mm^2)	Bacterial Concrete (N/mm^2)
1.	3	0.92	1.56
2	7	1.89	2.71
3.	14	2.11	3.37
4.	28	2.77	3.89
5.	56	2.95	4.01

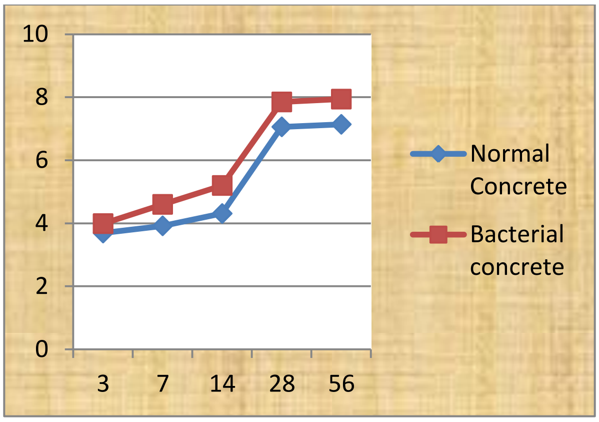

Fig 3: *Plot of Flexural Strength vs Age (Days).*

Table-3: Split Tensile Strength Test Results for 3, 7, 14, 28, 56 days

SL.NO	Days	Normal concrete (N/mm^2)	Bacterial concrete (N/mm^2)
1.	3	18.83	24.36
2.	7	20.84	27.09
3.	14	22.76	29.6
4.	28	29.99	38.98
5.	56	32.41	40.11

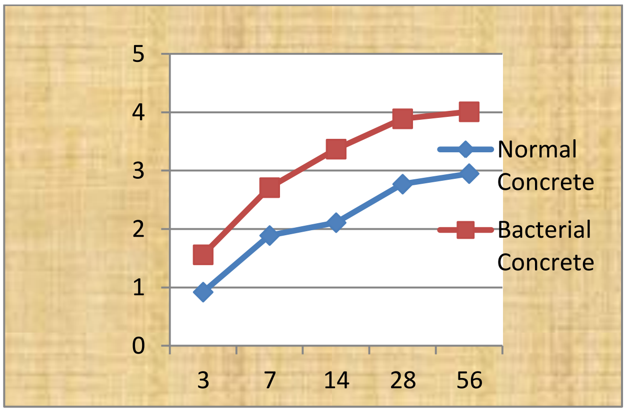

Fig 4: *Plot of Split Tensile Strength vs Age (Days).*

Fig 5: *Specimen of Split Tensile Strength Test*

4. Conclusion:

The Bacterial concrete has given good results compared to normal concrete.There was significant improvement of compressive strength by 30% in concrete with bacteria. The Split Tensile Strength is increased by more than 35%and Flexural Strength has increased by more than 8% for bacterial concrete. This concrete can be used to prevent cracks and hence saving the structure from corrosion of steel.

5. Scope for future study:

The different species of the bacteria can be tried with different grades of concrete. Concrete can also be tested with different proportion of fly ash and GGBS.

6.Acknowledgements:

We acknowledge the help rendered by Mr.Kannan, Assistant Professor, Department of Biotechnology**,** MIT Manipal for providing and getting cultured bacteria in their laboratory. Our sincere thanks to Dr.Narayan.Shenoy and Mr.Chandrashekar of MIT Manipal for allowing conducting tests in the Civil Engineering Department MIT Manipal

7. References:

[1] Abhijithsinh Parmar, Ankith Patel ,Vismay Shah,SandeepKhorasiya,DipanPatel(2013).”Improvement on the concrete cracks by using Bacillus Pasteurii”. International Journal for scientific Research & Development (IJSRD)| Vol.1 Issue 1, 2013.

[2] Navneet Chahal ., Rafat Siddique ., Anita Rajor., (2012). “Influence of bacteria on the compressive Strength, water absorption and rapid chloride permeability of fly ash concrete.” Construction and Building Materials 28 (2012), pages 351-356.

[3] Virginie Wiktor ., Henk M. Jonkers. (2011). “Quantification of crack-healing in novel bacteria-based self-healing concrete.” Cement & Concrete Composites, 33., (2011), pages 763–770.

[4] S. Sunil Pratap Reddy, M.V. Seshagiri Raob, P. Aparnac and Ch. Sasikalac. (2010). “Performance of standard grade bacterial concrete.” Asian journal of civil engineering (building and housing) | vol. 11, no. 1 (2010), pages 43-55.

[5] Achal, V., Mukherjee, A., Basu, P . C., and Reddy, M. S. (2009). “Lactose mother liquor as an alternative nutrient source for microbial concrete production by Sporosarcina pasteurii.” Journal of industrial Microbiology and biotechnology, 36, 433-438.

[6] Achal, V., Mukherjee, A., Basu, P . C., and Reddy, M. S. (2009). “Strain improvement of sporosarcina pasteurii for enhanced urease and calcite production.” Journal of industrial Microbiology and Biotechnology, 36, 981-988

[7] IS 269 (2013), “Ordinary Portland Cement, 33 Grade — Specification-(Fifth Revision)

[8] IS-8112 (2013),“Specification for 43 grade ordinary Portland”.

[9] IS 12269:1987 “Specification for 53 grade ordinary Portland.”

[10] IS 5816:1999 “Method of test for splitting tensile strength of concrete”.

[11] IS 516:1959 “Method of test for strength of concrete”.