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# A STUDY ON STRENGTH CHARACTERISTICS OF BACTERIAL CONCRETE

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**Abstract** – *Cracking in concrete is an inevitable phenomenon which has been an area of in the field of civil engineering. Bacterial concrete is an innovative approach aiming to close the cracks produced in concrete structures. This project aims at finding the optimum concentration at which bacteria is to be added in order to obtain the best results. The results were arrived at by conducting the Compressive Strength test, Splitting Tensile test and the Ultrasonic Pulse Velocity test. It was found that the addition of bacteria (Bacillus Subtilis) at $10^5$ cells/ml concentration proved to have higher strength characteristics.*

***Key Words***: Bacillus subtilis JC3, Inoculation, ultrasonic pulse velocity test

## 1. INTRODUCTION

Cracks in concrete are inevitable and are one of the predominant weaknesses in concrete and cause loss of strength of structure with time. They provide a pathway for harmful substances such as chlorides, carbon dioxide, and ultimately oxygen and water to get in to the reinforcement, cause corrosion, rust resulting in deterioration of concrete. Cracking is a major source of concern because of the need for repair which can be terribly expensive. Bacterial concrete or self healing concrete uses bacteria which react with water and metabolize crystals, which closes the crack and protect the steel within. Bacterial concrete is made by embedding bacteria in the concrete that are able to constantly precipitate calcite. Bacillus subtilis JC3 is the bacteria used for remediating the cracks in concrete. This phenomenon is called Microbiologically Induced Calcite Precipitation. This technique is highly desirable because the mineral precipitation induced as result of microbial activities is pollution free and natural. Thus, it becomes a better substitute to other alternatives which are non-degradable like epoxy resin.

## 2 MATERIALS REQUIRED

2.1 Cement:

OPC of grade 53 of specific gravity 3.125

2.2 Coarse aggregates:

Coarse aggregates conforming to the specifications of IS10262:2009-Zone II and specific gravity of 2.77

2.3 Fine aggregates:

M sand of specific gravity 2.6 and conforming to the specifications of IS10262:2009-Zone II

2.4 Water:

Natural potable water was used. It satisfies the provisions of IS 456:2000.

2.5 Microorganism:

Bascillus Subtilis JC3 cultured in nutrient agar broth.

## 3. METHODOLOGY

3.1 Procuring of bacteria

The bacteria of concentration of $10^8$ cells/ml was procured from Agricultural center, Mannuthy. The viability of the bacteria was checked in the Microbiology department of MA college.

3.2 Serial Dilution of bacteria

The bacteria obtained were serially diluted with water to the required concentration of $10^3$ ,$10^5$ ,$10^7$ cells/ml, under the guidance of Microbiology Dept. of Mar Athanasius College, Kothamangalam

3.3 Casting

Four sets of M 20 Grade concrete cubes and cylinders were cast with and without bacteria. Each set consists of 10 cubes and 3 cylinders .

The 4 different sets of specimens of M20 grade were normal concrete and bacterial concrete specimens of concentrations $10^3$,$10^5$,$10^7$cells/ml. The total number of cubes cast were 40 and that of cylinders was12.

3.4 Curing

Potable water was used for 7, 14 and 28 days of curing.

3.5 Testing

Compressive strength test on concrete cubes (15*15*15cm$^3$) and cylinders (height = 30 cm, Diameter = 15 cm) was done on 7,14 and 28 days. Splitting tensile strength test on concrete cylinders was conducted on 28th day. Also the Ultrasonic Pulse Velocity test was conducted on concrete cubes on 7$^{th}$ 14$^{th}$ and 28$^{th}$ day at Techshore Technical solutions, Kaloor.

## 4. TESTS AND OBSERVATIONS

4.1 Compressive strength test

This test gives an idea about the characteristics of concrete. The compressive strength of concrete depends on many factors such as water cement ratio, cement strength, quality of concrete material, quality control during production of concrete etc. The test was conducted on concrete cubes of size 15x15x15cm$^3$

**Table 1**: Compressive strength test for M20 grade concrete on 7, 14 and 28 days.

| Concrete type | 7$^{th}$ Day strength (N/mm$^2$) | 14$^{th}$ Day strength (N/mm$^2$) | 28$^{th}$ Day strength (N/mm$^2$) |
|---|---|---|---|
| Normal Concrete | 15.68 | 19.16 | 22 |
| 10$^3$ cells/ml | 16.55 | 22.56 | 23.38 |
| 10$^5$ cells/ml | 18.72 | 24.21 | 26.30 |
| 10$^7$ cells/ml | 16.98 | 22.91 | 23.912 |

4.2 Ultrasonic pulse velocity test

The UPV [Ultrasonic Pulse Velocity] test was conducted on the normal and bacterial concrete specimens under Direct method of testing. The equipment used was RTUL UX4600 of accuracy 0.1μs and frequency 60KHz.


Fig. 1: Pulse Velocity Testing Equipment

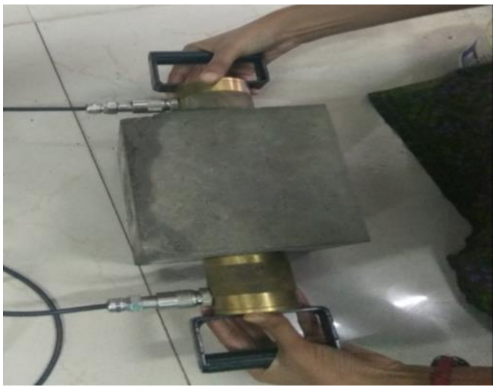


Fig 2: Transmitter and Receiver ends.

The UPV results are a direct indication of the density and hence the quality of the concrete specimens. High values of pulse velocities were expected from bacterial concrete specimens due to the filling of microcracks in them owing to the calcite precipitation.

**Table 2.1**: specification as per IS 13311 -Part 1 (1992 )

| Sl.No | Pulse Velocity by Cross Probing (Km /sec) | Concrete Quality Grading |
|---|---|---|
| 1. | Above 4.5 | Excellent |
| 2. | 3.5 to 4.5 | Good |
| 3. | 3.0 to 3.5 | Medium |
| 4. | Below 3.0 | Doubtful |

**Table 2.2:** Results of Ultrasonic Pulse Velocity test on concrete cubes (M20 grade).

| Concrete type | 7$^{th}$ day Km/s | 14$^{th}$ day Km/s | 28$^{th}$ day Km/s |
|---|---|---|---|
| Normal Concrete | 3.96 | 4.16 | 4.3 |
| 10$^3$ cells/ml | 4.23 | 4.42 | 4.51 |
| 10$^5$ cells/ml | 4.83 | 4.93 | 5.16 |
| 10$^7$ cells/ml | 4.51 | 4.63 | 4.75 |

4.3 Splitting tensile strength test (28$^{th}$ day )

Splitting tensile strength test in concrete cylinder (height-300mm, dia- 150mm) is a method to determine the tensile strength of concrete, which is one of its basic and important properties. Concrete due to its brittle nature is not expected to resist the direct tension and hence develop cracks when subjected to tensile forces. Thus this test directly indicate the load at which concrete members tend to crack.

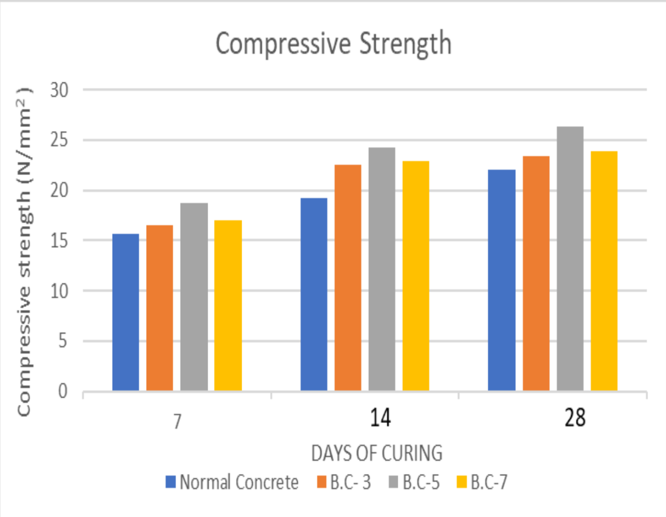
**Table 3:** Splitting tensile strength

| | Normal Concrete | Bacterial concrete of10$^3$ cells/ml | Bacterial Concrete of 10$^5$ cells/ml | Bacterial Concrete of 10$^7$ cells/ml |
|---|---|---|---|---|
| Splitting tensile strength N/mm$^2$ | 2.01 | 2.079 | 2.966 | 2.329 |

## 5. COMPARISONS OF RESULTS

### 5.1. COMPRESSIVE STRENGTHS OF CONCRETE SPECIMENS

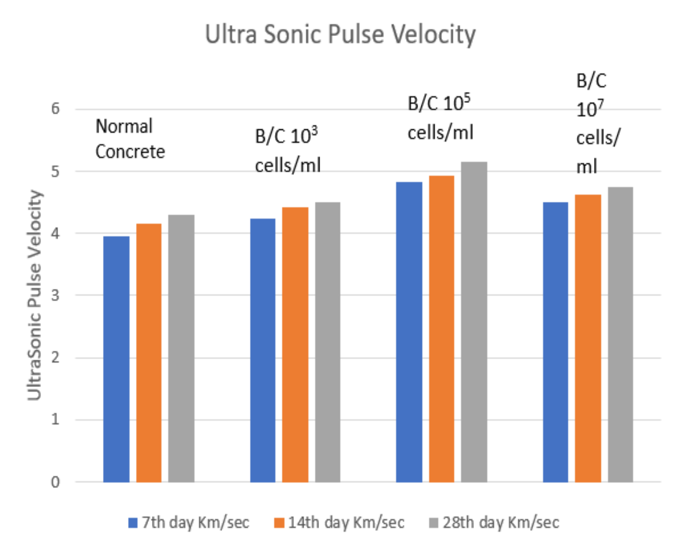
The graph gives an idea about the variation of compressive strengths of M20 grade concrete specimens for 7, 14 and 28 days of curing. The distinction between normal concrete and bacterial concrete specimens is well plotted.




**Graph 1:** Compressive strength test results for 7, 14 and 28 days of curing on M20 grade specimens.

## 5.2. ULTRASONIC PULSE VELOCITIES OF CONCRETE SPECIMENS

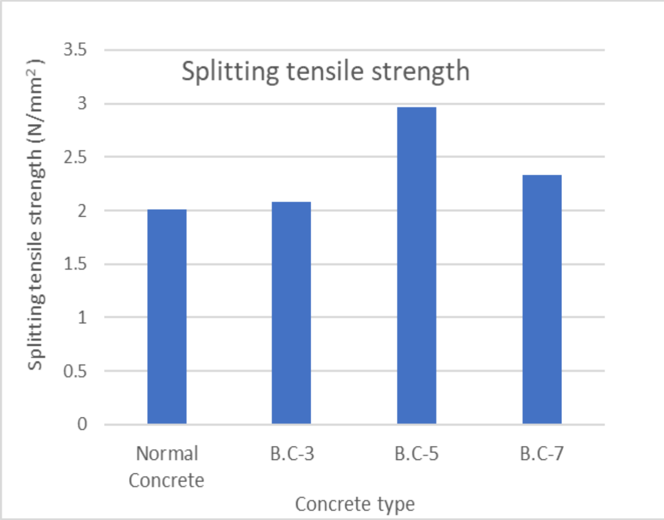
The Ultrasonic pulse velocity results for normal and bacterial concrete specimens on 7, 14 and 28 days were plotted.




**Graph 2:** Ultrasonic pulse velocity test results for 7, 14 and 28 days of curing for M20 grade concrete specimens.

## 5.3. SPLITTING TENSILE STRENGTHS OF CONCRETE SPECIMENS.

The results of splitting tensile test on M20 grade concrete specimens on 28th day of curing was plotted to obtain the graph below.




**Graph 3:** Splitting tensile test results on 28th day of curing for M20 grade concrete specimens.

## 6. CONCLUSION

We could infer from the experiments conducted so far, that bacterial concrete can effectivly increase the strength of concrete by closing the micro pores in concrete and making it denser. The 7th ,14th and 28th day strength of all specimens of bacterial concrete are stronger in compression than conventional concrete. The ultrasonic pulse velocity test also gave similar results that the bacterial concrete is of better quality than conventional concrete. And the optimum concentration of cells are found to be $10^5$cells/ml from the experimental results.

The table below shows the percentage increase in the strength of Bacterial concrete

**Table 4:** percentage increase in strengths.

| Concrete type | Increase in compressive strength | Increase in splitting tensile strength |
|---|---|---|
| BC, $10^3$ cells/ml | 5.81% | 3.43% |
| BC, $10^5$ cells/ml | 19.54% | 47.56% |
| BC, $10^7$ cells/ml | 8.69% | 15.87% |

## 7.REFERENCES

[1] IS 456:2000,"Plain and Reinforced Concrete-Code of Practice".

[2] J.Vinaya Singh, k.MalliKarjun Rao, G. HathiRam "Strength Characteristics of Bacterial Concrete," IJEEE, vol. 3, Dec. 2016, ISSN 2348-4748

[3] Arun K Chakaraborty ,Sandip Mondal , " Bacterial Concrete : A way to enhance the durability of concrete structures " , ICJ ,July 2017 ,Vol.91 , No.7

[4] Meera C.M ,Dr.Subha V , "Strength & Durability assessment of Bacteria based self healing Concrete " ,IOSR – JMCE , e-ISSN: 2278-1684,p-ISSN: 2320-334X, PP 01-07

[5] H. M. Jonkers , "Bacteria based self healing concrete ",HERON Vol. 56 (2011)

[6] SathishKumar.R, "Experimental Study on the Properties of Concrete Made With Alternate Construction Material", International Journal of Modern Engineering Research (IJMER), Vol. 2, Issue. 5, Sept.-Oct. 2012, pp-3006-3012

[7] PradeepKumar.A and Akhila Devi, "An Experimental Work on Concrete by Adding Bacillus Subtilis," IJETE, vol. 2, April 2015, ISSN 2348-8050

[8] H.S. Patil, D.B. Raijiwala, Hingwe Prashant and BhabhorVijay—Bacterial concrete "A self healing concrete", International Journal of Applied Engineering Research, Vol. 3, No. 12, 2008, pp.1719–1725.

[9] S.S.P Reddy, M.V.Seshagiri Rao, P.Aparna and Ch.Sasikala. "Performance of standard grade bacterial ('Bacillus Subtilis') concrete", Asian Journal of Civil Engineering (Building and Housing) Vol. 11,No.1, 2010.

[10] Van Tittelboom, K., De Belie, N., De Muynck, W., and Verstraete, "Use ofbacteria to repair cracks in concrete. " , Cement Concrete Res 40: 157-166, W (2010)