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# An Experimental Study of Bacteria on M20 Grade of Concrete

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**Abstract**
Concrete forms cracks that cannot be avoided and this is the main issue for concrete failures. The cracks bring about penetration/absorption of water into the concrete thereby reducing its life period. Therefore, this research work is going to find materials that can improve the characteristics of concrete to make it sustainable for use in construction.Self-healing concrete or bacterial concrete process revealed certain results through the addition of calcite-precipitating bacteria in concrete as shown by different researchers. This study is more concerned with finding out the adequacy of mixing these self-healing calcites depositing bacteria with concrete. Thus,by bio-mineralization process, it can increase the compressive strength of concrete, lower its porosity and reduce the seepage of water. When concrete specimens are cast with bacterial solution considerable strength is noticed. Many researchershave invented methods to test the properties on the use of bacteria in concrete. Various tests on the concrete slab were performed, by combining two or more types of bacterial solution as well as the mixed percentage of bacterial solution.A bacterial solution is used for surface application on the slab to test the sealing capacity.The results obtainedare then compared with normal concrete. The time takento increase the strength and for long-term sustainability are biological changes in construction material. This current study shows how bacteria affect the different properties of concrete.

**Keywords: -**Concrete, Cracks, Self-healing concrete, Bacterial concrete, Calcite precipitating bacteria/Calcite depositing bacteria, Bio-mineralization,biological changes

## 1. Introduction

A building material that is made up of fluid cement (binding material) mixed with fine aggregate (sand) and coarse aggregate (gravel), this mixture which later gets hard after some time is known as concrete. The typical concrete mix consists of; 10-15% cement, 15-20% water, and 65-75% aggregate. Concrete is a strong and well-built construction material, which is easily available and comparatively less expensive than other construction materials hence, it is commonly used worldwide. The only disadvantage of concrete is the mass production of concrete that causes adverse outcomesfor mother nature.The bearing strength of concrete is very high for compression load, but cracks mostly occur because the material is weak in tension. However, the cracks in the concrete pose a problem. Concrete is one of the commonly used building materials for construction which can easily form cracks. The cracks that developed in the concrete are due to various factors such as rate and quantity of drying, durability and strain, flexibility and plasticity, creep, drying shrinkage, etc.Cracks developed to resultin a consequential reduction in the serviceable life of the concrete and high renewable cost. Formation of cracks and their succession due to the influence of tensile stresses is a main drawback of concrete which conceals it to a poisonous atmosphere because of access to harmful compounds. For crack healing purposes manufactured products like adhesive are used. However, these products procure their own disadvantages, andnot only are they costly but also change the look of the structure to some extend and require uniformpreservation.

### 1.1 Objective

The aim of the current research study is to improve sustainable development and determine applicable materials and products to reduce cracks developed in concrete. Bacterial concrete or self-healing, a process in which calcite-precipitating bacteria is added to the concrete is popular among many researchers and they have been showing positivity with their results. The principle of bacterial-based self-healing concrete is that carbonate-precipitating bacteria are added to concrete during the mixing process.

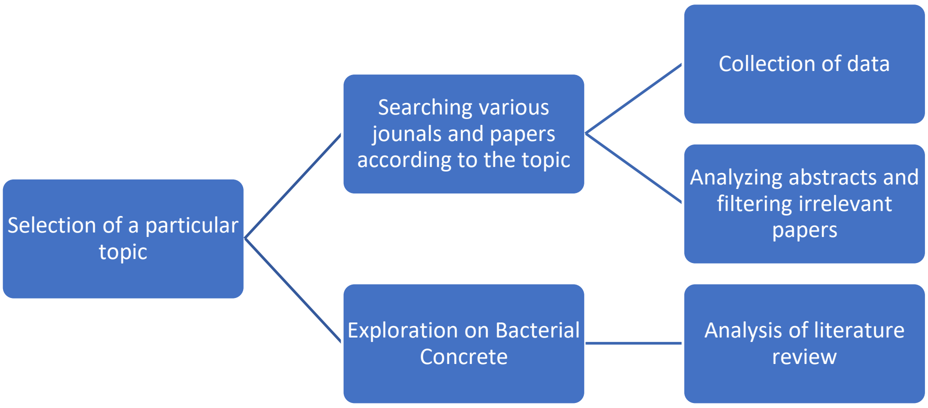


**Fig1.1 Methodology of Study**

In our project, the bacteria used is Bacillus Clausii, and is a commonly used Bacillus spp. probiotic. The antimicrobial and immunomodulatory properties of B. clausiiare used to cureand prevent intestinal bacterial flora disorders, with particular efficacy suggested for diarrhea according to clinical trial data and a systematic review and meta-analysis. Through testing of small trials,it has been found out that B. clausii spores areused to prevent infection in new born babies; for treating rhinitis, common cold, epiglottitis, and laryngitis, etc in children; and in adultsto cure severe or constantdysentery, SIBO (small-intestine bacterial overgrowth), and unfavourableimpact of Helicobacter pylori therapy.

But, recently in our project to try something new, other than using Bacteria B. subtillis which is mostly used in Bacterial Concrete Mix. We are using Bacteria B. Clausii which are easily available in the pharmaceutical shop to study and check if it will have any effect when being used in the concrete mix.

## 2. Literature Review

**Shubham Ajay Puranik, Siddharth Jain, G Sritam, SayaliSandbhor; issue-11S, September 2019.** According to the research paper that was published by the above authors we can see that the compressive force of concrete appeared to increase considerablywhen adding bacteria. Bacillus sphaericus of 30ml (one of the 4 commonly used in the family of bacteria) was used in M20 grade concrete mix which showed maximum improvement in compression strength in comparison with ordinary concrete strength. By applyingcertain suitable bacteria, it has been decided that it can be used as a segregate for waterproofing.

**Mayur Shantilal Vekariya1, Prof. Jayeshkumar Pitroda2; Issue- 9September 2013.**After the literature study, we observed that Bacterial concrete technology has been demonstrated to be preferable in many constructions as a building material because of its eco-friendly nature, self-healing abilities and increase in durability of various building materials than many of the conventional technologies. Many researchers working on various Bacterial concrete projects haveenhancedour knowledge of the possibilities and limitations of biotechnological applications on differentconstruction materials. With different experimental work, we saw that various cementitious and stone materials show improvement in compressive strength, decrement in permeability, water

Vol 12 Issue 02 2023
ISSN NO: 2230-5807

absorption, and reinforced corrosion. This method is easier and more suitable to use for the cementation process. Shortly, this will give the origin for ultimatestandard structures that will be profitable and eco-friendly but, additional work is neededso as toenhance the workability of this technology froma theoretical, frugal, and empirical point of view.

**Dr. K. Chandra Mouli; Issued-September, 2018.** Bacillus Subtilis along with its nutrients was used during this research by Dr. Chandra Mouli. The addition of bacteria increased compressive strength which was mainly due to the deposition of microbial induced calcium carbonate precipitation on microorganism cell surfaces and within the pores of mortar. It was found that in normal mortar, an increase in bacteria cell concentration up to 106 cells/ml increased compressive strength. A maximum increase in compressive strength was achieved at 106 cells/ml. Using B. Subtilis for 7 days, the percentage increase in compressive strength of 45ml and 60ml bacteria is higher than conventional concrete.

**Abhishek Pandit, Sahila Shaikh, Pranjali Mangalwedhekar, Sakshi Jagtap, Swapnil Gorade; Issued-May, 2018.** In this paper, it was concluded that cracks in concrete are repaired by bacteria which produces calcium carbonate crystals that close the small cracks and increase their strength and durability. Countless researchers have conducted experiments on bacteria and discovered that it improves the strength of conventional concrete by 15% in 7 days and 18-20% by 6 in 14 days approximately. Microorganisms produced from the precipitation of calcium carbonate occupy the empty spaces, this decreases the permeability of water by decreasing cracks width. Bacteria addition to concrete also reveal corrosion resistance, acid and sulphate attack resistance, and drying shrinkage. Admixtures like fly ash, silica fume, and fibers as well produce better strength.

### *2.1 Summary of literature review*

After going through all the literature above, it is noticed that the bacteria Bacillus category displays non-poisonous activity, ready to survive in unfriendly conditions of concrete. The results reveal Bacillus sphaericusenhances the compressive strength in contrast to ordinary concrete. The cell concentration of 105 cells/ml of mixing water gives high compressive strength, contingent upon Bacillus bacteria. Compared to other self-healing techniques, microbiologically induced calcite precipitation (MICP) is a good, remunerative, and 8 eco-friendly techniques. Bacterial concrete made ready with ground granulated blast-furnace slag (GGBS), silica fume, fly ash, and fibers (natural or artificial) permits better strength and durability. Microbial calcite precipitation was quantified by XRD (X-Ray Diffraction) analysis and confirmation of the presence of calcite precipitation inside cracks by SEM (Scanning Electron Microscopy). Due to the use of self-healing material in concrete, consistent inspection and maintenance of the concrete structure are not required.

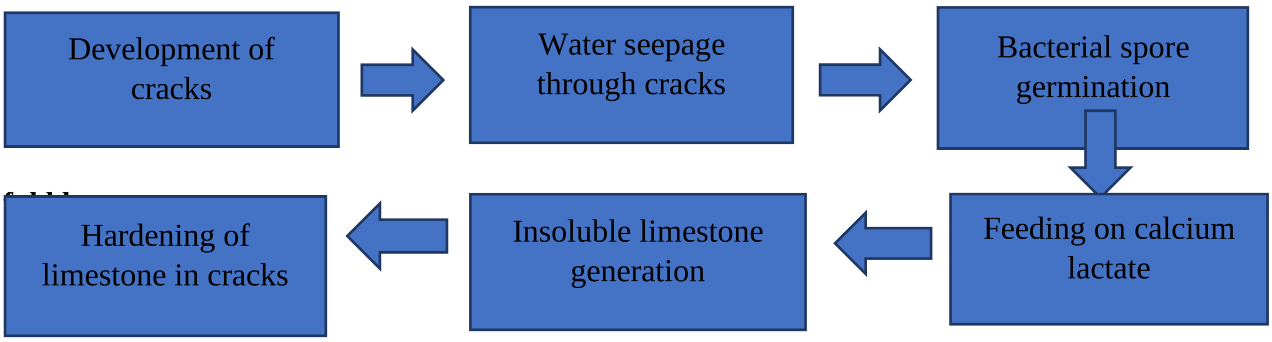


**Fig 2.1 Crack Healing Mechanism**

Vol 12 Issue 02 2023
ISSN NO: 2230-5807

**3. Experimental Programme**

AIM: - The aim is to determine the compressive strength of a standard M20-grade bacterial concrete mix of different proportions.

MATERIAL USED: - Ordinary Portland Cement (OPC), Coarse Aggregate (20-25mm), Fine Aggregate (4-4.5mm), Bacteria (Bacillus clausii).


**Fig. 3.1 Bacteria Bacillus Clausii**

**PROCEDURE OF CONCRETE CUBE CASTING: -**

**a)** Polish the ordinary cube moulds 6 Nos entirely and firm all nuts-bolts precisely.
**b)** Apply grease to all contract surfaces of mould.
**c)** Conventional concrete and bacterial concrete are prepared separately. Bacteria added in the concrete is done by direct method during the mixing process.
**d)** Fill the Conventional concrete/Bacterial concrete in cubes in 3 layers.
**e)** Each layer is compacted with 35 Nos of stroke by tamping rod.
**f)** Place the mould on the vee-bee consistometer for better consistency of the concrete.
**g)** At the end of last layer, polish the top surface by trowel.
**h)** Remove the specimen out of the mould after 24 hours.
**i)** Extra care should be taken while removing to avoid breaking of edges.
**j)** Immerse the specimen in clean fresh water untill the time of testing.

Fig 3.2 Cube Casting

**PROCEDURE FOR CONCRETE CUBE TEST**

Apparatus for Concrete Cube Test:Compression testing machine (CTM)

- **a)** Cubes of size 150mm x 150mm x 150mm (IS: 456:2000) were casted. 4 conventional concrete cubes 2 for 14days and 2 for 28days. 4 bacterial concrete cubes (15ml), 2 for 14days and 2 for 28days. And 4 bacterial concrete cubes (30 ml), 2 for 14days and 2 for 28days.
- **b)** Once the curing time period is over,take out the specimen from the water and clean off excess water from the surface.
- **c)** Wipe out the bearing surface of the testing machine thoroughly.
- **d)** The specimen should be place in the machine in such a way that the load induced should be at the opposite sides of the cube cast.
- **e)** The specimen should be placed in the centre on the base plate of the machine.
- **f)** Spin the adjustable partsmoothly by hand so as tomeet the upper surface of the specimen.
- **g)** The load must be applied gently without shock and constantly at the rate of 140 kg/cm$^2$/minute until the specimen breaks down.
- **h)** Note down the highest load and identify any abnormalcharacteristics in the type of failure.

**Fig 3.3 Before cracks & After cracks during CTM test**

***3.1 Compressive strength of M-20 conventional concrete and Bacillus Clausii-14 days & 28 days***

| Sl. No | Grade (M) | Name | Proportion (ml) | Days | Load (KN) | Compressive Strength (N/mm$^2$) | Average Compressive Strength (N/mm$^2$) |
|---|---|---|---|---|---|---|---|
| 1 | 20 | Conventional | 0 | 14days | 107 | 4.75 | 4.7 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Concrete | | | 105 | 4.66 | |
| 2 | 20 | Bacillus Clausii | 15 | 14days | 127<br>124 | 5.64<br>5.51 | 5.57 |
| 3 | 20 | Bacillus Clausii | 30 | 14days | 156<br>153 | 6.93<br>6.8 | 6.86 |
| 4 | 20 | Conventional Concrete | 0 | 28days | 239<br>242 | 10.62<br>10.75 | 10.68 |
| 5 | 20 | Bacillus Clausii | 15 | 28days | 274<br>278 | 12.17<br>12.35 | 12.26 |
| 6 | 20 | Bacillus Clausii | 30 | 28days | 312<br>320 | 13.86<br>14.22 | 14.04 |

## 4. Results & Discussion

From the above table,it is clearly shown that the average compressive strength of bacterial concrete with bacillus clausii of 15ml and 30ml for 14 days and 28 days is more than the average compressive strength of conventional concrete (14 days&28 days).

- It was observed that the compressive strength of bacterial concrete showed a serial increase to conventional concrete.
- The maximum increasein compressive strength of bacterial concrete compared to conventional concrete at 14 daysis 18.51% for 15ml.
- The maximum increase in compressive strengthof bacterial concrete compared to conventional concrete at 14 daysis 45.95% for 30ml.
- The maximum increase in compressive strength of bacterial concrete compared to conventional concrete at 28 daysis 14.79% for 15ml.
- The maximum increase in compressive strength of bacterial concrete compared to conventional concrete at 28 daysis 31.46% for 30ml.
- There was an improvement in compressive strength for every 15ml bacterial mix sample when compared to any other.

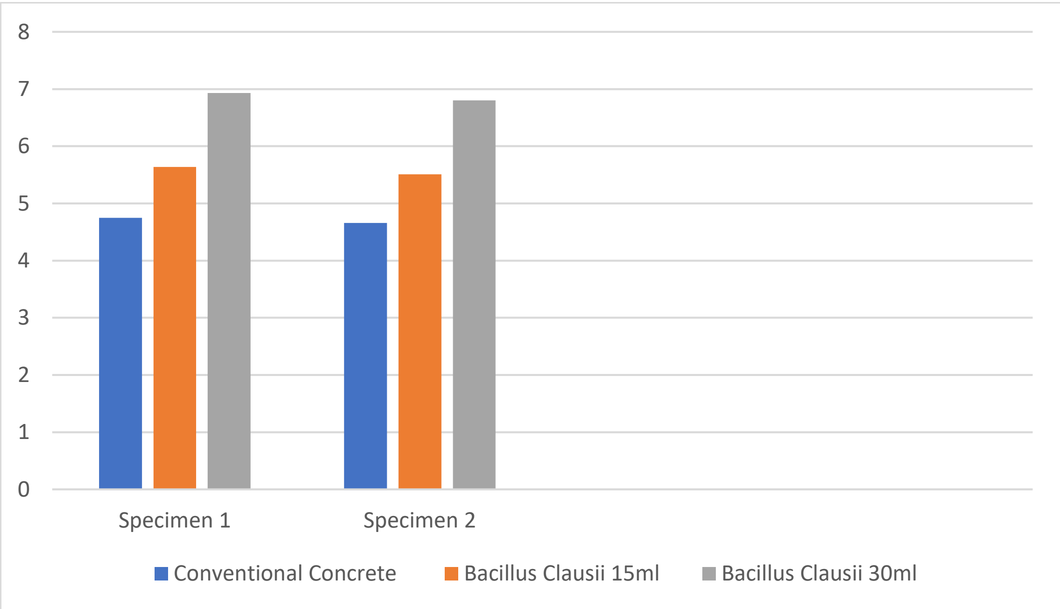

**Chart 3.1- Graphical chart of 14-days Compressive strength of conventional concrete and bacillus clausii**

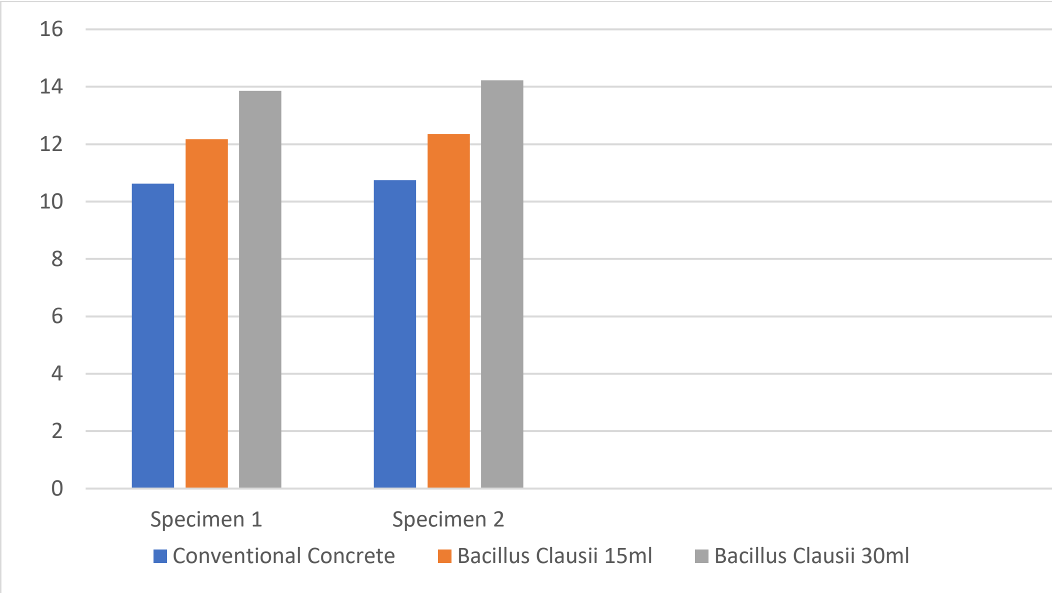


**Chart 3.2- Graphical chart of 28-days Compressive strength of conventional concrete and bacillus clausii**

## 5. Conclusion

- The maximumvolume of bacteria used in the concrete is 30 ml.
- Bacterial concrete is advantageous to conventional concrete due to its self-healing capacity and eco-friendly nature.
- The cost of Bacterial concrete is more. So, it is profitable when we go for higher Reinforced Cement Concrete structures. By using bacterial concrete, the rehabilitation cost can be reduced.
- From the above test results, it is showing that the combination of bacterial concrete with Bacillus Clausii gives us more compressive strength than conventional concrete.
- Thus, it can be concluded the presence of bacteria in concrete can improve the strength ofthe concrete structure.

## 6. Future Scope

- Following the same procedure as the present work, in the future we will use X-ray Diffractometer to characterize cementitious materials.
- Using the different grades of concrete and expanding the test such as Tensile Strength/Stress.
- Adding various admixtures to enhance the performance of concrete and observing its changes.
- Making use of different types of bacteria like Bacillus Subtilis, Bacillus pasteurii, and Bacillus Cohnii to get better results and explore more about Bacterial Concrete.

## 7. References

[1] Vekariya, M. S., 1, & Pitroda, P. J., 2 (2012). *Bacterial Concrete: New Era for Construction Industry*. International Journal of Engineering Trends and Technology (IJETT) – Volume 4 Issue 9- Sep 2013. http://www.ijettjournal.org/

[2]Khan, F., 1, Chavan, J., 2, Nalawade, S., 3, Kumbhar, O., 4, & Vaidya, P. R., 5 (2022*)*. A REVIEW PAPER ON BACTERIAL CONCRETE. International Journal of Creative Research Thoughts (IJCRT). http://www.ijcrt.org/

[3] MOUNIKA, K., Chaitanya, J. N., & CHANDRAMOULI, D. (2018*).* EXPERIMENTAL STUDY ON BACTERIAL CONCRETE. SSRG International Journal of Civil Engineering (SSRG-IJCE). http://www.internationaljouralssrg.org

[4] Puranik, S. A., Jain, S., &Sandbhor, G. S. S. (2019). Bacterial Concrete- A Sustainable Solution for Concrete Maintenance. International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-8, Issue-11S, September 2019.

[6] Abhishek kumar, A. A., EveenaStephen, 1, Merin George, 2, Ansafmuhammad, 3, & Naveen Charles, 4 (2020). *Evaluation of Strength and Durability Propertiesfor Various Amount of Bacillus Subtilis Bacteriain Concrete*. International Journal of Engineering Research & Technology (IJERT)ISSN: 2278-0181 Vol. 9 Issue 06, June-2020. http://www.ijert.org

[7] Pappupreethi k, RajishaVelluvaAmmakunnoth, & P. Magudeaswaran (2017). *BACTERIAL CONCRETE: A REVIEW*. International Journal of Civil Engineering and Technology (IJCIET) Volume 8, Issue 2, February 2017. http://www.iaeme.com/IJCIET/

[8] Tirpude Sahu Kirti. An experimental study on partial replacement of cement by red mud for m- 30 concrete. Harbin gongyedaxuexuebao/journal of harbin institute of technology. 2022; 54(6): 57-61.

[9]NajmuddinSaifee Sakina, Maheshbhai Lad Divya, RameshbhaiJuremalani Jayesh. Critical appraisal on Bacterial Concrete. International Journal of Research & Development Organization (IJRDO- Journl) Of Mechanical and Civil Engineering. 2015; 1(3): 10-14

[10] Ravindranatha, 1, N. Kannan, 2, &Likhit M. L, 3 (2014). *SELF-HEALING MATERIAL BACTERIAL CONCRETE*. IJRET: International Journal of Research in Engineering and Technology.

[11]Manikandan, A. T., 1, & Padmavathi, A., 2 (2015). *An Experimental Investigation on Improvement of Concrete Serviceability by using Bacterial Mineral Precipitation*. IJRSI, Volume II, Issue III, March 2015, ISSN 2321 - 2705. www.rsisinternational.org/IJRSI.html

[12] Kumar, J. B. G., 1, Prabhakara, R., 2, & Pushpa, H., 3 (2013). *Effect of Bacterial Calcite Precipitation on Compressive Strength of Mortar Cubes*. International Journal of Engineering and Advanced Technology (IJEAT)| PP: 486-491 | Volume-2 Issue-3, February 2013. https://www.ijeat.org/portfolio-item/C1186022313/

[13] Depaa, R. B., & Felix Kala, T. (2015). *Experimental Investigation of Self HealingBehavior of Concrete using Silica Fume and GGBFS as Mineral Admixtures*. Indian Journal of Science and Technology DOI: 10.17485/Ijst/2015/V8i36/87644 Year: 2015, Volume: 8, Issue: 36, Pages: 1-6.

[14] Bai, Chithra& Varghese, Shibi. (2016). AN EXPERIMENTAL INVESTIGATION ON THE STRENGTH PROPERTIES OF FLY ASH BASED BACTERIAL CONCRETE. 10.6084/M9.FIGSHARE. 3837999.V1.

[15]Babarao Gawande, A., Khandekar, Y. S., &Rahate, O. P. (2016). *APPLICABILITY OF CONCRETE TREATED WITH SELF-HEALING BACTERIAL AGENTS*. International Journal of Civil Engineering and Technology (IJCIET) (Vol.7, No. 5).