



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Special Issue 3, May 2024

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com

Experimental Investigation of Self Healing Concrete by using Bacteria *Bacillus Subtilis*

Prof.S. U. Balte

Assistant Professor, Dept. of Civil Engineering, Sinhgad Institute of Technology and Science, Narhe, Pune, India

L. Onkar, G. Pravin, L. Rutik, W. Rutik

UG Students, Dept. of Civil Engineering, Sinhgad Institute of Technology and Science, Narhe, Pune, India

ABSTRACT: Self Healing concrete is referred as the concrete having ability to heal or repair itself against the structural damages & environmental conditions. Self healing is classified into two categories that are Autogenous healing & Autonomous healing. It is a mixture of concrete & bacteria which affects the properties & characteristics of the concrete in certain limit. Bacteria are found in the nature in any conditions like soil, water, ice, plane land, residual waste etc. Application of bacteria in Self healing concrete impacts its comp. strength, crack healing capacity, durability etc. As the concrete got cracks on its surface the bacteria begin to multiply & they get exposed to oxygen. They get multiplied & form metabolic reaction which causes calcite precipitation in the concrete to seal cracks. *Bacillus Subtilis* is a gram positive bacterium which is found in soil. It is rod shaped & can form a tough & protective endospores. Which allows the *B. Subtilis* to tolerate extreme environmental conditions. The *B. Subtilis* is widely used in agricultural additives feeding & animal husbandry to enhance health of animals & living things. In case of concrete, the spore powder of *subtilis* bacteria is available for application in concrete surface. The self healing concrete provides better results by improving comp. strength of concrete as compared to conventional concrete. Self healing concrete is suitable in coastal structures, near marine areas, earthquake prone zones etc. It has low maintenance cost. The concrete can be known as sustainable & environment friendly.

KEYWORDS: Self Healing concrete, Autonomous & Autogenous healing, *Bacillus Subtilis*, Endospores, Calcite precipitation, Metabolic reaction, Spore Powder, Conventional concrete, Compressive strength, Durability, Coastal structures, Earthquake zones, Sustainable, Environment friendly.

I. INTRODUCTION

The self healing concrete is a concept of healing concrete by itself with the use of bacteria present in it. The concrete is also known as Bacterial concrete. It not only seals the cracks but also partially or entirely recovers the mechanical properties of the structural elements. This kind of concrete is also known as self-repairing concrete. Because concrete has a poor tensile strength compared to other building materials, it often develops cracks in the surface. These cracks reduce the durability of the concrete because they facilitate the flow of liquids and gases that may contain harmful compounds. If microcracks expand and reach the reinforcement, not only will the concrete itself be susceptible to attack, but so will the reinforcement steel bars. Therefore, it is essential to limit the crack's width and repair it as quickly as feasible. Self-healing concrete would not only make the material more sustainable, but it would also contribute to an increase in the service life of concrete structures and make the material more durable. As the conventional concrete is most widely used material in the world for the construction. Concrete has low tensile strength in nature. Self healing concrete improves durability of structure. It increases compressive strength of structure by providing support to the structure with the help of bacteria present in the surface. After formation of cracks the concrete begins to lose its characteristic strength, durability, lifespan etc. These defects are to be repaired on urgent basis & it is mandatory. The application of bacterial powder in concrete is a crucial part of the research as it affects the properties of concrete. The implementation of self-healing concrete offers several advantages. Firstly, it enhances the service life of structures by mitigating the impact of cracks. This can lead to reduced maintenance costs and a more sustainable approach to construction. Additionally, self-healing concrete contributes to improved safety, as structural vulnerabilities due to cracking are minimized. Maintenance cost get reduced due to self healing concrete.

Bacillus subtilis is a bacteria to be used in the concrete application. The bacteria is available in spore forming powder.

The various percentage of bacillus sub. Powder is taken for application into the concrete. The proportion is taken as 3% & 6% of the cement quantity present in concrete. The results are to be checked after 3,7, & 28 days after the casting of concrete. The found observations & results can define the achievement of the strength of bacterial concrete as compared to conventional concrete. Bacterial healing of concrete is classified as autonomous & autogenous healing. Autonomous healing includes the application of crystalline hydrophilic additives. Micro encapsulation is the form of autonomous healing of concrete as it repair the concrete by artificial means to the self healing concrete.

Autogenous healing is the ability of concrete to repair cracks in the presence of moisture. Moisture or water acts as a healing agent in the self healing concrete. Direct application of bacteria in chemical or powder form in concrete is done by following the process. The bacteria application is done carefully in the process as it affects the properties of concrete & economical cost accordingly.

II. LITERATURE SURVEY

In the case study, the performance of Self Healing concrete were investigated in the various areas. The main aim of the paper is to study the comparison of Self healing concrete & Conventional concrete in terms of compressive strength after certain days. The cracks were formed on the concrete surface after casting the cubes to check the ability of concrete to heal the cracks by application of bacillus subtilis bacteria. The autogenous method of healing is adopted in the research paper. The possibility of failure of structures is studied in the literature reviews. The healing process of concrete can vary according to the method implemented by an individuals. The economic cost of the project may also change accordingly. Various experiments & investigations are carried on the Self Healing concrete or Bio concrete that provide us sufficient information to perform the work as per specifications.

I M Jain, Prithviraj B Madane , Harshal Patil, Rahul R Rajput (2019):

‘Experimental investigation of bacterial concrete using Bacillus Sphaericus & Bacillus Pasteurii’-

This paper investigates the possibility of increment in the strength of concrete by the microbiologically induced bacterial growth. Here an attempt was made by using the bacteria “Bacillus sphaericus” and “Bacillus pasteurii”. Concrete cubes, beams and cylinders were cast with the addition of bacteria and its compressive strength, flexural strength and split tensile strength were investigated. There was an increase incompressive strength, flexural strength and split tensile strength of concrete with addition of bacillus sphaericus and bacillus pasteurii. Increment in strength of concrete using Bacillus Sphaericus was more as compared to the concrete made with Bacillus Pasteurii.

Ravindranatha , N. Kannan , Likhit M (2017):

‘Self-Healing Material Bacterial Concrete’-

The requirement of high durability for structures exposed to harsh environment such as seafloor, offshore, tunnels, highways, bridges, sewage pipes and structures for solid, liquid wastes containing toxic chemicals and radioactive elements may not be achieved using today’s ordinary portland cement (OPC). This research gives information about the aims at increasing the strength and the total durability of the concrete used in the present day by introducing bacteria (Bacillus pasteurii). This micro organism is a soil bacterium. Bacillus pasteurii exhibits a phenomenon known as bio-calcification as a part of its metabolic activity. Bio-calcification is a process through which the micro-organism externally secretes calcium precipitate, which in the presence of a carbonate ion forms CaCO_3 which fills up the voids in the concrete texture thus making it more compact. This inturn improves the strength in concrete due to growth of the filler material within the pores of the concrete mixer. A comparison study was made with concrete cubes and beams subjected to compressive and flexural strength tests with and without the bacterium. It was found that there was high increase in strength and healing of cracks subjected to loading on the concrete specimens.

Nikhil Gaikwad, Sakshi Bhalerao (2021):

‘The Review on Self healing concrete’ –

Published a paper on Self healing concrete by using different type of materials, procedures, methods to attain good, sustainable concrete. Even after proper precaution taken during mixing, casting and curing, we come across cracks.

Eventually, crack formation in concrete has become inevitable phenomenon. There are various reasons which can cause cracks to our structure like temperature differences, application of heavy loads etc. Crack increases seepage which leads to corrosion of reinforcement, durability, life of the structure. Currently, we use epoxy system, acrylic resins to heal cracks which are not environmental friendly. Also, one cannot go physically to do the maintenance at such locations like high rise buildings, basements, underwater structures due to difficulty in accessibility, high threats of accidents. In such cases, self healing concrete is effectively useful.

The research papers mentioned above were preferred by us to perform the project work. To attempt the process of application of bacteria bacillus subtilis into the concrete & observation of the healing process is done by us accordingly. The procedure mentioned in the above papers was found relevant to perform the project work relative to the topic of research. The comp. strength of self healing concrete were found more as compared to the conventional concrete as per the results.

III. PROPOSED METHODOLOGY AND DISCUSSION

The casting of concrete is an essential procedure to be followed. The application of bacteria bacillus subtilis is also necessary to continue the research work & experiment.

Material used for the work –

1. Cement –

The cement of OPC 53 grade is used to cast the concrete. It was fresh & free from lumps during the use of it. The Initial & final setting time of cement is 30 mins & 600 mins respectively.

Fineness of cement – 8%

Std. Consistency – 33%

Sp. Gravity of cement – 3.15

2. Fine sand –

The fine sand passed through IS sieve of 475 mm was used by us for mixing. The fine sand shall be washed before mixing for the better results. It removes dust & excessive silt content present in it.

Sp. Gravity of Fine sand – 2.43

3. Coarse Aggregate –

The aggregates of 20 mm in size were used in the mixing. They were tested by performing sieve analysis test. In general, Angular aggregates should be preferred during mixing. It helps in good bonding within particles & proper mixing. Coarse aggregates should be washed before mixing for the better results.

Sp. Gravity of Coarse Aggregate – 2.87

4. Water –

The main component in the mixing is water. It should be taken in to the appropriate amount. Neither less nor more. As it affects the bleeding & workability of concrete. The water taken for the mixture should be fresh & potable or soft. It should be free from suspended solids.

5. Bacillus Subtilis powder –

The powder were used by us for application in concrete for making self healing concrete. The powder was taken accordingly for the mixture.

Quantity of powder purchased – 2 kg approx. (By adding 3% & 6% of Bac. Subtilis content to be mixed in concrete).

Proportion of B. Subtilis powder – 3% & 6% of Cement content

- **Mix Design of concrete –**
Grade of concrete – M 25 (1:1:2)

Sr. No	Materials	Quantity (Kg/m ³)	Proportion
1	Cement	438.10	1
2	Fine sand	649.44	1.48
3	Coarse Aggregate	1081.20	2.46
4	Water (W/C Ratio = 0.45)	197.16	0.10

Table no.1 Mix design of concrete

Mix proportion of concrete (M 25) = 1: 1.48: 2.46: 0.1

Methodology:

The methodology of experimental work is given in the form of flowchart.

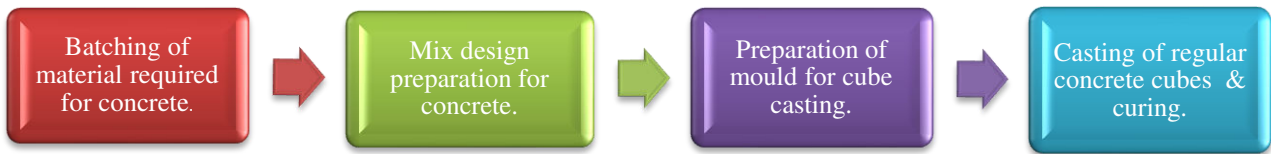


Fig no.1. Flowchart of Casting & Curing of conventional concrete

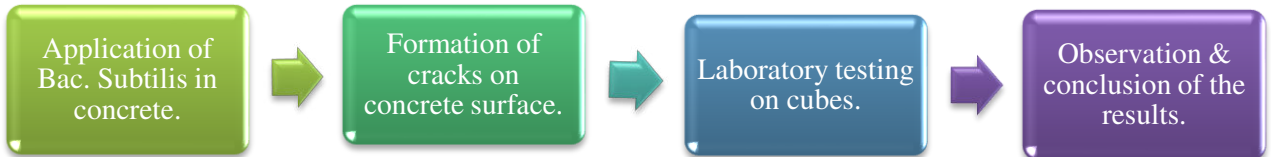


Fig.no. 2. Flowchart of application & results of concrete

The conventional concrete & Bacterial concrete of M25 grade was casted during the experiment. The cubes were kept for curing. After the casting of concrete, The compression test were carried out after 7 & 28 days. The Bac. Subtilis powder were added in concrete mixing in proportion of 3% & 6% of cement content. The cracks were formed on the concrete surface by using cutter to observe the healing capacity of concrete. The compression test was carried on the concrete to find out the compressive strength of concrete for comparison of Self healing concrete with conventional concrete.

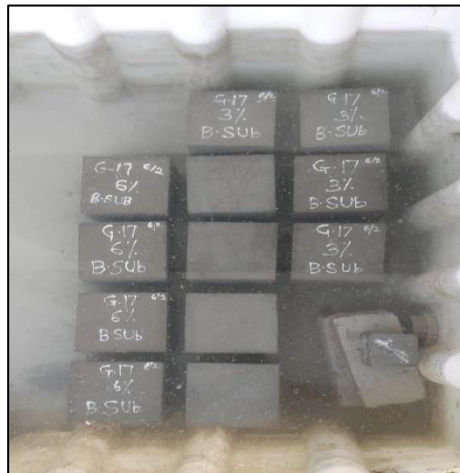


Fig no. 3. Casting & Curing of cubes

EFFICIENT DISCUSSION

- 1. Study of topic** – The study of topic in case of all aspects is necessary to achieve expected & appropriate results.
- 2. Understanding the scope of work** – As the concrete is mostly used material we need to study the properties of concrete, characteristics & its all parameters. The areas where the proposed Self Healing concrete need to be studied to explore its suitability.
- 3. Requirement of material** – The material requirement should be studied to avoid wastage of material & cost expenses.
- 4. Management of work** – As the concreting work is depend on time factor in terms of Curing, Casting, Moulding, Testing of concrete cube. Hence, proper time management of work is necessary to achieve better results with quality.
- 5. Rate analysis** – The rate analysis of all items required for the work is necessary to achieve economy in all aspects.
- 6. Availability of Bacteria** – The bacteria used in the experiment should be used carefully & made available in adequate quantity to avoid financial loss. As the bacteria impacts on the characteristics on the concrete, The bacteria should be handled carefully & kept in suitable temperature & free from environmental exposure.
- 7. Safety measures** – Safety measures should be followed on site to avoid accident & injuries. It may harm experimental work also by leading to disturbance in the work.
- 8. Machinery testing & results** – The instruments should be handle with care to achieve better results. The obtained results should be recorded on time. It will help in concluding correct outcome of an experiment.
- 9. Cleanliness & disposal** – The remaining material or rabbit should be disposed off after performing an experiment to maintain hygiene. Waste material can cause pollution in the surrounding area or site.

IV. RESULT

In the experiment Compression test was performed on both conventional & self repairing concrete cubes. At the end of test it is found that the Compressive strength of Self healing concrete is increased as compared to conventional concrete.

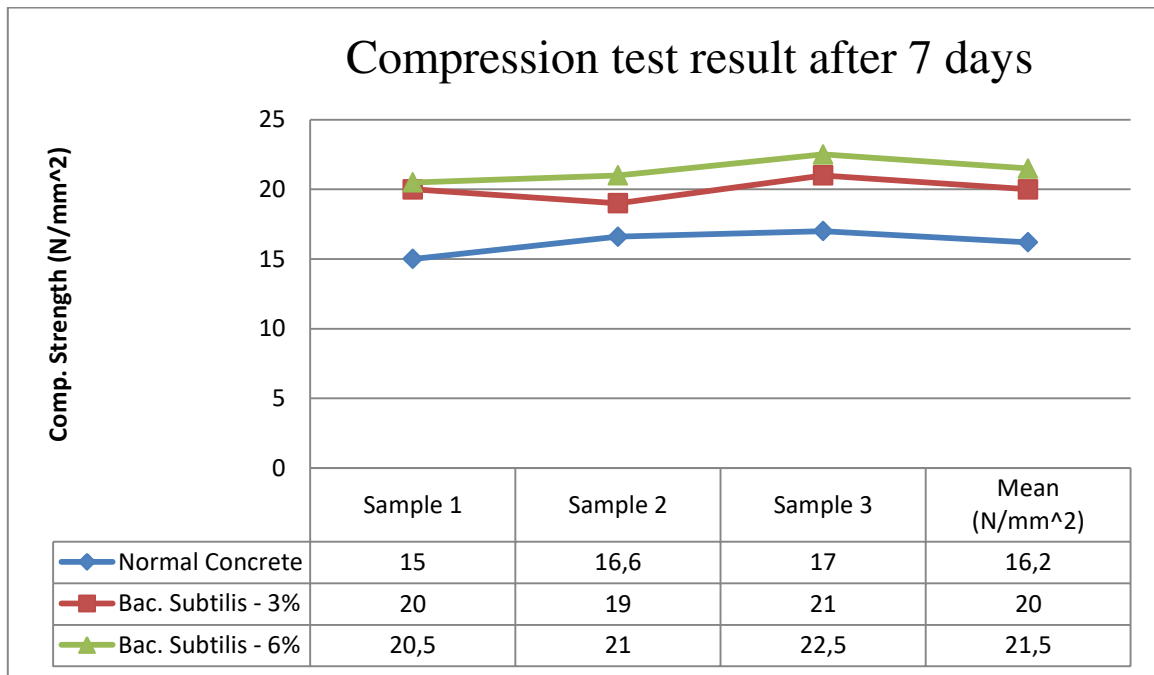


Table no. 2. Compression test results after 7 days

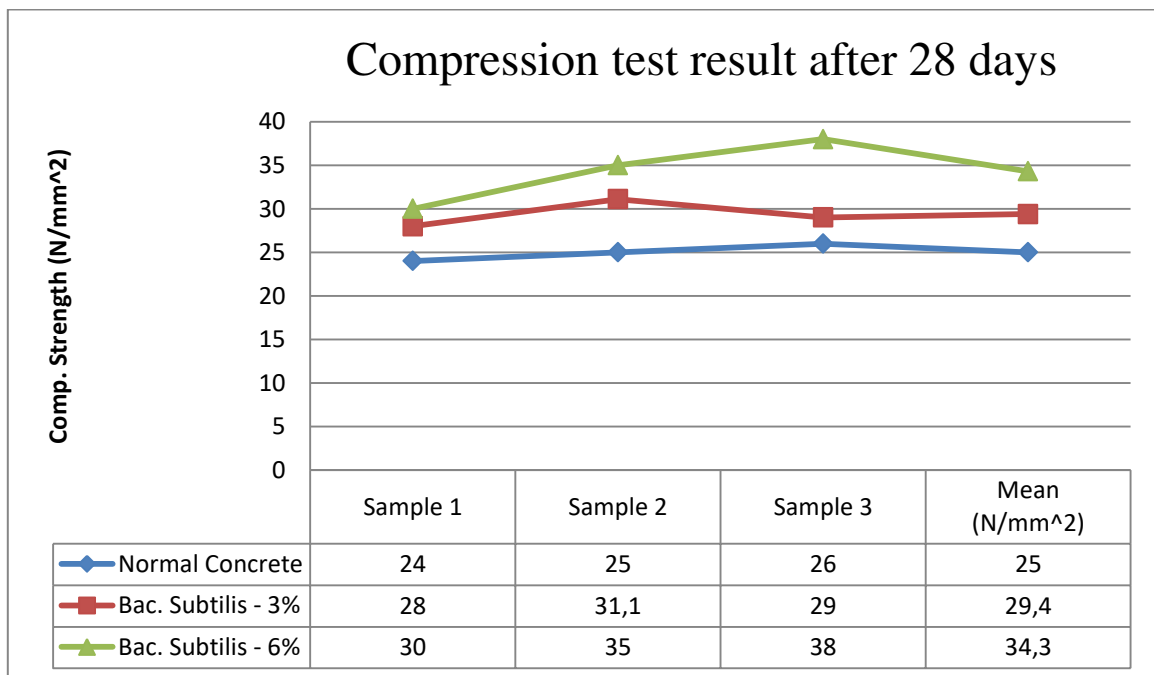


Table no. 3. Compression test results after 28 days

As per the found results we recorded that,

- The Compressive strength of Self Healing concrete is increased as compared to 7 & 28 days of curing as compared to conventional concrete.
- The cracks formed on the concrete surface of dimensions 80 mm were healed upto 50% i.e. 40 mm in 30 days. The cracks were filled upto 2 mm from total depth of cracking 5 mm i.e. in terms of percentage recovery rate of crack healing in depth is 40% in 30 days.

Sr. no	No of days of Curing	Normal concrete mean strength	Bac. Subtilis - 3% concrete mean comp. strength	Bac. Subtilis - 6% concrete mean comp. strength	Percentage (%) increase in comp. strength
1	7	16.2	20	-----	24 %
2	7	16.2	-----	21.5	34 %
3	28	25	29.4	-----	18 %
4	28	25	-----	34.3	37 %

Table no.4. Comp. Strength increase in percentage (Regular concrete vs. Self healing concrete)

V. CONCLUSION

By implementation of the experimental work we found that the compressive strength of concrete is increased by application of Bacillus Subtilis bacteria as compared to Conventional concrete. Obtained results concluded that the self healing concrete has more compressive strength than normal concrete. As the proportion of bacteria in concrete increases (i.e. 3% to 6%) the concrete gains more compressive strength. The cracks formed on the concrete took more than 30 days to heal properly. In the proposed project, The cracks were only cured upto 50% horizontally (on the surface) & 40% Vertically i.e. along the depth of cracks. The self healing concrete is a material which requires less maintenance cost compared to conventional concrete. The percentage (%) increase of Self healing concrete than conventional concrete in terms of compression test & compressive strength. As the the comp. strength of self healing concrete increases with addition of bacterial content in the concrete, It helps to speed up the construction. As the cost of bacteria required is considered to be in moderate quantity, it depends on individuals budget of construction. It can achieve economy & increases the durability of structure. The concrete is more suitable in water borne structures. The maintenance cost of self healing concrete gets reduced due to its healing capacity.

REFERENCES

1. I M Jain, Prithviraj B Madane , Harshal Patil, Rahul R Rajput (2019), “Experimental investigation of bacterial concrete using Bacillus Sphaericus & Bacillus Pasteurii.” International Conference on Insights in Mechanical & Civil Engineering (ICIMCE – 2019).
2. Nikhil Gaikwad, Sakshi Bhalerao (2021), “The Review on Self healing concrete” vol. 14, June 2021. International Research Journal of Engineering & Technology (IRJET)_ISSN 2395_0072.
3. Kusuma K (2018) “Bio Concrete by using bacteria – Bacillus Megaterium”. International Research Journal of Engineering & Technology (IRJET)_Volume-05_e-ISSN:2395.
4. B R Gautam (2018) “ Bacteria based Self Healing Concrete – A Bacterial Approach.” The International Journal of Engineering & Science (IJES)_ISSN (e) 2319_1813056.
5. Mohan Ganesh, (2017), “Experimental investigation on Self healing concrete by using Bacteria - Bacillus Cohnii.” International Journal of Civil Engineering & Technology (IJCIET)- Vol.8_pp 539 -545.
6. Jegatheeswaran.D, Narmatha.(2016) “Experimental Study On Self-Healing Characteristics Of Bacterial Concrete.” International Research Journal of Engineering & Technology (IRJET)_Vol.7.
7. Harshali J. , Mitali S., Neha A. , Pragati B.(2016) “Bio Concrete & Bacteria Based Self Healing Concrete.” International Research Journal of Engineering & Technology (IRJET)_eISSN:2319-1163 / pISSN:2321-7308.
8. N. Ganesh Babu, Dr. S. Siddiraju,(2015) “An Experimental Study On Strength And Fracture Properties of Self Healing Concrete.” International Journal of Civil Engineering & Technology (IJCIET)_Vol.7-ISSN_e0976-6316.
9. Ravindranatha , N. Kannan , Likhith M (2014) “Self-Healing Material Bacterial Concrete.” International Research Journal of Engineering & Technology (IRJET)_3(15):656-659.



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details