Educational Administration: Theory and Practice
2024, 30(5), 3510 - 3515
ISSN: 2148-2403
https://kuey.net/

Research Article

Bio Concrete For Sustainable Construction Industry In India

Dr Anjan Kumar Dutta[1*], Dr. Rajesh M. Bhagat[2], Yugasini S[3], Archana Tanawade[4], Devendra Dohare[5], Dr M Palanisamy[6]

[1*]HA 333, Flat 1 Sector 3, Salt Lake, Kolkata-700097, India.
[2]Assistant Professor, Department of Civil Engineering, Yeshwantrao Chavan College of Department of Civil Engineering, Nagpur, Maharashtra, India.
[3]Assistant Professor, Department of Civil Engineering, Rajalakshmi Engineering College, Chennai, Tamil Nadu-602105, India.
[4]Assistant Professor, Department of Civil Engineering, Vishwakarma Institute of Information Technology, Pune, Maharashtra, India.
[5]Associate Professor, Department of Civil Engineering and Applied Mechanics, Shri G. S. Institute of Technology and Science, Indore, Madhya Pradesh-452003, India.
[6]Professor and HOD, Department of Civil Engineering, Balaji Institute of Technology and Science, Laknapally, Narsampet, Warangal, Telangana-506331, India.

Citation:- Dr Anjan Kumar Dutta et al. (2024 Bio Concrete For Sustainable Construction Industry In India *Educational Administration: Theory and Practice*, *30*(5), 3510 - 3515
Doi: 10.53555/kuey.v30i5.3477

ARTICLE INFO

ABSTRACT

The paper explores advancements in self-healing concrete, addressing issues caused by crack formation. It introduces Bacillus subtilis bacteria, which precipitate calcite minerals, and evaluates its effectiveness alongside polyethylene fiber in M20 grade concrete. The optimal strength is achieved with a bacterial concentration of 105 cells/ml, increasing compressive strength by 13.2%, split tensile strength by 21.4%, and flexural strength by 16.04%. This demonstrates the benefits of self-healing concrete.

KeyWords: Bacillius subtilis JC3, Calcium carbonate precipitating, Crack, Strength and Durability properties.

1. OVERVIEW

Concrete is the most widely recognized material utilized for a wide range of development. Because of its solidarity and toughness, concrete became inescapable. The main imperfection in the utilization of cement is that it is feeble in strain. Since the substantial is frail in pressure the Chance of arrangement of break is more. Aside from this, freeze-defrost activity and shrinkage additionally lead breaking in concrete. Solidness of cement is exceptionally impacted because of breaks and it drives erosion of supporting bars. So it is extremely vital for track down the appropriate fix system for recapture the strength of cement. In substantial designs, fix of breaks generally includes applying a concrete slurry or mortar which is clung to the harmed surface. Fixes can especially be tedious and costly. For break fix, various strategies is accessible like impregnation of breaks with epoxy based fillers [1], plastic restricting specialists like acrylic, polyvinyl acetic acid derivation, butadiene styrene, and so on. Yet, customary fix frameworks have various disadvantageous angles, for example, unique warm extension coefficient contrasted with concrete and furthermore affect climate and wellbeing. Thusly, bio based calcite precipitation has been proposed as another option and economical, natural amicable break fix strategy [2].

Bacterially prompted calcium carbonate precipitation has been proposed as another option and ecological agreeable break fix strategy. Microbial calcite precipitation is mostly because of unreasonable movement and carbonate bio mineralization of microscopic organisms. The types of the microbes family Bacillus were found to flourish in the high-soluble climate [3]. Salt resilience, temperature range, pH range and extracellular items are significant ordered rules which are utilized in various species in the class Bacillus [4].

In our review, bacterial species Bacillius Subtilis is utilized to work on the strength of cement. Scientists have shown that the microbiologically prompted endospore shaping microorganisms can recuperate breaks actually. The standard behind in bacterial break recuperating system is that the microorganisms ought to ready to change solvent natural supplements into insoluble. Inorganic calcite gems which seal the breaks [5]. At the point when breaks show up in a substantial construction and water begins to leak in through, the spores of the microscopic organisms begins microbial exercises on contact with the water and oxygen. During the time spent accelerating calcite gems through nitrogen cycle, the solvent supplements are switched over completely to insoluble $CaCO_3$.

The bacterial corruption of urea locally expands the pH and advances the microbial statement of Calcium carbonate in a calcium rich climate. Through this cycle, the bacterial cell is covered with a layer of calcium carbonate [6]. It emulates the cycle by which bone breaks in the human body are normally mended by osteoblast cells that mineralize to change the bone [7].

A. Polyethylene Fiber

Polyethylene is a polymer. Some no. of ethylene monomers gets together with each in the blend of polyethylene. Polyethylene is a hard, solid, solid and a correspondingly steady material that ingests next to no water. It has great gas hindrance properties and great synthetic opposition against acids, lubes and oils. It very well may be exceptionally straightforward and lackluster however thicker segments are typically obscure and grayish. It has a round cross segment and blended in with the substantial at items in up 4% by volume or a constant organization of fibrillated fiber to create high fiber content composite.

B. Collection of Bacteria

Because of high interior pH, relative dryness and absence of supplements the normal microorganisms can't make due in the substantial climate. The pH of concrete and water when blended is 13, which isn't appropriate for living beings to get by. Specialists found that main the kinds of bacterial family bacillius are reasonable to flourish in this high basic climate. It is additionally viewed that as, bacillus is the main class that can frame spore in the unfriendly climate. Such spores have very thick cell walls that empower them to stay whole for as long as 200 years while trusting that a superior climate will sprout. They would become enacted when the substantial begins to break. The course of mineral precipitation brings down the pH of the exceptionally soluble cement to values in the reach (pH 10 to 11.5) where the bacterial spores become enacted.

2. RESOURCES AND APPROACHES

2.1 Particulars of specimen

Around 24 3D squares of size 150X150x150mm were cast to test the compressive strength on seventh and 28th day. 12 examples of chambers of size 150x300mm and crystal of size 100x100x500mm were cast to view as the split malleable and flexural strength separately.

2.2 Principles of Bacteria

The microorganisms utilized in this study are Bacillius subtilis. The microorganisms are refined in mass on the way of life medium. The way of life medium is arranged utilizing supplement stock which comprise of Peptone - 2-gram, Glucose - 2 gram, Meat remove - 2gram and Sodium chloride-0.8 gram. The way of life medium is cleaned in autoclave at 121°C at the tension of 15lps.The microbes is then presented, mass refined and weakened according to prerequisites. Staining is finished to track down the appropriateness and morphology of microscopic organisms. Just gram-positive microscopic organisms are reasonable for concrete. Bacterial count is estimated utilizing haemocytometer under magnifying lens. The way of life of microbes is depicted in the accompanying figures.

Test	To determine	Result
Haemocytometer test	Cell concentration	10^5 cells/ml of bacterial solution
Gram staining	Morphology	Gram positive
Urease test	Calcite precipitation	Color change – yellow to pink
$CaCO_3$ test	Quantity of calcite precipitation	3 mg/l

Table1. Various test on bacteria

2.3 Mix Design

Substantial blend extent is planned according to IS 10262-2009 and the blend proportion is 1: 1.63: 2.84 with the water concrete proportion 0.45.

2.4 Possessions of Resources

- The concrete utilized in this review is OPC, 53 grades Chettinad concrete which fulfills IS: 12269-1987.
- The fine total of zone II with explicit gravity 2.6, fineness modulus 3.1 and dampness content 2.5% is utilized and they are found according to IS: 383-1970.
- The coarse total of 20 mm size with explicit gravity 2.85, fineness modulus 3.69 and dampness content 0.26 % is and they are found according to: 383-1970.
- Refined water is utilized for this review. The properties of water are fulfilled according to 3025 - 1964 section 22, section 23 and IS: 456 - 2000.

3. INVESTIGATIONAL PROCEDURE

The rut test was completed on new cement to actually look at the usefulness of every single substantial blend. It tends to be tried according to IS: 1199-1959.

1.1 Pressure test:

The compressive strength of cement is tried on solid shapes utilizing pressure testing machine. The pace of 140 kg/cm2/min according to IS 516: 1964 and definitive burdens were recorded. The bearing surface of machine was cleared off perfect and the outer layer of the example was cleaned. The example was put in machine and the hub of the example was painstakingly adjusted at the focal point of stacking outline. The heap was applied at a consistent pace of 140 kg/cm2/min until the example fizzles and the greatest burden applied on example was recorded. The compressive strength of the substantial was determined utilizing the accompanying recipe and the outcomes are organized.

$$\text{Compression strength} = \frac{P}{A}$$

Where,
P - Load in (N)
A – Area in (mm^2)

1.2 Split tensile test:

Part rigidity of cement is tried on chamber utilizing pressure testing machine. The split elasticity test for chambers was completed according to IS 516: 1964. Example was kept on a level plane between the stacking surfaces of an all inclusive testing machine and the heap was applied until disappointment of the chamber. The disappointment load was noted and strength was determined utilizing the accompanying recipe.

$$\text{Split Tensile Strength} = \frac{2P}{\pi LD}$$

Where,
P = Ultimate load (N)
L = Length of cylinder (mm)
D = Diameter of cylinder (mm)

1.3 Flexural test:

Flexural strength is estimated utilizing general testing machine. The flexural strength is the capacity of a bar or section to oppose disappointment in twisting. It is estimated by stacking un-supported cement footers with a range multiple times the profundity (generally 100 x 100 x 500 mm). The flexural strength is communicated as ―Modulus of rupture‖ in N/mm^2. Modulus of Crack is around 12 to 20 percent of compressive strength. Be that as it may, the best connection for explicit materials is acquired by research center tests. The examples are exposed to outer restoring are tried after the 28 days. The flexural strength test for bar was completed according to IS 516:1964. Example was kept on a level plane between the stacking surfaces of an all inclusive testing machine and the heap was applied until disappointment of the chamber. The disappointment load was noted and more limited length from break to help strength was estimated. Then, at that point, flexural strength was determined utilizing the accompanying recipe.

When $a \geq 133$ mm

$$R = \frac{PL}{bd^2}$$

When $110 < a \leq 133$ mm

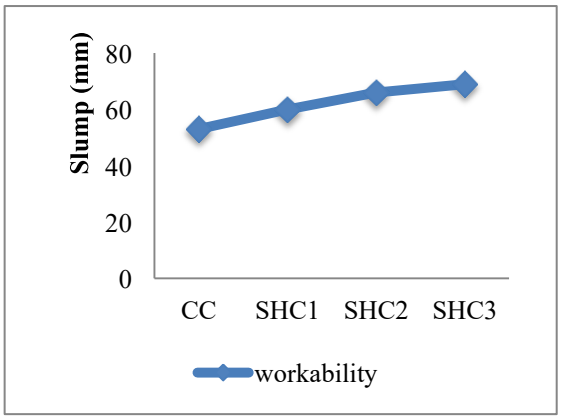
$$R = \frac{3Pa}{bd^2}$$

Where,
R - Modulus of rupture in N/mm^2
P - Maximum Load in N L - Span in m a - Shorter length from crack to support in mm b - Average width in mm, d - Average depth in mm.

4. RESULT AND DISCUSSION

A. Workability

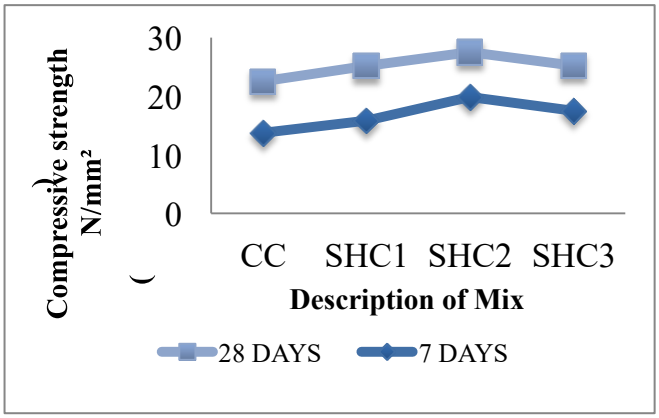
Graph.1. shows the variety of usefulness as far as rut esteem. The downturn values lies somewhere in the range of 53 and 69. From the outcomes, Among all blends the most extreme usefulness is acquired for SHC3specimen, though the functionality of examples SHC1 and SHC2 are closer to control example. The perception on new substantial shows that there happens little draining in the substantial example SHC3. It is observed that there is an expansion in droop with the expansion in convergence of bacterial cells. Hence the functionality of cement is expanded with the expansion in bacterial fixation. The aftereffect of downturn test uncovers that every one of the substantial blends have medium usefulness.



Graph.1. Variation of Slump value

B. Compressive Strength

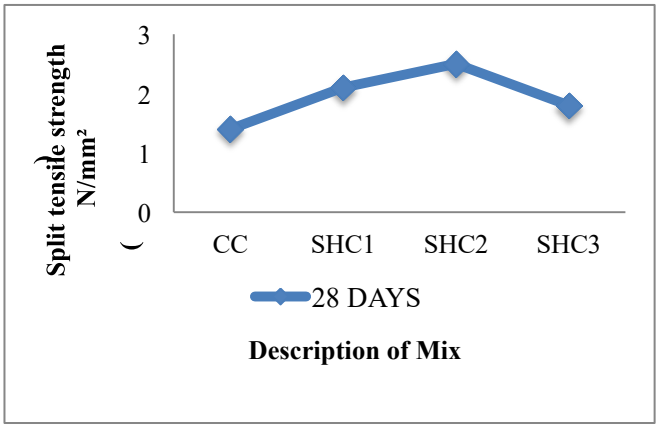
Graph.2. shows the variety of compressive strength of cement on 7 days and 28days. The outcomes showed that the strength of Self-mending concrete has barely higher than the control concrete. The most extreme strength is gotten for SHC2 concrete. The level of addition in strength of SHC2 concrete is 13.2%. The addition in strength is because of the development of filler material inside the substantial and the dead cells present in the substantial. The presence of dead cells additionally diminishes the porosity and break development in concrete.



Graph.2. Variation of Compressive strength of concrete

C. Split Tensile Strength

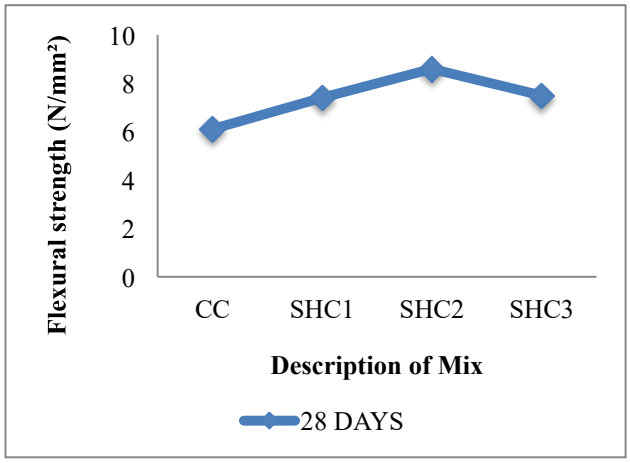
Graph.3. shows the variety of parted elasticity of cement. The outcomes showed that the rigidity of Self-mending cement of SHC1, SHC2 and SHC3 are expanded contrasted with the control concrete. Greatest strength is acquired on SHC2 concrete and the level of addition in strength is 21.4% contrasted and control concrete. Higher bacterial fixation in substantial prompts more deterioration of urea, which contains higher centralization of Ca2+. This assists with working on the strength.



Graph.3. Variation of Split tensile strength of concrete

D. Flexural Strength

Graph.4. shows the variety of flexural strength of cement. The level of addition in strength contrasted with control example is 16.04%. It is expanded with the expansion of bacterial cell. This was because of the explanation that bacillus subtilis has more calcium precipitation to recuperate break in concrete. The outcomes showed that the flexural strength of Self-mending cement of SHC1, SHC2 and SHC3 are expanded than the control.



Graph.4. Variation of Flexural strength of concrete

5. CONCLUSION

Microbial substantial innovation has ended up being superior to numerous ordinary advances as a result of its eco-accommodating nature, self-abilities to mend and expansion in solidness of different structure materials. The general advancement of solidarity and sturdiness of Self-recuperating concrete by utilizing Bacillius subtilis microbes and polyethylene fiber has explored and contrasted and control concrete. The best improvement of 105cells/ml for all ages. The showed that a 13.2% increment in multi day compressive strength, split rigidity by 21.4% and flexural strength by 16.04% was accomplished. The more CaCO3 precipitations, the better oneself recuperating impact will be. The centralizations of microorganisms and Ca 2+ will more noteworthy how much hastened CaCO3. Polyethylene fiber can be expanded its mechanical properties of the substantial. This cycle brings about the precipitation of significantly higher measures of calcium carbonate inside the break to be mended. The justification for this can be made sense of by the rigorously substance processes in the control and extra organic cycles in Oneself mending concrete. • Ideal strength is acquired on SHC2 substantial example. Bacillus subtilis strain can work on the qualities of concrete composites

6. REFERENCES

1. Bang S.S., Galinat J.K. and Ramakrishnan V., ―Calcite precipitation induced by polyurethaneimmobilized Bacillus pasteurii.‖ Enzyme Microb. Technol., pp 404– 409,2001.
2. DE Belie N., and DE Muynck W., ―crack repairs in concrete using biodeposition‖ taylor &francis group @, London, 2009.Raijiwala D.B.,Bacterial Concrete: A Self-Healing Concrete‘, The ICFAI University Journal of Structural Engineering, Vol. I (2), pp. 56-63,2008.
3. De Muynck W., Cox K., De Belie N. and Verstraete W., ―Bacterial carbonate precipitation as an alternative surface treatment for concrete‖, Constr. Build. Mater.Vol.22, pp.875 -885,2008.
4. Holt J., Bergey ‘s Manual of Determinative Bacteriology, 9th ed. Williams & Wilkins, Baltimore, 1994.
5. Henk M. Jonkers and Erik Schlangen., ―A two component bacteria-based self-healing concrete‖ Concrete Repair, Rehabilitation and Retrofitting Vol.2, pp 215-220,2009.
6. IS 10262:2009 ―Indian Standard code of Recommended Guidelines for Concrete Mix Design‖, Bureau of Indian Standards, New Delhi.
7. IS 456:2000 _Indian Standard Code of Plain and Reinforced Concrete Code of Practice ‘, Bureau of Indian standards, New Delhi.
8. IS 383:1970 _Indian Standard Code of Coarse and Fine Aggregates from Natural Sources for Concrete‘, Bureau of Indian Standards, New Delhi.
9. Seshagiri Rao M.V., Srinivasa Reddy V.,Hafsa M., Veena P. and Anusha P, ―Bioengineered Concrete – A Sustainable Self-Healing Construction Material‖,Research Journal of Engineering Sciences., Vol. 2(6),pp. 4551,2013.
10. Shetty M.S. (2002), _Concrete Technology Theory and Practice‘, S.Chand and Company ltd, New Delhi.
11. Neville, A. ―Autogenous healing—A concrete miracle?‖ Concr. Int., 24, pp 76–82,2002

12. Vijeth N Kashyap and Radhakrishna ―A Study on the effect of Bacteria on Cement Composites‖,International Journal of Research in Engineering and Technology, pp 356-360, 2013.