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Experimental Investigation on Mechanical Properties of Bacterial High-Performance Concrete by using Bacillus Subtilis

Abhradip Mitra[1], Prof (Dr) Biman Mukherjee [2]
[1]*PG Student, Department of Civil Engineering, Narula Institute of Technology, Kolkata, India*
[2]*Professor, Department of Civil Engineering, Narula Institute of Technology, Kolkata, India*

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ABSTRACT-
The goal of this study is to look at the properties of the microbe Bacillus Subtilis in order to improve c oncrete strength. Cracks in concrete are an inherent vulnerability of the material.Water and other salts f ilter through these fissures, introducing corrosion a nd lowering the life of the concrete.As a result, ther e was a need to develop an intrinsic selfhealing mat erial capable of repairing fractures in concrete. Bec ause of the diverse circumstances, concrete structur es have numerous durability difficulties, which resu lt in irreversible damage to the structure and finally a decline in the strength of the concrete structure. As a result, to increase the mechanical qualities of c oncrete constructions, Bacillus Subtilis replaces ce ment. Bacillus Subtilis is utilized for this purpose, and its weight is replaced by 0%, 1%, 2%, 3%, 4%, and 5%. Numerous tests, such as compressive strength, flexural strength, and split tensile strength, were performed at various percentages of Bacillus Subtilis 0 percent, 1 percent, 2 percent, 3 percent, 4 percent, and 5 percent over a 28-day curing time and compared to high performance concrete.

Key Words: Bacillus Subtilis, Application, Mechanical Properties, Bacterial Concrete, High performance concrete.

I. INTRODUCTION

Bacterial concrete is a better form of concrete that c an repair itself independently.
Another advantage of bacterial concrete is that it im proves the mechanical and durability qualities of co ncrete in both natural and laboratory situations.
Concrete is the most significant component in the c onstruction industry since it is inexpensive, easily a ccessibleand simple to cast. However, the disadvan tage of these materials is that they are weak in tensi on, break under continuous stress, and are subject t o hostile environmental agents, which reduces the l ife of structures constructed with these materials.
This type of damage occurs both during the structur e's early life and during its existence. Calcium Carb onate produced by Bacteria (Calcite)
Precipitation has been expected as an alternate and environmentally friendly crack treatment method, t herefore boosting the strength of construction mate rials.
Selfhealing concrete might solve the problem of co ncrete constructions deteriorating far before their se rvice life is over. Concrete is a significant material used in construction, from building foundations to bridges and subterranean structural structures.Whe n tension is applied to conventional concrete, it cra cks.
Because the other predefined materials for strength increase were not healthy for the environment, wer e more expensive than bacterial concrete, and requi red frequent maintenance. The purpose of this resea rch is to learn about the importance of various micr oorganisms in concrete.

II. MATERIALS

Materials utilized in this study to produce self-healing concrete are as follow:

Material Used	Designation
Cement	Ordinary Portland cement of 53 Grade conforming IS 269:2015.
Ground granulated blast furnace slag	Ground granulated blast furnace slag (GGBS)

(GGBS)	conforming IS 12089:1987.
Silica fume (SF)	Silica fume (SF) conforming IS 15388:2003.
Fine Aggregate	River Sand conforming Zone II as per IS 383:1970.
Coarse Aggregate	Single Sized Aggregate of Nominal Size 10 mm conforming IS 383:1970.
Steel Fiber	Hooked End Steel Fiber.
Bacteria	Bacillus Subtilis 10^9 (Batiforte)
Calcium lactate ($C_6H_{10}CaO_6$)	Panchamru Chemical
Chemical Admixture (HRWR)	CHRYSO® Delta G820 is a superplasticizer based on POLYCARBOXYLIC ETHER.
Water	Running Portable Water, free from solid content and adherent chemical compounds.

III. METHODOLOGY

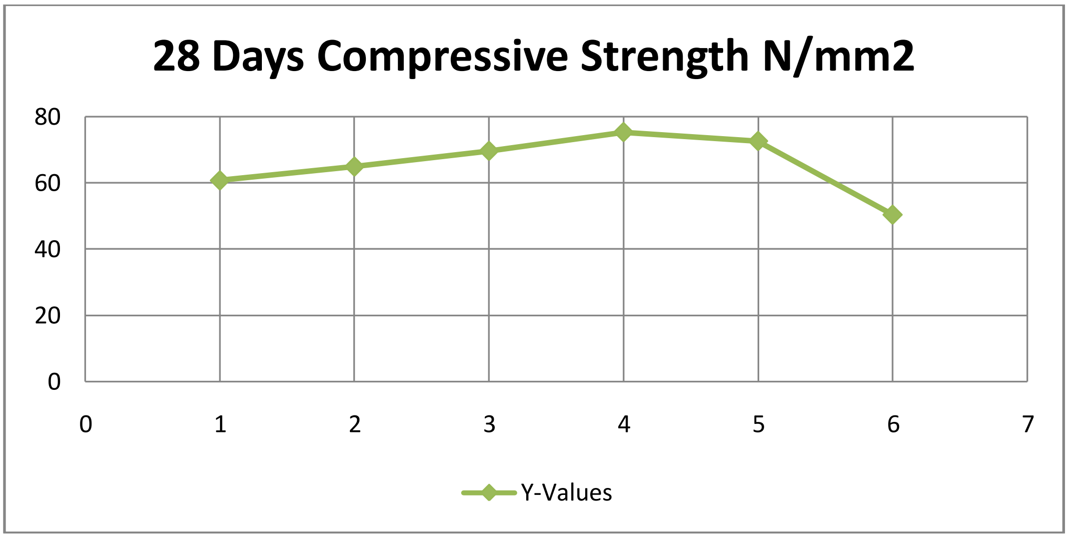
The methodology adopted to accomplish the objective of the experimental investigation and execution of work was done step by step as follows:

1) Mix design- Mix design was done for the M60 grade of concrete as per the guidelines given in IS: 10262 (2019) and IS 456 (2000). The mixes were designed after considering many trail mixes. Bacillus Subtilis added by 0%, 1%, 2%, 3%, 4% and 5% by weight of cement. The water to cement material ratio (w/c) was maintained at 0.30.
2) Weighing- The quantity of all ingredients of the concrete i.e. cement, Bacillus Subtilis, fine aggregate, coarse aggregate, and water for each batch was determined as per the mix design ratio and weighed using the weighing machine available in the laboratory.
3) Mixing- The process of mixing various ingredients adopted was as per IS: 516-1959 and the hand mixing process was adopted for mixing the concrete.
4) Preparation of molds- Before casting the specimens, all cube, beam, and cylinder molds were cleaned, screwed tightly, and oil was applied to all surfaces to prevent the adhesion of concrete during casting.
5) Compaction- Placing of concrete in oiled molds was done in three layers and each layer was stamped 25 times with the tamping rod. After tamping the molds.
6) Curing- After 24 hours, all the casted specimens were demoulded from the molds and marked (to identify the casting batch) and immediately put into the curing tank for a period of 28 days. The specimens were not allowed to become dry during the curing period.
7) Testing- Specimens were taken out from the curing tank after 28 days to perform various tests. Three numbers of specimens in each sample were tested and the average value was calculated. Fresh concrete property like workability was examined during casting by slump cone test. Hardened properties were found by carrying out the experimental work on cubes, and beams for compressive strength, flexural strength, and split tensile strength.

IV. RESULTS AND DISCUSSION

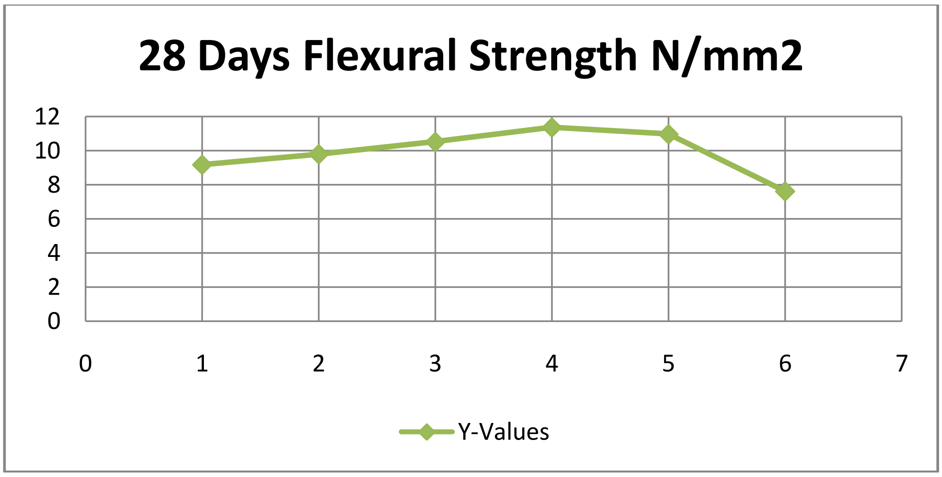
As work is carried out in single stages, the result of all stages is presented in graphical form. Tests are performed on cubes, beams & cylinders and their 28 days strengths have been determined. Comparison based on strength of different mix proportions is carried out. Comparisons of strengths for 28 days are also formulated.

Compressive Strength- Compressive strength test is performed on 3 cubes of each batch mix for 28 days. There are 6 batch mixes each one having 3 cubes. 18 cubes are tested for 28 days each. An average of 3 values as tabulated in subhead results are considered fordiscussions.



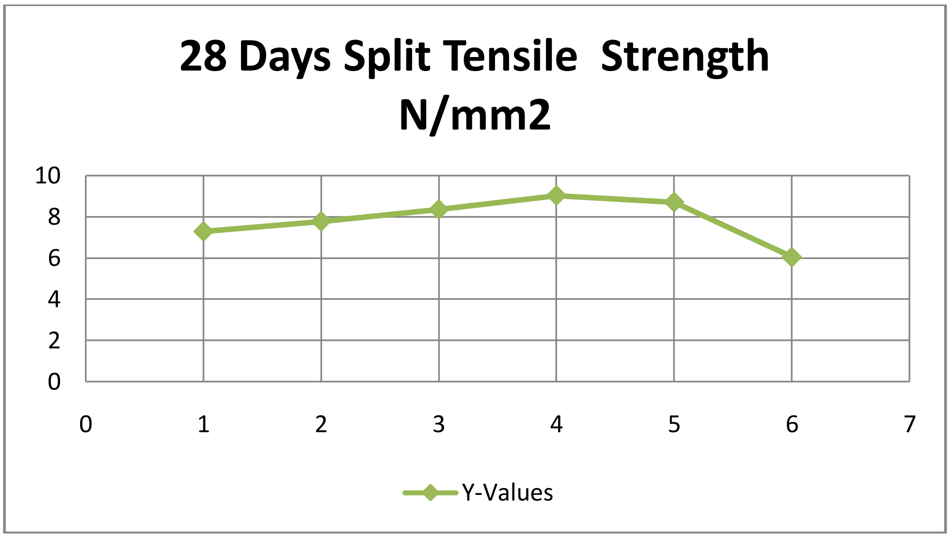
As shown in the graph: 28 days strength is analyzed at 0%, 1%, 2%, 3%, 4% and 5% replacement by bacteria , and compressive strength is increased by 7.15%, 15%, 24.36% and 19.9 respectively as compared to the conventional concrete mix and decrease 16.71% when 5% bacteria mixed.

Flexural Strength- Flexural strength test is performed on 3 beams of each batch mix for 28 days. There are 6 batch mixes each one having 3 beams. Of these 18 are tested for 28 days each. An average of 3 values as tabulated in subhead results, are considered for discussions.



As shown in the graph: 28 days strength is analyzed at 0%, 1%, 2%, 3%, 4% and 5 replacement by bacteria, and flexural strength is increased by 6.74%, 14.58%, 23.83% and 19.97 respectively as compared to the conventional concrete mix and decrease 16.71% when 5% bacteria mixed.

Split Tensile Strength- Split Tensile Strength is performed on 3 cylinders of each batch mix for 28 days. There are 6 batch mixes each onehaving 3 cylinders. 18 cylinders are tested for 28 days each. An average of 3 values as tabulated in subhead results are considered for discussions.



As shown in the graph: 28 days strength is analyzed at 0%, 1%, 2%, 3%, 4% and 5% replacement by bacteria, and split tensile strength is increased by 6.72%, 14.54%, 23.87% and 19.48% respectively as compared to the conventional concrete mix and decrease 17% when 5% bacteria mixed.

V. CONCLUSION

The following conclusions are made from the detailed experimental investigations conducted on the behavior of normal-grade conventional concrete.

- Bacteria Bacillus Subtilis plays a significant role in the compressive strength of normal concrete at 0%, 1%, 2%, 3%, 4% and 5% replacement by bacteria, and compressive strength is increased by 7.15%, 15%, 24.36% and 19.9 respectively as compared to the conventional concrete mix and decrease 16.71% when 5% bacteria mixed.
- Bacteria Bacillus Subtilis plays a significant role in the compressive strength of normal concrete at 0%, 1%, 2%, 3%, 4% and 5% replacement by bacteria, and and flexural strength is increased by 6.74%, 14.58%, 23.83% and 19.97 respectively as compared to the conventional concrete mix and decrease 16.71% when 5% bacteria mixed.
- Bacteria Bacillus Subtilis plays a significant role in the compressive strength of normal concrete at 0%, 1%, 2%, 3%, 4% and 5% replacement by bacteria, and split tensile strength is increased by 6.72%, 14.54%, 23.87% and 19.48% respectively as compared to the conventional concrete mix and decrease 17% when 5% bacteria mixed.

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