

Strength and Durability of Concrete by Bacterial Power as Replacement

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Abstract

*Concrete is the foremost building material broadly used in construction of building, but concrete cracks are inevitable and are one of the inherent shortcomings of concrete. The major downside of concrete is its low tensile strength due to occurrence of micro crack when the load applied is more than its limit and this paves way for the seepage of water and other salts. This instigates corrosion and causes the whole structure endangered and leads to the non-performance of structure. To predict this type of failure due to cracks and narrow openings, a bio mineralization approach in concrete has evolved in recent years. The present work is focused on a naturally occurring spore-forming bacterium i.e., *Bacillus sphaericus* which is isolated from soil is used in concrete to carried out the compressive and split tensile strengths of bacterial inclusive concrete with different percentages as 0ml, 10ml, 20ml and 30ml for M25 grade concrete. Among the different dosages, the strength and durability properties yield better results for 30ml bacterial powder as compared with normal concrete.*

Keywords: *Tensile strength, flexural strength, Bacteria Powder, Micro crack and Bacillus sphaericus etc.*

1. Introduction

Concrete is a structure material which comprises of binder and an aggregate. Concrete is acceptable in a wide range of building construction. Fly debris and silica fume can be utilized in concrete mix as a result of its lightweight and high thermal insulation. As of late numerous new types of building materials are being utilized. These incorporate asbestos, plastics, metals and textures. Tar-based waterproof materials, polyvinyl chloride clay, paper flooring and dissolvable coatings for inner wall are other building materials. In any case, the disadvantage of this material is that it effectively cracks because of its low elasticity. Cracks can happen during any phase of an existence of a concrete structure. They can be because of concrete material itself as on account of volume instabilities or because of external elements, for example,

external stacking, cruel environmental exposure, poor development methodology or structures blunder. At the point when cracks show up in the concrete, the chances for corrosion of the installed steel arises this could eventually ruin the integrity of the structure. Without prompt consideration, the cracks can extend and cause broad harm which has a negative effect on performance and durability of concrete structures. However, with low cement content in concrete, will probably not highlight a huge

autogenous crack recuperating limit as most, if not all, concrete particles have just experienced full hydration during early age. Accordingly, to improve the sturdiness of such a moderately modest and earth feasible concrete, an alternative self-healing component has prone to be incorporated. A mechanism can be given by mineral-delivering microscopic organisms. Ramachandran et al., [1] examined the impact of the buffer solution, type and measure of microorganisms on compressive strength of portland concrete mortar cubes. To decide this both living and dead cells of *P. aeruginosa* and *S. pasteurii* were explored. In the wake of demolding, the casted cubes were put in a urea and calcium chloride solution for seven days. At lesser concentration, the presences of *S. pasteurii* to expand the compressive strength of cubes, while the commitment of *P. aeruginosa* to the strength was seen as unimportant. The most noteworthy compressive strength was resulted with mortar cubes prepared with *Bacillus* sp. CT-5 that were incubated for 28 days (31MPa) when contrasted with those with water (23Mpa) and NBU medium (24Mpa). There was about 36.15% increase in the compressive strength of mortar samples at 28 days, prepared with bacterial cells contrasted with control. The testimony of a calcium carbonate crystal layer on a superficial level results in a decreased in the penetration properties [2]. Tittelboom, et al [3] contemplated the use of microscopic organisms to repair cracks in concrete, inspected the objective of this current examination is to consider the potential use of bacterial species that is *B.sphericus* to improve the strength of concrete. The compressive strength and split tensile test were conveyed both on traditional and concrete specimen. It was seen that there was an extensive increase in the yield strength of concrete paste. The utilization of microscopic organisms i.e., bacteria will improve the strength and ductility of concrete cement in this way it seems a promising field sooner rather than later. The impact of microscopic organisms on the compressive strength, water ingestion and quick chloride porousness of fly ash concrete, concluded *Sporosarcina Pasteurii* in fly ash concrete upgraded the compressive strength, diminished the porosity and penetrability of fly ash concrete. Inclusion of microorganisms, chloride entrance limit of fly ash concrete diminished with increment in microbes focus [4]. F. Pacheco-Torgal, et al [5] assessed that the weakening of reinforced concrete structures in a typical issue because the material has a high penetrability which permits water and other forceful media to enter, therefore prompting consumption issues. The utilization of sealers is a typical method of adding to durability of concrete. Notwithstanding, the most widely recognized ones depend on natural polymers which have some level of harmfulness. The Regulation (EU) 305/2011 identified with the construction products regulation stresses the need to diminish unsafe or hazardous substances Ongoing examinations in the field of biotechnology show the capability of bio inspired materials in the development of low harmful solutions. This paper surveys current information on the utilization of microscopic organisms for concrete with upgraded toughness. It covers the utilization of microscopic organisms in concrete mix and furthermore bio mineralization in concrete surface treatments. Examination gaps are portrayed. Results from practical applications in which there is exposure to ecological conditions are as yet required so as to affirm the significance of this new methodology. Ruoting Pei, Jun Liu, et al [6] examined the role of *Bacillus subtilis* bacterial cell as a solid admixture to enhance the mechanical properties of cement. The bacterial cell walls intervene microbial instigated carbonate precipitation, a procedure wherein Ca CO_3 is formed from Ca^{2+} particles and broke up CO_2 . Predictable with such information, incorporation of bacterial cell walls enhanced carbonation of Ca (OH)_2 and development of Ca CO_3 in concrete. Besides, the bacterial cell walls essentially expanded compressive strength of cement by 15% while additionally diminished porosity at 28 days of relieving. Test for Ca CO_3 precipitation in vitro demonstrated that bacterial cell walls, yet not dead cells, quickened carbonation of Ca^{2+} particles in Ca (OH)_2 solution. Khanna et al., [7] considered the procedure streamlining and scale-up creation and further inferred that a microscopic organism to be a *Bacillus thuringiensis* helps in fermentation process by delivering delta endotoxin creation. The concentration of inorganic carbon and pH helps the microorganisms and microbial process for the usage of natural acids [8].

2. Materials and Methodology

2.1 Materials used for casting.

In this research work , the size of aggregate less than 4.75mm is considered as fine aggregate. The sand particles are liberated from dirt or inorganic material and found as hard and durable which was put away in open space and free from residue and water which complies with IS 383-1970 and comes

under this zone. The aggregate size more than 4.75 mm is considered as coarse aggregate which is found from unique bed rocks. A coarse aggregate are available as a fiddle like rounded, sporadic or somewhat rounded, rakish, flaky and is free from natural polluting influences and the dirt. *Bacillus sphaericus* is a gram-positive, mesospheric, rod shaped bacterium generally found on soil. It can shape safe endospores that are tolerant to high temperatures, synthetic substances and ultraviolet light and can remain viable for long periods of time. *Bacillus sphaericus* is purchased from varsha bioscience and technology India pvt ltd, Hyderabad. Cement is used as a binder in concrete, which is a basic material for construction. Ordinary Portland Cement (OPC) locally available in Bengaluru (RAMCO) of 50kg Bags were used in the experiment.

2.2 Methodology

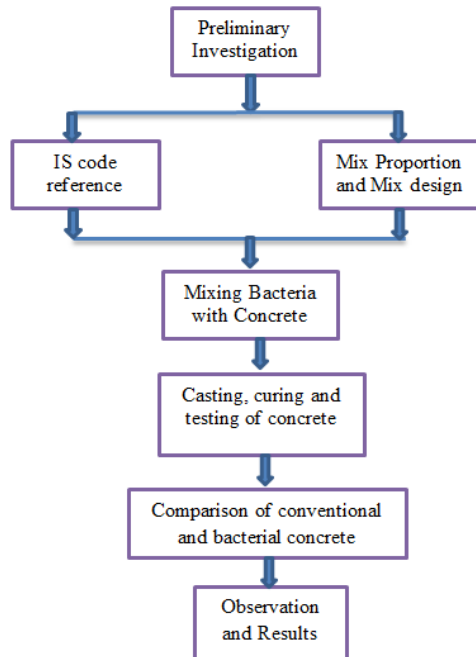


Figure 2.1 : Methodology of the study

2.3 Parameters for mix design M25

2.3.1. Case(i) Effect of partial replacement of cement by bacterial powder

For cube (M25 1:1:2)

i. Volume = $0.15 \times 0.15 \times 1.15 = 3.375 \times 10^{-3} \text{ m}^3$

Volume = $1.1 \times 3.375 \times 10^{-3} = 3.715 \times 10^{-3} \text{ m}^3$ (Considering 10% wastage)

ii. Wight of concrete = $3.7125 \times 10^{-3} \times 2400 = 8.91 \text{ kg}$

iii. Cement = $8.91 / 1+1+2 = 2.227 \text{ kg}$

iv. Fine aggregate = $1/1+1+2 \times 8.91 = 2.227 \text{ kg}$

v. Coarse aggregate = $2/4 \times 8.91 = 4.455 \text{ kg}$

vi. Water /cement ratio(0.5)

W = $0.5 \times 2.227 = 1.1135 \text{ liter} = 1113 \text{ ml}$

Cement quantity when bacterial powder is added: For BP-10gram = $2.217 \text{ kg} - 20 \text{ gram} = 2.207 \text{ kg}$

2.3.2. Case (ii) Mix design for cylinder

Diameter = 150mm

Height or length = 300mm

i. Volume = $\pi/4 \times 0.15^2 \times 0.3 = 5.301 \times 10^{-3} \text{ m}^3$

= $1.1 \times 5.301 \times 10^{-3} \text{ m}^3$ (Considering 10% wastage)

ii. Weight of concrete = $5.8311 \times 10^{-3} \times 2400 = 13.995 \text{ kg}$

iii. Cement = $1/1+1+2 \times 13.995 = 3.5 \text{ kg}$

iv. Fine aggregate = $1/1+1+2 \times 13.995 = 3.5 \text{ kg}$

v. Coarse aggregate = $2/1+1+2 \times 13.995 = 6.995 \text{ kg}$

vi. Water/cement ratio (0.5):

$W=0.5 \times 3.5 = 1.75 \text{ liter} = 1750 \text{ ml}$

Cement quantity when bacterial powder is added:

For bacterial powder of -10 gram = 3.490 kg -20 gram = 3.480 kg -30 gram = 3.47 kg

2.4 Casting of cube specimen for compression and split tensile test.

Cubes of 150mm*150mm*150mm were casted to carry out the compression testing. The cubes were casted for different concentration of the Bacterial powder. The percentage of Bacterial content was selected as 0%, 10%, 20% and 30%. Moulds of 150mm*150mm*150mm were taken and oil was applied to the interior part of the moulds. The materials namely coarse aggregate, fine aggregate and cement was taken with respect to the value obtained in the mix design.



Figure 2.2 : Casting of cube specimen

Similarly Cylinders of diameter 150mm and height 300mm were casted to carry out the split tensile testing. Moulds of diameter 150mm and height 300mm were taken and oil was applied to the interior part of the moulds. The materials namely coarse aggregate, fine aggregate and cement was taken with respect to the value obtained in the mix design. Figure.2.2. shows the number of cubes casted for different percentage of bacterial powder.



(a) For compression test



(b) For split tensile test

Figure 2.3: Experimental set up

3. Results and discussions:

The compression test and the split tensile test conducted as shown in Fig.2.3 (a) and (b) respectively. The results obtained from the experimental data are discussed below.

3.1 Compressive strength of bacillus sphaericus bacteria in concrete

The cubes after curing for seven, fourteen and twenty eight days curing were tested for its strength. The compression testing machine was used to find the strength of the material as shown in Fig.2.3 (a). The Figure.3.1 shows the compressive strength variation for different concentration of bacteria. It is observed that the compressive strength generally increases by increasing the curing days also the compressive strength of the cube increases with the inclusion of bacteria content. The maximum compressive strength among the different combinations was found to be 36 N/mm² at 30ml bacillus sphaericus bacteria content for 28 days curing process.

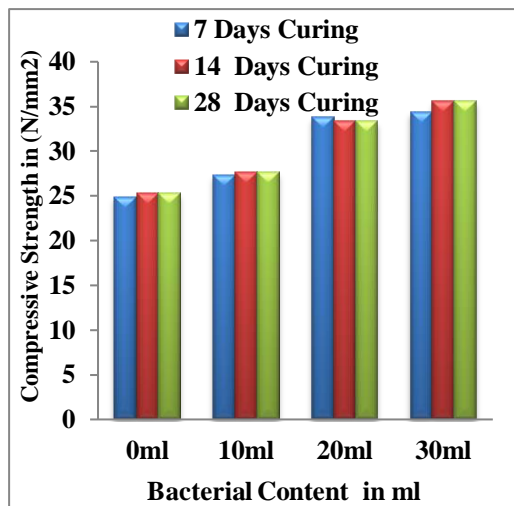
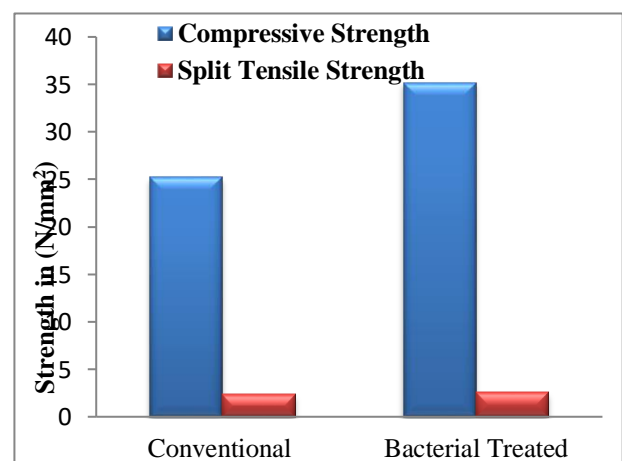


Figure 3.1: Compressive strength between normal concrete blocks and bacterial treated concrete blocks

3.2 Split Tensile strength of bacillus sphaericus bacteria in concrete

The cylinders after curing for seven, fourteen and twenty eight days were tested for its strength. The Split Tensile testing set up used to find the strength of the material as shown in Fig.2.3 (b). The Figure.3.2 shows the split tensile strength variation for different concentration of bacteria. It is noticed that the split tensile strength generally enhances by increasing the curing days also the split tensile strength of the cylinders enhances with the inclusion of bacteria content. The maximum tensile



strength among the different combinations was found to be 2.84 N/mm² at 30ml bacillus sphaericus bacteria content for 28 days curing process.

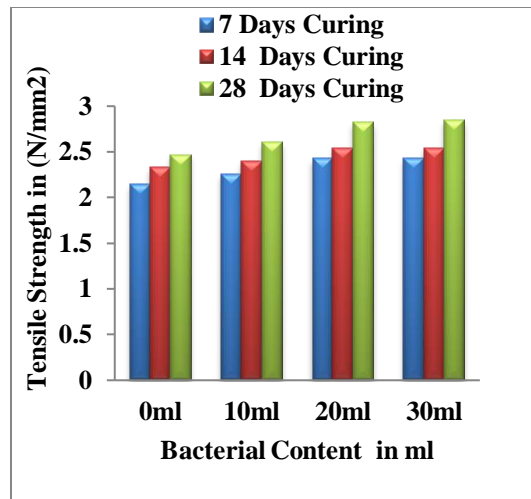


Figure 3.2: Split tensile strength between normal concrete blocks and bacterial treated concrete blocks

3.3 Comparative study of average compressive strength of concrete with addition of bacteria.

Figure.3.3 below shows the comparison of split tensile strength and compressive strength between normal concrete blocks and bacterial treated concrete blocks. It is noticed that the compressive strength of the casted cubes enhanced by 10% as compared with conventional casting and split tensile strength of the casted cylinders increased by 0.3% as compared with conventional casting. Hence the casted cubes exhibit the maximum strength when it is treated with bacteria.

Figure 3.3: Comparison between conventional and bacterial treated concrete blocks

4. Conclusions

From the above investigational, the conclusion are stated as

- Generally, the strength of the cubes increases with increasing the curing days.
- For strength assessment, cubes were tested for different bacterial concentration. It was observed that compressive strength and tensile strength of the concrete increases with addition of bacillus sphaericus bacteria.
- The maximum compressive strength of 36 N/mm² and tensile strength of 2.84 N/mm² was obtained at 30ml concentration of bacillus sphaericus bacteria powder in the mix of M25.
- Generally, addition of bacteria powder enhances the concrete performance and is cost effective technique.

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