INVESTIGATION OF BACTERIAL CONCRETE'S STRENGTH AND DURABILITY PROPERTIES

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ABSTRACT

Concrete is the most recognized building material for its unfavorable strength and durability features. It has extremely high compressive strength and very weak in tension, owing of which reinforcing is employed in concrete to take the stress. As the concrete is brittle, it always results in the production of fractures in the stress zones upon loading and leads to the durability difficulties by limiting the life time of the buildings. To address such durability difficulties standard repair procedures like crack filling with epoxy injections and use of extra reinforcement for minimizing the crack width were in usage which entails a lot of economics. This lead to the invention of self-healing concrete idea employing some bacteria mixing in the concrete and the crack produced will be self-healed by bacteria as a consequence of reproduction of the bacteria. In the current study, it was explored to determine the strength and durability qualities of the M30 grade concrete by adding bacteria called Bacillus Subtilis as at varied percentages like 5ml, 10ml, 15ml and 20ml for 500ml of water to be combined in concrete. It was shown that at 10ml of bacteria for 500ml

of water produces better strength qualities when compared with the standard concrete. As part of durability investigations, when the cubes are submerged in 5 percent H_2SO_4, at 10ml of bacteria it exhibiting the superior performance than the ordinary concrete.
Keywords: Concrete, Bacteria, Cracks, Self-healing, Durability.

INTRODUCTION

It is also known as microbial concrete or self-healing concrete. This is a study of both microbiology and engineering. Self-healing concrete, as the name indicates, is capable of repairing itself without the need for human involvement. Biologically produced calcium carbonate may be used to repair any concrete building that has visible fissures. Concrete's major flaw is its susceptibility to tension failure under prolonged strain. Concrete cracks have a substantial impact on the structure's long-term durability. Aesthetic value may be preserved by using the bacterial remediation approach while fixing historically significant buildings. In order to investigate the mechanical qualities of the aforementioned concrete at different bacterial concentrations, tests are being carried out.

OBJECTIVES OF THE STUDY

Bacillus Subtilis was used in this investigation to determine the mechanical characteristics of the M30 grade concrete by altering the amount of bacteria mixed into 500ml of water to be mixed in concrete to explore the durability of self-healing concrete at 5% H_2SO_4 dilution.

MATERIALS USED

- Ordinary Portland cement 53 grade (KCP cement) with specific gravity of 3.15
- Locally available river sand with bulk density of 1712 kg/m3 and specific gravity of 2.613 and confirming to zone-2 of IS:383
- Coarse aggregate with bulk density of 1682 kg/m3 and specific gravity of 2.822
- Baccillus subtilis Bacteria

METHODOLOGY

There are three key qualities that determine the concrete's toughness: compressive, tensile, and flexural. Bacillus subtilis (Bacillus subtilis) was introduced to 500 ml of water while mixing concrete in order to determine the strength qualities. There were also comparisons made between the bacteria added to the concrete mix and ordinary concrete in terms of total volume.

The following number of cubes, beams, and cylinders were cast and tested for the same purpose.

Cubes – 9 tested for **10, 20 & 30** days.

Cylinders – 3 tested for **30** days.

Beams – 3 tested for **30** days.

After that, they're put through a durability test that involves soaking them in a solution of 5 percent H2SO4 for 15 and 30 days to see how much weight and strength they lose. The acid-resistance factor has also been determined.

EXPERIMENTAL INVESTIGATION

The experimental research includes of casting of 9 cubes, 3 cylinders and 3 beams for each trail to measure compressive, tensile and flexural strengths accordingly by taking varying quantity of bacteria for every 500ml of water. Cube specimen size is of 15 cm x 15 cm x 15 cm, cylinder specimen dimension is 15 cm x 30 cm and beam specimen is 50 cm x 10 cm x 10 cm.

The moulds are coated with a lubricant before putting the concrete. After a day of casting, the moulds are removed. The cubes, cylinders and beams are transferred to the curing tank carefully.

MECHANICAL PROPERTIES

Concrete's mechanical qualities are mostly determined by its strength. The testing of concrete and its performance in compressive strength, split tensile strength, and modulus of rupture are included in the computation of mechanical characteristics. The standard specification IS 516 – 1959 confirms the methods and calculations used in these three tests.

Compressive Strength

The cubes' compressive or crushing strength is the most important quality to test. Compression testing machines are used to measure the compressive strength of cubes by gradually loading them. The indicator on the top of the machine reads the failure load.

With a maximum compression strength of 3000KN, cubical specimens are tested after 30 days of curing on the machine. Dial gauge readings are used to record the point at which a cubical specimen fails. Applying a crushing load on the cube's surface results in compressive strength. Ten days, thirty days, and ninety days of tests on compressive strength are all summarized here.

$$\textbf{Compressive strength} = P/A\ N/mm^2.$$

Split Tensile Strength

Two steel plates are positioned horizontally below and above the cylinder specimens after 30 days of curing. The specimens are then placed on a tension strength machine with a maximum capacity of 1000kN and tested. The dial gauge records the maximum load at which the cylinder specimen fails. Compression testing is also performed on the cylindrical specimens. The cylinders are oriented with the cylindrical face toward the loading surface and positioned in an axial orientation.

$$\textbf{Split tensile strength} = 2P/LD$$

Flexural Strength

When the prismatic specimens have been curing for 30 days, they are put on a 100 kN flexure strength machine with two points of loading 13.3cm from each end.

$$\textbf{Flexural Strength } f_{cr} = PL/bd^2$$

The modulus of rupture is denoted by 'fcr'.

The 'f' value is mainly based on the shortest distance of line fracture 'a' If 110mm < a < 133mm, $f_{cr} = 3PL/bd^2$

If a > 133mm, $f_{cr} = PL/bd^2$

If a < 110mm, the test shall be discarded

Table 1: Compressive strength of cubes

Grade	Mix Designation	Copressive strength of concrete in MPa					
		10 days	% increase	30 days	% increase	90 Days	% increase
M30	M0	24.32	.	39.26	.	41.23	.
	M1	29.72	22.20	45.26	15.28	45.27	7.60
	M2	32.16	32.16	46.39	18.16	49.54	20.15
	M3	30.16	24.01	43.26	10.10	45.86	11.22
	M4	28.65	17.80	41.33	5.20	43.14	4.63

Table 2: Split tensile strength results M30 Grade

Grade of concrete	Mix Disignation	Tensile strengthof concrete in Mpa	
		30 days	% Increase
M30	M0	3.42	..
	M1	3.79	11.80
	M2	3.91	15.34
	M3	3.81	12.39
	M4	3.69	8.85

Table 3: Flexural strength results M30 Grade at 30 days

Grade of concrete	Mix Disignation	Flexural strengthof concrete in Mpa	
		30 days	% Increase
M30	M0	4.21	..
	M1	4.59	5.28
	M2	5.09	16.74
	M3	4.89	12.16
	M4	4.79	9.86

DURABILITY TEST

Sulphuric acid (H2SO4) is used to test the acid resistance of concrete. Acid concentrations in water are calculated to be 5%. IS 516-1959 and ASTM C666-1997 were used as the study's reference standards.

Using varied concentrations of Sulphuric acid (5%), immersion times of 15, 30, and 60 days, and various weights and volumes of plain concrete and bacterium concrete, the goal of this research is to determine how different weights and volumes of Sulphuric acid affect the strength of the samples. There are 500mm*360mm*160mm plastictrays that are used to submerge the cubes of concrete in the sulphuric acid. Each of the M0, M1, M2, M3, and M4 designations requires the use of five trays, one for conventional testing and the other four for bacteria concretecubes. First tray contains conventional tray, second contains 5ml bacteria concrete for each 500ml of water cubes; third contains 10ml bacteria concrete for each 500ml of water cubes; fourth contains 15ml bacteria concrete for each 500ml of water cubes; fifth contains 20ml bacteria concrete for each 500 ml of water cubes.

For both weight loss and strength loss, the same cube is evaluated at the end of a certain immersion time period, using the same cube for both tests. To make the most of the available surface area, the cubes are arranged in trays in a staggered fashion. The trays are protected from evaporation by being covered. Immersion/exposure to H2SO4 for 28 days is examined. The cubes are rinsed under running water to remove any loose particles from the surface.

DURABILITY RESULTS

Percentage weight loss = [(Initial weight-Final weight)/Initial weight]*100

Percentage strength loss = [(Initial strength-Final strength)/Initial strength]*100

Percentage weight loss and percentage strength loss of cubes in 5% H_2SO_4

Table 4: % Weight loss & % strength loss in H_2SO_4 for M30 Grade

MIX	Curing Under 5% H2S04			
	% weight loss after 15 days	% weight loss after 30 days	% strength loss after 15 days	% strength loss after 30 days
M0	3.58	5.78	9.54	59.58
M1	2.99	4.59	8.96	54.98
M2	2.81	4.54	8.32	55.78
M3	2.96	4.68	8.66	56.18
M4	3.12	4.89	9.04	58.21

Table 5: Acid durability factor for M30 Grade in 5%H_2SO_4

Mix	Acid Durability Factor (%) in 5% H2SO4					
	ADF fo 15 days			ADF for 30 days		
	% loss in strength	Relative strength S(%)	ADF	% loss in strength	Relative strength S(%)	ADF
M1	9.54	90.46	45.23	60.36	59.58	59.58
M2	8.96	91.04	45.52	55.52	54.98	54.98
M3	8.32	91.68	45.84	54.26	55.78	55.78
M4	8.66	91.34	45.67	56.98	56.18	56.18
M5	9.04	90.96	45.48	58.17	58.21	58.21

CONCLUSIONS

Addition of microorganisms has increased the strength and durability qualities of the concrete. At 10ml optimal percentage of bacteria for 500ml of water, the augmentation of the compressive strength at early ages is quite great eventually culminating in 18 percent , split tensile strength as 15.34 percent and flexural strength as 16.74 percent . As part of durability experiments, the acid utilized by the bacterial concrete is less compared to the traditional concrete. Under 5 percent H2SO4 acid curing at 28 days the percentage weight loss is 6 percent and the percentage strength loss is 3.8 percent which has smaller weight and strength losses than the traditional concrete. From the foregoing it can be inferred that bacillus subtilis may be readily cultivated and safely employed in increasing the performance features of concrete

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