EXPERIMENTAL INVESTIGATION ON SELF-HEALING BACTERIAL CONCRETE

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Abstract

The service life of the structure have reduced in today's construction field due to the low durability, strength factors and various other properties of concrete structures exposed to the environment. A novel strategy to restore or remediate cracks formed in the structures is bio-mineralization of Calcium Carbonate using microbes such as Bacillus. This research gives the information about increasing the durability of the concrete structure by introducing bacterial cell and other required nutrients for the process of bio-calcification where the micro-organisms secrete Calcium Precipitate which in the presence of Carbonate ion forms Calcium Carbonate(Calcite) layer thus self-healing the cracks. Thus the durability of the concrete structure will increase and a study has to be carried out with concrete cubes subjected to bacterium.

Keywords: *Bacteria, Bacillus Pasteurii, Calcium Carbonate, Compressive Strength, Water Absorption.*

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1. INTRODUCTION

Concrete is the recurrently used building material. It has the advantage of being formed into any desired shape most conveniently. It is an artificial stone acquired by mixing aggregates, cement and water and allowing the product to cure for hardening. It's essential attributes are cement and water which react with each other chemically, to form another material having the serviceable strength. The strength of concrete depends upon the quality of its attributes, their relative quantities and the manner in which they are mixed, compacted and cured. It is possible to produce concrete of different specifications for various purposes by suitably adjusting the proportions of cement, aggregate and water.

It is essential for the structures that the serviceability should be above board. So as to attain this serviceability the minor cracks in the structure should be avoided which later may cause the structure to deteriorate. The cracks in the structure can be sealed or remediated without any repairing works. The process of self healing of cracks can be implemented to self heal the cracks and thus the repairing and rehabilitation can be avoided.

2 MATERIALS AND METHODS

2.1 Materials

The materials used in this research work are ordinary Portland cement of 53 grade, river sand, coarse aggregate of 20mm nominal size, calcium lactate and bacteria Bacillus Pasteurii.

2.2 Preparation of Specimens

Concrete mix proportions of ratio 1:1.5:3 is used for the preparation of specimens. Conventional specimens were casted. Bacterial specimens where the water is replaced by the bacterial solution of about 20%, 30% and 40% are also casted in parallel. The specimens were cured under tap water at room temperature and tested at the age of 7, 14 and 28days.

Fig -1: Bacterial Solution

3. TESTS ON CONCRETE

3.1 Compressive Strength Test

The casted specimens of size 150mm*150mm*150mm cubes were tested to determine the compressive strength at the age of 7, 14 and 28days.

3.2 Water Absorption Test

The sizes of 150mm*150mm*150mm cubes were tested to determine the water absorption percentage at the age of 28days.

4. RESULTS AND DISCUSSION

The various results obtained from the compressive strength test and water absorption tests were discussed and tabulated. The charts representing the test results were also provided. The table 1 indicates the results of the compressive strength of the conventional concrete cubes whereas the table 2, 3, 4 indicates the results of the compressive strength of the bacterial concrete cubes with 20%, 30% and 40% of bacterial solution respectively. The table 6 indicates the results of the water absorption of the conventional concrete and the bacterial concrete. The comparative results of compressive strength and water absorption of the conventional concrete cubes and bacterial concrete cubes were indicated in the table 5 and 7 respectively.

Table -1: Conventional Concrete Cubes

Trial	Compressive Strength N/mm^2		
	7days	14days	28days
1	16.02	22.19	24.66
2	14.30	19.81	22.01
3	13.79	19.09	21.22

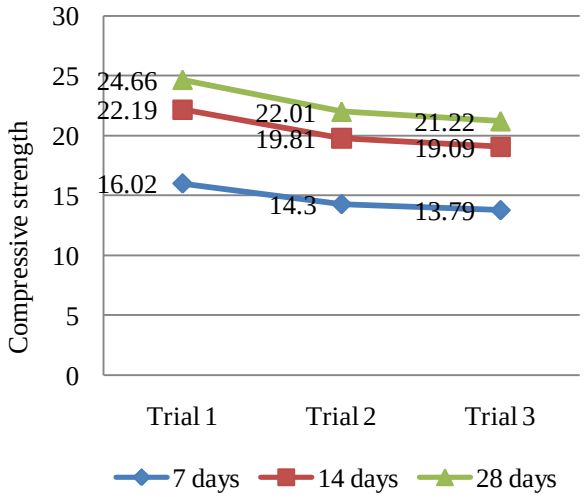

Chart -1: Compressive strength of Conventional Concrete Cubes

Table -2: Bacterial Concrete cubes with 20% of bacteria and 2 % of calcium lactate

Trial	Compressive Strength N/mm^2		
	7days	14days	28days
1	14.59	20.21	22.45
2	15.08	20.88	23.21
3	13.38	18.53	22.74

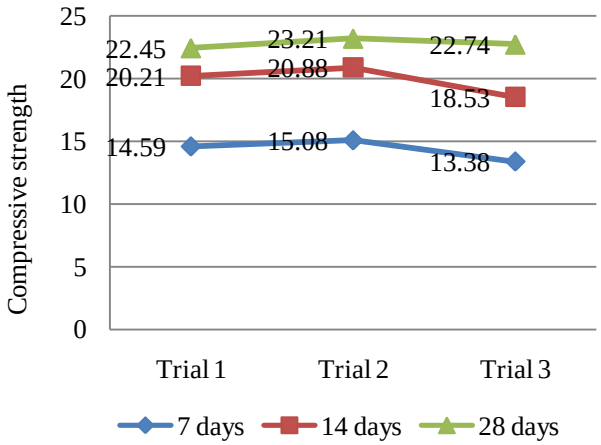

Chart -2: Compressive strength of Bacterial Concrete cubes with 20% of bacteria

Table -3: Bacterial Concrete cubes with 30% of bacteria and 2 % of calcium lactate

Trial	Compressive Strength N/mm^2		
	7days	14days	28days
1	14.28	19.78	21.98
2	15.80	21.88	24.32
3	14.32	19.83	22.03

Table -4: Bacterial Concrete cubes with 40% of bacteria and2 % of calcium lactate

Trial	Compressive Strength N/mm^2		
	7days	14days	28days
1	13.17	18.24	22.45
2	14.38	19.92	22.13
3	15.26	21.24	23.49

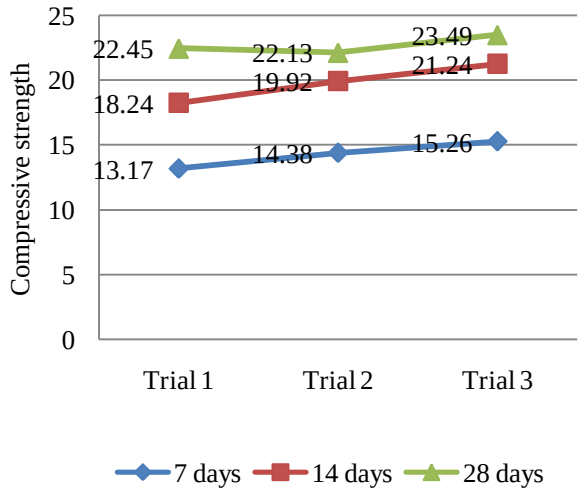

Chart -3: Compressive strength of Bacterial Concrete cubes with 30% of bacteria

Table -5: Comparison of Compressive Strength results

S.No.	Average Compressive Strength N/mm^2			
	Conventional concrete	Bacterial concrete		
		20%	30%	40%
1	22.63	22.80	22.77	22.69

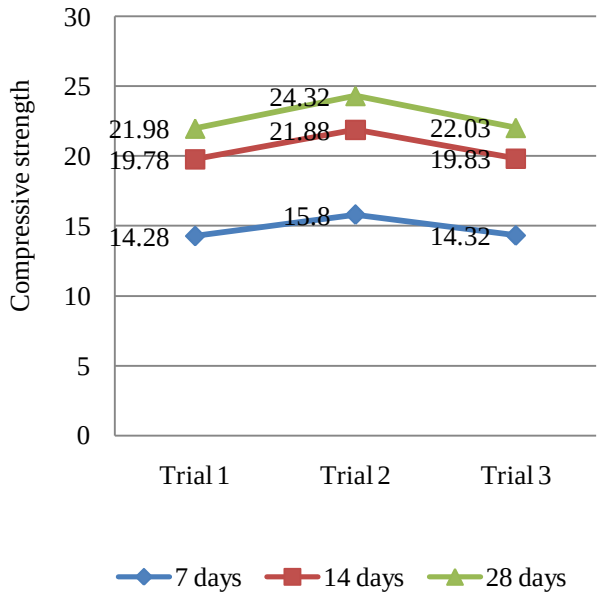

Chart -4: Compressive strength of Bacterial Concrete cubes with 40% of bacteria

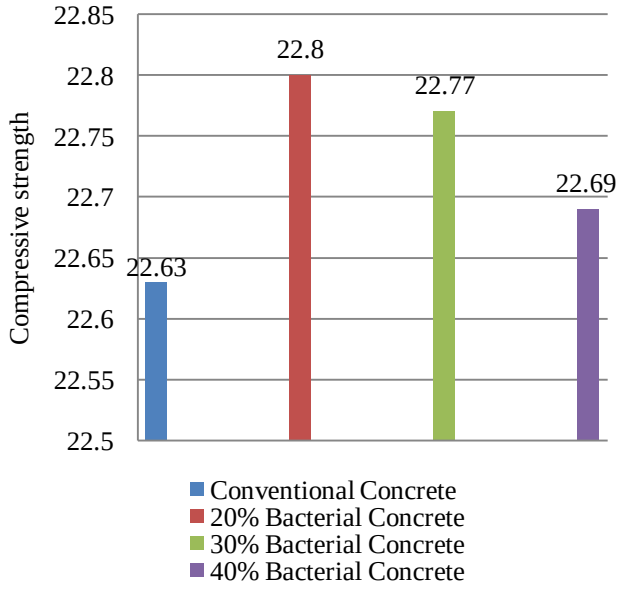

Chart -5: Comparison of Compressive strength of concrete cubes

Table -6: Water absorption of concrete cubes in percentage

S.No	Water Absorption in %			
	Conventional Concrete	Bacterial concrete		
		20%	30%	40%
1	2.463	1.321	0.993	1.269
2	2.494	0.956	0.979	1.382
3	2.439	1.581	1.211	1.097

Table -7: Comparison of Water absorption results

S.No	Average Water Absorption in %			
	Conventional concrete	Bacterial concrete		
		20%	30%	40%
1	2.465	1.286	1.061	1.249

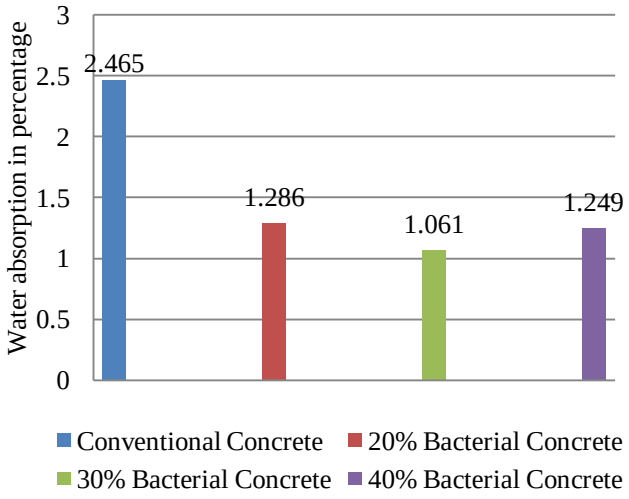

Chart -6: Comparison of water absorption of concrete cubes in percentage

Based on the experimental result, the following were discussed.

- Tests performed in this research suggest that the bacterial concrete is an interesting candidate for use in concretes for applications in the mixture.
- The self healing nature was found in the concrete casted with bacterial solution. The cracks were found sealed with the calcium carbonate precipitate.
- There is no change in the load carrying capacity, the compressive strength of the bacterial concrete when compared with the conventional concrete.
- It is found that the compressive strength in case of concrete cubes casted with the bacteria is same when compared with the conventional concrete.
- As expected relatively minor cracks in the concrete were sealed and henceforth the path to reinforcement is blocked.
- From the obtained water absorption results, it is found that the bacterial concrete has lesser water absorption

when compared to the conventional concrete and the water absorption and durability are inversely proportional to each other.

- Concrete prepared by using bacteria gives aesthetically pleasant appearance.
- The reinforcement corrosion that is caused due to the ingress of liquids and other ions can be stopped and thus the permeability can be reduced and hence the durability aspect of structures is enhanced.
- Furthermore this method bacterial concrete will be very effective incase of underground structures and water retaining structures where repair is difficult or even impossible.
- In order to overcome some of the durability problems, this method of using bacterial cell has become viable and it is even eco-friendly type of remediation.
- The maximum amount of calcite precipitation occurred in the area close to the surface of the cracks in concrete cubes i.e., in the upper layer, middle layer and the lower layer. This is due to the fact that the bacterial cell grows at a higher rate in the presence of oxygen and induces precipitation of $CaCo_3$ around the surface area of the cube.

CONCLUSION

From the discussion it is concluded that, the use of bacteria Sporosarcina Pasteurii in concrete can serve as the best option in Microbially Induced Calcite Precipitation due to its various special features. The method of self healing by the incorporation of bacteria into the concrete has greater advantage that it will save manual inspection, repair, time, money and moreover increase structure durability. The minor cracks in the structures can be remediated and the compressive strength of the concrete was found to be same as the conventional concrete. Since there is a lesser water absorption in the bacterial concrete, greater will be the durability of the concrete. Further study has to be carried out inorder to determine the limitation of percentage replacement of bacterial solution as only 20%, 30% and 40% of bacterial solutions were used in this study. The study exhibited that there are both advantage and even limitations about different healing agent and thus more research have to work as a further study.

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