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Experimental Investigation on Durability Aspects on Bacterial Concrete with M-Sand

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Abstract

The main aim of this study is to observe the behavior of E-coli bacteria on durability properties of concrete, also know the effect of replacement of natural sand by M-Sand(40% replacement), with different cell concentration(0,105,107 cells/ml) of E-coli bacteria were used for concrete mixes. The test was carried out on the durability properties after complete curing of 28 days. The test results shows inclusion of E-coli bacteria in concrete has an ability to enhance durability by reducing water absorption and sorptivity of concrete and also have great resistance ability to sulphate.

Keywords: *- Precipitation, Micro cracks, Self-healing, Bio-mineralization, Calcite, Cell concentration, etc*

INTRODUCTION

The cracks on concrete structure are commonly occurred, they may be small or large but these cracks will affect the aesthetic view and also serviceability of the structures. The concrete structure will cracks under the sustained loading and concrete will fail under the tension, so the steel bars are embedded into the concrete to take care of tensile forces. The steel reinforcement bar is well covered with concrete to avoid the corrosion of steel bars.

Even by providing steel reinforcement bars, some cracks are formed on the structures, these cracks will affect the durability of the concrete structure. Due to these cracks the ingress of water and ions take place and impairment of the structure starts with the corrosion of steel.

Hence if we find the better method that can automatically fill the pores or cracks that can be more reliable and economical, now a day from the many research found convenient method is self-healing concrete, by this method the cracks get filled and it act as water tight.

In the Self-healing concrete cracks are sealed automatically and it will not allow the water to pass away from the concrete and pores are filled.

Objectives of study

Following are the objectives of the thesis work

1. To study the effect on durability aspects of concrete due to variation of bacterial concentration

2. To investigate the effect by the partial replacement of natural sand by M-Sand on durability properties of bacterial concrete and conventional concrete

3. To know the microbial calcite precipitation mechanism in the concrete by SCM

Water absorption test results

METHODOLOGY

The investigations are carried out in accordance with the objectives of the study. The all experiment is done for M-25 grade of concrete as it has structural applications. The concrete mix is made with the locally available materials.

In the reference mix of concrete the Natural sand is replaced by M-sand (40% M-Sand). The bacteria of E-coli strain of purely cultured strains were introduced in the concrete with different concentrations (0, 105,107 cells/ml) is mixed with water in the ratio of 1:4 (1 part of bacteria and 4 part of water) and specimens are casted and tested was conducted as per the objectives.

RESULTS

Durability tests of concrete like water absorption test, Sorptivity test and Sulphate resistance test are carried out on specimens of bacterial and normal concrete and average results are mentioned in tables below.

Table -1: Variation of water absorption of bacterial concrete with different cell concentrations

Overall Water absorption		
Parameters	**Average water absorption in %age**	**Comparison with standard specimen**
Normal Concrete, 0 cells/ml	6.07	-
M-Sand 40%, 0 cells/ml	4.96	-1.11
Bacterial Concrete, 10^5 cells/ml	5.33	-0.74
40% M-Sand, 10^5 cells/ml	4.60	-1.47
Bacterial Concrete,10^7 cells/ml	5.85	-0.22
40% M-Sand, 10^7 cells/ml	4.92	-1.15

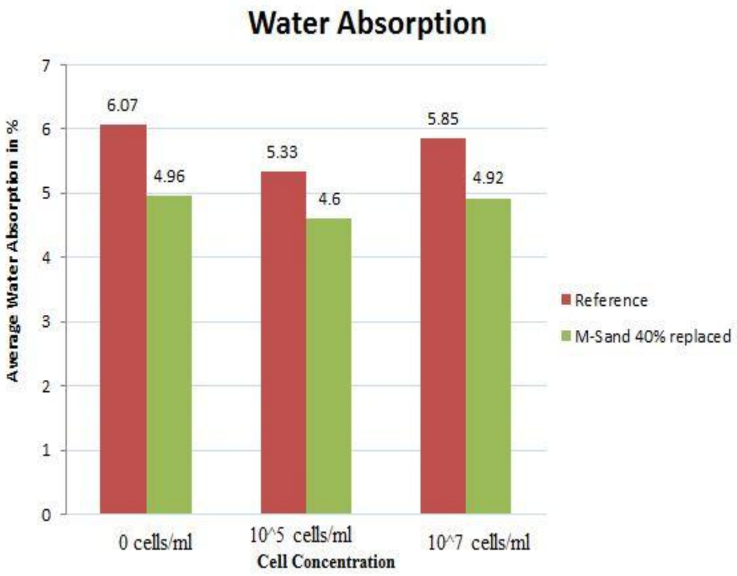

Chart 1: Cell Concentration vs. Avg. WA of Bacterial Concrete with different Cells/ml Concentration

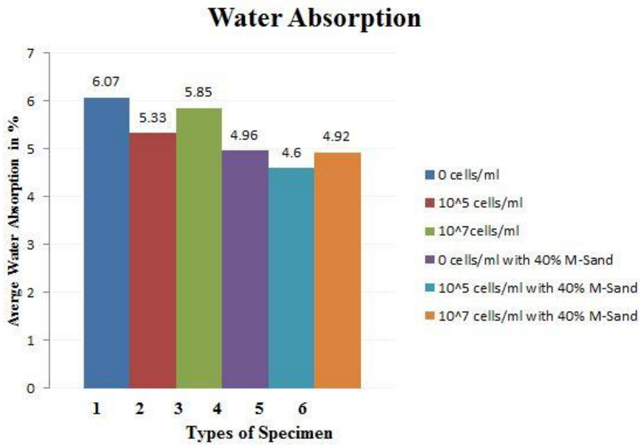

Chart -2: Variation of Avg. WA of Bacterial Concrete with different Cell Concentration.

Sorptivity test results

Table -2: Variation of sorptivity of bacterial concrete with different cell concentrations

Overall Sorptivity		
Parameters	**Average sorptivity in %age**	**Comparison with standard specimen**
Normal Concrete, 0 cells/ml	5.18	-
M-Sand 40%, 0 cells/ml	3.18	-2.0
Bacterial Concrete, 10^5 cells/ml	2.62	-2.56
40% M-Sand, 10^5 cells/ml	2.10	-3.08
Bacterial Concrete,10^7 cells/ml	3.78	-1.4
40% M-Sand, 10^7 cells/ml	2.65	-2.53

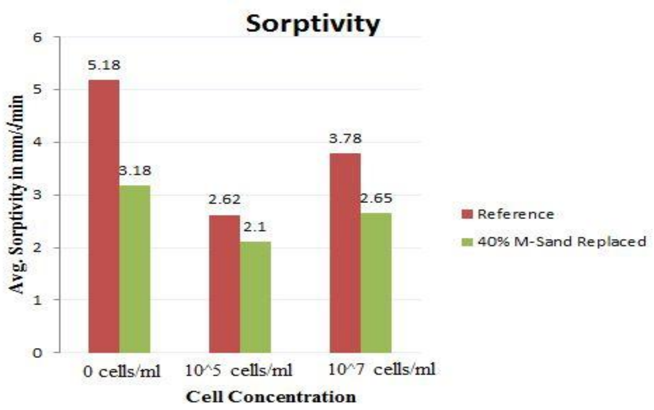

Chart 3: Cell Concentration vs. Avg. Sorptivity of Bacterial Concrete with different Cells/ml Concentration

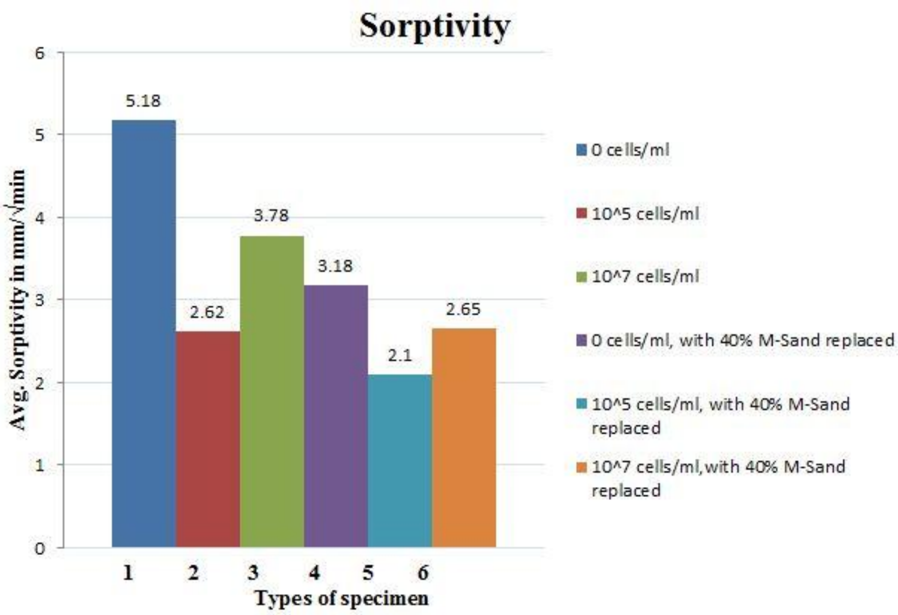

Chart -4: Variation of Avg. Sorptivity of Bacterial Concrete with different Cell Concentration.

Sulphate resistance results

Change in weight of specimens

Table -3: Change in weight due to sulphate attack, bacterial concrete with different cell concentrations

Overall change in weight due to sulphate attack(5% $MgS0_4$, solution)		
Parameters	**Avg. change in wt. (%)**	**Comparison with standard specimen**
Normal Concrete, 0 cells/ml	+0.23	-
M-Sand 40%, 0 cells/ml	+0.073	-0.157
Bacterial Concrete, 10^5 cells/ml	+0.076	-0.154
40% M-Sand, 10^5 cells/ml	+0.036	-0.194
Bacterial Concrete,10^7 cells/ml	+0.147	-0.083
40% M-Sand, 10^7 cells/ml	+0.073	-0.157

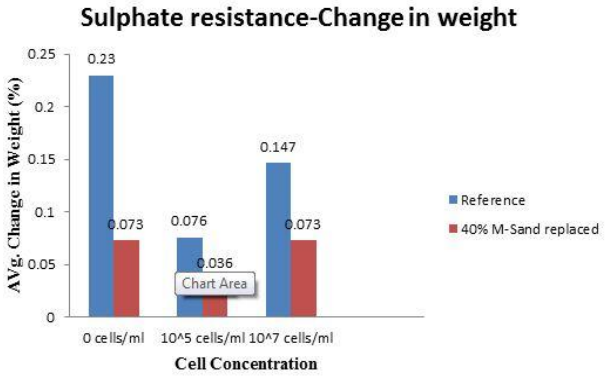

Chart 5: Cell Concentration vs. Avg. change in weight of Bacterial Concrete with different Cells/ml Concentration

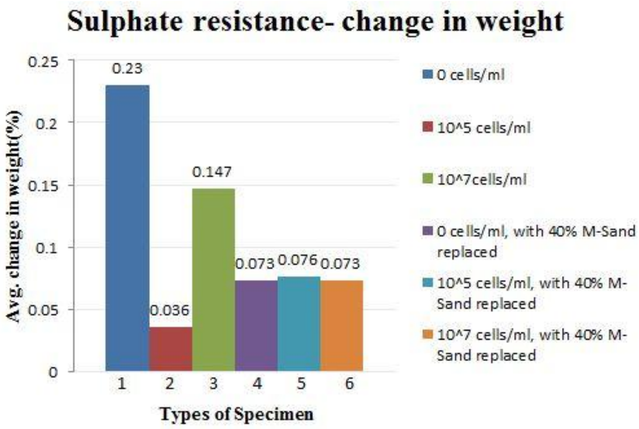

Chart -6: Variation of Avg. change in weight of Bacterial Concrete with different Cell Concentration.

Change in compressive strength

Table -4: Change in compressive strength due to sulphate attack, bacterial concrete with different cell concentrations.

Overall change in compressive strength due to sulphate attack(5% $MgS0_4$, solution)		
Parameters	**Avg. Change in Comp. strength N/mm^2**	**Comparison with Standard Specimen**
Normal Concrete, 0 cells/ml	+1.41	-
M-Sand 40%, 0 cells/ml	+1.63	+0.22
Bacterial Concrete, 10^5 cells/ml	+2.37	+0.96
40% M-Sand, 10^5 cells/ml	+5.48	+4.07
Bacterial Concrete,10^7 cells/ml	+1.48	+0.07
40% M-Sand, 10^7 cells/ml	+4.29	+2.88

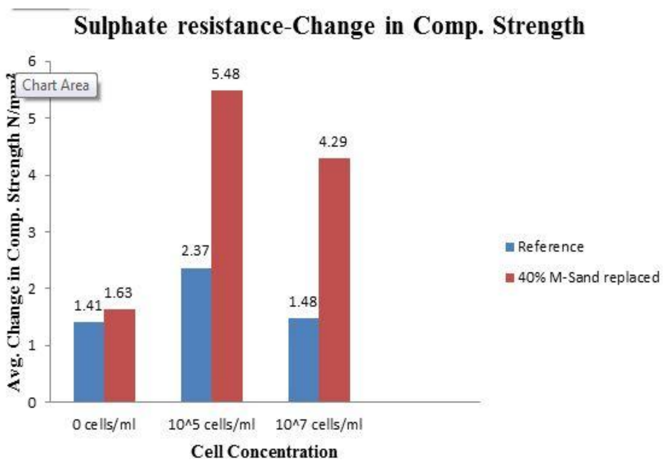

Chart 7: Cell Concentration vs. Avg. change in Compressive strength of Bacterial Concrete with different Cells/ml Concentration

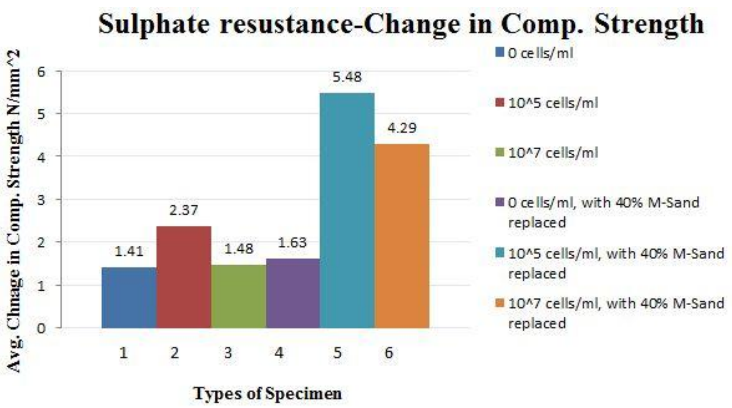

Chart -8: Variation of Avg. change in compressive strength of Bacterial Concrete with different Cell Concentration

OBSERVATION AND DISCUSSIONS

Following are the observations were made on the experimental work.

Water absorption

From the table 1 and chart 2, it shows the variation of water absorption with different cell concentration, it clearly indicate that for 40% of M-sand replacement with 10^5 cells/ml concentration shows the significant decrease in water absorption, this is happens due to pores and voids are filled by the M-Sand and calcite layer, hence there is less water penetration into the concrete, by this improves the resistance ability of cementitious materials.

Sorptivity

From the table 2 and chart 4 shows the variation of average sorptivity value with different cell concentration and with or without replacement of M-Sand. It's clearly indicated that as the cell concentration increases sorptivity decreases. For the 10^5 cells/ml concentration with 40% M-Sand replacement shows the maximum reduction in the sorptivity. This is due to presence of higher amount of calcium in the concrete, which is deposited due to precipitation of calcium carbonate by E-coli strain bacteria, this calcite layer will automatically fills the voids and pores which are present in the concrete, hence there is no water intake within the concrete. And improves the ability of resistance to cementitious material hence it enhances the better durability.

Sulphate resistance

Change in weight

From table 3 and chart 6 it indicated that as the cell concentration increases the decrease in of change in weight. For 40% M-Sand with 10^5 cells/ml concentration shows the very less change in weight of specimen as compared to standard specimen, Even after all the specimens are immersed in the 5% MgSo4 solution for a period of 45 days. The weight of specimens is increased due to presence of small pores that filled with the magnesium sulphate and increased the weight of specimens.

Change in compressive strength

From the table 19 and Graph 21 shows the variation of compressive strength with different cell concentration of bacteria, even after immersion in the MgSo4 of 5% solution for 45 days the compressive strength has increased, this is indicate that the effect of sulphate is not possible for 5% solution and test can be performed for longer period. For the specimen 5 shows the maximum increment in compressive strength.

Overall observation shows the inclusion of 10^5 cells/ml concentration of E-coli bacteria shows the higher durability as compared to normal and 10^7 cell/ml concentration. 10^7 cells/ml concentration is obtained in the range of 19 to 25 hours, in this stage bacteria were in the death phase, hence they are not active and cannot precipitate required amount of calcium carbonate.

SEM analysis

Fig. 1 shows the SEM image of bacterial concrete, it is evidently shows the presence of crystalline calcium carbonate precipitated by E-coli strain bacteria. SEM analysis shows the precipitation of calcite layer on the surface of concrete which filled the small pores which are present in the concrete. The E-coli bacteria had precipitated high amount of calcium carbonate within the concrete and confirmed the calcite layer is present in it, and it is not harmful for the human body and economical under the environmental condition and which enhances the impermeability of concrete by this better durability of concrete is achieved.

CONCLUSIONS

Based on the experimental study following are the conclusions were made

1. The water absorption can be reduced by utilizing E-Coli strain of bacteria in the concrete which will increase the durability of concrete structure.
2. The E-Coli strain of bacteria plays a major role in reducing the water sorptivity of concrete by this increase in the durability.
3. Replacement of natural sand by 40% M-Sand gives the best possible results for enhancing durability of concrete by reducing both sorptivity and water absorption.
4. Bacteria with 10^5 cells/ml concentration in concrete by replacing natural sand by M-Sand proves to be more economical.

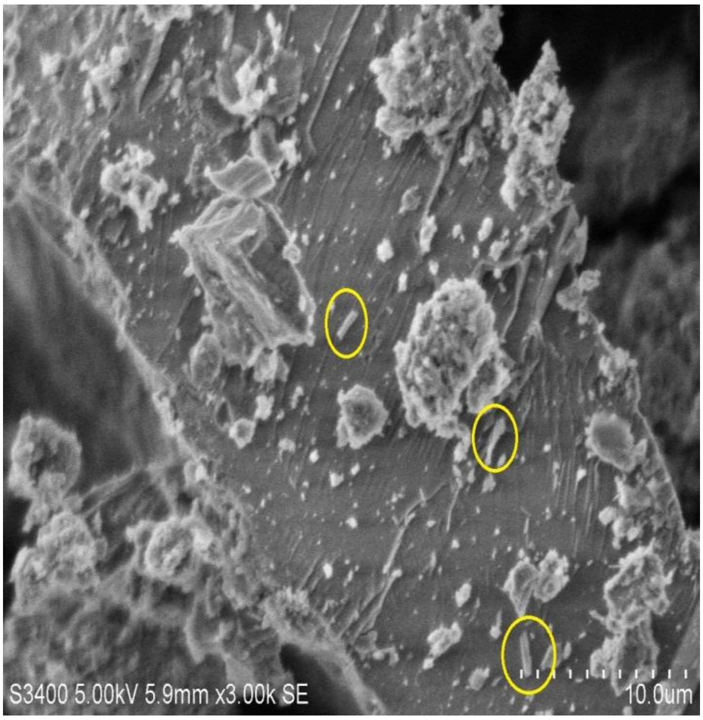

Fig. 1: Shows picture of SEM of concrete of bacterial induced calcite deposition.

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