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An Investigation on Bacterial Concrete

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ABSTRACT

Cracking in concrete is the main concern throughout the structures because it causes loss of strength with time. Hence a special type of environmental free solution is to be made for maintenance purpose. Therefore a bacterial concrete is prepared. However, the drawback of this material is that it easily cracks due to its low tensile strength, & due to temperature expansion, contraction, whereas the creep & shrinkage also produce cracks. While bigger cracks deteriorate structural integrity, also hair-line cracks may result in durability problem. In this study we will discuss about the self-healing process of concrete is process by which the cracks obtained in the body of concrete get repaired by itself or it required some external help to complete self healing activity. The bacterial species called Bacillus subtilis for increasing the strength of concrete and decreasing the porosity at 28 Days. Though these species are eco-friendly and does not cause any harm to human and use for improving the resistance of concrete when exposed to alkaline, sulfate and freeze-thaw environments. This paper mainly comprises of activation of bacteria and focuses on strength of bacteria concrete with normal concrete and also filling of cracks.

Keywords: Bacterial Concrete, Bacillus Subtilis, Self Healing, Compressive Strength.

I. INTRODUCTION

Cracks often occur in concrete because of low compressive strength and flexural strength after application of load on a structure. Water or aggressive material may seek in the concrete through cracks. Inspecting and then repairing these cracks are time consuming and costly. So we have come up with a new concept of crack healing concrete by releasing healing agents inside the concrete when cracks appear. Ghosh et.al. investigated seven different bacterial concentration of shewanella species(10-10^7cells/ml) and obtained optimal bacterial concentration to be 10^5cells/ml with corresponding 25% increase in compressive strength. In these research paper, We have discussed an environmental friendly self-healing concrete technique.

In previous research carried out, Bacillus sphauricus bacteria were used to precipitate calcium carbonate. In this, the bacterial cell get coated with a layer of calcium carbonate the aim of our research work is to use $CaCO_3$ precipitated by the Bacillus subtilis to heal the crack in concrete.

Cracks often occur in concrete because of the low tensile strength of this material. Rapid crack healing is necessary since it is easier for aggressive substances to ingress into concrete through cracks than through the concrete matrix. It is known that it is costly to inspect, monitored repair cracks. Moreover, some of the repair methods currently used is not so sustainable [Neville 1996].

Therefore, it would be desirable if concrete cracks could be healed autonomously by releasing healing agents inside the matrix when cracks appear. In this study, an eco-friendly and self-healing crack repair technique is explored. Previous research has shown that Bacillus sphaericus bacteria are able to precipitate calcium carbonate ($CaCO_3$) on their cell constituents and in their micro-environment by conversion of urea ($CO(NH_2)_2$) into ammonium (NH_4^+)and carbonate(CO_3^{2-}). The bacteria locally increases the pH and promotes the precipitation of calcium carbonate in a calcium rich environment. Through this process, the bacterial cell is coated with a layer of calcium carbonate The aim of our study is to use this bio-precipitated $CaCO_3$ to heal cracks in concrete. A calculation showed that precipitation of $CaCO_3$ is not enough to fill wide concrete cracks completely. So its solution is to restrict the wide expansion of the crack i.e. by using bacillus subtilis to heal cracks in concrete.

1.1 Advantages

Microbial concrete in crack remediation:- Specimens were filled with bacteria, nutrients & sand. Significant increase in compressive strength & stiffness values as compared to those without cells was demonstrated. Better resistance towards freeze-thaw attack reduction:-Application of microbial calcite may help in resistance towards freeze-thaw reduction due to bacterial chemical process and also it can reduce the permeability than freezing process decreased.

Reduction in permeability of concrete:-Effect of microbial concrete on penetration properties was studied by different researchers. Permeability can be investigated due to surface treatment result in an increased resistance towards carbonation and chloride ingress. Carbonation is related to the nature and connectivity of the porous giving rise to higher carbonation depths.

Reduction in corrosion of reinforced concrete: Application of microbial calcite may help in sealing the path ingress and improve the life of reinforced concrete structure.

1.2 Objectives

Primary objective of Bacterial Concrete is healing of developed cracks. Secondary or long term objective is to check the self healing ability of concrete. Comparing the Compressive Strength of Bacterial Concrete with Normal Concrete.

II. METHODS AND MATERIAL

2.1. Activation of Bacteria

2.1.1. For Nutrient Broth

Initially pro-biotics like Curd, Sporolac and Soil were used as sample for testing. Nutrient Broth was taken as per proportion in the conical flask with air tight cotton plug was placed in autoclave at 120°C for 15psi. The surrounding was made free from microbes by spreading spirit and lighting candles in the working area in sterile condition. Further the dilution process was carried out in the same sterile condition. Conical Flask were kept in incubator at 37°C for 24-48hrs.

Figure 1. Sterlised chamber

2.1.2. For Nutrient Agar

Autoclave suspension at 120°C at 15psi for sterilizing medium and melting agar. Pour Molten agar into petri dish under sterile condition. Add 2-3 drops of pro-biotics like Curd, Sporolac and Soil were used as sample for testing. Petri dish were kept in incubator at 37°C for 24hrs.

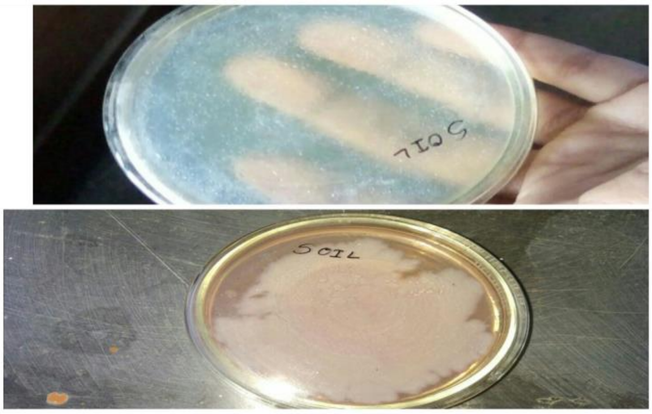

Figure 2. Activated bacteria in nutrient agar

2.2. Mix and proportion

2.2.1. For Normal Concrete

Mix Proportion for grade M30

Cement :Fine Aggregate :Coarse Aggregate :Water

1 : 1.6 : 2.9 : 0.46

2.2.2. For Bacterial Concrete

Mix proportion is same as normal concrete. The 17% water quantity is replaced by bacterial culture solution.

3.0 RESULTS AND DISCUSSION

3.1. Microscopic Result

The activation of bacterial concrete was done successfully as it emits green colour in chromophore agar and appears pink colour in microscope shown in figure 3

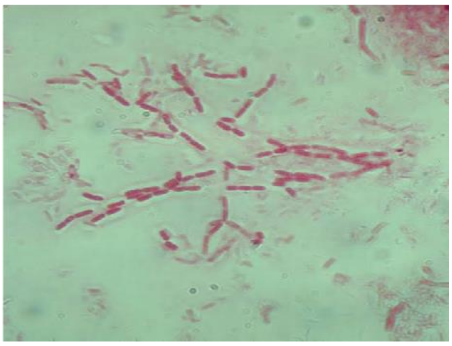

Figure 3. Microscopic view

3.2. After Activation

The cloudy appearance has also been observed in the culture which shows the presence of Bacillus subtilis in the nutrient broth shown in fig.4.

Figure 4. Bacterial solution in conical flask

3.3. The results of compressive strength

3.3.1. For 7days:-

Table 1. Compressive Strength of 7 days

Type of concrete	Cube 1	Cube 2	Cube 3	Average (KN/m2)
Normal concrete (KN/m2)	18.5	18	17.8	18.1
Bacterial concrete (KN/m2)	22	23.11	24.08	23.06

3.3.2. For 14 days:-

Table 2. Compressive Strength of 14 days

Type of concrete	Cube 1	Cube 2	Cube 3	Average (KN/m2)
Normal concrete (KN/m2)	24	25.33	24.8	24.71
Bacterial concrete (KN/m2)	32	31.48	29.2	30.89

3.3.2. For 28 days:-

Table 3. Compressive strength of 28 days

Type of concrete	Cube 1	Cube 2	Cube 3	Average (KN/m2)
Normal concrete (KN/m2)	31.11	30.45	29.77	30.44

Bacterial concrete (KN/m2)	34.22	35.1	33.56	34.29

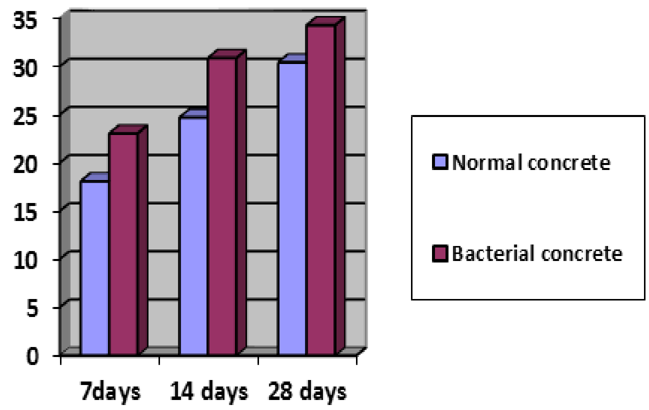

Figure 5. Graphical representation of compressive strength

From above result we can conclude that the Compressive strength of Bacterial Concrete have been increased by 26% as compared to Normal Concrete.

III. CONCLUSION

The Self healing is done by Bacteria by precipitating calcite in cracks in concrete. The activation of bacteria was also done successfully. The species of Bacillus Subtilis was extracted from soil sample. The compressive strength of Bacterial Concrete was successively increased as compared to Normal Concrete.

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