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Self Healing Concrete

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Abstract: *Crack formation is very common phenomenon in concrete structure which allows the water and different type of chemical into the concrete through the cracks and decreases their durability, strength and which also affect the reinforcement when it comes in contact with water, CO2 and other chemicals. For repairing the cracks developed in the concrete, it requires regular maintenance and special type of treatment which will be very expansive. So, to overcome from this problem autonomous self-healing mechanism is introduced in the concrete which helps to repair the cracks by producing calcium carbonate crystals which block the micro cracks and pores in the concrete. The selection of the bacteria was according to their survival in the alkaline environment such as B. pasteurii, Bacillus subtilis and B. spharicus which are mainly used for the experiments by different researchers for their study. The condition of growth is different for different types of bacteria. For the growth, bacteria were put in a medium containing different chemical at a particular temperature and for a particular time period. Bactria improves the structural properties such as tensile strength, water permeability, durability and compressive strength of the normal concrete which was found by the performing different type of experiment on too many specimens had varying sizes used by different researchers for their study of bacterial concrete in comparison with the conventional concrete and from the experiment it was also found that use of light weight aggregate along with bacteria helps in self healing property of concrete. For gaining the best result a mathematical model was also introduced to study the stress-strain behavior of bacteria which was used to improve the strength of concrete.*

Keywords: Bacteria, Bacillus pasteurii, Concrete, Bacillus sphaericus

I. INTRODUCTION

Concrete is very good material to resist the compressive load to a limit but if the load applied on the concrete is more than their limit of resisting load, it causes the strength reduction of concrete by producing the cracks in the concrete and the treatment of the cracks in very expensive. Some of the property like durability, permeability ad strength of the concrete structure is also decreases. Due to increase in the permeability of the concrete the water easily pass through the concrete and come in the contact with the reinforcement of the concrete structure and after some time corrosion start due to this strength of the concrete structure will decreases so it will be necessary to repair the cracks [1]. By introduce the bacteria in concrete it producing calcium carbonate crystals which block the micro cracks and pores in the concrete [2]. In concrete micro cracks are always avoided but to some extent they are responsible to their failure in strength. The selection of the bacteria is depend on the survive capability of bacteria in the alkaline environment. Most of the microorganisms die in an environment with pH value of 10 or above [3]. Strains of the bacteria genus Bacillus will be found to succeed in high alkaline environment. The bacteria survive in the high alkaline environment that formed spores comparable to the plant seeds. The spores are of very thick wall and they activated when concrete start cracking and water transude into the structure. The pH of the highly alkaline concrete lowers to the values in the range 10 to 11.5 where the bacterial spores become activated. There many bacteria other then Bacillus which are survive in the alkaline environment shown in Table 1 [4].

Capillary Water Suction

Increase in water penetration resistance was determined by a sorptivity test, based on the RILEM 25 PEM (II-6) was carried out. Capillary water suction used to find out the absorption capacity of the bacterial concrete as compared to the conventional concrete. The value lower than 1 shows the relative decrease of water absorption and the value greater

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than 1 indicates the relative increase in water absorption. The result was expressed as the relative capillary absorption index as proposedby [31]. By performing the experiment on the various specimens it was found that the conventional concrete shows the lower value of relative capillary index. Willem De Muynck et al. also compare the pure culture and uerolytic mixed culture from his study it was found that the pure culture of *B. Sphaericus*had value of relative capillary index was lower as compare to the uerolytic mixed culture due to addition of the soluble calcium ion

Gas Permeability RILEM- CEMBUREAU method was used to find the Gas permeability using the principal as the Hagen- Poiseuille relationship for laminar flow of a compressible fluid through a porous body having small capillaries under steady state. Martin Sommer oxygen permeability experiment used measure the rate of flow of oxygen. It was found that the reduction of permeability in bacterial concrete as compare to the conventional concrete

Oxygen Consumption Measurement Oxygen consumption measured when oxygen consumed by aerobic bacterial metallic conversion of calcium lattice. For the study the optical oxygen micro sensors were used for quantification of water submerged control and bio chemical healing agent containing mortar specimens and it can be calculated by calculating the change in oxygen concentration in the linear part of the gradient in the diffusive boundary layer using Fick's first law of diffusion. J= - Doxygen * dC(z) / dZ Where Doxygen is the diffusion coefficient of O2 in water, and C(Z) is the concentration of O2 at depth ZTake out cylinder after 3 days and dried it. The dry cylinder was fitted inside the PVC ring. During the water permeability test the vacuum saturation allows to establish a steady flow condition in a specimen which was first vacuumed in the vacuum chamber for 2-3 hours and then de-mineralized water was added into the chamber. The cylinder was kept immersed completely into the water for 24 hours due to the completely immersed specimen the vacuum stopped. Then cylinder was taken out and prepare for the water permeability test. The whole setup kept watertight so that the specimen was in saturated state throughout the whole process of the measurement. The time for the decrease the water level from *h0*till*hf*in the glass tube was measured for 30 days of testing this water related with the water permeability of the cracked specimen. By the help of the Darcy's law, the coefficient of water permeability of the specimen can be calculated by the following equation: K=atln(h0/ hf)

Concrete Sample Willem De Muynck et al. made a concrete specimen to study and for performing the test on the self-healing nature of concrete by using the ordinary Portland cement CEM 152.5 N, Sand, Aggregate and Water. The mould having the following dimension 150 mm X 150 mm X 150 mm, 150 mm X 150 mm X 600 mm and 160 mm X 160 mm X 70 mm were used. The specimens were placed in the room for 27 days at 20 – 25°C. After 28 days the compression test is done the prepared cube 150 mm X 150 mm X 150 mm and it is found that the mean compressive strength was 55.2 N/mm2 with a standard deviation of 2.19 N/mm2 [1]. Henk M. Jonkerset al. Preparing the specimen of the concrete having the following ingredient such as 53 grade cement, Fly ash, Fine and Coarse aggregate and microorganism of *Bacillus subtilus*is cultured and added to the water during the mixing of concrete in difference concentration like 105 cells/liter, 106 cells/liter and 107 cells/liter. Prepared M40 grade concrete cube of size 150 mm X 150 mm 150mm for measuring the mechanical properties a cylindrical specimen of 150 mm diameter and height of 300 mm were casted [24]. Srinivasa Reddy V et al. made a specimen to find the stress-Strain of the concrete sample were made of high strength grade of concrete such as M60. A cylindrical specimen were made of diameter 150mm and height 300mm. total 12 number of specimen were casted with bacterial concrete

Encapsulation Light Weight Aggregate LWA is also used for improving the self healing property of the concrete. The ordinary aggregate of size 2-4mm which was replaced by the light weight aggregate of same size corresponding to a healing agent content of 15 kg m-3 concrete [27] this change will affect its compressive strength. Capacity to heal cracks was substantially improved for concrete containing in LWA encapsulated healing agent

II. CONCLUSION

Introducing the bacteria into the concrete makes it very beneficial it improves the property of the concrete which is more than the conventional concrete. Bacteria repair the cracks in concrete by producing the calcium carbonate crystal which block the cracks and repair it. Many researchers done their work on the self healing nature of concrete and they had found the following result that bacteria improves the property of conventional concrete such as increase in 13.75% strength increased in 3 days, 14.28% in 7 days and 18.35% in 28 days. The development of calcium carbonate crystal Decreases the water permeability by decreasing the width of cracks from 0.5 mm to 0.35 mm. Compressive strength

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was increases by 30.76% in 3 days, 46.15% in 7 days and 32.21% in 28 days and in mathematical modal it was found that the bacterial concrete shows the better value of stress and strain as compared to controlled concrete for the high strength grade of concrete

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