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Micro Structural Analysis of Bacterial Concrete

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Abstract**:** Concrete is the most widely used construction material in the world. Despite its different qualities in the construction, it has many limitations. It is weak in tension, has limited ductility and less resistance to cracking. The primary reason for the cracking of concrete can be attributed to porosity in texture (microscopic level) of structural members which allows moisture and water to seep into the concrete members and hence, leads to corrosion of steel reinforcements. Although, a variety of waterproofing agents and surface treatments like the water repellants such as silanes or siloxanes are available which are used to enhance the durability of concrete structure, they suffer from various limitations like incompatibility, susceptibility to UV radiations and are also expensive. A technique was proposed in remediating cracks and fissures in concrete by microbiologically inducing calcite precipitation. Microbes like Bacillus pasteurii, can induce the precipitates of calcite. It can increase the durability performance of concrete with increase in the concentration of bacteria. Moreover, this calcite layer can also improve the impermeability of the specimen, thus increasing its resistance to alkaline, sulphate and freeze-thaw attack.

Keywords: Cracking, Steel Reinforcement, Siloxane, Microbes, Calcite.

I. Introduction

Bacteria are single celled microbes. The cell structure is simpler than that of other organisms as there is no nucleus or membrane bound organelles. Instead their control centre containing the genetic information is contained in a single loop of DNA. Some bacteria have an extra circle of genetic material called a plasmid. The plasmid often contains genes that are responsible for differences between bacteria. For example, it may contain a gene that makes the bacterium resistant to a certain antibiotic. Bacteria are relatively simple, single celled organisms. These are classified based on three categories, namely, based on shape, gram stain and oxygen demand. Classification of bacteria various types of bacteria used in construction.

II. Types of Bacteria

Bacteria are generally classified into three categories:

Based on shape

- Spirilla
- Bacilli
- Cocci

Based on gram staining

- Gram positive
- Gram negative
- Based on oxygen demand
- Aerobic
- Anaerobic

III. Spectroscopy Analysis

1. *SEM Analysis*

SEM (Scanning Electron Microscope) is a high magnification microscope. The calcite precipitation by bacterial isolate in the micro cracks and pores in concrete samples is to be analyzed using SEM.

SEM photo Figures are to be obtained using Jeol JSM – 6390 apparatus at an accelerating voltage of 0.5 to 30 kV. Broken pieces of cube samples obtained from compressive strength test are to be collected and dried at 1000C in oven for 3 days. Samples are to be gold coated with a sputter coating prior to examination.

2. *EDAX ANALYSIS*

Energy-dispersive X-ray spectroscopy (EDS, EDX, EDXS or XEDS), sometimes called energy dispersive X-ray analysis (EDXA) or energy dispersive X-ray microanalysis (EDXMA), is an analytical technique used for the elemental analysis or chemical characterization of sample. It relies on interaction of some source of X-ray excitation and a sample. Its characterization capabilities are due in large part to the fundamental principle that each element has a unique atomic structure allowing a unique set of peaks on its electromagnetic emission spectrum (which is the main principle of spectroscopy).

To stimulate the emission of characteristic X-rays from a specimen, a high-energy beam of charged particles such as electrons or protons (see PIXE), or a beam of X-rays, is focused into the sample being studied. At rest, an atom within the sample contains ground state (or unexcited) electrons in discrete energy levels or electron shells bound to the nucleus. The incident beam may excite an electron in an inner shell, ejecting it from the shell while creating an electron hole where the electron was. An electron from an outer, higher-energy shell then fills the hole, and the difference in energy between the higher-energy shell and the lower energy shell may be released in the form of an X-ray. The number and energy of the X-rays emitted from a specimen can be measured by an energy-dispersive spectrometer. As the energies of the X-rays are characteristic of the difference in energy between the two shells and of the atomic structure of the emitting element, EDS allows the elemental composition of the specimen to be measured.

IV. Results

Fig.1. &.2. shows the scanning electron micrograph and energy dispersive X-ray Spectrum of control concrete sample.

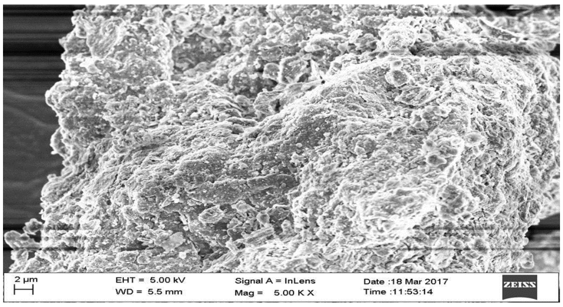

Fig.1. SEM Analysis of Bacterial Concrete

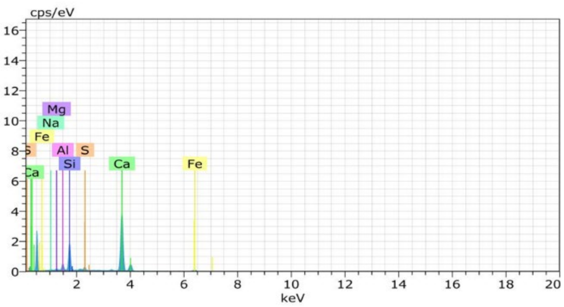

Fig.2. EDAX Analysis for Control Concrete

The scanning electron micrograph of control concrete sample shown in Figure 1 indicates the presence of limited individual crystals. The EDX spectrum of control concrete sample shown in Figure 6.2 indicates the presence of calcium (Ca) and the weight% of calcium is 6.2 %. Figure 3 & 4 shows the scanning electron micrograph, energy dispersive X-ray spectrum and X-ray diffraction pattern of bacterial concrete sample with combination of Bacillus megaterium, Bacillus licheniformis, Bacillus pumilus.

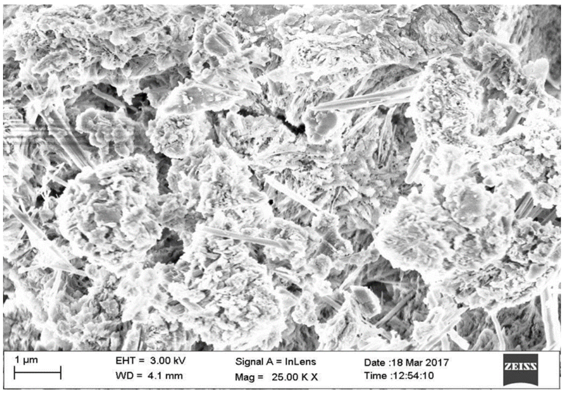

Fig.3. SEM Analysis of Bacterial Concrete

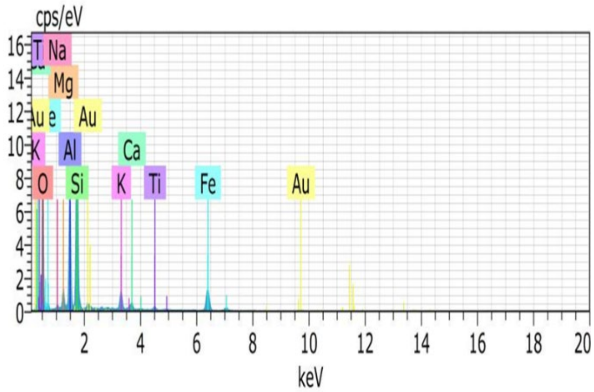

Fig.4. EDAX Analysis for Bacterial Concrete

The scanning electron micrograph of concrete samples with combination of Bacillus megaterium, Bacillus licheniformis, Bacillus pumilus shown in Figure 3 indicates the presence of individual crystals. The EDX spectrum of concrete samples with combination of Bacillus megaterium, Bacillus licheniformis, Bacillus pumilus shown in Figure 4 indicates the presence of calcium (Ca) whose intensity is more than that of the control concrete sample shown in Figure 2. The weight% of calcium is 9 % which is more than that of control concrete sample.

V. Conclusion

The strength of bacterial concrete specimens increased with respect to non-bacterial concrete specimens. The reason for this increased strength and durability of bacterial concrete specimens with respect to control concrete specimens is due to the plugging of micro cracks and pores in concrete with calcite crystals precipitated by bacteria. The presence of calcite was visualized in the scanning electron micrographs of bacterial concrete samples Bacillus megaterium, Bacillus licheniformis, Bacillus pumilus. The high intensity and weight% of calcium in these bacterial concrete samples also proved that high amounts of calcite (Ca) were present in them.

Krishnapriya, S., & Babu, D. V. (2015)., also reported the self-healing of cracks in concrete. The calcite crystals were visualized by using SEM and confirmed by using EDAX.

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