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ECO FRIENDLY LOW-COST BIO-BRICK

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Abstract – *Biomineralization is the chemical alteration of an environment by microbial activity that results in the precipitation of minerals. Biologically induced mineralization is the chemical modification of an environment by biological activity that results in supersaturation and the precipitation of minerals. Microbially induced calcite precipitation (MICP) refers to the formation of calcium carbonate from a supersaturated solution due to the presence of their microbial cells and biochemical activities. In this project, Bio blocks are developed by calcium carbonate (CaCO3) precipitation process and controlled by MICP process. In this study, Steel slag and lime sludge are used as calcium sources for the induction of CaCO3. Steel slag is not only used as a source of calcium, and it is substituted for sand in bio-block. The induction of CaCO3 precipitation binds steel slag grains together at the particle-particle contacts, which increases the strength and stiffness of the bio-block. The types of bacteria that are used in the bio -block for mineralization are Bacillus Pseudofirmus, Bacillus subtilis and Bacillus megaterium. The project aims to use the industrial residue, steel slag as binding material instead of Portland cement. Steel slag has less cementitious in nature. However, Carbon di Oxide (CO2) can activate steel slag to form definite carbonate bond matrix. Therefore, steel slag is an ideal storage stock for CO2 sequestration, which is one of the greenhouse gases. Nevertheless, the CO2 sequestration due to normal mineralization in steel slag is not very efficient.*

Key Words: Bacteria, Calcite Carbonate Precipitation, Compressive strength, Environmental Protection

1. INTRODUCTION

The Bacillus megaterium and bacillus subtilis continuously precipitates a calcite over a brick with a high impermeable layer, which increases the compressive strength and prevents the water into the brick, which increases automatically durability of the brick. In the production of bio-brick which consists of complex biological as well as a chemical reaction takes place during calcium carbonate precipitation. The below chemical equation represents a biological process of the Bio-brick calcite precipitation. This chapter deals with the manufacturing process of Bio mineralised steel slag bricks by using bacteria and waste material of steel slag from industry. The introduction of bacteria and nutrients to sand, and through bacterial processes of calcite precipitation binds particles together, ultimately creating a sandstone material. The use of slag from steel plant in the manufacturer of bricks useful disposal but also help in environmental pollution control. The properties of Bio mineralised steel slag bricks such as strength and carbon uptake were mainly investigated.

2. MATERIAL

This chapter deals with the manufacturing process of Bio mineralized steel slag bricks by using bacteria and waste material of steel slag from industry. The introduction of bacteria and nutrients to sand, and through bacterial processes of calcite precipitation binds particles together, ultimately creating a sandstone material. The use of slag from steel plant in the manufacturer of bricks useful disposal but also help in environmental pollution control. The properties of Bio mineralized steel slag bricks such as strength and carbon uptake were mainly investigated.

The types of bacteria used in the bio brick for mineralization are

- Bacillus megaterium
- Bacillus subtilis

2.1. BACILLUS MEGATERIUM

The Bacillus megaterium is a aerobic spore forming neutralophilic bacterium found in diverse habitats but commonly regarded as a soil bacterium. Its ability to utilize different carbon sources and grow at a wide temperature range 3o C to 45o C makes it an ideal industrial process. Bacillus megaterium has been industrial employed for more than 50 years, as it possesses some very useful and unusual enzymes and a high capacity for the production of exoenzymes. It is also a desirable cloning host for the production of intact proteins, as it does not possess external alkaline proteases and can stably maintain a variety of plasmid vectors.

Fig -1: BACILLUS MEGATERIUM

2.2. BACILLUS SUBTILIS

The bacillus subtilis cells are rod-shaped gram-positive bacteria that are naturally found in soil and vegetation bacillus subtilis grow in the mesophilic temperature range. The optima temperature is 25o C to 35o C. Stress and starvation are common in this environment therefore, Bacillus subtilis has evolved a set of strategies that allow survival under these harsh condition makes it an ideal industrial process

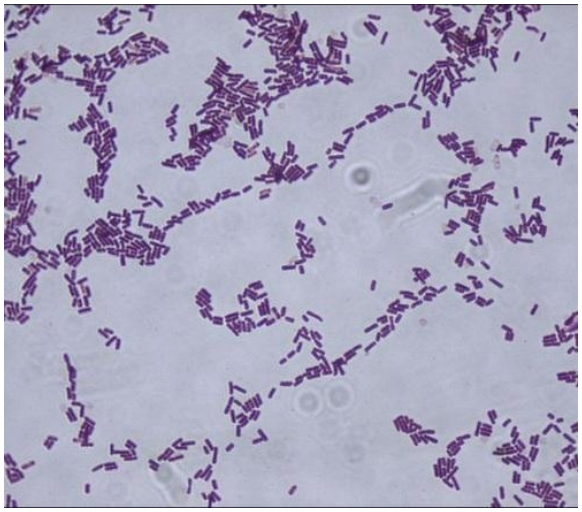

Fig -2: BACILLUS SUBTILIS

3. RAW MATERIAL

3.1. Steel slag

The steel slag characteristics vary between the grades of the steel. Higher grades of Steel have high carbon content and lower grade of steel slag have low amount of carbon and combination of atmospheric oxygen to produce the CO2.The initial stage of steel slag is formed from manufacturing process of steel is called as furnace slag. Molten steel is poured in to ladle. This form of steel slag is helps to absorb the lot of De oxidation contents to produce another type of slag is called as Raker slag. These steel slags are used as replacement of aggregates in Bio bricks. To develop the bonding capacity without addition of sand. This process of manufacturing steel slag consists of higher amount of silicates. In lot of industries the steel slag will manufacture by oxygen process. The gives the production process of steel slag.

3.2. LIME

Lime originates with its earliest use as building mortar and has the sense of sticking or adhering. Lime obtained from rocks and minerals cut, crushed, or pulverized and chemically altered. Burning converts them into highly caustic material Quicklime and by addition of water, it turns into less caustic called slaked lime or hydrated lime. The process is called slaking of lime. Slaked lime is also called as calcium hydroxide. It is a colourless, crystal or white powder. Lime is another material to replacement of

sand particle in Bio bricks is shown. It is also used as a binding material in Bio bricks. In this project lime is obtained from Mercury chemicals.

3.3. SUPER-ABSORBING POLYMER (SAP)

Sodium polyacrylate is an example of a super-absorbing polymer. It is a cross-linked (network) polymer that contains sodium atoms. It absorbs water by a process called osmosis. When the (sodium-containing) polymer is placed in contact with water, there is a tendency for the sodium to distribute equally between the network and the water. That means, some of the sodium atoms want to leave the network and move to the water. When these sodium atoms leave, they are replaced with water molecules. Water swells the polymer network to try to keep the sodium concentration balanced between the polymer and the water. The cross-links that connect the chains together prevent them from dissolving/breaking apart in the water. Sodium polyacrylate can absorb 800 times its weight in distilled water, but only 300 times its weight in tap water, since tap water contains some sodium, calcium and other mineral salts.

Fig -3: SUPER-ABSORBING POLYMER (SAP)

4. EXPERIMENTAL

MANUFACTURING PROCESS OF BRICKS

(a) Collect the waste material,

(b) Mixing of waste material,

(c) mixing bacteria and Super-Absorbing Polymer

The collection of material and mixing with bacteria to develop the bonding strength of bricks. To achieve the higher strength of bricks by using waste materials are compare than conventional clay bricks. High amount of 42% steel slag is mixing with 50 ml of bacteria in addition with distilled water 650ml in this mix proportion creates the better strength of Bio bricks. In lime has high amount of calcium is produce the high compressive strength to bricks.

Nutrient broth medium at daily of 100ml/ 1.3gram. Fabrication process is proceeding at room temperature. The bacteria culture then collected and add to Super-Absorbing Polymer (SAP) which absorbed the bacteria and stored inside.

4.1. FABRICATION PROCESS

The bricks are building materials which are generally available as rectangular blocks. The initial process of bricks the wooden mould (230mm x 110mm x 75mm) is placed at ground and it is open at top and bottom. The oil is applied at four sides of the mould. The Oil is required to reduce the friction of this bricks at the time of remoulding. The mixing of these materials was filled in wooden mould and tamping at number of blows to reduce the pores in bricks. In these bio mineralized steel slag bricks were got high bonding strength at mixing duration. The raw material is mixed and Super-Absorbing Polymer (SAP) is added to the mix and it had been transferring to the fabrication at sudden period. The brick mound is then lifted up from the ground. So, these bacteria produce the self-healing capacity at when these bricks were effect of weathering.

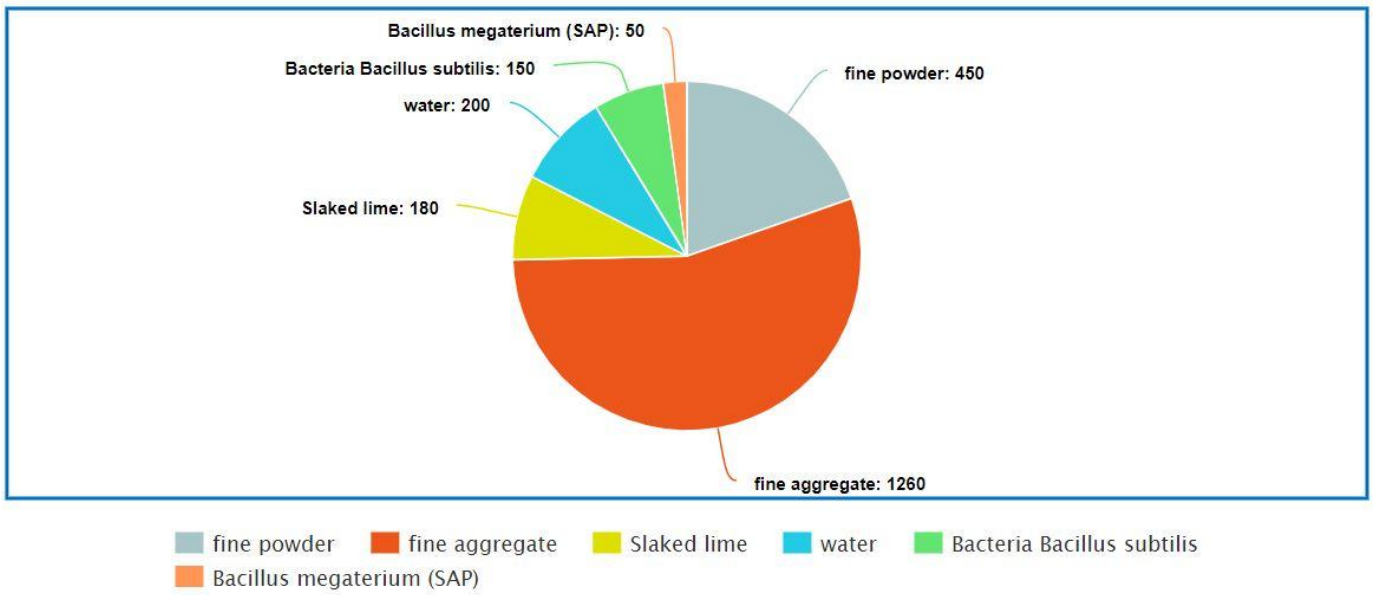

Fig-4: brick composition pie chart

TABLE -1: BRICK COMPOSITION

		Steel slag				Bacteria	
S.No	**Steel slag/ Slaked lime**	**fine powder**	**fine aggregate**	**Slaked lime**	**water**	**Bacillus subtilis**	**Bacillus megaterium**
1	0.4	450 kg/m³	1260 kg/m³	180kg/ m³	200 ml /m³	150 ml /m³	50 grams /m³

4.2. BRICK MOULDS

The bricks are mounding with suitable Mix proportions of mineral. The bricks were manufacturing with sharp corner edges and less pores in it. To develop the porosity of bricks by using these waste materials. Brick mould are dry up to 3hour at the time the carbonation process will started using CO2 present in the air. These bricks are getting proper finishing and smooth surface of this material.

4.3 CARBONATION PROCESS

The rate of carbonation is accelerated by supplying carbon dioxide from external resource at certain pressure. Leakage proof, chamber is connected to Co2 cylinder. Steel slag bricks are placed inside the chamber for hours, and Co2 is supplied to the chamber at a pressure of 0.3Mpa. This accelerated carbonation is done for different combinations of brick. It consists of a compressed Co2 Gas cylinder, Carbonation chamber, pressure transducer and a pressure regulator. Gas Pressure is maintained at 0.3MPa. The formation of calcium carbonate mineral present at following equation.

$$CaO + CO2 \longrightarrow CaCO3$$

The carbonation chamber of capacity of six bricks is developed using cylinder. The Bottom of the cylinder is sealed and the top cover is provided with Rubber seat in order to avoid the leakage of carbon dioxide. The carbon di-oxide is supplied through the nozzle provided at the top of the cylinder. This carbonation process is done for bio bricks with bacillus megaterium and bacillus subtilis bacteria.

5. RESULTS AND DISCUSSION

The bio mineralized steel slag bricks were tested in compressive strength testing machine This test is carried out by following the guide lines of IS: 3495 (part 1) - 1992.The crushing strength varies with the different ratio and nutrient broth supply conditions. The high compressive strength was observed for bricks with bacillus subtilis and megaterium bacteria with

artificial supply of CO2. This increase in compressive strength is due to presence of bacteria and artificial supply of CO2 which is responsible for reduction in porosity. The production extra cellular calcium carbonate forms a dense structure. The bricks show an increase in strength for 0.5 % of SL/SS ratio.

5.1. COMPRESSIVE STRENGTH WITH ACCELERATED CARBONATION

The compressive strength of the bricks also tested for bricks with external CO2 supply. In this, we can observe that the strength of all the bricks was improved after carbonation process. The strength of the bricks shows an increase in strength of 52% bricks. Here we can notice that the bricks with SL/SS ratio of 0.5% show an increase in strength.

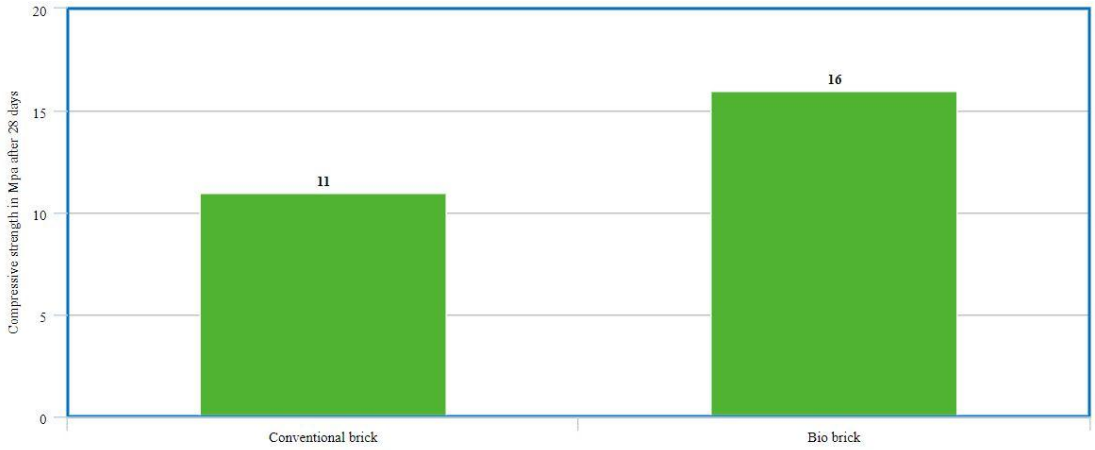

Fig-5: COMPRESSIVE STRENGTH

5.2 WATER ABSORPTION WITH CARBONATION

The water absorption test helps to identify the porosity and permeability capacity of bio mineralized steel slag bricks. The after carbonation of bio mineralized steel slag bricks the strength properties was developed. The porosity and permeability properties are reduced in bio mineralized steel slag bricks after carbonation. The different mix proportions of bio mineralized steel slag bricks were investigated in water absorption test with carbonation. For comparison of water absorption in bio mineralized steel slag bricks at before and after carbonation test results

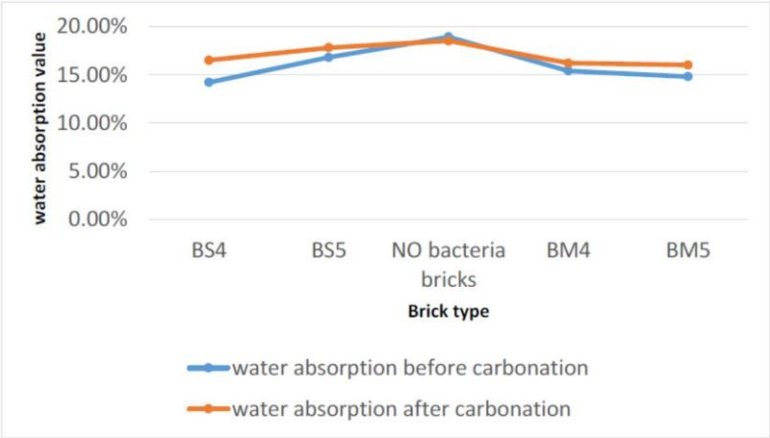

Fig-6: WATER ABSORPTION WITH CARBONATION

CONCLUSIONS

From the above experimental investigation, the conclusion is explained below, Calcium Carbonate precipitation is achieved in the steel slag bricks by bio-mineralization. The bio-mineralization is activated by the artificial supply of CO2.The present study develops the strength of bio mineralized steel slag bricks by using Bacillus subtilis and Bacillus megaterium bacteria. The highest compressive strength of bio mineralized steel slag brick prism is 25 MPa. bio mineralized steel slag bricks and prism were analyzed by ANSYS and ABAQUS. The chemical composition analysis helps to identify the calcium carbonate content

growth in between initial day to final day by using artificial supply of CO2 and the slow release of Bacillus megaterium bacteria by using super-absorbing polymer. Water absorption capacity showed direct influence amount of calcium carbonate precipitation in bricks. SEM and XRD analysis indicate the development of strength by these microbial activity and formation of extra cellular calcium carbonate precipitation in bricks.

REFERENCES

[1] Abhjit Mukherjee, Navdeep Kaur Dhami, B.V.V. Reddy, and M. Sudhakara Reddy (2011)" BACTERIAL calcification for enhancing performance of low embodied energy soil-cement bricks "International conference on sustainable Construction and Building Materials and technologies, Vol.3, pp. 2-10

[2] D. Bernardi, J.T DE Jong, B.M. Montoya, B.C. Martinez D (2014), „BIOBRICKS: BIOLOGICALLY cemented sandstone bricks", Construction and Building Materials, Vol.55, pp.462–469.

[3] D. Karunagaran (2014), „Eco Friendly Brick Produced by the Reaction of Bacteria", SSRG International of chemical engineering research, pp.1-5.

[4] Hamid Kalhori, Raheb Bagherpour (2017), „Application of carbonate precipitating bacteria for improving properties and repairing cracks of shot Crete", Construction and Building Materials 148.

[5] Salwa mutlaq al-thawadi (2011), Ureolytic bacteria and calcium carbonate formation as a mechanism of strength enhancement of sand", Journal of Advanced Science and Engineering Research, Vol.1, pp. 98-114.

[6] Kai Wang, Chunxiang Qian, Ruixing Wang (2016), „The properties and mechanism of microbial mineralized steel slag bricks", Construction and Building Materials, Vol.113, pp.815–823.

[7] Meena murmur (2011) „Evaluation of strength characteristics of steel slag hydrated matrix", Construction and Building Materials, pp.1-81.

[8] Nithiya (2016), „Experimental investigation on bricks by using various waste materials", International journal of latest trends in engineering and technology, Vol.6(3), pp.395-402.

[9] Willem De Muyncka, Nele De Beliea, Willy Verstraeteb (2010), „Microbial carbonate precipitation in construction materials: a review", Ecological Engineering, Vol.36, pp.118–136.

[10] Vignesh Kumar and Soundara (2016), „Study on strength and durability properties of steel slag bricks" Construction and Building Materials, Vol.2 (2).