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An Experimental Analysis on Bacterial Brick and Comparing with Conventional Brick

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***Abstract*: 1.3 trillion bricks are manufactured for each year, out of this 10 percentages of bricks made through the hands on coal-burnt ovens. Kiln burnt brick emits about 1.4 pounds of carbon per brick, which pollute the atmosphere severely all over the world. This paper discusses about the preparation of ecofriendly bricks using the bacteria which will give effective way to settle down in the natural process. The bacteria that is used for the repair of brick to eradicate the plugging of pores and to avoid the cracks in the brick. In this process it utilizes the microbial mineral precipitation to manufacture the bricks which will improve its behavioural patterns. It will also discuss about the chemical processes took place in the brick. The present research helps the construction industry as well as public to increase the brick durability and reduce the carbon emission, which results to a pollution free environment.**

***Keywords*: bacterial brick**

1. Introduction

This paper discusses about the brick manufacturing with use of the microbial bacteria. The brick that forms the major component in the construction which will show the easy availability and the convenient cost. It uses the microbiologically induced calcium carbonate precipitation (MICP) to settle down the soil and it will be creating more stability to the brick. It will also use this for the various process. It has the ability to set the heal the crack of the construction materials. It will induce some microbial actions which will results some sedimentation process. In this process the bricks can be manufactured in the room temperature itself. In this process the microbiological calcite precipitate will stick as microbes in the sand that joined together like glue which results the brick that turns to the sand stone.

2. Methodology

The raw materials which are required for the manufacture were collected depends upon the quantity needed. The raw materials used in this project are sand, lime powder and bacteria. The collected raw materials are tested based on the nature. Specific gravity test and grain size distribution test are performed for sand. Fineness test, initial setting time test, final setting time test and specific gravity test for lime. The material which satisfies all the above test are thus taken to the further process.

The bacteria selected for generating calcium precipitate should satisfy the following criteria;

1. Calcium concentration.
2. The value of pH.
3. Nucleation availability
4. Dissolving organic carbon.

The bacteria which satisfies all the above-mentioned criteria is selected for this project and the project is proceed by using the bacteria. Generally, bacteria belong to bacillus genus satisfies all these conditions. These type of bacteria has a self-healing capacity, which is used to fill cracks in the surface of concrete. The main purpose of this bacteria is to generate calcite crystals.

Bacillus thuringiensis is a common soil bacterium. These bacteria have the ability for calcite precipitation and solidify the given soil by calcium and urea through process of biochemical reaction. The soil is the major raw material for production of bacterial bricks. Urea is an organic compound used as food for bacteria. Water is the important element in producing a bacterial brick. The water stimulates a chemical reaction when it gets mixed with the soil, hydration process starts sequentially. The quantity and quality of the water are the key parameters to get a good compressive strength.

The method starts with mold preparation. Mold is prepared by a wooden frame. The inner dimension of the wooden frame is like conventional brick dimension 20 x 10 x 7 cm. Soil is mixed with water and filled in the mold as three-layers. Each layer is well compacted to attain a maximum dry density which reduces pores in the brick which results an increased durability and compressive strength of brick without any heating process. The solution contains urea, calcium oxide and micro-organism bacillus thuringiensis is mixed and poured into the wooden mold. After few days bacteria consumes urea as food and precipitates calcite between the soil grains. In this process chain of Biochemical reaction takes place on hydrolyzing urease enzyme with water it generally forms two compounds. They are:

1. Carbon dioxide
2. Ammonia.

$(NH_2)_2CO + H_2O \rightarrow CO_2 + 2NH_3\ CaO + CO_2 \rightarrow CaCO_3$

The presence of ammonia will increase the pH in the brick which helps to have the crystalline structure for the brick. The

carbon dioxide then reacts with calcium oxide (CaO) to form calcium carbonate. At last the calcium precipitate helps in changing soft clay into crystalline form and then converted into hard bricks.

Manufactured brick kept under the room temperature for 3 to 5 days to attain full growth. In the construction of the wall using bacterial brick the strength and durability of the brick increases because of the bacterial growth. When the water seeps through cracks of the brick and reaches the bacteria, again the biochemical reaction is stimulated and calcite precipitate is formed along the crack occurred in brick.

3. Tests on bacterial bricks

The following tests are performed on bacterial bricks to check its suitability for construction purpose. The various test conducted on bacterial bricks are as follows:

- Absorption test
- Crushing strength test
- Hardness test
- Shape and size test
- Color test
- Soundness test
- Structure of bricks

Our bacterial brick satisfies all the above test and it can be used for a construction purpose.

A. Water absorption test

The rate of water absorption is one of the important parameter of the brick because it affects mortar and grout bonding during the wall construction. If the brick absorbs more water content from the mortar, that results in the reduction of the strength of brick. In this test, the selected bacterial bricks are dried in the oven at 1050 C to 1100 C and the process continues until they attain practical standard weight. The bacterial bricks are removed from the oven and kept at the room temperature. Now measure the weight of the brick at the dry stage and kept it as W1 kg. After the dry brick immersed in the water completely for 24 hours then the weight of the wet brick be W2 kg.

The quality of the brick is divided into three categories based on the water absorption of brick by Indian standard (IS: 1077: 1992) bricks classification and specification. First quality brick should not absorb the water more than 20 percentage of its own weight. Second quality brick should not absorb water more than 22 percentage and third quality brick should not absorb the water more than 25 percentage. The results of water absorption test indicate the conventional brick absorbs morewater than the bacterial brick which is shown in table 1. Hence the bacterial brick significantly satisfied the requirement of Indian standard (IS: 1077: 1992) brick classification and specification.

B. Crushing strength

A trial consists of 3 bricks of each case are considered. The brick is placed in compression testing machine with the smooth surface on the top. Steel plate should be kept over a brick specimen to withstand the load and the load is applied gradually to the brick. The load is applied until the brick fails.

Table 2 shows the compressive strength test result and the comparison of compressive strength between bacterial brick and conventional brick. The bacterial brick gives higher compressive strength compared to the conventional brick. The average strength of bacterial brick is 9.16 N/ mm2which is more than the conventional brick 7.7 N/ mm2. The compressive strength difference between the conventional and bacterial bricks is found to be nearly 19%. This result shows us the bacterial bricks are much stronger than the conventional bricks and hence results in higher durability.

C. Hardness test on bacterial bricks

A good brick should be resistant to scratches against sharp things. For this test, a sharp edged tool or finger nail is used to make scratch on brick. The brick is said to be hard if it is free from scratch impression. The brick satisfies this condition so it is fit for construction.

D. Soundness test on bacterial bricks

Soundness test of bricks show the behavior of brick against sudden impact. In this test, two bricks are chosen randomly and struck with each other. Then sound produced must be clear bell ringing sound and brick would not break. The bacterial brick satisfies this condition and it will not break, therefore it could be used for construction purpose.

E. Color test of bacterial bricks

A good brick shall possess bright and uniform color throughout its body. The bacterial brick possesses bright and uniform color throughout its structure; hence it is fit for construction.

F. Structure of bacterial bricks

A bacterial brick is picked randomly from a group of bricks and broken into two pieces. The inner portion of the brick is observed, if it is free from lumps and it remains homogeneous then it is said to be a good brick.

Table 1
Water absorption test of conventional brick and bacterial brick

S. No.	Size of Bricks (cm)	Identification mark	Dry weight (kg)	Wet weight (kg)	Percentage of water absorption
1	21x10x 10	Conventional brick	3.22	3.89	20.8%
2	20x10x 7	Bacterial brick	3.33	3.96	18.9%

Table 2
Crushing strength value of bricks

Crushing strength value of conventional brick(N/ mm^2)	Crushing strength value of bacterial brick(N/ mm^2)
7.7	9.16

G. Shape and size test

The standard normal size of the bacterial bricks is 20cm x 10cm x7cm. If all the bricks are of similar size, then it is qualified for construction work.

4. Conclusion

This paper gives the solution for the process of brick making using the bacteria. Since the bacteria will be used for the many purpose it can also use in the construction and this process will be used for the brick manufacturing. The different types of bacteria with different properties to produce the amount of calcite precipitation may help the chemical process. It will observe the significant strength of bacteria in the manufacturing of bacterial brick. The brick making process will vanish the carbon dioxide associated with the fire. The carbon will be removed from the atmosphere because of the bacteria. The process has also the potentiality to remove the pollution from the environment.

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