International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.11 No.02, pp 132-136, 2018

A Comparative Analysis of Bacteria Made Bio Brick and Conventional Brick

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Abstract : All over the world brick manufactured nearly 1.3 trillion brick for each year, in this 10 percentages of bricks made through a hand in coal-fired ovens. Coal-fired brick emits 1.4 pounds of carbon per brick, which pollute the atmosphere severely all over the world. The large export countries like india & china facing the problem of carbon emission. On another side modernization took place in the construction industry, due to the modernization durability of the structures reduced. Brick is the most used construction material in the construction from the ancient time itself. The manufacturing of conventional brick requires a high temperature, hence this research focused on developing a biobrick with a help of bacteria named as bacillus pasteuri, which has characteristic of calcite precipitation. The present research helps the construction industry as well as public to increase the brick durability and reduce the carbon emission, which results pollution free environment. The brick manufactured by bacteria, which reduce the carbon emission nearly 800 million tonnes per year.
Key Words : Sustainability, Bacteria, Calcite Precipitation, Compressive strength, Environmental Protection.

Introduction

Brick is an important construction material from the ancient time itself, but even though after the modernization in the construction industry, there is a research gap in the development of eco-friendly brick. The brick manufactured with the raw material of clay through three sequential stages like molding, drying and burning process, in which burning process requires high temperature. The high temperature produced from the woods which lead to deforestation at the same time it releases carbon and pollutes the atmosphere severely. Biobrick is aspecial type of brick. It has automatic ability to repair itself. Humans have power to precipitate minerals through teeth and bones, not only a human even micro-organism also have the ability to precipitate the minerals.Likewise,Bacillus Pasteruiis the soil bacteria which have characteristic of calcite precipitation.

International Journal of ChemTech Research, 2018,11(02): 132-136.

DOI= http://dx.doi.org/10.20902/IJCTR.2018.110215

The Bacillus Pasteruii 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 increasesautomatically durability of the brick. In the production of bio-brick which consists of complex biological as well as achemical reaction takes place during calcium carbonate precipitation.The below chemical equation represents a biological process of the Biobrickcalcite precipitation-

$$(C_a^{2+} + CO_3^{2-} \rightarrow C_aCO_3 \downarrow)$$

In the part of metabolism Bacillus pasteuri precipitate, a numerous amount of urea,which stimulates the urea to produce $CO_2$and ammonia, sequentially pHvalue increased in the surrounding, where ions Ca^{2+} and CO_3^{2-} precipitate as $CaCO_3$. In conventional brickscracks are inevitable in which water infiltrates through these cracks initiates corrosion and thus reduce the life of brick. Bio brick is an innovative construction material for polluted countries.Various literaturehas been studied to precede this research and the following literature core concepts were considered and analyzed. Karunagaran discussed the preparation of soil brick with help of Bacillus pasteuribacteria to improve the brick durability without affecting the environment. The process of manufacturing brick in this method requires less manpower andthe brick formed at the room temperature. The bio brick produced from the bacteria through a calcite precipitation which will reduce the environmental pollution and increase the structure durability[1].Vekariyastates microcracks are the important resonate for structural failure. The author defines different type of bacteria with their biochemical reaction. The brick manufactured bybacteria is betterthan many conventional brick manufacturing technologies because ofself-healing and eco-friendlycharacteristics. The Author gives a certain advantage to the improvement of brick compressive strength, reduction permeability in the brick which results inincrease of the durability of the brick[3].Reddy aims to develop the mathematical model to identify thestress-strainbehavior of brick. Researchers used Bacillus subtilus bacteria for precipitating the calcite carbonate which seals the brick surface through a thick layer of calcite crystals. The above process automatically prevents water seeps through a brick[4].Pratyushsuggested that the brick is very commonly used construction material which has fewer crack resistance and high water absorption. In some cases, brick exposed to various atmospheric conditions and it leads to the deterioration of brick surface and develops aninvisible crack.The author looks at the innovative idea to avoid these causes by the use of bacteria in a brick production. Different species of micro-organism has thecluster to prepare a brick and properties of brick measured. The result shows 36 percentage of compressive strength increased than the conventional brick manufacturing[5].

The developed innovative construction material of AAC block forenvironmental friendly. The AAC brick requires less amount of heat energy compared to the conventional brick manufacturing process. When compared to conventional,non-conventional brick costsless,energy consumption and carbon emission parameters which helps to the sustainable production of the brick. The researchers attempt to replace red brick with AAC block. The AAC block reduces 20 percentage of dead load on the structure. There areCertain advantages listed by the researcher are 2-3 times lighter weight compared to the conventional brick, faster construction, and fire resistant[7]. The brick exposes to the different atmospheric condition which contains polluted gas. The Main factor influencing the brick is the durability. In recent days (MICCP) (microbiologically induced calcium carbonate precipitation) is the best method to improve brick properties[8].Ramakrishnan introduced a novel technique for remediating cracked bricks through calcite precipitation. In the manufacturing process of brick, living organism forms inorganic solids. Bacillus Pasteruii is a type of soil bacteria which has numerous amount of calcite precipitation. The compressive strength and stiffness of the fractured bricks can be enhanced by adopting these techniques[6].

Experimental

Material

Bacillus Pasteruii is the common soilbacteria.It is also called as Sporosarcina pasteuri from ancient taxonomy. These bacteria have the ability to precipitate calcite and solidify the given soil by calcium and urea through the way of biochemical reaction. Thesoil is the major raw material to producebio bricks. Urea is an organic compound used as food for bacteria. Water is the important element in producing a bio brick. The water stimulatesa chemical reaction when it mixed with the soil, sequentially hydration process starts. The quantity and quality of the water are the key parameters to get a good compressive strength.

Method

The method starts withmold preparation.Mold is prepared by awooden frame.The inner dimension of the wooden frame is like conventional brick dimension 19 x 19 x 9 cm. Figure 1 shows soil mixed with water and filled in the mold bythree-layers. Each layer is compacted well to attain a maximum density and it reduces pores in the brick which results inincreased durability and compressive strength of brick without heating process. The solution contains urea, calcium chloride andmicro-organism bacillus pasterui is mixed and poured into the wooden mold. After few days bacteria consume urea as food and precipitate calcite between the soil grains. In this process chain of Biochemical reaction takes place to harden the brick. Manufactured brick kept under the room temperature for 28 days to attain full growth. After the construction of the wall using bio 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 brick's crack.

Figure 1: Mixing of the soil with Biochemical solution

Results and Discussion

The brick removed from the mold after the 14 days of the growth of micro-organism and it kept for another 14 days in the free air for curing. After the 28 days, the cured bio brick are tested for compressive strength and water absorption. A conventional brick is also manufactured at the same time along with bio bricks and the same tests are repeated.

Water absorption test

The rate of water absorption is the important parameter of the brick because it affects mortar and grout bonding during the wall construction. If the brick absorbsmore water content from the mortar, that results in the reduction of the brick's strength. In this test, the selected bio bricks aredried in the oven at 105^{o} c to 110^{o} c and the process continues until they attain practical standard weight. The bio bricks are removed from the oven and kept atthe room temperature. Now measure the weight of the brick at thedry stage and kept it as W1 kg. After the dry brick immersed in the water completely for 24 hours then theweight of the wet brick be W2 kg.Figure 2 shows the setup of water absorption test.

Figure 2: Brick immersed inwater for 24 hours

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 shouldnot absorb water more than 22 percentage and third quality brick should not absorbthe water more than 25 percentage. The results of water absorption test indicate the conventional brickabsorbs morewater than the bio brickwhich is shown in table 1. Hence the bio brick significantly satisfied the requirement ofIndian standard (**IS: 1077: 1992**) brick classification and specification.

Table 1 Water absorption test of conventional brick and bio brick

S.NO	Size of Bricks (cm)	Identification mark		Dry weight (kg)	Wet weight (kg)	Percentage of water absorption
1	**19x9x9**	Conventional brick	Sample **A**	3.22	3.89	**24.07 %**
			Sample **B**	3.56	4.20	
			Sample **C**	2.90	3.89	
2	**19x9x9**	Biobrick	Sample **A**	2.95	3.68	**19.92 %**
			Sample **B**	3.35	3.89	
			Sample **C**	3.33	3.96	

Compressive strength

Both conventional and bio bricks each of 9 specimens are made for the compressive strength test. Initially, 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 specimento withstand the loadand the load is applied gradually to the brickat the rate of 14 N/mm^2. The load is applied until the brick fails.

Figure 3 shows the compressive strength test result and the comparison of compressive strength between bio brick and conventional brick.The bio brick gives higher compressive strength compared to the conventional brick. The average strength of bio brick is 9.16 N/mm^2which is more than the conventional brick 7.7 $N/mm^{2.}$ The compressive strength difference between the conventional and bio bricks is found to be nearly 19%. This result shows us the bio bricks are much stronger than the conventional bricks and hence results in higher durability.

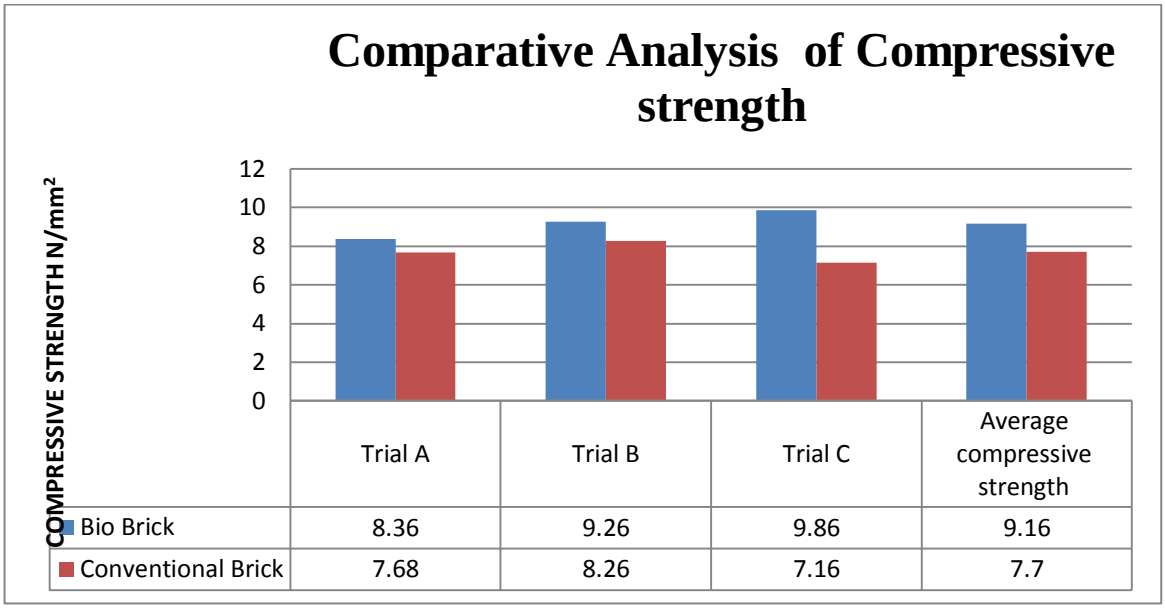

Figure 3: Compressive strength test of conventional and bio brick

Hardness test

Bio bricks are tested for its hardness with the help of fingernail. None of the bricks has shown impression on the surface of the brick, which implies all the bricks are harder in nature.

Soundness test

In the soundness test, two bio bricks are struck with each other. It indicates that all the bricks have clear ringing sound with no damage at the edges of the bio bricks.

Conclusion

The conventional brick are used in the construction industry for so many years, even though, it has limitations. This makes a researcher to develop innovative and alternative material for conventional brick. Therefore,the researchers developed bio brick by the use of micro-organism to precipitate calcite in between the soil grains. On comparing the conventional brick with bio brick, the bio brick has the higher compressive strength of 9.16 N/mm^2. The bacteria's in the brick precipitatecalcite in between soil grains and fills the pores and thus increases density. This increase in density directs the automatic increase in compressive strength. The bacteria consume water and stimulate biochemical reaction again,in which calcite precipitated in between the crack, increases the durability of the structure. Bio bricks are manufactured without the heat energy and absorb less water compared to the conventional bricks.

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