International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 09, September-2015

Study of Replacement of Cement by Lime in Manufacturing Soil - Cement Brick

Eliedson De Carvalho/Sheyla Marques
Emanuel Amaral/José Diôgo De Almeida
Department of Civil Engineering
Federal Institute of Alagoas - IFAL
Palmeira dos Indios AL, Brazil

Eliedson De Carvalho
Coordination for the Improvement of Higher Education Personnel – CAPES
Brazilian Science Mobility Program
Northern Virginia Community College
Annandale VA, United States

***Abstract*—Production of soil-cement bricks when compared to production of ceramic bricks can be an ecologically viable alternative. Since the first process does not use burning in its manufacturing, it can avoid air pollution and deforestation. This article aims to analyze the effectiveness and feasibility of manufacturing holed soil-cement bricks that are produced in a hydraulic press, with total and partial replacement of cement by hydrated lime as from binary and ternary compositions. In this research, the study of the characteristics of the brick was made by using an experimental methodology involving five different mixtures of soil, cement (14%, 12%, 8%, 4%, 0%) and lime (0%, 2%, 6%, 10%, 14%) respectively in these proportions. The tests were performed over seven and fourteen days (cure period) with fifteen specimens for each mixture in order to find a composition with the best cost-effectiveness for its application in large-scale manufacturing. Tests of mass loss by immersion, water absorption and compressive strength were performed to characterize the bricks. The results are expressed in the article and are classified as favorable according to Brazilian Association of Technical Standards - ABNT.**

Keywords—Soil-Cement Brick; Lime; Ecological Brick.

I. INTRODUCTION

Searching for a decent house is a natural inclination that exists in each human being. In the Brazilian constitution, having a decent house is considered a fundamental right of life. According to the Brazilian Institute of Geography and Statistics (IBGE), the housing deficit in Brazil grew by 30% in the last 10 years, which accentuates the necessity to build new low-cost housing. Therefore, it is essential for new systems and technologies to emerge that can help neglected families enjoy their constitutional rights. In the building of affordable housing, the utilization of so-called ecological bricks (made from soil-cement) is widespread by the virtues of its quick production, lack of need for specialized labor, and the possibility to be manufactured in a collective community effort, providing a satisfactory social and economic return.

Soil-cement bricks represent an alternative in harmony with the guidelines of sustainable development because they require low power consumption in the extraction of raw material, do not require the process of burning, and reduce the necessity of transport since the bricks can be made of soil that comes from the own place of building [10]. Through the use of holed brick, there is a remarkable reduction in waste and volume of generated rubbish. Furthermore, the holed brick can speed up the construction process, provide economy of materials and labor, and eliminate the destruction of walls for passage of pipes. Since the bricks have holes that are overlaid in the cement, they form ducts through which the wires and hydraulic lines are passed. [12]

Lime has been used in construction for over 4000 years because it is an air binder. Specifically, it obtains its hardening properties by the reaction with carbon dioxide (CO2) in the atmosphere. Therefore, it was chosen for use in manufacturing the bricks in binary and tertiary compositions. Beyond lime's binding property evidenced in mortar, it is also regarded for its water retention capacity that avoids detachments in masonry and minimizes shrinkage in curing.

The objective of this research is to study the partial or total replacement of Portland cement by hydrated lime. It is intended to evaluate the technical feasibility of the bricks' use and the influence on the brick's quality.

II. MATERIALS AND METHODS

The research procedure was primarily based on studying material characterization as well as on conducting tests of mass loss by immersion, water absorption, and compression resistance.

A. Raw Material

- Soil – it is a vital constituent in the manufacturing of soil-cement bricks. As the most abundant element in the mixture, it directly influences the final quality of the brick that is produced. Sandy soil is best suited because it usually has a composition of about 70% sand and 30% clay. The Brazilian Technical Standard 10833 [7] stipulates that the soil must have a liquid limit of no more than 45% and a plasticity index of less than 18%. The soil that was used in this research was collected around the Federal Institute of Alagoas - Campus Palmeira dos Índios from the land removed for construction of new institution facilities.
- Cement - Portland cement is the product obtained by pulverization of clinker, which essentially consists of hydraulic calcium silicates, with a certain proportion of natural calcium sulfate that contains additions of substances to modify its properties or facilitate its use [9]. In the production of samples, the 'Portland cement CP II-Z 32 RS' was used because it is pozzolanic, common, and easily acquired due to its popularity.

ISSN: 2278-0181
Vol. 4 Issue 09, September-2015

- Hydrated Lime – In construction, hydrated lime is used as a key element in the preparation of settlement mortar and long lasting coating. Its use in soil-cement bricks is validated since it can further increase the plasticity and useful life of the brick. Being an alkaline product, hydrated lime prevents oxidation of fittings, and also due to this characteristic, it acts as a bactericide and fungicide. Furthermore, it helps prevents the formation of stains and early decay of masonry. During this research, we used the hydrated lime CH-I, which is sold in 20 kg bags

B. *Dosages*

According to the Brazilian Association of Portland Cement [8], the determination of the best dosage to manufacture brick consists of a test sequence and a subsequent interpretation of established criteria in the experiment, in order to find the ideal compositions of soil, cement, and lime.

The following table depicts the five compositions that were utilized in the process of testing and characterization of samples:

TABLE I. DOSAGES OF EACH SAMPLE COMPOSITION

COMPOSITION	CEMENT (%)	LIME (%)	SOIL (%)
01	14.0	0.0	86.0
02	12.0	2.0	86.0
03	8.0	6.0	86.0
04	4.0	10.0	86.0
05	0.0	14.0	86.0

C. *Sample Modeling*

The dried constituents, which include soil, cement, and hydrated lime, were weighed and mixed until achieving a mass with uniform color, to which water was then added to attain a new homogenization. When the mixture reached a perfect state, it was brought to the hydraulic press (Fig. 1) to model the brick. Then, the sample was removed to start its healing process.

Fig. 1. Hydraulic Press

Figure 2 shows a sample of the holed soil-cement brick after its healing process:

Fig. 2. Holed Soil-Cement Brick

III. RESULTS AND DISCUSSION

A. *Grain Size Analysis*

The soil grain size tests were performed according to the Brazilian Technical Standard 7181 [3]. The results are shown below (Figure 3):

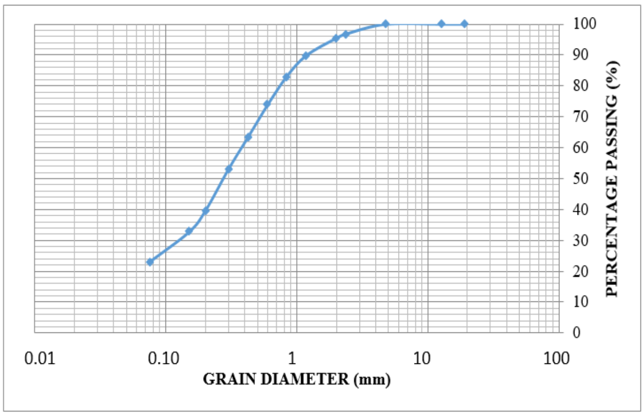

Fig. 3. Graph of Soil Grain Size Analysis

As shown at Figure 3, the soil presents several grain sizes, which means it has sufficient characteristics to be used in soil-cement brick manufacturing.

B. *Liquid Limit*

The liquid limit test followed the Brazilian Standard [1], as well as its specificities.

The Brazilian Standard for soil-cement brick manufacturing requires a liquid limit lower than or equal to 45%. The average of the six tested samples had a result of 30% that effectively meets the standard. From the results, it is possible to plot the following graph:

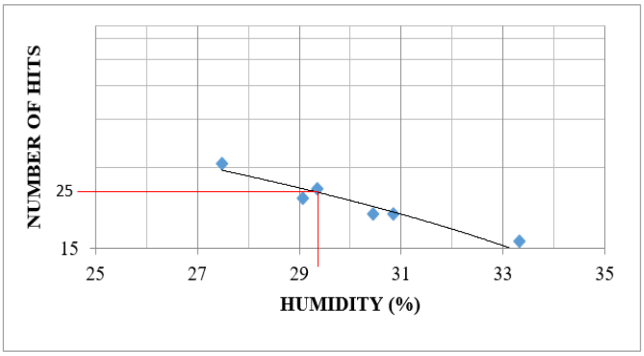

Fig. 4. Graph of liquid limit and 25 hits standard point

C. *Plastic Index*

The five tested samples presented an average plasticity limit of 22%. Since the plasticity index is given by the difference between the liquid limit and the plasticity limit, we obtained an index of 8%, meeting the standard that requires a value less than 18%.

D. *Water Absorption*

The test results are below the 20% threshold that is stipulated by the Brazilian Standard. The composition 01 samples (14% cement) had the highest absorption. Brick samples produced by the addition of 2%, 6% and 10% lime did not show significant difference. On the other hand, the composition 05 samples that contained only lime and soil did not present any result because the bricks disintegrated when they came into contact with water. The following graph shows the average results of water absorption under the conditions mentioned above:

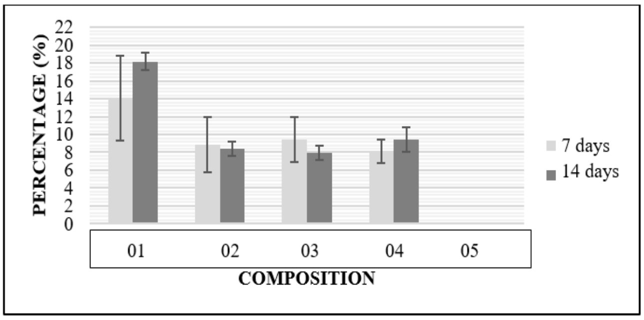

Fig. 5. Water Absorption Results (%)

E. *Mass Loss by Immersion*

The results are shown in the following graph:

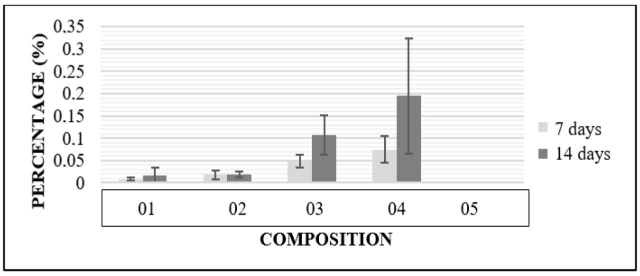

Fig. 6. Results of Mass Loss by Immersion (%)

The composition 01 and 02 samples showed the best results and did not present significant difference. However, it was observed that the percentages of wasted dry matter did not exceed the maximum value of 5% that is required by the Brazilian Test Method [11] for any of the compositions.

F. *Compression Resistance*

The following graph shows that the first three compositions responded positively according to the Brazilian Standard that requires a minimum resistance of 2 MPa at the age of 28 days.

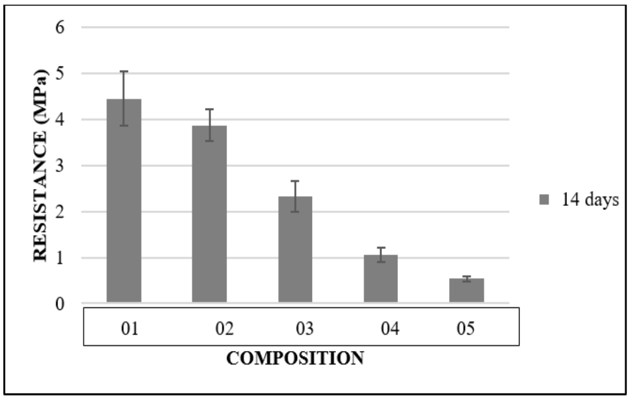

Fig. 7. Results of Compression Resistance (MPa)

IV. CONCLUSION

Since the results were analyzed as satisfactory to the minimum requirements of the technical standards, the holed soil-cement bricks with the incorporation of hydrated lime seem to be a viable ecological alternative.

As the research is still in progress, we expect to finalize the best composition based on resistance and a cost benefit analysis. Then, we plan to create a collective group effort in order to help a neglected community to produce the bricks in an attempt to give them the chance of having a better life.

ACKNOWLEDGMENT

The authors wish to express their sincere gratitude to Coordination for the Improvement of Higher Education Personnel and Northern Virginia Community College for providing us the opportunity to participate of the Brazilian Science Mobility Program, which made possible to write this paper. In addition, the writers truthfully thank Federal Institute of Alagoas for helping them and sponsoring this research. Finally, the group wants to acknowledge the support of Dr. Sheyla Marques who has been essential for this research by conducting and supervising the students.

REFERENCES

[1] Brazilian Association of Technical Standards – ABNT. "NBR 6459: Solo -.Determinação do limite de liquidez. Método de ensaio" (Soil – Determination of liquid limit - Method). São Paulo, 1984. 6p.

[2] Brazilian Association of Technical Standards – ABNT. "NBR 7180: Solo - Determinação do limite de plasticidade. Método de ensaio." (Soil – Determination of plasticity limit – Method). São Paulo, 1984. 3p.

[3] Brazilian Association of Technical Standards – ABNT. "NBR 7181: Solo – Análise granulométrica. Método de ensaio." (Soil – Grain Size Analysis – Method). São Paulo, 1984. 15p.

[4] Brazilian Association of Technical Standards – ABNT. "NBR 7182: Solo – Ensaio de compactação. Método de ensaio." (Soil - Test of soil compactation - Method). Rio de Janeiro, RJ, 1986. 10p.

[5] Brazilian Association of Technical Standards – ABNT. "NBR 7215: Cimento Portland – Determinação da resistência à compressão." (Determination of compression resistance). Rio de Janeiro, RJ, 1996. 8p.

[6] Brazilian Association of Technical Standards – ABNT. "NBR 8491: Tijolo maciço de solo-cimento. Especificação." (Soil-cement solid brick). Rio de Janeiro, RJ, 1994. 4p.

[7] Brazilian Association of Technical Standards – ABNT. "NBR 10833: Fabricação de tijolo maciço e bloco vazado de solo-cimento com utilização de prensa hidráulica. Procedimento." (Manufacturing of soil-cement bricks and blocks with hydraulic press). Rio de Janeiro, RJ, 1989. 3p.

[8] ABCP - Brazilian Association of Portland Cement. "Boletim Técnico 112- Fabricação de tijolos e blocos de solo-cimento com a utilização de prensas manuais." (Manufacturing of soil-cement bricks and blocks with manual press). São Paulo, 1988.

[9] Bauer, L. A. Falcão. "Materiais de construção." (Construction Materials). 5th. Rio de Janeiro: LTC - Livros Técnicos e Científicos Editora S.A., 2005.

[10] Grande, F. M. "Fabricação de tijolos modulares de solo-cimento por prensagem manual com adição de sílica ativa." (Manufacturing of soil-cement bricks with manual press plus adding silica fume). São Carlos: EESC-USP, 2003. 165p. Dissertação Mestrado – Escola de Engenharia de São Carlos, Universidade de São Paulo.

[11] ME-61 – "Métodos de ensaio determinação da perda de massa por imersão de solos compactados com equipamento miniatura." (Methods of determination of loss mass by immersion to compacted soil). Recife, 2003. Vol 12/ME-61.

[12] Souza, M. I. B. "Análise da adição de resíduos de concreto em tijolos prensados de solo-cimento." (Analysis of adding concrete waste in soil-cement bricks). Ilha Solteira: UNESP, 2006. 121p. Dissertação Mestrado.