Construction and Building Materials 52 (2014) 391–395

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Innovative interlocked soil–cement block for the construction of masonry to eliminate the settling mortar

Liliana Fay [a,b,*], Paul Cooper [b], Henrique Fay de Morais [c]

[a] *Universidade Federal Rural do Rio de Janeiro, Rio de Janeiro, Brazil*
[b] *University of Wollongong, Faculty of Engineering, Sustainable Buildings Research Centre, NSW, Australia*
[c] *Escola Superior de Propaganda e Marketing – ESPM, Rio de Janeiro, Brazil*

HIGHLIGHTS

- We develop a fitting construction component aiming the construction of masonry without mortar.
- Soil can be stabilized and your impermeability and mechanical resistance increased with the addition of other materials.
- Prototypes were tested with three different mixtures of soil–cement.

ARTICLE INFO

Article history:
Received 30 September 2013
Received in revised form 11 November 2013
Accepted 11 November 2013
Available online 8 December 2013

Keywords:
Block
Soil–cement
Fitting system
Innovative masonry

ABSTRACT

The current work developed the morphology of a new component of construction made with an easy acquisition and low cost material: soil–cement, a material and procedure proven, tested, and regulated. The redesign of a new construction component aims to facilitate the rise of the masonry through an innovative construction process, in which the settling mortar can be eliminated with a perfect fitting system. With the fitting block designed, the mould for pressing was developed and prototypes were conformed in three soil–cement mixtures showing production feasibility. Tested according to the related standards, the prototypes were submitted to resistance of compression, water absorption and sizing. The results showed that only the water absorption parameter did not comply with the standards and therefore must be targeted by future research in order to improve the mixture composition.

1. Introduction

Due to the increased industrialization process, the construction industry has become more like the other industries, guided by the same production laws, and the usage of the earth has been gradually replaced by increasingly sophisticated materials such as steel, concrete, aluminium and plastics.. However, the earth has been revealing itself as the material with the highest potential to reintroduce the traditional economic and constructive habits. These habits, though very important, must not preclude, in any way, the search for new materials and techniques consistent with environmental friendly practices, and so contribute to the formulation of cheaper and simpler processes [1].

Raw earth and industrial wastes may have their water proof and mechanical resistance substantially increased with the simple addition of other materials in a stabilizing role, even in small quantities, such as lime, cement and chemical additives. This technique is nowadays called “cold or unfired stabilization”. From the early eighties until today, numerous studies have been implemented on the application of traditional materials and on the reuse of industrial wastes as raw materials for the manufacture of basic building components for residential construction. Among them is the soil–cement that was standardized by ABNT.[1]

Currently many Universities and Research Institutions have been investigating this topic and trying to draw the attention of the housing sector for this issue.

According to CASTRO [2], the product engineering deals with the manufacturing processes and quantitative methods for the products definition, whereas the industrial designing process suggests a product conception method that is integrated to the process conception. The innovative technological alternatives are a group of options that theoretically satisfy the social, economic and environmental conditions and that may inspire innovative solutions compared to traditional techniques.

* Corresponding author at: University of Wollongong, Faculty of Engineering, Sustainable Buildings Research Centre, NSW, Australia. Tel.: +61 242392198.

E-mail addresses: lilifay@ufrrj.br (L. Fay), pcooper@uow.edu.au (P. Cooper), hfay1@hotmail.com (H.F. de Morais).

[1] ABNT – Associação Brasileira de Normas Técnicas (*Brazilian Association of Technical Standards*).

0950-0618/$ - see front matter
http://dx.doi.org/10.1016/j.conbuildmat.2013.11.030

When due to restrictive conditions it is impossible to apply to the building a highly mechanized industrial assembly, execution of construction processes through joined effort utilizing rationalized components becomes an alternative. Then there is the need to place emphasis on rational design for the components involved in the construction of residences to achieve desired productivity in terms of number of units produced.

The application of soil–cement as raw material in the manufacture of building components comes to meet this requirement due to be a low cost material with great durability; in addition, it is adaptable to stable configurations so has multiple possibilities for its use as building material.

2. Objectives

The objective of the work was to rationally develop the project of a component aiming to the construction of masonry without mortar. This was done through the development of a soil–cement block plug that would provide stability of the shape and also ensure a perfect fitting system. This component should be part of a masonry construction system capable of dealing with a modular architecture without losing the flexibility of adaptation required by the other systems, following the population growth and urban expansion.

As a specific objective it aimed to enable the manufacturing process and testing of prototypes with three different mixtures of soil–cement according to the ABNT standards of soil–cement.

3. Manufacturing of soil–cement blocks

According to Oliveira [3], the typical manufacturing process of the soil–cement blocks includes: identification and extraction of soil, the storage of the raw materials, the process of crumbling the clods and sifting, the soil dosing, the addition of stabilizers and/or additives and water, the homogenization and conformation of the mixture, followed by drying and curing of the final product, and finally the quality control and the product certification. Packaging and conveyance are included in the distribution.

The conforming process of the soil by dry-pressing is one of the simplest and most used. The soil, with low humidity ratio or containing a binder, fills a metallic mould onto which the pressure is applied through a puncture in order to form the green compact. It is a relatively low cost process that may be used to obtain components of different shapes on a high scale manufacturer. Representing the synthesis of the whole process, the conformation is the most important part as it is responsible for shaping the components and thus defining their role.

The compacting pressure is the factor that determines the component properties. Regardless of the used stabilizer, the compacted soil properties vary linearly and directly related with the increment on the compacting pressure up to 4 or 10 MPa, depending on the soil's characteristics; from this point on, the properties become either asymptotes or even reverse the behavior for some types of soil. From 0.7 MPa of pressure the components already present conditions for being used by masonry. It is desirable to have pressures applied as to achieve 100% of compaction compared to the normal 'proctor' test, although 80% still result in good products. The compaction rates, which depend on the applied energy and on the soil's characteristics, must stay within the ratios of 1.65:1 and 2:1 [4]. The operation cycle of a press includes 3 steps: mould feeding, compacting and extraction of the component. The feeding may be manual or automatic, either way caution must be taken so the volume of received material by the mould is always constant. Regarding the compaction, with mechanical presses the pressure is applied until the end of the defined course generally defined by an eccentric mechanism whereas with hydraulic presses the pressure may be set to change when the piston reaches a certain point or when the power system achieves its maximum pressure. The component's extraction is done normally by displacement of the mould's bottom that pushes it upwards until the edge.

Fig. 1 illustrates the distribution of density within the cylindrical mould according to the pressing conditions.

After the conformation the product needs to lose the added water at the same time as it participates in the chemical reaction of the stabilizer. Either way, the drying process provides a humidity gradient between the centre and the surface of the component. The quality of the final product depends on a series of controls performed onto the raw materials, the production process and the final product. Common controls include soil control (homogeneity and particles' size), humidity control (of the soil and the mixture) and product control (dimensional control, mechanical resistance control and durability control) [5].

3.1. Hollow soil–cement blocks

The soil–cement blocks are similar to the bricks of soil–cement in everything except the shape, the holes and the press needed for the production. Their dimensions require the hydraulic press, with double direction compaction. The hydraulic press with only one compaction direction is used for the manufacturing of components with maximum height of 80 mm and has one compacting piston whereas the press with two compaction directions is utilized for the manufacturing of components up to 200 mm high and has two compacting pistons.

3.2. Standardization and legislative framework

The ABNT standards [6–9] for the manufacturing and testing of soil–cement blocks, specifications summarized in Table 1, were introduced in the eighties when the IPT[2] and the BNH[3] made researches regarding the soil–cement. Out of those, the ones still valid are:

As for the characteristics of the soil, the requisites include passing through (100%) the sieve ABNT number 4 (4.8 mm), 10 to 50% through the ABNT sieve number 200 (0.075 mm), having no more than 45% for the liquid limit and an plasticity index of no more than 18%.

Aiming not to hamper the production process, the NBR 10835 allows the manufacture of blocks with different dimensions as long as their other characteristics still comply with the standard and the parts involved on the deal agree.

4. Redesign discussions

The redesigning project of the fitting block shape, with the main function of optimizing the constructive process of the masonry by eliminating the settling mortar, also considering who will use it, where and how it will be used, accounting for the following parameters: shape and role, modulation, ergonomics, aesthetic and appearance, technique, costs and sustainability.

4.1. Shape and role

The conforming process of a component for a constructive group is determined by the technical function that must be

[2] IPT – Instituto de Pesquisas Tecnológicas de São Paulo (*Technological Research Institute of São Paulo*).

[3] BNH – Banco Nacional da Habitação (*National Bank for Housing*).