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Experimental and numerical study of Interlocking Stabilized Earth Blocks mechanical behavior

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ABSTRACT

One of the modern techniques of earth construction is the Interlocking Stabilized Earth Block (ISEB), which realizes the requirement of a certain type of construction in an economic and technical way compared to conventional materials. The use of this technique fits suitably within the framework of high environmental quality since the process uses an abundant material not requiring a lot of transformation energy.

The aim of this study is to perform compressive tests on superposed ISEB that are laid dry without grout mortar. Testing results show that the contact area and the clearance between the blocks have an effect on the masonry's compressive strength, causing it to decrease. For that, particular attention is given to analyzing the contact area effect on the mechanical behavior of superposed ISEB. A finite element method (FEM) analysis is also performed in order to highlight the effect of the local stress around the clearance on the macroscopic compressive behavior of the masonry. Finally, a simplified spring model is considered in order to estimate the vertical apparent Young's modulus of ISEB walls.

1. Introduction

In Tunisia, for several decades, earth construction has been neglected due to the development of conventional materials such as cement and concrete. Today, because of the ecological and social contexts, we begin to show a higher interest for earth. Stabilized Earth Blocks (SEB) through the techniques of molding blocks can be a solution used for load bearing masonry. In fact, the high energetic burning process at high temperature of earth blocks is replaced by a further compaction by using a mechanical press and through the provision of stabilizers [1–5].

Various works have been carried out in order to study the physical and mechanical behavior of SEB such as; compressive strength, density, stabilizer content, durability, water absorption, shrinkage and thermal conductivity [6–11]. Indeed, a major focus was mortar's characteristics [12–16]. Interlocking Stabilized Earth Block (ISEB) laid dry without grout mortar has recently appeared. This technique is faster and presents an economical advantage because it can be handled easily. Although interlocking blocks were studied a few years ago [17–19], little attention has been paid to the effect of interlocking on the mechanical properties of the earth structures.

This paper focuses on an experimental and numerical study of the mechanical behavior of the ISEB under compression. The compression tests on one smoothed block, two interlocked blocks and three interlocked blocks will be first presented. Then, the effect of the interlocking and the contact area between the blocks on their mechanical behavior will be analyzed. A simplified Finite element modeling of the tests will be performed. The superposed blocks with clearance between them will be assumed linear elastic with a criterion limiting the principal stresses by the tensile and compressive strengths of the material and a Coulomb friction criterion limiting the stress vector components at the interface between blocks. Afterwards, a comparison between numerical and experimental data will be presented. Finally, a simplified approach is proposed to predict analytically an equivalent vertical Young's modulus of ISEB considered homogeneous.

2. Description of the used ISEBs

The ISEBs used in this work were provided by SOIB which is an industrial unit in Tunisia. These ISEBs are prepared by a locally available red earth, sand and addition of 8% of ordinary Portland cement. The selected soil was air dried and sieved 8 mm sieve. The stabilized soil was then mixed and hydraulically compressed in a mould under a pressure of some 12 MPa using equipment supplied by Hydraform Concepts which is the Hydraform block making machine. The main objective of soil compaction is to increase its density and strength and to reduce its porosity and sensitivity to water. The blocks obtained are stacked and cured by spraying

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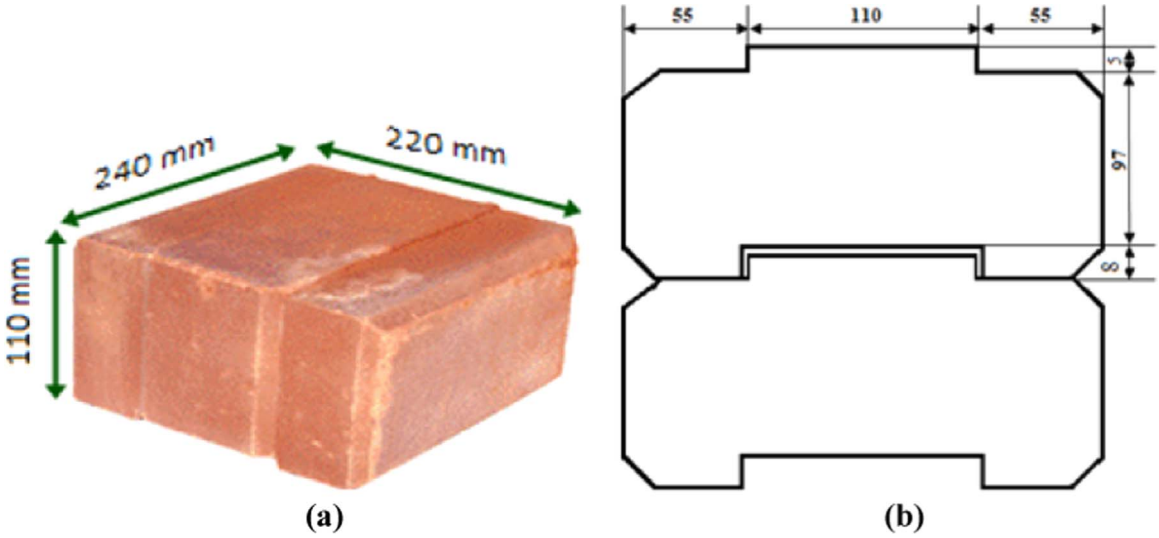

Fig. 1. Interlocking block: (a) block's geometry; (b) block's design and dimensions (dimensions in mm).

water for 7 days under a tarp. When cured, the blocks can be dry-stacked.

The ISEBs were 240 × 220 × 110 mm blocks designed according to the African Regional Organization for Standardization (ORAN) [20]. Blocks are laid with two heels on each other without mortar (Fig. 1).

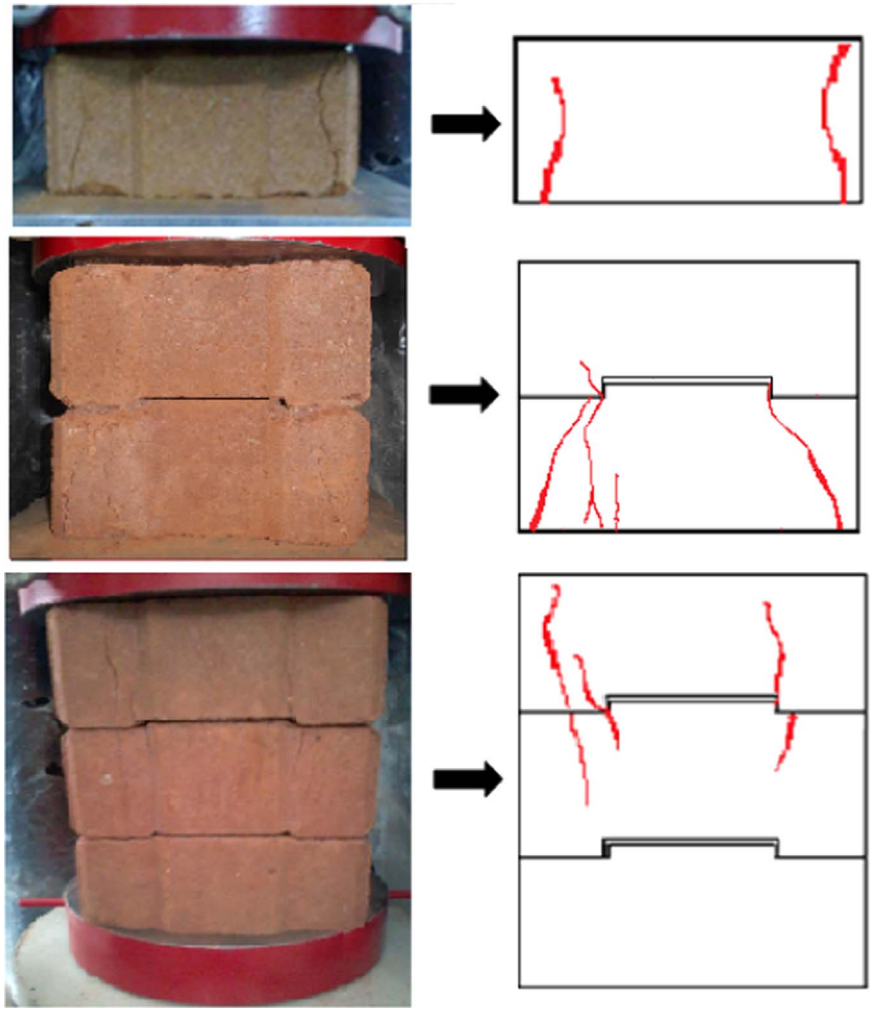

Fig. 2. Compression tests and cracking pattern for one block, two and three interlocked blocks.