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Vernacular housing practices in Burkina Faso: representative models of construction in Ouagadougou and walls hygrothermal efficiency

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Abstract

In Burkina Faso, particularly in Ouagadougou, the walls of the houses are made of several local materials. The choice of a material implies a suitable constructive technique and an appropriate architecture. The walls are either earth-based, i.e. Compressed Earth Blocks (CEBs) or Adobe, or based on cement-based materials such as hollow concrete blocks. This paper proposes a description of the vernacular construction practices according to the material used for the walls and tries to explore the hygrothermal behaviour of various wall compositions. A hygrothermal simulation of a hollow concrete blocks wall and a CEBs wall using the WUFI®Pro software is carried out in order to compare the humidity flux passing through interior surface of each wall and to analyze the influence of integrated moisture in the calculation of heat flow. It is shown that, for CEBs wall, both thermal and hygrothermal simulation of heat flow give similar results.

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Keywords: Earthen bricks; Compressed earth blocks; Hollow concrete blocks; Hygrothermal properties;Climate; Building materials;Architecture

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1. Introduction

Materials used by humans in building construction require energy for their production or extraction. According to the World Business Council for Sustainable Development, the construction sector uses 40% of the total energy produced in the world. The building sector alone accounts for over half of the world's CO2 emissions [1]. To reduce these emissions, housings must be adapted to the climatic context, and to some extend based on local materials. In Burkina Faso, the government has initiated some research and promotion programs on so-called "friendly materials". One of the government's projects was LOCOMAT, from 1991 to 2011. The LOCOMAT project's strategies included the promotion of local building materials, i.e., earth-based materials. The choice of wall materials is influenced by various factors including climatic response, availability, cost, and socio-cultural parameters. The traditional architecture of Burkina Faso, due to populations' values, cultures and climate, is characterized by earth-based techniques [2] but there is an increase of constructions made with imported material like cement. 2006 statistics show that 69.4% of the dwellings have adobe walls, and 13.8% have walls in hollow cement blocks [3]. Cement-based constructions are gaining popularity despite the fact that their "modern" materials and architecture are not adapted to the local climate and are suspected to create discomfort. On the opposite, recently developed earth based techniques such as compressed earth blocks (CEBs) or clay bricks are supposed to improve the comfort in housing due to their high thermal inertia and capacity to regulate the moisture [4].

It is possible by means of a hygrothermal simulation to show the efficiency of the materials of the walls in hot and dry climate. Many studies focus on predicting the indoor thermal climate and use a thermal or hygrothermal simulation of building envelope. Fati Z. and al.[5] modeled a dwelling and studied the time lag of several building materials from Burkina Faso including earth materials according to the geographic orientation of each walls. In [6], a dynamic thermal simulation is carried out using TRNSYS in dry and hot climate and gives, for dwelling made with CEBs, interior temperature and humidity during one year. In [7], a combined heat and moisture simulation is being conducted with different types of CEBs walls. This paper is part of a more comprehensive research on earthen habitat in a hot and dry climate. In addition to the previous research, this paper shows the influence of humidity gradient in dynamic environment on the calculation of thermal transfer through a CEBs wall and the moisture flow through compressed earth blocks wall and hollow concrete blocks wall.

2. Objective and method

Several materials are used in vernacular architecture to build the walls in Burkina. These walls' energy efficiency aspect particularly deserves to be studied in this hot and dry climate. Previous researches have investigated the energy efficiency of different walls in this environment. We try to integrate the effect of the hygric properties of materials on mass and on heat transfers through the walls and see how this can have an impact on indoor climate. Therefore, we need to classify the architecture according to the nature of the walls. We can distinguish three types of houses described below: *Modern cement block houses; houses from Adobe blocks* and *houses whose walls are made of compressed earth blocks*. This distinction has been established through contacts with local actors, field immersion and literature review. Four architects, two associations, one builder and *several* construction sites were surveyed. The description of each case is based on field observations supported by the literature[2, 8, 9].

2.1. Modern cement block houses

This type of dwellings represents 48% of the buildings in Ouagadougou[3]. These buildings' envelopes are made of cement materials (Fig. 1). The envelopes are usually composed of a cement exterior coating of 2 cm, a hollow concrete blocks wall of 15 or 20 cm and a cement interior coating of 2cm. For esthetical finishing, a layer of paint can be applied on interior and exterior coating. The bricks are built using a cement mortar of vertical thickness between 3 and 8 cm. The roof can be heavy or light. In the first case, it consists of reinforced concrete floor. In the case of a light roof, the frame is made of wooden rafters or metal tubes directly supported by the walls or reinforced concrete beam. The whole is covered by a sheet metal. When the walls are load-bearing, the foundations are made of cement concrete and cement cyclopean concrete. When the walls are not load-bearing, the stability is ensured by a system of beams,