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Performance assessment of earth constructions under the Chilean energy rating system software

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Abstract

This research aims to evaluate the benefits of energy savings in earth constructions, in the Chilean climatic context. Another aim is to identify how well CCTE_CL v2.0 software (CCTE), used by the Chilean energy rating system, is able to predict energy consumption in earth constructions. Understanding the parameters, assumptions and limitations utilized by the software and how they affect the evaluation is also within the aims. A case study with exterior earth walls was created and compared with a second model with a lightweight construction system. Both exterior walls have the same U-value; therefore, its difference remains only in the mass of the exterior walls. The models were built in CCTE software and then replicated in a more advance software, in this case Design Builder. This allowed for comparing their performance. It was found that the use of earth walls is able to generate a reduction in energy demand when compared to a lightweight construction system. Another finding is that, although CCTE software is able to address the incorporation of earthen materials and predict the benefits of thermal mass, some parameters embedded in the software can lead to an underestimation of the benefits of an earthen house. The previous, when results are compared to an evaluation performed with parameters considered by more advanced and complex software tools.

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Keywords: Earth construction; thermal mass; rating tools; simulation software

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1. Introduction

Earth has been used as a construction material since more than 9000 years ago and examples can be found all around the world[1].It has also been estimated that from one third to one half of the world's population lives in earth houses[2]. Nevertheless, nowadays modern earth buildings need to fulfil more requirements than their previous counterparts, like thermal regulation codes and requisites related to energy consumption and comfort. In order to check compliance with these new requirements, different tools have been developed. Sustainable rating systems, certifications and software products are among them. The previous has brought with it a concern because some regulation codes, their rating tools and the software on which they rely for the assessment procedure, do not provide results that coincide with the actual performance of earthen houses. Discrepancies have been attributed, among other factors, to the fact that codes and computer modelling tools are based completely on the steady-state thermal resistance of materials where only the U-value is relevant [3]. This is without considering that the greatest advantages of earthen materials are within its dynamic and hygrothermal behaviour, as a result of the simultaneous absorption, storage and release of both heat and moisture [4].

Several studies have evaluated the impacts of thermal mass on energy consumption and/or comfort [5; 6; 7; 8; 9; 10; 11]. Results vary widely among them considering the studies have been conducted in a wide range of climates. Two of them found that the use of massive walls, versus lightweight constructions, reduces heating energy consumption but increases, slightly, the cooling energy loads [7; 9]. Zhu, et al. [9] also concluded, after two years of monitoring two built houses, that the interior surface temperature of massive walls remains more stable than the interior surface temperature of a wood frame system. This leads to a more stable and comfortable indoor temperature in the massive-wall house. It was also confirmed that the mass walls have the ability of time lagging the transmission of heat. Kosny, et al. [6] after simulations for 10 U.S climates with a residential building with massive materials on external walls versus a lightweight system, concluded that in a wide range of U.S climates, heating and cooling energy requirements can be reduced when wood-frame systems are replaced with massive walls of an equivalent R-value. Currently some standards and thermal code regulations have recognized the benefits of the use of thermal mass in some climates by allowing less insulation levels, or a specific U-value increase, for buildings that incorporate thermal mass in comparison with lightweight construction systems like metal or wood-frames. ASHRAE standard 90.1 2010 for example, for its prescriptive method, admits around a 30% increase in U-values when thermal mass is used for exterior walls [10].

Earth also has a humidity buffer capacity which is its potential to stabilise indoor relative humidity fluctuations. This means it is able to absorb, store and release water vapour. Several studies related with hygrothermal properties of earth construction technologies have been carried out [12; 13]. They studied the effects, on indoor relative humidity values, of the use of stabilised rammed earth and clay composite as internal coating. In both cases the relative humidity fluctuations were reduced.

Related to the Chilean context, in 2013, an energy rating system for housing was launched. It is expected to provide information and to influence the decision making process when buying a new dwelling. Although it is at a pilot stage, the plan is to make it mandatory. The rating system includes CCTE_CL v2.0 (CCTE) software as an alternative method to calculate energy demand and check compliance with the thermal regulation. The Chilean thermal regulation requires that the envelope of every residential building comply with a maximum thermal transmittance threshold. When CCTE software calculates the monthly and annual building energy consumption, it compares the energy demand with the demand of a reference building, assumed to have same geometry, characteristics and usage profiles of the initial one, but thermal transmittance values for the building envelope's components equivalent to the maximum ones allowed for the specific climatic zone [14]. Therefore, its main objective is to be a compliance check tool.

This study aims to evaluate the performance of an earthen house versus a lightweight system and understand its impact on energy savings in the Chilean climatic context. Also it aims to identify how well CCTE software is able to predict energy consumption in the case of earth constructions and understand the parameters, assumptions and limitations utilized by the software and how they could affect the energy rating of earth construction technologies.