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REVIEW

Review of economic and environmental benefits of earthen materials for housing in Africa

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Abstract
Solutions to housing problems must deal with the issue of building materials – especially advancing those which lower construction cost and costs to the environment. This paper aggregates and reviews empirical evidences to show the advantages and disadvantages of earthen construction materials in terms of cost, energy and thermal properties. We reviewed 136 academic outputs from 17 African countries. Apart from a few studies that differ, literature concurs that earthen construction materials are generally cheaper, cleaner and more thermally comfortable. Notwithstanding the advantages, the level of uptake is presently low. Earthen materials' strength and durability are key limitations. We identify possible areas for future research and present specific recommendations that can promote the uptake of earthen materials for housing construction in African cities.

Contents

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1. Introduction and motivation

Challenges associated with delivering adequate and affordable housing to people in the low-income category is usually linked to the issue of construction materials and technology. Literature shows that materials constitute the largest single input in housing construction, accounting for 60–70% of total cost in Ghana (Danso and Manu, 2013), around 65% in Nigeria (Mogbo, 1999), over 76% in Tanzania (Wells et al., 1998) and 68% in Kenya (Syagga, 1993). A number of scholars have established the fact that escalating cost of building materials is one of the major factors responsible for the widening gap between demand and supply of affordable and adequate housing (Adedeji, 2007; Zami and Lee, 2010; Assaf et al., 2010; Kulkarni et al., 2014). Two-digit inflation on the price of construction materials, in the recent years, have resulted in continual increase in housing costs in some countries (Tesfaye, 2007; Kanjumbaf et al., 2016).

Housing inadequacy is not only a function of rising prices. The impact of construction materials and technology on the environment deserves attention. Housing demand and investment opportunities that accompany urbanisation mean greenhouse gas (GHG) emissions through construction might double by 2050 (UNEP/CIDB, 2009). Most part of the resources needed to build houses for all are non-renewable. These problems motivate the need to (re)consider the promotion of materials that result in lower construction costs and minimal costs to the environment.

Earthen construction materials, with a long history in Africa (Fathy, 1973; Denyer, 1978) are one of the most experimented technologies in the current search for economically and environmentally sustainable housing (Dayaratne, 2011). They are known for certain advantages and disadvantages which have not been sufficiently understood, documented or regulated, thus hampering appropriate knowledge sharing within Sub-Saharan Africa (Obonyo et al., 2010). Benefits associated with this material are not fully explored because research outputs have not been properly brought together (Adogbo and Kolo, 2006). The absence of aggregated empirical evidence on the touted benefits and little-known demerits of earthen materials motivates the review reported in this paper.

We review literature providing evidence on the advantages and disadvantages of earthen construction in terms of cost, energy and thermal properties. By identifying and discussing available proofs, we seek to further arouse interest in earthen materials and technologies in housing projects in African cities. Review on an indigenous building material like this can inform policy in this part of the world where urbanisation is putting pressure on economic, ecological and environmental resources (Wells, 1995; Adegun, 2011).

1.1. Categories of earthen systems used in housing construction

Earthen construction materials and technologies, as considered in this paper, are in four broad categories – simple clay (adobe) blocks, rammed earth, clay/soil plus other components and machined blocks. Fig. 1 shows an example in each of the categories. While rammed earth (Fig. 1a) is associated with wall construction, cob and straw, pole and mud, wattle and daub, earth-bags are examples of clay's combination with other components (Fig. 1c, e and f). Machine processed blocks are mechanically compressed or oven-baked and then stabilised or strengthened with materials or additives such as cement, fly ash and fibre. Cement Stabilised Earth/Soil Blocks (CSEB/CSSB), Interlocking Stabilised Soil Blocks (ISSB) and Composite Compressed Earth Block (CCEB), shown in Fig. 1d, fall into this last category.

2. Review methods

This review includes five steps (after Green, 2005): (i) framing a question (ii) identifying relevant studies (iii) assessing the studies (iv) extracting evidences (v) analyzing and presenting findings. A comprehensive search for academic outputs (from 1980 to 2016) was conducted in Scopus and Google scholar databases. Google scholar complements Scopus/Web of science because it 'covers more publications and citations' and includes 'publications produced by researchers in developing countries that cannot afford the ISI's or Elsevier's subscription' (Onyancha and Ocholla, 2009:62).

The search algorithms combined words such as 'earthen', 'adobe', 'mud/clay', 'rammed earth', 'building', 'housing'. The initial and general search returned over 8000 outputs in both Scopus and Google scholar. A country-specific refinement then followed (See Table 1 for numbers returned per country). A total of 136 publications - journal articles, conference proceedings, book chapters, thesis/dissertations, reports related to earthen building and housing were selected from the country-specific outputs. Although not all the 136 outputs selected dealt with the economic, energy and environmental merits and demerits of earthen housing, they reflect the geographical distribution of earthen building/housing bibliography in Africa. Question about the advantages or disadvantages of earthen construction over other materials guided a review of the selected papers. The outputs, and their references, were reviewed to identify cases of merits and demerits in comparison with other materials.

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