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Effects of thermal insulation on thermal comfort in low-income tropical housing

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Abstract

This paper evaluates the effects of thermal insulation on thermal comfort in low-income tropical housing in Uganda. Dynamic thermal simulations are conducted to assess the effects of wall, roof and floor insulation strategies. 96 combination scenarios are simulated for various geometries, insulation and construction methods. Adaptive approach is used to evaluate the conditions within the case study buildings. The results indicate that external wall insulation improves thermal comfort in all conditions whereas internal wall and floor insulation may deteriorate the conditions. Roof insulation is the most effective strategy to reduce the risk of overheating. Due to the effectiveness of roof insulation and marginal improvements of external wall insulation, especially for brick walls, wall insulation may be disregarded when used in conjunction with roof insulation.

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Keywords: Thermal Comfort; Overheating; Tropical; Low-income; Housing; Uganda

1. Introduction

Uganda is an East African country with a population of around 39 million people and an area of over 241 thousand square kilometres [1,2]. According to UNDP [3], with an HDI score of 0.483 Uganda is ranked 163 out of 188 countries in the Human Development Index. Around 38% of Uganda's population live in poverty [3]. Over 60% of Uganda's

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urban population live in slums [4,5] and over 50% live in single-roomed overcrowded properties [6] built from low quality materials (Figure 1). Moreover, rapid urbanisation and growing housing demand are some of the other current challenges of the country [7]. Currently, embodied energy of construction methods and materials seems to be the major challenge which requires immediate attention to mitigate negative environmental effects of the construction industry [8,9].

Fig.1. Low-income housing.

Adobe, cob, rammed earth, wattle and daub (also known as mud and poles), burned bricks, stabilised earth blocks; and concrete are the most common walling materials used in many developing countries including Uganda [10,11,12,13,14]. Table 1 shows the most common construction methods/materials in urban areas of Uganda. Over 84% of homes in urban areas of Uganda are covered with iron sheet and 12% with thatch. With nearly 84%, brick is also the most common walling material and cement/concert (71%) is the most common flooring material in urban areas of the country.

Table 1. Most common construction methods/materials in urban areas of Uganda (%) [15].

Roof Construction*	Iron sheets Roof	84.1
	Thatched Roof	12
	Other	4
Wall Construction*	Brick Wall	83.9
	Mud and Poles Wall	12.4
	Other	3.8
Floor Construction*	Earth Floor	25.2
	Cement Floor	70.8
	Other	4

*Up to 0.1% discrepancies.

Despite a moderate tropical climate, , rapid replacement of traditional methods and materials with relatively modern methods and construction such as iron sheet roof and hollow concrete blocks etc., due to various social and practical reasons, along with climate change and global warming have transformed overheating and thermal discomfort into a major issue in Uganda. According to UN-HABITAT [16], the average temperature in Uganda is expected to increase by1.5 ºC in the next 20 years and by up to 4.3 ºC by 2080. The climate change, poverty and inappropriate construction