Case Studies in Construction Materials 7 (2017) 15–29

Contents lists available at ScienceDirect

Case Studies in Construction Materials

journal homepage: www.elsevier.com/locate/cscm

Case study

Life cycle cost of different Walling material used for affordable housing in tropics

Chameera Udawattha*, Rangika Halwatura

Department of Civil Engineering, University of Moratuwa, Sri Lanka

ARTICLE INFO

Keywords:
Tropical climate
Embodied energy
Life cycle cost
Walling materials
Construction cost
Maintenance cost and operation cost

ABSTRACT

The energy consumption of affordable housing industry plays a vital role in the environmental sustainability, waste generation and energy consumption. The development of sustainable housing construction methodology helps its country's economic development and sustainable development. Wall and roof are the most significant building component in a dwelling unit. The walling materials can determine the cost of the building as well as the total life cycle cost of a dwelling unit. In this study, the total life cycle cost of a basic dwelling unit in Sri Lanka, made of mostly available walling materials such as Brick, Hollow cement block, and Cabook, the Mud concrete blocks were calculated by using energy accounting hierarchical structure. The life cycle cost incurred due to change in above-mentioned walling materials were calculated and measured. Additionally, total LCC compared and analyzed.

The results show that mud concrete block is the most suitable walling material. The brick has the highest account for the embedded energy. The hollow cement block is the worse building materials in tropics and its carbon footprint is comparatively higher. Even though the brick has higher embedded energy and construction cost, in a long run brick is less expensive than hollow cement block and Cabook walling material. Concluding, mud concrete block is comparatively most sustainable walling material for building affordable housing in tropics.

1. Introduction

Selecting energy-efficient construction method or construction materials for affordable dwelling units have an effective impact on environment conservation [1–3] because the quantities are higher comparing other building typologies, like offices warehouse etc. [4]. Calculating embedded energy and life cycle cost is in a way stepping towards the environmental conservation [5]. Thence, this study endeavors to measure the environmental sustainability of the application of different walling materials.

1.1. The objective of this research

The objective of this research is to empathize the energy content of different walling materials used to build affordable houses in tropical climatic condition and compare their life cycle cost. Different types of walling materials were selected for the study considering their popularity. National statistical data was used to understand the most popular walling materials in the country.

In addition, newly invented walling materials such as mud concrete block (MCB) [6] used to compare with existing walling material pallet.

* Corresponding author.
E-mail address: udawatthe@gmail.com (C. Udawattha).

http://dx.doi.org/10.1016/j.cscm.2017.04.005
Received 10 November 2016; Accepted 12 April 2017
Available online 08 May 2017

Nomenclature

BOQ	Bills of quantities
Cab	Walling material made of hard soil cuts.
CC	Cleaning cost
EC	Energy Cost
EE	Embedded energy
FC	Fixed Cost
HCB	Hollow cement Block
IC	Initial Cost
LCC	Life Cycle CostLife cycle cost
M	Medium scale buildings
MC	Maintenance cost
MCB	Mud concrete block
NPV	Net present values
NTA	Not available
OC	Overheads
Off	Office building
Re	Refurbishment
Re	Retrofit
Res	Residential buildings
RV	Resale value
SI	Suitability index
UC	Utilization cost

Mud concrete block is a novel walling material. This is not the typical cement composed soil block. The mud concrete block is a walling block made of soil. In the composition of MCB, sand and metal of concrete are replaced by fine and coarse aggregates of soil. The precise gravel and sand combination governs the strength of the MCB. Cement in this soil concrete is also used as a stabilizer in very low quantities.

And also, this research may alleviate to constitute a concrete argument in selecting walling materials not only for the construction however, also for the total lifespan of affordable dwellings in the country.

Walling materials are important because it plays an immense role in the total cost of the building, life cycle cost, and energy content (see Table 1). It accounts for more than 15% of the total cost of the building in Sri Lanka [22]. Not only the cost but also, the roof and wall material is important in reducing the external heat gain, they are our third skin [23–25]. Comparing different walling materials, however, also ranking those walling materials is the extended objective of this research. Then this study would help the funding agencies and general public to understand the real value when selecting walling materials for their affordable houses and choose on the best suitable material considering the embedded energy and total life cycle cost.

Table 1
Recent attempts to calculate life cycle cost of different buildings and building materials.

Source	Country	Nos. of cases	Type of building	Type of walling materials	Size (m^2)	Life-span
Delbert [1]	Sweden	1–2	Res.m	Gypsum wall board	700–1520	50
Takano et al. [7]	Finland	5	Other	Brick,Cement fibre board, Wood plank, Galvanized steel sheet	120	50
Cole and Kenan [8]	Canada	14–25	Office	Wood and steel frame	4620	50
Crawford [9]	Australia	1	Res.	Bricks	254.2	50
Dutil and Rousse [10]	Canada					
Emmanuel [11]	Sri Lanka	4	wall	Brick, Cement blocks, Wattle, and daub	$10m^2$	60
Fay et al. [12]	Australia	26–27	Res		128	50
Feist [13]	Germany	28–33	Res	gypsum plaster covering all internal surfaces; woodchip wallpaper, water paint	156	80
Hallquist	Norway	–	Res m		?	40
Hamidul Islam [14]	Australia	3	Res.	FC Sheet, Building paper (reflective foil) Insulation and Air gap Softwood plates, studs, noggins Plasterboard	101	50
Keoleian et al. [15]	USA	2 (re)	Res.	Brick	228 m2	50
Li [16]	Japan	3	store	Steel structure, steel cladding	15000 2000 1800	–
Mithraratne and Vale [17]	New Zealand	36–38	Res	Timber studs and wall framing, plaster board, insulation, skirting, brickwork, mortar, cavity ties, ashings Fibre cement weatherboard Wooden panelling External rendering	94	100
Scheuer et al. [18]	USA	39	Other	aluminium/glass curtain wall, partially concrete masonry unit/ brick facing, glass fibre heat insulation, U-value 0.134 W/m^2 K (0.043 Btu/h ft2 F); fourth, fifth and sixth floor: pre-cast concrete planks, glass fibre heat insulation	1	75
Suzuki and Oka [19]	Japan	40–49	Res	wooden,lightweight steel	1253–22,982	40
Thormark [3]	Sweden	50	Res		120	50
Winther and Hestnes	Norway	52–56	Res		110	50
Winther [20]	Norway	–	Office	Exposed brick	4800	1
Zimmermann et al. [21]	Switzerland	57–60	Other	Diff.	Na.Avg.	50
Fay et al. [12]	Australia	26–27	Res	Brick, Timber	128	100