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A semi-quantitative framework of building lifecycle analysis: Demonstrated through a case study of a typical office building block in Mexico in warm and humid climate

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ABSTRACT

The Building Lifecycle Assessment (BLCA) has initiated development of lots of new tools and methodologies to calculate the rates of consumption in all phases of buildings' construction, service-life, and disposal. The prospective BLCA methodologies have been developed into several programmes to simulate the buildings pre-construction in order to reduce the waste of energy. However, the results of these methodologies are not very accurate and reliable for building design and decision-making. Hence these are mostly designed for developed countries without any flexibility to serve the developing countries.

This study investigates the capability of a new semi-quantitative BLCA framework, developed at the University of Sheffield in United Kingdom, for application to international scope, adaptation with the international-updatable data, and for the benefit of being able to utilise unlimited support of external programmes and standards to calculate building key values such as energy (embodied, operational and total energy), carbon, water, and so on through the building lifecycle. In that accordance, this capability has been investigated through a typical Mexican office-building block, with specific consideration of 'energy' value (as an example). In terms of operational energy, in this paper, the framework is benefitting from an external programme called HAP, developed by 'Carrier' company.

The results reveal the advantages of the newly developed semi-quantitative BLCA framework and its capacity to allow adaptation with the local programmes for calculation of overall values such as the total energy). It highlights and discusses both sensitivity and credibility of the outputs when compared with the existing conventional BLCAs.

1. Introduction

A Lifecycle Assessment (LCA) of construction materials and complete structures measures lifetime environmental performance from extraction to manufacturing then transportation, installation, use, maintenance and finally disposal/recycling (Athena, 2009). Therefore, LCA offers an effective way to decrease waste in different stages of design, build or manufacture. In recent years, this cyclical basis has been extended to an investigation of energy (embodied and operational) and carbon (Hauschild, 2005; ISO14040, 2006; LexicueEncycloBio, 2009; Masters, 2001; Zabalza Bribián et al., 2009). In terms of sustainability and environmental impact, the performance of materials and structures in buildings should strive for minimising energy consumption and carbon footprint.

However in many countries, there is no clear methodology to achieve reliable results for calculating energy consumption of building design scenarios during their lifecycle. Accordingly, the main purpose of this study is to examine the newly developed semi-quantitative framework (Kashkooli & Altan, 2010) in the School of Architecture at the University of Sheffield for adaptation with the case studies out of the United Kingdom. In this paper, the investigation considers calculation of energy value, i.e. embodied energy (EE), operational energy (OE) and the total energy values, for demonstration purpose in three scenarios of building shape and its impact on BLCA using a case study in Mexico, with same size, material profile and sun orientation. Hence, the methodology considers and benefits from an external programme called HAP (Hourly Analysis Programme), which is developed by 'Carrier

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✓	Section	Detail	Material
FL-BT	Flooring	Concrete Slab	Concrete (general)
			Virgin Steel-Bar & Rod (general-UK typical)
		Tiling	Plastic (General)
			glue (Plastic-resin-general purpose polystyren)
	Internal Walls	Building Central Core	Concrete (general)
			Virgin Steel-Bar & Rod (general-UK typical)
			Plaster (general)
			Colour (paint-general)
		Internal Walls	Wood (Timber-General)
			Recycled Paper (general-predominantly recycled)
			Resine (Plastic-resin-general purpose polystyren)
	External walls	External walls	Concrete (general)
			Virgin Steel-Bar & Rod (general-UK typical)
			Plaster (general)
			Colour (paint-general)
	Ceiling	Suspended Ceilling	mineral fibres (mineral wool)
			metal wire (Iron-1mmx20cm-4no/m2)
			Plastic (General)
	Collumns	Collumns	Concrete (general)
			Virgin Steel-Bar & Rod (general-UK typical)
			Plaster (general)
			Colour (paint-general)
	Windows	Glass	
		Frame	
	Electrical	Wire	Copper
			Plastic (General)
		Lamps	Glass (general)
		Lamp holders	Plastic (General)
		Sockets	Plastic (General)
		Suitches	Plastic (General)
			Copper(General)
		Chanels	Plastic (PVC)
	Mechanical	Pipes	Plastic (PVC)
		Fitting	Plastic (PVC)
Total			

Fig. 1. High sensitivity of the new measurement approach in details of building materials and components (Kashkooli, 2013).

Corporation' company for designing of HVAC (Heating Ventilation and Air Conditioning) systems.

This study has been carried out to examine the capability of the framework developed in order for showing the best choices of design from energy view point in other locations in the world (the newly developed BLSA framework was originally tested for locations in the UK (Kashkooli, 2013).

2. Methodology

2.1. A semi-quantitative BLCA framework

The semi-quantitative framework (Kashkooli & Altan, 2010, 2012) was developed in a PhD research investigating existing building LCA tools for the category of 'design and decision-making support' (Forsberga & Malmborgc, 2004; Haapio & Viitaniemi, 2008; Ortiz et al., 2007; Petersen, 2002; Raymond & Culaba, 2009) in order to establish a complete and a more sensitive measurement approach to examine case studies, based on more credible input data taken from other external sources.

The framework suggested an excel-based calculation engine which was developed to calculate BLCA values such as energy (an input), carbon dioxide (an output), water, etc. This calculation is established on a semi-quantitative approach, which means aiding from other environmental assessment programmes and databases in order to achieve more realistic figures that can be used by building designers and decision-makers. The calculation is covering embodied values (the primary consumption of energy, water and so on, and emissions of carbon used through the linear flow of materials) during the construction process, the operation phase