Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 118 (2015) 794 – 801

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Sustainable Design, Engineering and Construction

Life cycle assessment of common materials used for exterior window shadings in residential buildings

Hamed Babaizadeh[a], Nasim Haghighi[b], Reza Broun[c], Somayeh Asadi[d]*

[a]Stantec Consulting Inc., 500 Main Street, Baton Rouge, LA 70801, USA
[b] Department of Civil & Architectural Engineering, Texas A&M University, Kingsville, TX 78363, USA
[c]Department of Civil Engineering, University of Texas at Arlington, Arlington, TX 76019, USA
[d] Department of Architectural Engineering, The Pennsylvania State University, 104 Engineering Unit A, University Park, PA 16802 ,USA

Abstract

The use of daylight has become an essential concern in improving environmental quality and decreasing overall energy consumption by providing natural daylight, which results in minimizing the energy use for indoor lighting, cooling and heating loads. Exterior solar shadings for windows have been widely used in hot or subtropics climates to reduce energy consumption and cut air conditioning costs in residential sector. The most common material types used in exterior solar shadings are aluminum and wood.

Life cycle assessment (LCA) was used to evaluate the environmental effects of the aforementioned materials in typical exterior shadings used in residential buildings. The study compiled a Life-Cycle Inventory (LCI) for quantifying and characterizing the energy consumption and emissions to the environment of these common materials during the life cycle of solar shadings. A life cycle methodology that follows the International Organization for Standardization (ISO) 14040 standard for life cycle assessment was used in this study. Based on the analysis conducted, the positive and negative effects of aluminum and wood shadings on environment for different types of shadings are presented. It was concluded that wood shadings are more environmentally-friendly than aluminum shadings during their life cycles and are better alternatives to be used by building professionals to achieve a more sustainable design.

Peer-review under responsibility of organizing committee of the International Conference on Sustainable Design, Engineering and Construction 2015

Keywords: Sustainable building materials; Exterior solar shading; Life cycle assessment (LCA); Environmental performance

* Corresponding author. Tel.: +1-8148653013; fax: +1-814-863-47809.
E-mail address: asadi@engr.psu.edu

Peer-review under responsibility of organizing committee of the International Conference on Sustainable Design, Engineering and Construction 2015
doi:10.1016/j.proeng.2015.08.516

1. Introduction

According to recent studies, building sector is responsible for 30 to 40% of the general public's total energy demand and approximately 44% of the total material use [1]. Therefore, environmental performance analysis of construction materials within their life cycles is critically substantial to lead building professionals towards design of sustainable buildings to reduce the negative environmental impacts and also to diminish the energy consumption in building sector. Life cycle Assessment (LCA) is a great technique that can be used to compare the environmental impacts of building materials and products helping the decision-makers to select more sustainable alternatives in construction.

LCA technique has been widely applied to single building components including windows and walls, or entire buildings. Broun et al. [2-3], investigated the breakdown of primary greenhouse gas (GHG) emissions and energy use of the two most common exterior wall types including insulated concrete form (ICF) and cavity walls in the U.K. They concluded that the ICF wall system environmentally performs better than the other alternative. In another study conducted by Babaizadeh and Hassan [4], LCAs of a clear float glass window and a similar nano-sized titanium dioxide (TiO_2) coated glass window (as a potential substitute for clear glass windows commonly used in residential buildings) were analyzed and compared. TiO_2 coated glasses have the ability to purify the environment by capturing some of the air pollutants while the production of the coating itself increases the environmental loads and depletes some fossil fuel and electricity. The results of the study conveyed the technology has positive impact on acidification, smog formation and eutrophication while increase environmental loads on human health and ecological toxicology categories. The overall normalized environmental performance of coated glass was better than clear glass suggesting the window type as a prominent alternative to be used in sustainable building designs [4].

Windows are the most significant components of the building envelope in terms of energy use and comfort [5-7]. Depending on their properties, exterior window shadings can significantly effect on indoor air conditioning of the buildings by reducing direct solar gain (maximum of 80% reduction) [8]. These devices protect buildings against extreme solar radiation effectively before it passes through fenestration glazing which results in decrease in overall cooling and heating loads [9]. Kim et al. compared a proposed exterior shading with 3 different configurations of conventional shading systems used in high-rise buildings in South Korea [10-11]. A series of measurements and simulations have verified the distinguished advantages in illumination and building energy consumption by using external shading devices.

The focus of this study is to conduct a comparing life cycle assessment of aluminum and wood, the main two common materials used in exterior window shadings, in order to determine the more sustainable option. The selected materials were compared to each other under two common and effective shading configurations in a typical building located in the hot-humid climate zone. To achieve this objective, a cradle-to-grave Life Cycle Inventory (LCI) for quantifying the consumed energy and emitted pollutants due to use of the shadings during the extraction, transportation, manufacturing, in-service and end-of-life phases was complied. The Building for Environmental and Economic Sustainability (BEES) model and SimaPro 8.0 software were employed to develop the LCI of the exterior window shadings. The life cycle assessment framework used in this study was based on a life cycle methodology that follows the International Organization for Standardization (ISO) 14040 standard for life cycle assessment.

2. Methodology and problem formulation

2.1. Exterior shading configurations

A hot-humid climate with extreme solar radiation characteristic was carefully chosen to compare aluminum vs. wood shadings. The geographical information of the location of the building is shown in Table 1. The most effective exterior shading types commonly used in the U.S. residential buildings are illustrated in Figure 1. Table 2 shows the required dimensions for the two introduced configurations based on ASHRAE standards for a typical 1.2m × 1.4 m window area.