Transportation Research Part D 17 (2012) 442–450

Contents lists available at SciVerse ScienceDirect

Transportation Research Part D

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

Planning strategies for promoting environmentally suitable pedestrian pavements in cities

Joan-Manuel F. Mendoza [a,*], Jordi Oliver-Solà [a,b], Xavier Gabarrell [a,b,c], Joan Rieradevall [a,b,c], Alejandro Josa [d,e]

[a] Sostenipra, Institute of Environmental Science and Technology, School of Engineering, Universitat Autònoma de Barcelona, Campus de la UAB, Bellaterra, 08193 Barcelona, Catalonia, Spain
[b] Inèdit Innovació SL, Carretera de Cabrils, km 2, 08348 Cabrils, Barcelona, Catalonia, Spain
[c] Department of Chemical Engineering, School of Engineering, Universitat Autònoma de Barcelona, Campus de la UAB, Bellaterra, Cerdanyola del Vallès, 08193 Barcelona, Catalonia, Spain
[d] Department of Geotechnical Engineering and Geosciences, School of Civil Engineering, Technical University of Catalonia – Barcelona Tech, Campus Nord, C/Jordi Girona 1-3, Building D2, 08034 Barcelona, Catalonia, Spain
[e] Institute of Sustainability, Technical University of Catalonia – Barcelona Tech, Campus Nord, Building VX, Plaça Eusebi Güell, 6, 08034 Barcelona, Catalonia, Spain

ARTICLE INFO

Keywords:
Pedestrian pavements
Life cycle environmental assessment
Concrete pavements
Asphalt pavements
Granite pavements
Sidewalk construction

ABSTRACT

This paper examines the relevance of incorporating comprehensive life-cycle environmental data into the design and management of pedestrian pavements to minimize the impact on the built environment. The overall primary energy demand and global warming potential of concrete, asphalt and granite sidewalks are assessed. A design with a long functional lifetime reduces its overall primary energy demand and global warming potential due to lower maintenance and repair requirements. However, long-lived construction solutions do not ensure a lower life-cycle primary energy demand and global warming potential than for shorter-lived designs; these values depend on the environmental suitability of the materials chosen for paving. Asphalt sidewalks reduce long-term global warming potential under exposure conditions where the functional lifetime of the pavements is less than 15 years. In places where it is known that a concrete sidewalk can have a life of at least 40 years, a concrete sidewalk is the best for minimizing both long-term primary energy demand and global warming potential. Granite sidewalks are the largest energy consumers and greenhouse gas contributors.

1. Introduction

New Urbanism puts emphasis creating a pedestrian-friendly environment where walking is promoted as a broadly accessible mode of sustainable transportation and safe recreation while facilitating commercial and social exchange and encouraging citizens to be physically active. The environmental benefits of promoting pedestrian networks are calculated based on the assumption that suitable and well-connected infrastructures can increase walking activities while limiting the demand for motorized transport. Pedestrian pavements are therefore designed to be technically, economically and aesthetically suitable for users and developers, often involving a pedestrian need hierarchy. The design process, however, fails to apply comprehensive life cycle environmental data to identify suitable construction solutions and urban management strategies that contribute to minimizing environmental impacts.

* Corresponding author. Tel.: +34 935 813760; fax: +34 935 868008.
E-mail address: joanmanuel.fernandez@uab.cat (J.-M.F. Mendoza).

1361-9209/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.trd.2012.05.008

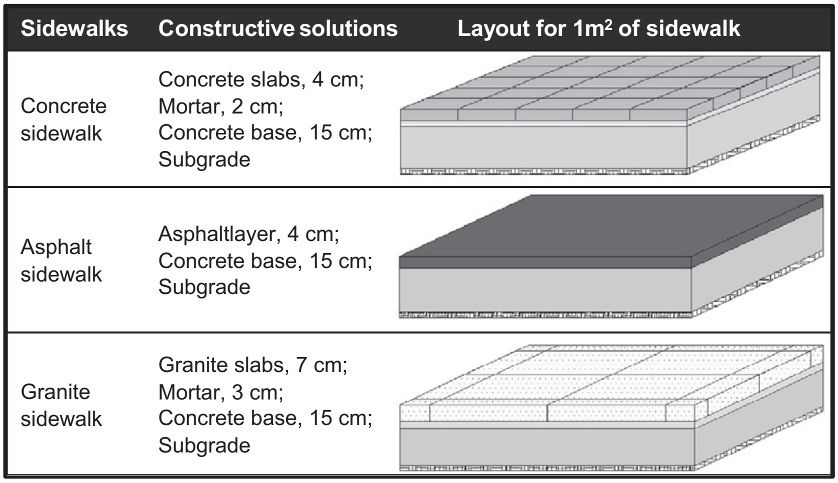

Fig. 1. Structural sections of the sidewalk designs.

Based the European Commission's (2010) goal of reducing fossil energy consumption and greenhouse gas (GHG) emissions by 20% by 2020, we focus on assessing the life-cycle embodied energy and GHG emissions of three common types of sidewalks found worldwide that use concrete slabs, granite slabs and asphalt as surface paving materials. The paper integrates the collection of a life-cycle inventory (LCI) of the energy and material flows associated with the entire life cycle of an asphalt sidewalk and updates the corresponding life-cycle inventories of the structurally equivalent concrete and granite sidewalks addressed in Oliver-Solà et al. (2009) and Mendoza et al. (2012).[1]

2. Methodology

The environmental performances of the sidewalk constructions were evaluated according to the LCA methodology (International Standardization Organization 14040, 2006).

2.1. Functional Unit

A functional unit (FU) provides a reference for accounting for and evaluating the inputs and outputs related to the life cycle of the systems under assessment. It is defined as one square meter of sidewalk located in central Barcelona, Spain, that supports pedestrian and (sporadic) light motorized traffic over a period of 45 years. Sidewalks include all pavement layers extending from the compacted soil (subgrade) to the surface (top layer).

Although sidewalks emphasize pedestrian comfort, vehicles tend to travel or park over them (i.e., during cleaning or to enter or exit a parking lot). Sidewalks designs are therefore considered to accommodate this extra loading.

Due to the high degree of uncertainty related to the average service lives of pedestrian pavements a specific benchmark must be used to define the timeframe for which life-cycle impacts are quantified. Oliver-Solà et al. (2009) set this timeframe on the assumption that an area equivalent to the entire sidewalk surface (including inner and outer, residential and non-residential urban areas) is reconstructed every 45 years in the city of Barcelona because of trenching or maintenance of underground services. We used the same assumption to define our analysis period.

2.2. Description of the sidewalks

Concrete sidewalks are the most common type worldwide because they are considered consistent, durable and economic. Asphalt sidewalks are chosen for their initial low cost, but they have a shorter service life than concrete. They are more susceptible to damage from weather and normally require more maintenance, increasing their economic cost over time (Federation of Canadian Municipalities and National Research Council, 2004). Granite sidewalks may be more aesthetically pleasing than concrete or asphalt sidewalks, but their construction cost is normally higher. Granite is the natural stone that is most commonly used for exterior paving due to its three fundamental characteristics: hardness, durability and aesthetics (Federación Española de la Piedra Natural, 2005).

[1] Oliver-Solà et al. find that, by optimizing the design of concrete sidewalks according functions, environmental impacts can be reduced by 74% per square meter. Mendoza et al. show that by using the more environmentally suitable flooring material, urban planners can reduce their environmental impacts to 139% per square meter.