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SciVerse ScienceDirect

Procedia Engineering 21 (2011) 883 – 890

Procedia Engineering

www.elsevier.com/locate/procedia

2011 International Conference on Green Buildings and Sustainable Cities

Materials selection for green buildings: which tools for engineers and architects?

Elisa Franzoni[a*]

[a]*Diparimento di Ingegneria Civile, Ambientale e dei Materiali, Università di Bologna, Via Terracini 28, I-40131, Bologna, Italy*

Abstract

The selection of building materials plays a key role in the achievement of the 'Green Buildings' target and is performed both at an early stage of the design process (when general and strategic choices concerning the building are made) and at the working plan (when materials available on the market are selected). The latter aspect is important exactly as the first one for the actual fulfilment of 'greenness' requirements, but architects and engineers in charge of this choice often lack of evaluation tools supporting them in materials' selection. In the present paper, after a brief discussion about the critical aspects of the definition of 'green building materials', the tools presently available for the selection of building materials are overviewed and discussed, with particular attention to the selection of materials at the working plan stage. The applicability of such tools is therefore discussed, with particular reference to the Italian market.

Selection and/or peer-review under responsibility of APAAS

Keywords: materials; enviornmental impact; indoor air quality; building evaluation assessment tools; product datasheet.

1. Introduction

The building sector's environmental impact is enormous, as it accounts for the use of 40% of the natural resources extracted in the industrialized countries, the consumption of 70% of the electricity and the 12% of potable water, and the production of 45-65% of the waste disposed to landfills [1]. Moreover, it is expected to increase, due to the growth in global population from 6.5 billion in 2005 to approximately 9.0 billion in 2035 [2]. In this scenario, the mitigation of the environmental impact of buildings is a primary issue.

* Corresponding author.
E-mail addresses: elisa.franzoni@unibo.it

doi:10.1016/j.proeng.2011.11.2090

In the past decades, a great effort was addressed toward the reduction of the energy required in the operation phase of the building (energy required for heating, cooling, ventilation, lighting, hot water, operating appliances, etc.) and the adoption of more efficient technical solutions and materials [3] led to an improvement in the energetic performance of buildings during their service life. The contemporary impulse to the exploitation of renewable energy sources led to a rapid growth of the Zero Energy Building (ZEB) concept [4], implying a zero annual balance between the energy used for the building's operation and the energy gained from renewable sources, such as in 'solar houses' [5]. The Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings establishes the target of 'near zero energy buildings' for public buildings at 2018 and for all new buildings at 2020 [4].

Meanwhile, growing attention was addressed also to the pre-use phase of the building [6], i.e. to the environmental impact of building materials (raw materials extraction, manufacturing process and delivering to the construction site). Such impact can be quantified by means of the parameters identified in the Life-Cycle Assessment (LCA) procedure (ISO 14040), such as energy requirement, contribution to greenhouse gases production, water depletion, etc. Among these environmental parameters, which are fundamental for the mitigation of the buildings' impact but quite difficult to quantify and to transpose into public opinion, particular importance has gained the so-called 'embodied energy' (EE) of building materials [7]. Embodied energy usually represents the energy consumed in the materials' extraction, production and delivery to the construction-site, but according to several authors [2, 6, 8] it should include also the 'recurrent' embodied energy used in the maintenance and refurbishing processes of building materials and components, and the demolition energy, necessary for deconstruction of building and disposing of materials. Even neglecting the other forms of environmental impact caused by building materials, the only EE now accounts for 2-38% of the overall energy consumed over the 50-years building's lifetime in conventional buildings and for 9-46% in low energy consumption buildings [9], thus pointing out the great importance of the selection of sustainable building materials in the design process. Indeed, some authors state that low energy buildings perform better than zero energy buildings in a whole life cycle perspective [8], due to the use of high energy intensive materials (i.e. with high EE [2]) in the latter ones. For this reason, the need of 'life cycle zero energy buildings' or 'net-zero energy buildings' has been recently addressed, in order to take into account not only the operational energy, but the energy consumed in the whole life cycle, according to a real 'cradle to grave' philosophy [5].

The considerations reported above substantiate the key role that the materials' selection plays in the building design process for the achievement of the 'green building' goal. However, such selection give rise to two main questions:

- what are 'green building materials'?
- which tools are presently available for materials' environmental assessment and, hence, for their selection?

In the present paper, after a brief discussion of the critical aspects in the definition of 'green building materials', the tools presently available for the selection of building materials are overviewed and discussed. Particular emphasis is given to the selection of materials at the working plan stage, when architects and engineers must make a choice among the products available in the market and this give rise to several problems, which will be presented and discussed, with particular reference to the Italian situation.

2. 'Green building materials' definition

A univocal and universally accepted definition of 'green building materials' still doesn't exist and they are generally considered as environmentally friendly [10] or environmentally responsible [11] materials.