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Sustainability assessment of an innovative lightweight building technology for partition walls – Comparison with conventional technologies

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ABSTRACT

The growing necessity to save material and energy resources, together with an increasing concern over the environmental issues and uncertainties on the evolution of the economy, have impelled minimalist-approaches to Architecture and Engineering. This created a new necessity for reducing, to the minimum necessary expression, the used building materials and elements. When analysing the overall material inputs of a building, it is possible to conclude that the interior partition walls have the higher contribution to the material inputs, when compared to other non-load bearing construction elements. Other aspect to highlight is that a great portion of building designs are not flexible in use and therefore buildings are not suitably adjustable to the permanent updating of life-styles and variations on the composition of the households. Although there are some lightweight building technologies, in most cases the construction practice all over Europe makes use of heavyweight and static partition walls. This paper will focus the advantages of lightweight partition walls and may contribute for the development of new partition wall technologies. It presents a sustainability assessment of a new lightweight sandwich membrane building technology for indoor partitions developed within a research project. The used methodology comprises the environmental, functional and economic life-cycle analysis. In order to identify the advantages of the building technology under development, each different design approach for the conceptual technology will be compared with two reference technologies: i) the heavyweight conventional partition wall (hollow brick wall); and ii) the lightweight reference gypsum panels wall (plasterboard wall).

1. Introduction

The Human being, as other living creatures, grows and depends on the conditions of the surrounding environment. Therefore, preserving the environment is a matter of survival, but reality shows that it is not the case in most times. The intensification of climate changes and as consequence the increasing frequency of natural disasters are costs of the way of living acquired by Humans. Global urbanization and the ever increasing demands for higher living standards among the world's population are underlying causes for the need to develop urban infrastructures, negatively influencing the necessary balance between the built and natural environments [1].

Nowadays, most of the activities of the developed societies take place inside the buildings. All these activities are normally associated to excessive energy and other resources consumption and emission of pollutants, having as consequences several impacts in the outdoor and indoor environments and in the health of the living beings.

The construction sector is responsible for resource depletion and environmental damage. It is recognized for its high-energy consumption, global greenhouse gas emissions, solid waste generation and pollution at all levels. The records shows that building activities are responsible for exploring and consuming about 40% of the natural resources such as stone, sand, wood and water [2]. In fact construction is the human activity that most damages the environment. It includes removing the soil, cutting existing trees and changing the local ecosystems, among other pernicious

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impacts. Then, as construction activities grow, the need for materials, energy and machinery also increases. In the end, the environment is completely transformed and in some cases this depletion is irreversible.

In the past, buildings were generally made with local materials. It reduced the transportations costs and the environmental impacts to a certain location. Nowadays, the construction is more global and it becomes normal to build a house, for example, with global material such as concrete, bricks, cement, steel, aluminium, increasing the energy costs and the environmental impacts mostly associated to the production and transportation of these materials.

The actual poorly designed or managed built environment and the waste of resources throughout the life-cycle of buildings has a significant impact on global environment. Nowadays, due to an increasing awareness of the effects of the contemporary development model on climate change and the growing international movement towards high-performance/sustainable buildings, the current paradigm of building is changing rapidly. Such change is affecting both the nature of the built environment as well as the methods of designing and constructing a facility. This newly emerging approach differs from the established practice in the following important ways [3]: by selecting project team members on the basis of their eco-efficient and sustainable building expertise; increased collaboration among the project team members and other stakeholders; greater focus on global building performance than on building systems; a strong emphasis on environmental protection for the whole life-cycle of a building; careful consideration of worker health and occupant health and comfort throughout all phases; scrutiny of all decisions for their resource and life-cycle implications; the added requirement of building commissioning, and a real emphasis on reducing construction and demolition waste.

A building project can be regarded as sustainable only when all the different dimensions of sustainability (i.e. environmental, economic, social and cultural) are taken into account. Common concerns in several agendas include those of reducing the use of non-renewable materials and water, as well as the production of emissions, waste and pollutants. The following goals are the most often found on sustainable building project agendas [4]: optimization of site potential; preservation of regional and cultural identity; minimization of energy consumption; protection and conservation of water resources; use of environmentally friendly materials and products; healthy and convenient indoor climate, and optimized operational and maintenance practices. To attain these goals, mainly the growing necessities to save material and energy resources, it is necessary to develop and use new building technologies with lower embodied material quantity [5]. Weight plays an increasingly significant role when it comes to the environmental impact of a building. Lightweight constructions require less material, save fuel on transport to the building site, and can be designed with smaller assembly fittings [6].

Sustainability issues in construction were originally concerned to the thermal efficiency of buildings, due to the duration of the operation phase, which represents the greatest amount of energy consumption in the whole life-cycle of a building. A great effort has been done in recent years to promote energy efficiency in buildings, with the increase of mandatory insulation of the outer shell, as well as more efficient indoor climate control systems. Theoretically, it is actually possible to design and build “zero energy buildings”, or even, buildings that are featured to have a positive energy balance. After this achievement, to keep decreasing the overall environmental life-cycle impact of a building, the focus should be switched to the embodied energy of building materials and to the construction phase [7].

Partition walls are important building elements and have a great importance in the overall life-cycle impacts of a building. A partition wall is a thin element built to divide the indoor space into rooms or other compartments. Additionally, it is used to enable more effective space organization and to improve comfort and safety [8].

Generally, partition walls are non-load bearing. For a load-bearing wall, strength to vertical loads is an important factor of design, since it influences the overall structural behaviour of the building. In a partition wall, the main structural requirement is to have the necessary strength to support a suitable surface for decoration and the accidental impacts resulting from the occupation of the building.

Addis and Schouten [9] refer that partitions have emerged as building sub-systems, as result of several factors, including the development of frame construction where internal walls are no longer required to have a load-bearing function. Due to emergent aspects, the contemporary internal partition walls design is based in new requirements. Those requirements include, among others [9]: the speed of organizational and technological change; the increased number and complexity of services to be accommodated; the quality and aesthetic requirements to satisfy; the need for acoustic separation of compartments; the flexibility for changing the area and organization of the internal spaces; thinner elements in order to maximize the net areas; higher environmental life-cycle performance; and optimal life-cycle costs.

The life-cycle environmental impacts of an internal partition wall solution result directly from the attributes of the used materials – such as the embodied energy and thermal properties – and from the way the solution is built and maintained. Literature shows that partition walls have the higher contribution to the overall life-cycle impacts, when compared to other non-load bearing construction elements, as presented in Fig. 1 [9].

The following paragraphs will present the steps for designing a conceptual lightweight sandwich membrane partition wall (LSM) that performs better than the conventional heavyweight and lightweight technologies used in the Portuguese construction market. Although the conceptual partition wall is compared with the conventional building technologies used in the Portuguese context, results are intend to contribute for the development of more sustainable building elements at international level. Additionally, the life-cycle and the multi-criteria decision making approaches discussed in this paper can contribute for the evolution of the generic methodology to assess the sustainability of building elements and to the international understanding by introducing an approach which takes into account the different dimensions of sustainability. This approach is based on the state-of-the-art in building sustainability assessment, including the latest developments achieved by standardization bodies and other international *fora*.

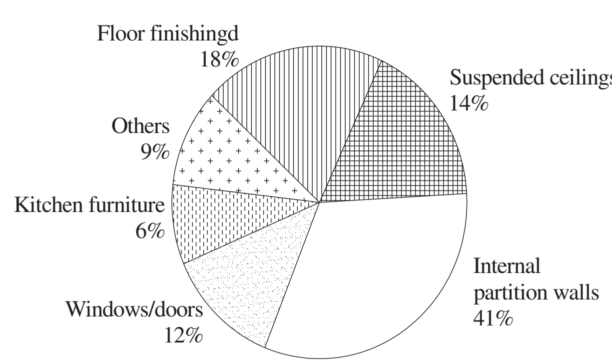

Fig. 1. Environmental impacts from materials use on non-load bearing construction elements of a typical house over 60 years (adapted from Ref. [9]).