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Life cycle assessment of building materials: Comparative analysis of energy and environmental impacts and evaluation of the eco-efficiency improvement potential

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ABSTRACT

The building industry uses great quantities of raw materials that also involve high energy consumption. Choosing materials with high content in embodied energy entails an initial high level of energy consumption in the building production stage but also determines future energy consumption in order to fulfil heating, ventilation and air conditioning demands.

This paper presents the results of an LCA study comparing the most commonly used building materials with some eco-materials using three different impact categories. The aim is to deepen the knowledge of energy and environmental specifications of building materials, analysing their possibilities for improvement and providing guidelines for materials selection in the eco-design of new buildings and rehabilitation of existing buildings.

The study proves that the impact of construction products can be significantly reduced by promoting the use of the best techniques available and eco-innovation in production plants, substituting the use of finite natural resources for waste generated in other production processes, preferably available locally. This would stimulate competition between manufacturers to launch more eco-efficient products and encourage the use of the Environmental Product Declarations.

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1. Introduction

At world level, civil works and building construction consumes 60% of the raw materials extracted from the lithosphere. From this volume, building represents 40%, in other words 24% of these global extractions. In Europe, the mineral extractions per capita intended for building amount to 4.8 tonnes per inhabitant per year [1], which is 64 times the average weight of a person, highlighting the need to work towards dematerialisation in building.

In Spain, every habitable square metre[1] of a conventional building requires a total of 2.3 tonnes of more than 100 types of materials. This figure represents only those materials that directly form part of the construction site. Additionally, if we consider the "Material Intensity per Service Unit" concept, which expresses the relationship between the weight of the resources (biotic, abiotic, air, water, erosion, etc.) affected by the manufactured goods process on the weight of the material produced, the previous figure is multiplied by 3, reaching 6 t/m^2 [1].

The manufacture, transport and installation in a building made of materials such as steel, concrete and glass require a large quantity of energy, despite them representing a minimal part of the ultimate cost in the building as a whole. This contradiction is known as the "Rule of the Notary" [2]. In addition, the extraction of minerals causes a significant reduction in the exergy of our planet's natural stock, which is mainly concentrated in iron ore with 63% of the total, aluminium with 24%, and copper with 6% [3,4], all of which are commonly used in construction.

The life cycle focus must help decision-making when selecting the best technology available and minimising the environmental impact of the buildings through their design or refurbishing [5,6]. Often, products that are presented as cheap in the medium term can have high maintenance or waste management costs and highly technological products can have very high production costs that are never recouped. Contrarily, it may be that when we consider the

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[1] The habitable area of a building is the usable area for housing, excluding other areas such as corridors, staircases, gardens, garages, streets, etc.

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