Construction and Building Materials 86 (2015) 149–158

Contents lists available at ScienceDirect

Construction and Building Materials

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

Methodology to assess the environmental sustainability of timber structures

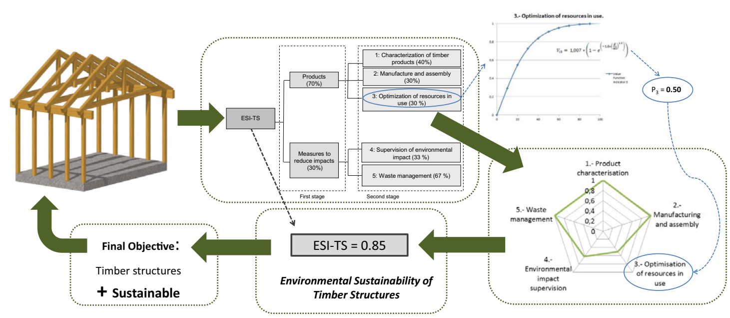
Jesús Cuadrado [a], Mikel Zubizarreta [a,*], Belinda Pelaz [a], Ignacio Marcos [b]

[a] Department of Mechanical Engineering, Faculty of Engineering of Bilbao, University of the Basque Country (UPV/EHU), Spain
[b] Department of Mechanical Engineering, Technical Industrial Engineering School of Bilbao, University of the Basque Country (UPV/EHU), Spain

HIGHLIGHTS

- This study presents an "Environmental Sustainability Index for Timber Structures".
- An environmental sustainability classification of timber structures is achieved.
- Its reliability has been tested through its application to a case study.
- It is easy to apply and it is flexible enough for use in different parts of the world.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 24 December 2014
Received in revised form 25 March 2015
Accepted 28 March 2015
Available online 10 April 2015

Keywords:
Timber
Construction
Environment
Sustainability
Methodology
AHP

ABSTRACT

Timber is a renewable material with excellent strength-to-weight ratios, insulating properties and it plays an important environmental role, acting as a CO_2 sink. Public awareness of sustainability and its importance in the construction sector is growing day by day, encouraging the use of more sustainable materials, as is the case of timber. To assist in this goal, this study presents a methodology to prepare an "Environmental Sustainability Index for Timber Structures" (ESI-TS). In no way intended for comparison with other construction materials, the index arrives at an environmental sustainability classification, with its set of indicators and relevant weights.

1. Introduction

The use of wood in structures has always been linked to human activities; for example timber trusses found in Ancient Greece (4th BC) are typical of traditional timber solutions [1]. This material has been of extraordinary importance for the progress of construction techniques and timber frameworks still represent a key solution in modern infrastructure across the world [2–6]: buildings, bridges, and railroad infrastructure among many others. Besides, the flexibility of its precast joints (mechanical fasteners) from a structural point of view produces interesting and secure structural schemes.

Over the passage of time, improvements in constructive techniques led to buildings of various heights, where the principal structural material was visibly timber. However, timber was progressively replaced as other materials such as iron, and then concrete and steel emerged, owing to the qualities of these new materials, such as their greater strength, inflammability and resistance to attack by biotic and abiotic agents.

* Corresponding author at: Department of Mechanical Engineering, Faculty of Engineering of Bilbao, University of the Basque Country (UPV/EHU), Alameda Urquijo s/n, 48013 Bilbao, Spain. Tel.: +34 946 017 399; fax: +34 946 014 215.
E-mail address: m.zubizarreta@ehu.es (M. Zubizarreta).

http://dx.doi.org/10.1016/j.conbuildmat.2015.03.109

In addition, the importance of the construction industry to the European Community (EU-28) can be underlined. As previously presented [7], this industry involves a major portion of the European economy; in 2010, it provided employment to over 15 million people and generated an added value of EUR 562 billion. However, the present situation of global crisis that has persisted over recent years in the EU may be exploited as an opportunity to analyze how to optimize infrastructures and buildings, with the objective of promoting sustainable development [8].

In addition to these two main factors (economic and social), the environmental factor is of key importance in terms of the outlook for global sustainability. The actual environmental crisis on the planet, where resources are becoming scarcer every day [9], implies environmental degradation due to problems linked to global warming, acid rain, and ozone depletion of the stratosphere, among others. Many of these effects are attributed to continuous industrial development on our planet. Thanks to sustainable development, there is today a greater awareness in society across all sectors and many actions are underway to reduce the impacts generated in the environment. As Jain and Jain [10] noted, in the final analysis, development and the environment are in all probability not independent dimensions.

In this sense, the construction sector has a lot to answer for, as it is one of the principal drains on natural resources and energy. As an example, during their 'lifecycle' (including building, maintenance and demolition), buildings are 'responsible' for 50% of total energy consumption and for 50% of total CO_2 atmospheric emissions [11].

Many of the actions in this sector concentrate on the use of materials with higher sustainable rates, in the widest sense; in other words, materials that are recyclable, reusable or naturally renewable, as in the case of timber [12–16]. As switching over to certain materials may not be globally achieved immediately, because of the disruption to present-day industry that such changes would cause, this process should be gradually developed. So, firms should continue to adapt to demand in society through product development, while striving to incorporate these new environmental requirements in their products [17].

Over recent decades, different procedures and methodologies to analyze the sustainability of buildings have been developed [18–23]. Some of these tools assess economic and social components, as well as their environmental impact, which are the 3 basic pillars of sustainability [24–26]. Moreover, the governments of various countries have participated in this process and have been introducing directives and standards that generalize this process of improvement. In the case of Spain, the regulations currently in force – the Technical Building Code [Código Técnico de la Edificación, in Spanish] [27], the Spanish Structural Concrete Code [Instrucción Española del Hormigón Estructural, in Spanish] [28] and the Spanish Structural Steel Code [Instrucción Española del Acero Estructural, in Spanish] [29] – have introduced measures related to the minimization of water and energy consumption as well as other materials in the building process [30].

Moreover, the characteristics of timber as a structural material, in terms of both strength and the environment, make it an ideal material for the construction of building structures. Even so, it is important to take into account that, as with all materials, timber has to comply with a series of standards, so that it is used as efficiently as possible from an environmental standpoint.

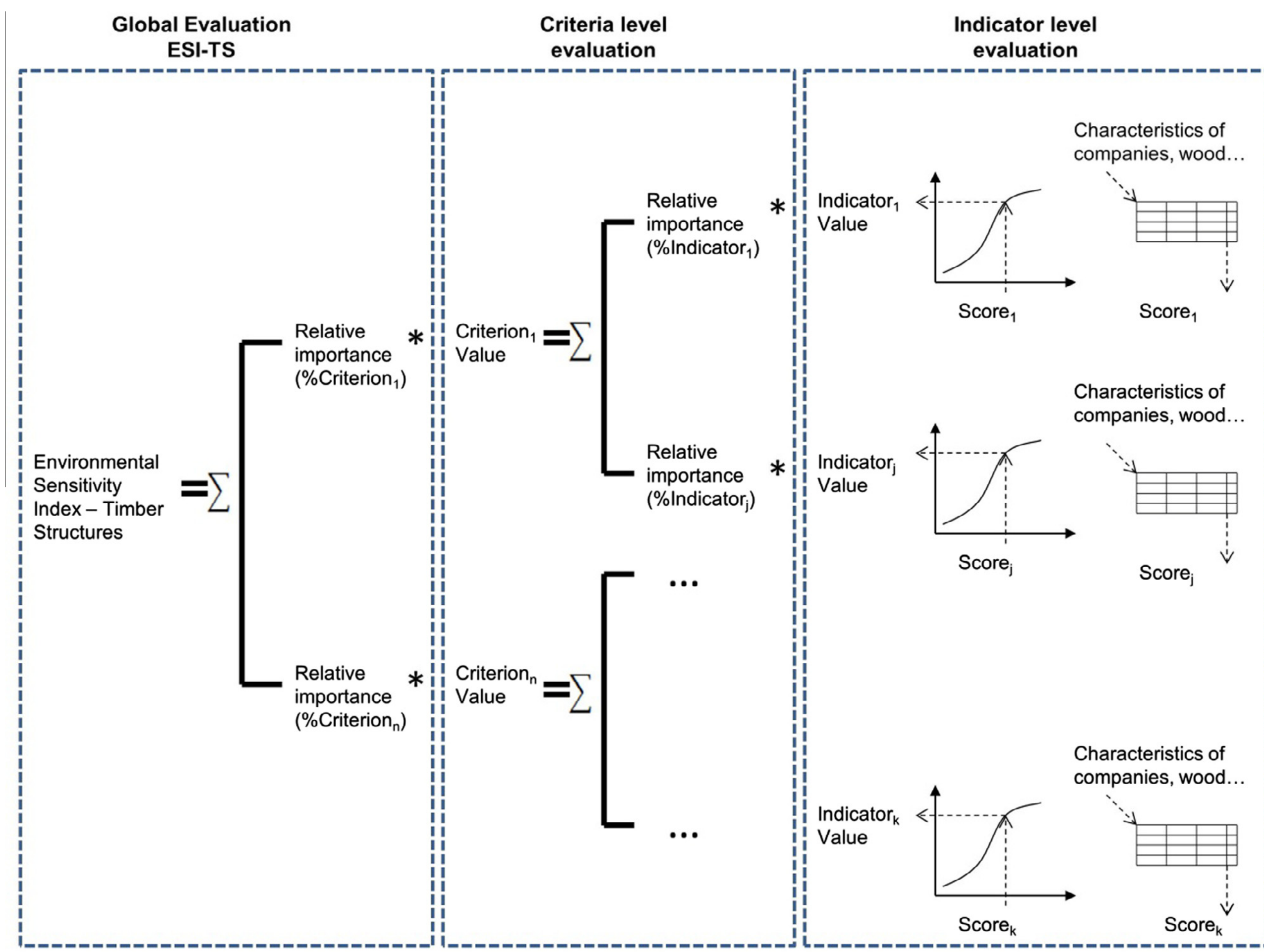


Fig. 1. General hierarchy diagram.