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ScienceDirect

Procedia Engineering 200 (2017) 317–324

Procedia Engineering

www.elsevier.com/locate/procedia

3rd International Conference on Natural Fibers: Advanced Materials for a Greener World, ICNF 2017, 21-23 June 2017, Braga, Portugal

Applications Of Natural Fibers On Architecture

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Abstract

This paper discusses the role of natural fibers on aligning architectural production, both aesthetically and technologically, with the site's local culture, economy, natural diversity and geographic singularities. This is a process that requires the association of contemporary and traditional techniques, demanding architects' creativity and textile engineering support. While contributing to the maintenance of biodiversity, revival of construction techniques and economic development, it may lead to a more sustainable and diverse non-vernacular architecture, that is, erudite architecture.

Peer-review under responsibility of the scientific committee of the 3rd International Conference on Natural Fibers: Advanced Materials for a Greener World.

Keywords: natural fibers; architecture; composite; fibrous materials; renewable resources

1. Introduction

Almost every single building until the half of the 19th century was made mainly of natural materials, which included mostly wood, but also local natural fibers derived from bamboo [1] among other types of fibrous materials, such as totora [2] and worldwide domesticated plants, such as cotton and linen. Natural fibers were used since the beginning of architecture in its vernacular form to ensure that it could be adequate to human needs, which vary a lot accordingly to cultural and spatial conditions. Most of the non-vernacular architectural production nowadays uses the same materials – concrete, steel, glass and brick masonry, due to the requirements of standardization and acceleration of the building process, resulting in an international architecture that ignores local reality most of the time. Natural fibers could be explored in the context of civil construction to allow architecture a more sustainable future, with a bigger variety of building materials, shapes and even improving current commonly used materials.

1877-7058
Peer-review under responsibility of the scientific committee of the 3rd International Conference on Natural Fibers: Advanced Materials for a Greener World
10.1016/j.proeng.2017.07.045

Among these impacts, the following topics will be discussed – contextualization and development, wood fiber load-bearing composites, walling, and NFC alternatives to wood appearance.

1.1. Contextualization and Development

After the Industrial Revolution of the late 1800s, human dependence on non-renewable dramatically increased [3]. New construction materials such as iron, steel and concrete considerably improved human life standards, allowing faster constructive processes, standardization and buildings with greater lifespans. Nonetheless, they also led to great increase of carbon emissions and the loss of thousands of natural-fiber building "vernacular architecture" (architecture that did not use formally-schooled professionals [4]) techniques all around the world, which relate to local cultural identities. Contemporary buildings' use and construction energy consumption account for about 40% of global CO_2 emissions, 15% of which is related to the production of construction materials [5]. Therefore, substituting synthetic building materials for natural fibers, is a goal to be achieved. The use of these natural materials might feel rewarding, due to their low environmental impact, attractive surface aesthetics and potential lower costs when compared to conventional materials [3]. On the other hand, developing natural fiber-based products that meet the needs of easy workability, weather resistance, durability and acceptable overall mechanical properties demanded by the civil construction segment is a considerable challenge that demands the association of both vernacular and high-end techniques.

A more intense use of these materials also requires knowledge of the building site's natural and cultural reality, in order to incorporate the fibers on the project. This is a relevant step for architectural contextualization, that is, ensuring that a building's formal and technological properties are in accordance to the environment where it is located [4].

Among natural building materials commonly used on vernacular architecture are reeds. These are tall, grass-like fiber-reinforced plants found on wetlands, which include bamboo, totora and sugarcane [5]. In Peru, for example, totora, commonly found across the Americas, especially on Lake Titicaca, is traditionally used by the Uros community to cover their wood-frame houses and allow the building of floating islands where they live on [2] (Fig. 1). Recent studies point out that the high strength and insulation properties of the totora fiber make it a useful material while dealing with extreme weather and earthquake conditions like those found among the Andean region [6]. Nonetheless, totora's floatability could be even more explored. Another substrate of special interest is bamboo. There are approximately 1200 species of bamboo, and, despite being a fast-growing, renewable resource, bamboo is rarely used on non-vernacular architecture, even though its tension strength is 20% higher than that of iron [1]. The plant's uses after dried include superficies sheating and vernacular structural techniques, which are creatively brought to erudite architecture by Colombian architect Simón Vélez [1]. The use of local natural fibers such as bamboo and totora ensures that the buildings materiality corresponds to the one of its natural environment, reviving local building techniques and associating them with contemporary ones. This process allows the construction of buildings, which are both, cheaper to be built, since local materials are used, and make use of a wider range of forms than just 90°angles (Fig. 2).

Fig. 1. Uros's totora house details. Adapted from [6].

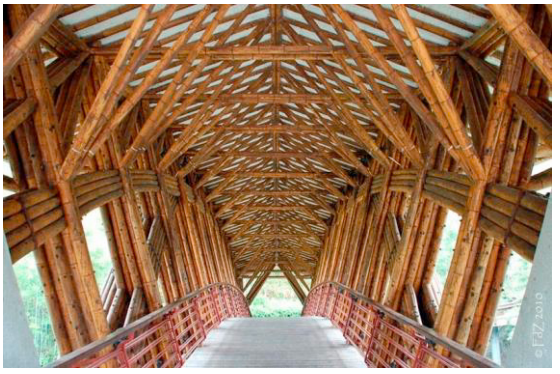

Fig. 2. Crosswaters Ecolodge's Bamboo Bridge, Guangzhou, China (2003). Simón Vélez. Adapted from [7].