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A self-built shelter in wood and agglomerated cork panels for temporary use in Mediterranean climate areas

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ABSTRACT

In recent years, the situation of migrants seeking protection in Europe has grown exponentially since 2013. In Italy, the greatest difficulty is related to landings. Over 170,000 people registered on the coast of southern Italy in 2014. In emergency situations, it is necessary to ensure shelter and medical care to everybody. Many centres are makeshift structures, such as old houses or hotels, which are difficult to manage and entail elevated costs. The shelter prototype can be used for humanitarian emergencies or post-disaster reconstruction projects but also for tourism purposes, in highly naturalistic environments, or for seasonal agricultural workers. The objective of this paper is to propose a prototype of a building module, composed of wood and multilayer agglomerated cork panels, as an environmentally sustainable shelter that can be assembled on any terrain. It takes advantage of the characteristics of cork, such as acoustic and thermal insulation, fire resistance, natural origin, resistance to moulds and microorganisms, and shows high thermal performance. It can be built in different geometries and volumes and not necessarily by skilled workers.

1. Introduction

In recent years, the demand for temporary buildings has considerably increased, also due to the European migrant crisis. A total of 3.8 million people immigrated to one of the 28 EU Member States in 2014, while at least 2.8 million emigrants were reported to have left an EU Member State. Germany reported the largest total number of immigrants in 2014, followed by the United Kingdom, France, Spain and Italy [1]. The figures of emergency: 686 landings since the beginning of 2015; 116,127 migrants' arrivals in Italy in the last eight months (Fig. 1). The host system is saturated and the Government is looking for twenty thousand new houses [2].

A temporary shelter may be a solution to the increasing demand for accommodation and may ensure a house to everybody. Furthermore, the elevated operating cost may be paid off by the high performance casing. Global sustainability is ensured in all the stages of the product's life, from cradle to grave: in the choice of materials, the ease of installation, the energy consumption during life, and the environmental impact of disposal. The objective of this paper is to propose a prototype of a building module as an environmentally sustainable shelter that can be assembled on any terrain. Indeed, the shelter can be used for rural tourism, which is a growing opportunity for development if it is able to meet the emerging tourism demand. Green tourism is a type of tourism promoted by operators who pay special attention to the relationship between tourist activity and nature, adopting operational strategies in a spirit of harmony and respect [3]. Moreover, modular architecture has been developed from human ergonomic factors, since man is the primary user of the designed space [4]. In this particular case, the possibility to transport structural elements on a truck, or inside a container, dictated modularity. In fact, owing to its modularity, the piece is easy to handle and can be assembled by only a few workers. It is important that a device can be easily assembled directly by the local (not specialized) workforce, and it is equally important not to use cranes to lift the structure, considering that the prototype is designed to be used in agricultural areas, which are not always easily accessible by work-site vehicles. After examining the state of the art in modularity, the prototype was built to comply with the following requirements:

- Easy transport and assembly;
- Limited size and weight of the pieces so that they can be assembled and easily handled by one man, without any special equipment or vehicle;
- Clean and simple construction site that requires neither connections nor special cuts to be made only by skilled workers;

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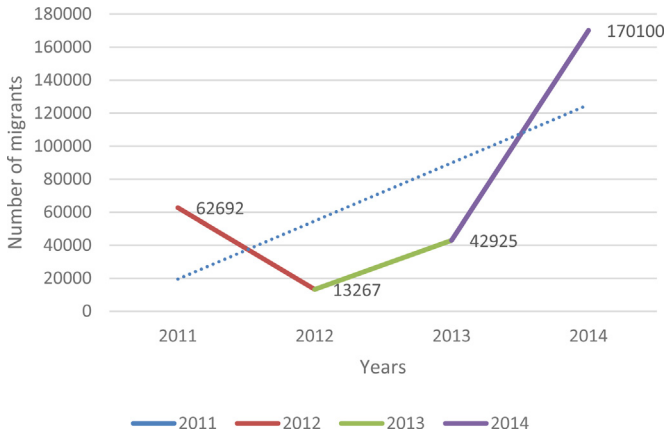

Fig. 1. Trend of migrants' arrivals on the Italian coasts between 2011 and 2014.

- Intuitive and fast assembly, which can be carried out by local workforce;
- Adaptability of the module to different terrains and units;
- Repeatability of the basic module in order to obtain different spatiality as requested.

2. Materials and methods

The prototype of the building module was made of wood and cork. Italy, along with Portugal, Algeria, Spain, Morocco, France and Tunisia, is the principal country exporting cork [5]. Cork trees occupy approximately 2.5 million hectares in large areas situated west of the Mediterranean basin [6,7] and on the Atlantic coast. The commerce of cork is environmentally friendly because, after harvesting, cork oak trees renew themselves; as a consequence, not a single tree is cut down. Its controlled use is not a threat for natural plantations. If forests maintain their economic value, people care for them, reducing the risk of fire and desertification. The cork oak tree has an average life span of 250–300 years. The cork bark is first stripped when the tree is 20 years old. After 9 years, it is possible to harvest the layer which has grown. Skilled workers pick up strips of cork bark without any harm to the tree. Cork is completely natural, renewable and recyclable. Furthermore, cork oak trees are fundamental in the process of protecting the planet from global warming: cork oak trees produce and release oxygen through photosynthesis and trap CO_2. The Mediterranean cork oak trees absorb 14 million tons of CO_2 every year [8]. The building industry uses cork for thermal and/or acoustic insulation, but also for elastic and anti-vibration expansion joints in major infrastructures. Cork is commonly used in the form of granules, which are mixed with lime for plaster, or of panels. Recently, it has been used to make inserts in porous, perforated bricks for curtain walls. In their studies on the thermal analysis of Egyptian perforated masonry red bricks, Bassiouny et al. showed that filling the holes with a low-thermal conductivity material, such as the polyurethane foam or cork, significantly increased the thermal resistance in the path of heat flow [9]. Thanks to the curtain panel of the shelter prototype, which is a multilayer agglomerated cork panel of recycled cork, and to its structure, which is made of wood, the entire shelter is a high example of fully recyclable bio-building structure.

2.1. Description of the structure

The structure was designed as a *timber frame* [10]. A succession of "wooden portals", composed of spruce boards hinged together, allow flexibility and modularity to the structure. The frame of the modular structure is made of 3 cm-thick and 16 cm-wide spruce boards and of columns of the same size as the horizontal beams in roofing and basement. This solution allows full interchangeability of the elements and contains the production costs of the prototype. There are systems for anchoring and stretching the tie rods at the nodes that connect the elements of the wooden portal, in order to brace the entire building module in the longitudinal direction. The wooden structure has a 3-cm × 16-cm T-cross-section to block the multilayer agglomerated cork panels (Fig. 2).

It is possible to build a modular unit by repeating the assembling procedure for any number of times. Thus, it is even possible to build a 3 m × 5 m shelter of 3 m of height.

2.2. The curtain panels

The walls of the shelter are made of multilayer agglomerated cork panels. Cork is a hypoallergenic, insulating, mould-, microorganisms- and fire-resistant material. No synthetic material can replicate its properties, which are the result of its flexible cell membrane and of its honeycombed structure [5]. Our solution of

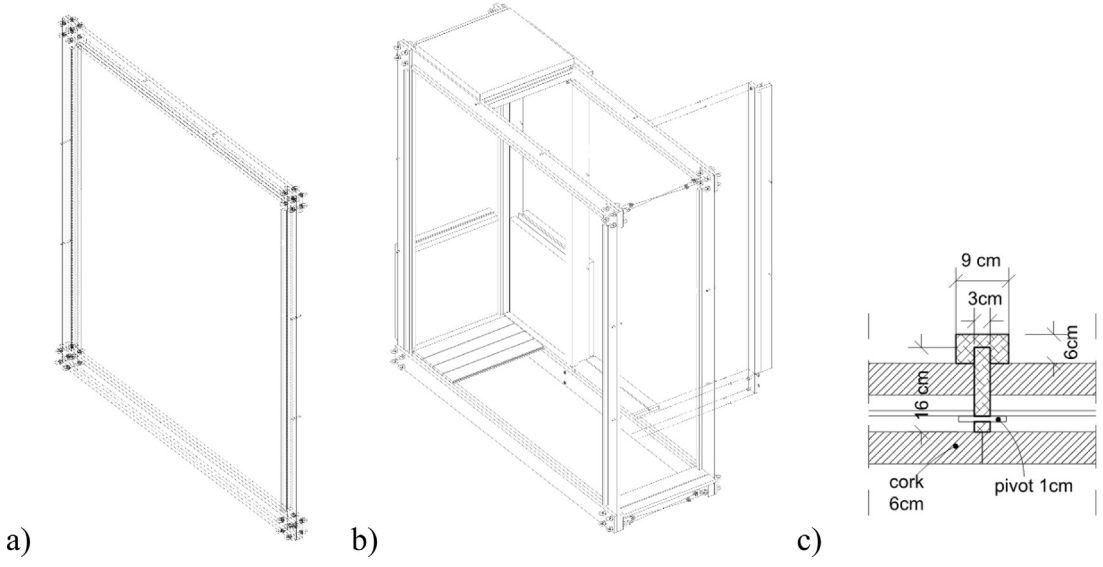

Fig. 2. The structure of the shelter prototype: (a) wooden portal, (b) single module of the shelter, (c) section of spruce structure.