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Fitness: sheep-wool and hemp sustainable insulation panels

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Abstract

FITNESs, *Fibre Tessili Naturali per l'Edilizia Sostenibile (Natural Textile Fibers for Sustainble Building),* is a research project concerning an experimental hemp and sheep wool insulation panel. The new panel has two main innovative features: unlike the already existing hemp and wool insulation mats, it is a semi-rigid product and it has a low environmental impact, as shown by the Life Cycle Assessment. FITNESs panels are particularly suitable for eco-building sector, they are 100% natural, recyclable and made with by-products from local production chains (Piemonte Region). The paper presents the results of thermal conductivity, acoustic absorption coefficient and thermal transmittance of an experimental wall measurements, in order to demonstrate the effectiveness of FITNESs panels as an insulation product for buildings.

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1. Introduction

The research team recently developed an innovative system with low environmental impact for the production of semi-rigid panels for thermal and acoustic insulation, obtained from recycled sheep's wool, from Piemonte region [1]. Starting from the previous work, a new semi-rigid panel was produced, where recycled sheep's wool is combined with hemp technical fiber.

Hemp (*Cannabis Sativa*) cultivation presents huge benefits for soils in crops rotation environmental field: this culture easily adapts to different types of climate and high yields can be produced with relatively low resources;

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moreover it exerts a restorative action on soils, leaving a considerable amount of organic waste, which benefits the cultures that follows in the rotation crops, as stated by Assocanapa [2, 3].

Moreover the high annual biomass production, and its strong ability to absorb CO_2 from atmosphere, hemp can be considered an interesting alternative source of energy valorization and biomass [4].

Interest in building for hemp materials especially relies in its recyclability, hygroscopic, water vapor permeability and durability properties, its resistance to mold and fungus attacks and the porous characteristics of fibers and shives; as well as its low environmental impact and low cost.

Hemp cultivation has deep roots in Italy, since medieval times, during Maritime Republics age when even in Piemonte region, particularly Carmagnola (To) gradually became a renowned center in the production and diffusion of hemp in the region and abroad. Up to 1960 Italy was among the first countries in the world for planted area and quality of products [5]. After a period following World War II in which hemp cultivation on our territory began gradually to disappear, it was re-introduced at the end of 1990s on a 350 ha area approximately; nowadays it is recovering importance thanks to the efforts of producers as Assocanapa and the recovered cooperation with industrial sectors on local short chain mechanism.

Products obtained from hemp stalks processing are shives (60-65%), fibers (20-25%) and dust (10-20%) [2]. Hemp fiber and shives find use in construction industry, particularly in bio-architecture, as raw materials for buildings thermal insulation, due to their physical characteristics [6]. Hemp shives begins to be widely used even in conventional buildings, often mixed with lime or cement to produce thermal insulating conglomerates.

Short Technical hemp fiber not meant for textile manufacture is currently quite hard to place on the market, also because of its reduced use in the paper manufacturing field [2]. In buildings it is mainly used to produce thermo-acoustic insulating panels or mats, but despite a good variety of hemp products for thermal and acoustic insulation of buildings, in most of the cases hemp is mixed with other synthetic materials and binders that make products not entirely biodegradable; furthermore there is also a lack of self-supporting rigid hemp panels on the market.

In Italy one of the main hurdles to hemp cultivation development is due to the lack of suitable machinery to separate fibers from shives, which generates significant production costs, while cost of fibers used in building insulating materials need to be relatively low [6]. Assocanapa and CNR IMAMOTER patented recently a prototype machine for hemp retting and defibering which could make the set up of a local short chain of hemp products of certain interest and more economically effective [7].

2. Fitness: sheep wool and hemp insulation panels

FITNESSs is a semi-rigid thermo-acoustic insulating panel made of a composite material, consisting of wool, which partially works as a binder - and hemp fibers. Even after the panel production process the two main components keep their own chemical and physical properties, as they remain separated by a zero thickness thin interface, which makes panels not homogeneous. Nevertheless the hemp fibers addition gives the product a relatively high density if compared with Cartonlana's, a 100% sheep wool semi-rigid panel realized during a previous research project, and an improved stiffness, due to hemp fibers tensile strength.

Hemp used for the production of the panels is cut and kept in the field for 4 months (October-February) to macerate. After maceration, it assumes a gray color and keeps a minimum shives residual, to be considered 1.25% of the weight approximately. Hemp shives is restrained by the fibers and can vary in size between 0.2 and 5 cm in length and 0.05 and 1 cm in thickness. Hemp fibers instead have 10 -70 cm length, but most of the fibers remain in a range between 10 and 20 cm length.

Wool comes from Piemonte region sheep breeding; it cannot be used in textile industry, due to its dark color and/or poor quality: fibers are too thick, and irregular length also. Sheep wool is usually washed and dried, but still contains plant debris trapped amongst fibers. As for hemp, treatments on the raw wool are reduced to a minimum, in order to minimize the energy consumption for the production of the panels. The production process consists in 3 main phases:

- The mixture of sheep wool and hemp fibers;
- The treatment with a soda solution in order to make wool fibers to release part of keratin protein, which works like a natural glue, pasting wool and hemp fibers together;