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Thermal and mechanical characterization of panels made by cement mortar and sheep's wool fibres

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Abstract

Green building and environmental sustainability are two important concepts for technicians and engineers. Among natural materials, usually considered as waste, sheep wool plays a fundamental role.
This paper is intended to learn more about the potential of these fibres inserted in cement mortar panels, investigating both the insulation properties and mechanical strength, trying to achieve an optimal compromise between these two aspects.
Therefore, in the laboratory of materials ENEA Research Centre Trisaia, several panels with different percentages of sheep wool were manufactured, tested and characterized according to technical standards.

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Keywords: recycled material; cement mortar; sheep wool; thermal and mechanical characterization; periodic thermal transmittance

1. Introduction

Here introduce the paper, and put a nomenclature if necessary, in a box with the same font size as the rest of the paper. The paragraphs continue from here and are only separated by headings, subheadings, images and formulae. The section headings are arranged by numbers, bold and 10 pt. Here follows further instructions for authors.

One of the most important challenges of future buildings is the reduction of environmental impact and energy consumptions in all their life phases, from construction to demolition.

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Nowadays the cement industry is responsible for 5-7% of global CO2 emissions [1]. In order to reduce them, recently in the field of eco-friendly practices, new technological solutions and new building materials have been developed [2] to protect natural resources [3]. So the concept of green materials involved both natural fibres and a big quantity of wastes. Natural fibres are used to improve mechanical performances of cement-based composites [4], in place of synthetic ones (e.g., PVA or polypropylene), because they ensure a better tensile strength, ductility and post-cracking behaviour [5] and, at the same time, they are increasingly appreciated thanks to the specific properties, the low price, the advantages for health and the recyclability.

The wastes are introduced as powder or filler or as aggregates in the concrete mix, with energetic, economic and environmental protection conveniences [6]. Even though the ingredients for the concrete manufacture are available almost everywhere, there could be opportunities to use some local wastes which have appropriate characteristics for concrete production [7]. According to their origins, natural fibres can be classified in ligno-cellulosic (from plants/vegetable), mineral (e.g. basalt fibres) and protein (from animals). These last fibres are grouped under the categories of hair (wool), fur (angora) and secretions (silk) [8].

In particular, sheep's wool, has begun to be marketed and promoted as an alternative material in civil engineering for both thermal and acoustic insulating applications [9].

It can be considered a renewable resource, as the average sheep produces between 2.3 and 3.6 kg of raw wool annually that must be sheared for the health of the animal, but in several regions it is not always adequately disposed or recycled [10], because it should to be considered a special waste, needing a sterilization treatment (at 130 °C) before its disposal.

In fact, about 75% of the wool (around 150 million tons per year), produced by the European sheep farms cannot be used by the textile industry.

Due to some mechanical treatments, performed in order to improve the workability, the quality of this wool is generally high.

According to available literature, there are few research regarding the sheep wool as addition in mineral composites, despite, as already mentioned, its use as reinforcement of cement in order to produce mortar or plaster involves several advantages.

This research intends to contribute to the management and reuse of sheep wool waste in order to reduce its impact on the environment; it is also focused on the possibility of using sheep wool fibres in the production of mortar, particularly for use as wall coatings, to create an additional and more sustainable market for a valuable resource.

To achieve this, mechanical behaviour and thermal conductivity of a cement mortar reinforced with wool fibres at three different fibre contents (2%, 5% and 7% by wt. of dry raw materials) were studied.

Nomenclature

λ	thermal conductivity of the specimen, *W/(m·K)*
d	specimen thickness, *m*
ΔT	temperature difference between the two faces of the test, *K*
A	area through which the heat passes, m^2
Φ	heat flux, W/m^2
N	calibration factor, *ND*
V	potential difference of the transducers, *V*
F	maximum load applied, *N*
f	flexural strength, N/mm^2
l	distance between the axes of the support rollers, *mm*
b	width of specimen, *mm*
d	depth of the specimen, *mm*
σ	compressive tension, *MPa*
ε	deformation, *mm/mm*