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Wood fiber vs synthetic thermal insulation for roofs energy retrofit: a case study in Turin, Italy

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Abstract

In this paper the thermal performance of synthetic and natural insulation materials under real applications are investigated through an experimental activity as well as numerical simulations. During the refurbishment of two houses in Turin (north western Italy) one roof was insulated with a natural material (wood fiber panels) and the other one with a business as usual synthetic material (XPS and polyurethane). An experimental activity was carried out, both during summer and winter seasons, and the results were used to validate a simplified model. During winter, as expected, the strongest influence on the global performance is related to the insulation thickness. As far as the summer season performance is regarded, for smaller roof surfaces, as for the analysed case study, no particular difference was noticed between the two solutions. A better control of the indoor air temperature was evaluated for the wood fiber insulation when applied on a large surface of the roof. In order to define the best cost-benefit retrofit solutions, ad-hoc evaluations need to be performed.

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Keywords: refurbishment; roof insulation; natural vs synthethic; embodied energy; wood fiber

1. Introduction

As it is shown in the state of the art, around the 11% of the building heat transmission occurs through the roof top. This building envelope element, in refurbished building, where the attics are converted in residential houses, constitutes the largest dispersing surface. Because its slope, roofs are also responsible of heat gain, assessed around 70%, and associated discomfort problem [1]. Therefore the importance to identify appropriate materials for the

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retrofit of existing buildings [2,3]. Since the design stage the choice of the material for roof insulation requires specific evaluations, considering the energy performance, as well as technological and economic issues. The performance level required by the standards, as well as the higher commercial value of buildings with low energy consumption, is moving the construction sector to the adoption of new solutions and materials. A high performance level of building envelope and a low energy consumption is a key factor in real estate and a "A Class" energy label is, nowadays, fairly common for the brand new buildings. Moreover, the use of natural material as well as the recycled one represents another highlighted issue and innovation factor driving the real estate market in Italy. This option can be a competitive advantage for designers and construction firms. In this framework, the designers, the construction firms and materials producers are looking for performing and economically sustainable technical solutions. Furthermore, in some cases the peculiarity of the local weather data, makes necessary to evaluate and to design the building envelope both for the winter and the summer season. It is clearly a technological dilemma and a compromise needs to be reached between the passive insulation and the thermal mass. This topic was investigated by means of an experimental activity together with some simulations on two different case studies.

The energy performance of two roofs located in Turin, north western Italy, both with residential use and positioned in a similar environment, was examined. For one case study, it was adopted a natural insulation material: wood fiber and timber fiberboard, with a relatively high specific heat, whilst in the second case study, the roof was insulated with more common materials, i.e. polystyrene and polyurethane panels. In both solutions, the regional standards regarding minimum thermal resistances are fulfilled. The projects are located in Turin (Italy) with hot summer season, from June to the beginning of September, as well as a pretty long and cold winter. A fairly good insulation is required but this environmental profile doesn't allow a passive strategy following the northern and central European schemes. In other words, the cold climate design issues must be associated with the hot climate design features. Nevertheless, the synthetic based insulation that we can consider as a «business as usual» solution do not presented a satisfactory behavior in summer due to the low thermal capacity of the insulation material. On the contrary high performance standards as required by local regulations can be achieved through the use of the wood fiber for its higher thermal capacity which confers the roof a better thermal performance along the whole year. Moreover, the wood fiber insulation was adopted by the designer to comply with an energy incentive protocol, provided by the local authorities of the City of Turin. The goal is to promote the achievement of thermal comfort during the summer season through the adoption of building envelope solution able to noticeably reduce the use of air conditioning. In this framework the adoption of a high thermal mass material, such as the wood fiber, can theoretically allow a better performance. To give evidence of the better summer behavior of such an option compared to the synthetic insulation, the shift in indoor air temperature was calculated, showing a considerable delay of the indoor temperature peak in regard of the exterior air temperature variations.

This paper discusses the results of an in-field measurement campaign and of related simulations of two real case studies aimed at assessing the actual thermal performances of a synthetic based insulation vs a wood fiber insulation, both adopted as roof-top refurbishment solutions. After the state of the art on the investigated materials, the methodology of the analysis is presented both for the in-field experimental and the simulation activity.

Nomenclature

C*	thermal equivalent conductance [W/m^2K]
EPD	Environmental Product Declaration
E_{24}	daily energy [Wh/m^2]
E_n	normalized daily energy [Wh/m^2]
$E_{n,tot}$	normalized total daily energy [Wh/m^2]
GWP	Global Warming Potential
HDD	Heating Degree Days [°C]
HF	Heat Flux [W/m^2]
I	solar irradiance [W/m^2]
mon	referred to a monitored data
sim	referred to a simulated data
t	temperature [°C]