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Nano insulation materials for application in nZEB

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Abstract

The energy efficiency of Nearly Zero Energy Buildings, whose construction will be compulsory in the near future across the European Union, imposes among other improvements of the actual common practice, the thermal behavior optimization of the elements that define the building envelope. In order to satisfy the nZEB requirements, the resulted conventional thermal insulation has increased thickness, which is inconvenient in several cases. In the paper it is presented an alternative solution, given by Nano insulation materials, such as aerogel and vacuum insulation panels, which have very good thermal insulating properties at reduced thickness. The research is conducted by reviewing several scientific articles regarding this subject. There are presented the properties and the improvement needs of the Nano insulation materials. Due to the novelty of this research field the article is a starting point for further studies following the integration of these materials into nZEB components.

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Keywords: heat transferl; thermal insulation; nanomaterials; nZEB.

1. Introduction

In the following years, across the European Union, there will be compulsory that every new building will fulfill the requirements of the nearly Zero Energy Buildings (nZEB) concept, as it is stated by the Directive 31/2010 - Energy Performance of Buildings Directive. [1]

There are no general requirements for the application of this concept in all countries, since each one established its own energy performance and ambition levels. However, there are some common criteria: the deadline (i.e. year 2020), targets regarding the reduction of the primary energy consumption and renewable energy technology use to a

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greater extent. In the case of retrofitting the existing buildings, there are no additional requirements to the present ones.

One of the measures which have to be taken from the design phase of every new building, in order to comply with the increased energy efficiency demands, is the thermal behavior optimization of the elements that define the building envelope. The use of the common thermal insulation materials to achieve the desired targets has some disadvantages. In most situations, it results large thickness of insulation, which can be inconvenient.

First of all, it damages the building aesthetics and it may not satisfy some urbanistic regulations. Probably the most obvious problem is given in this case by the withdrawal of the windows in the wall section, reducing the solar energy input. It may lead also to the use of larger windows in order to reduce this phenomenon, which has the disadvantage of increasing the thermal bridges around the glazing area.

Then, the production of larger quantities of materials increase the energy demands in the manufacturing stage has a higher ecological impact and an overall life cycle cost. Therefore, the use of these materials has its limits, regardless the level of thermal optimization of the building.

The construction industry has to develop new insulation materials, with increased energy performance to avoid the situations described above. In this situation, innovative solutions may come from the nanotechnology field, whose products for buildings can represent a possible solution to the future constructions' sustainability.

The nanotechnology is the engineering field which deals with the matter manipulation at atomic and molecular scale. The materials resulted from a nanotechnology process are called nanomaterials. These materials have applications in different areas. In the buildings' energy performance domain, there are developed sustainable light nanomaterials with increased insulation properties, their thermal transfer being reduced at the nanometric scale. In comparison with the common insulations, the nano insulation materials have 3-5 times lower thermal conductivities, resulting reduced material thickness needed to accomplish the same thermal performance requirements. This property provides a set of advantages for these materials.

First of all, they reduce the built area of the construction, which may be important for both existing and new buildings. For the new buildings, in the case of some urbanistic restrictions regarding the maximum built area, the use of nanoinsulation materials with reduced thickness may help to provide larger useful area. For the existing buildings, the use of these materials doesn't change the façade aesthetics, avoiding the situation in which a non-insulated building has a withdrawn façade in comparison with the insulated one, because of large thickness insulation.

At the same time, in the case of heritage protected buildings, the use of nanoinsulation materials with reduced thickness at the exterior of the building or as rendering components may preserve its façade. In the case of using these materials for the insulation of the existing horizontal elements, i.e. slabs on grade, current level slabs or terrace slabs, they have the advantage of maintaining the finishing level or doors heights. [2, 6]

There are several nanoinsulation products for buildings, each with its own particularities. Two of the most known and used are vacuum insulation panels and the aerogel, which are presented in this paper.

The paper is in accordance with the PhD thesis' first part of the PhD candidate, namely the state of the art in this field. Therefore, the theoretical background synthesis is the personal contribution of this work. This represents a first phase of the research and it is a starting point for future articles, which will include, among other aspects, thermal simulations of the building envelope elements using these materials, in order to prove their superior insulation properties.

2. Nanoinsulation materials

2.1. Vacuum insulation panels (VIP)

Vacuum insulation panels are composite nanoinsulation materials, consisting of a nanoporous core encapsulated by an impenetrable envelope with multiple functions.