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Building integration of aerogel glazings

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Abstract

The recent building practices have shown that aerogel glazings can be used as a multifunctional building envelope component for different purposes. Nevertheless, the distinctive physical properties and energy performance of aerogel glazings suggest that building integration of aerogel glazings may create architectural challenges, aesthetic problems, as well as concerns on their durability and environmental impact, thus highlighting the importance of developing guidelines to regulate the use of aerogel glazings in the building sector. This study discusses various approaches for the building integration of aerogel glazings by presenting a number of successful examples; the advantages of integration are quantified and suggestions are given to address the possible challenges.

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Keywords: building integration; aerogel; glazing; energy efficiency; environmental impact

1. Introduction

In most European countries, the building sector consumes about 40% of the total energy and contributes to about 30% of greenhouse gas emissions; therefore, improving energy efficiency of buildings has been regarded as one important measure to reach the EU 2020 energy and climate targets [1]. Different technologies, however, may be required to improve the energy efficiency of buildings, since buildings usually consist of various structural and/or

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functional components, such as windows, walls, floors, and roofs – each of them has rather different energy features and plays different but important roles on the overall energy efficiency of buildings. For example, previous studies have shown that windows can constitute up to 45% of the total energy loss through the building envelope, and windows with a low thermal transmittance (i.e., *U*-value) can substantially reduce the energy loss and saving cost [2, 3]. Not surprisingly, highly insulating glazing units and windows have been under rapid development; commercial products, such as multi-glazed windows [4], vacuum glazings [5], and aerogel glazings [6], have been sold for a wide range of applications, i.e., for both new buildings and window renovations towards energy efficient buildings.

We are particularly interested in aerogel glazings [7-10], which represent an interesting glazing technology and show a promising potential in the building sector. Aerogel glazings are architecturally similar to the conventional double glazings, where the air cavity between two clear glass panes is filled with silica aerogels – a manufactured nanoporous material with low density, low thermal conductivity, good optical transmittance, and excellent fire and acoustic resistance [12]. Both specular (Fig. 1a) and diffuse glazing units (Fig. 1b) can be achieved by using monolithic and granular aerogel materials, respectively. In practice, due to the high manufacture cost and weak mechanical strength of monolithic aerogel panes [13], aerogel glazings are usually assembled with granules, which gives translucent glazing units with improved thermal insulation, enhanced light scattering, and reduced sound transmission [11, 12].

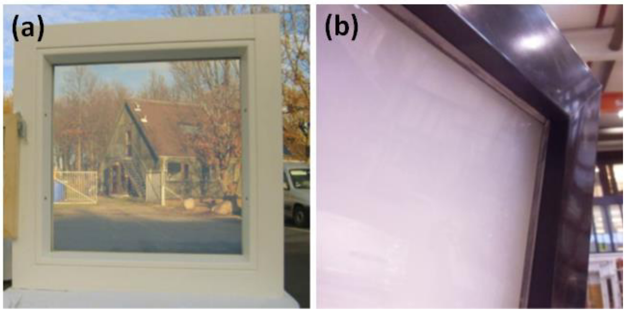

Fig. 1. (a) Specular [14] and (b) diffuse [10] aerogel glazings/windows.

The unique features of aerogel glazings not only make them an interesting building component for different applications, but also bring about challenges when integrating them into the building envelope. For example, replacing the traditional clear glass windows with aerogel glazings may change the user comfort, i.e., the loss of an unobstructed outside view. Aerogel glazings may be used to replace, partially or totally, the opaque building envelope component (e.g., walls or roofs) for daylight management purpose, which, however, may arise other concerns such as cost, energy performance, and safety of aerogel glazings [8]. Obviously, further studies are still necessary and important for the building related application of aerogel glazings. We discuss in this paper various approaches for the building integration of aerogel glazings by presenting a number of successful examples; the advantages of integration are quantified and suggestions are given to address the possible challenges. This work contributes to the development of guidelines to regulate the use of aerogel glazings in the building sector.

2. Properties of aerogel glazings

As any other building materials or components, how aerogel glazings are used in buildings depends mostly on their physical properties, especially the thermal and optical ones.

First of all, incorporating aerogel granules into the cavity of double glazings improves significantly the thermal insulation performance. As shown in Table 1, a double glazing with a 14-mm air cavity has usually a *U*-value of about 2.86 W/(m^2K); applying low emissivity (low-e) coatings and argon (Ar) filling can reduce further its *U*-value down to ~ 1.20 W/(m^2K). In contrast, a similar *U*-value of ~ 1.19 W/(m^2K) can readily be achieved by filling the air cavity of the normal double glazing with aerogel granules. More importantly, the thermal performance of aerogel