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Study of the use of vacuum insulation as integrated thermal insulation in ceramic masonry blocks

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Abstract

Vacuum insulation panels (VIP) are thermal insulation materials with very low thermal conductivity. VIPs are commonly used in a broad spectrum of technical fields; however, they only see a small-scale application in civil engineering. The reason is mainly their high price and difficulty of installation. VIPs are very vulnerable to mechanical damage, which typically causes the loss of their thermal insulation properties. This paper deals with the possibility of effective incorporation of these insulation materials into masonry blocks designed for exterior walls, where VIPs become integrated insulation. This application minimises the hazard of mechanical damage provided the insulation is placed in the block correctly. In this paper, four kinds of materials, applicable as the core of VIPs, are compared. This is a standard mineral wool, commercial VIP based on pyrogenic silica and two experimental types of VIPs based on cotton. Four application possibilities were proposed and thermal properties of individual variants were compared.

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Keywords: Vacuum insulation panel; thermal conductivity; masonry element; masonry constructions

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1. Introduction

The current share of energy needed for heating and cooling of buildings is 40 % of the total energy consumed. The high amount of energy needed for heating and ventilation has a negative impact on the environment, especially in terms of CO_2 emissions and the exploitation of non-renewable material resources (fossil fuels). Improving the energy performance of buildings is one of the key contemporary topics worldwide. In Europe, the thermal protection of buildings is regulated by the Directive 2010/31/EU of the European Parliament and Council. One of the ways of improving the energy performance of buildings described therein is the improvement of the thermal properties of building envelopes [1,2].

The building envelopes of masonry buildings (constructed as single-wythe structures) can be improved by several means. The thermal conductivity of the material of the building blocks can be reduced, their geometry (both internal and external) and thickness can be modified or they can have thermal insulation incorporated inside (integrated thermal insulation). Concerning ceramic masonry blocks, it appears that this way is the most promising and will enable further improvement of the thermal insulation properties of masonry without the need for increasing its thickness excessively.

2. Vacuum insulation panels (VIP)

VIPs are a new progressive type of thermal insulation with extremely low thermal conductivity. They consist of two basic parts – the core and the envelope. Each part has its specific function and must meet specific requirements. The VIP core is made from an insulation material with a very fine pore structure and extremely low thermal conductivity at low pressure. The function of the core is to maintain a constant near-vacuum negative pressure inside the insulation. It also protects the insulation from mechanical damage.

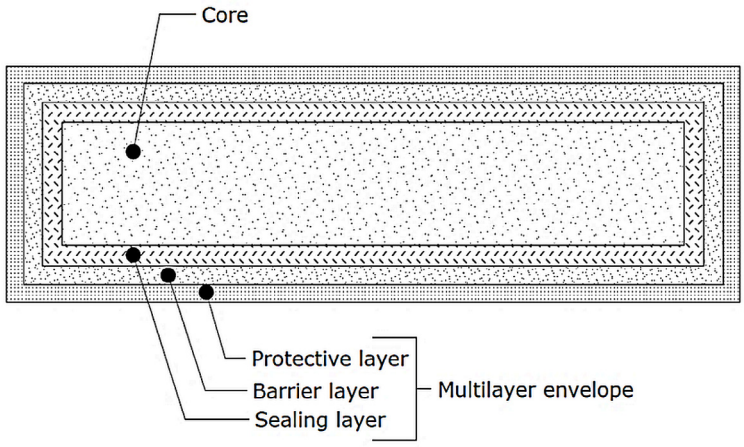

Fig. 1. VIP diagram.

VIPs have significantly lower values of thermal conductivity than thermal insulation commonly used in construction today. They are 5 to 10 times better than that of the common thermal insulation; specifically 0.003 – 0.008 $W \cdot m^{-1} \cdot K^{-1}$. Thanks to this, the use of VIPs significantly improves the thermal insulation properties of the whole structure. However, VIPs are rather fragile, since they lose their unique properties upon mechanical damage. Nowadays, VIPs are frequently used in refrigeration, whether in refrigeration boxes, temperature controlled vans or home appliances. In these applications, VIPs are firmly incorporated into the plastic or metal walls of these devices.