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Influence of EPS, mineral wool and plaster layers on sound and thermal insulation of a wall: a case study

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ABSTRACT

Different envelope solutions are used for the implementation of thermal insulation requirements, assuming that a solution that insures good thermal insulation will automatically insure good sound insulation. The use of External Thermal Insulation Composite System (ETICS) may be one of many solutions. The aim of the experiment was to evaluate how thermal insulation (EPS and mineral wool) and coating (plaster) layers of ETICS influence on sound and thermal insulation of a basic element (wall). The experimental results showed that added thermal insulation (EPS and mineral wool) and coating (plaster) layers of ETICS can influence the sound and thermal insulation of the wall differently. The addition of a thermal insulation layer of ETICS changes sound insulation (increases up to 4 dB) of wall with mineral wool, but in using EPS, has no significant influence. The addition of a coating (plaster) layer over the thermal insulation material layer allows an increase in sound insulation in both cases from 3 dB to 7 dB, but does not change the thermal insulation. The addition of a layer of thermal insulation changes the thermal insulation of basic wall – it increases up to 4.88 m^2 K/W with EPS and up to 5.09 m^2 K/W with MW, respectively. The influence on sound insulation depends on the type of thermal insulation material used, the presence or absence of a coating (plaster layer) and its thickness, while the influence on thermal insulation does not depend on these factors. It only depends on the presence of the thermal insulation layer.

1. Introduction

In recent years in the European Union, more and more attention has been paid to requirements for the thermal insulation of building's envelope [1–5] due to directives issued by the European Union, in which it is required that the Member States must take steps to increase the energy efficiency of their buildings [6]. The thermal issues often dominate and overshadow the question of a building's acoustic performance [7,8]. But this should not be so, because nowadays, environmental noise is a global problem throughout Europe and the rest of the world [9–13]. The European Environment Agency estimates that 65% of the residents of major European cities are exposed to noise levels of 55 dB L_{den} and 50 dB L_{night} [9]. Buildings could be protected from excessive noise by means of technical solutions, planning and regulations that are within the general concept of "environmental noise management" [14]. Technical solutions that are used to increase the sound insulation of buildings' envelopes are associated with a combination of high-performance external walls and windows (concerning their good sound and thermal properties). Various types of wall and window constructions (curtain walls, Trombe walls, autoclaved aerated concrete walls, double skin walls, green walls, multilayer glazing, vacuum glazing, aerogel glazing and etc.) are used for a building's envelope in order to ensure an appropriate sound insulation [8,15–25]. The different researches showed that increasing mass of construction or combing different type materials layers enables to increase the sound insulation. The combination of homogeneous and porous layers enables to increase the performance of the walls. The combination of different thickness of glass panes, usage of laminated glass, different thickness and large gaps between glass panes, higher density material (example aerogel) or gas (example Xeon) usage in gap between glass panes of windows enables to ensure better acoustic performance. The problem is that these technical solutions, especially those of walls, are frequently perceived of as a simple thermal resistance analogy, and the belief that providing good thermal insulation is enough to ensure proper acoustic performance is fairly common [8]. But this is not always so [8]. Another problem is that the requirements and recommendations within the area of the building and construction sector for the envelope of a building are not always coordinated to avoid incoherence in meeting different

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requirements (thermal and acoustic), which may conflict with each other, making them impractical or unachievable in practice [8]. In implementing these requirements, appropriate universal solutions that could not only be used for a building's façade, but also for partitions between garages and apartments, which are also part of a building's envelope, are needed [8]. The most common universal solution that is used is known as the External Thermal Insulation Composite System (ETICS) [8,26–29]. The use of ETICS has increased throughout the last decades in Europe [28,30]. In various research, most of the attention has been focussed on the physical-mechanical and thermal properties [28,30–36] of ETICS, while the acoustic properties have been disregarded [27]. Moreover, very little research has been done on evaluating the overall thermal and acoustic properties of ETICS. For example, Guigou-Carter et al. compared, measured and predicted the sound insulation features of thermally-retrofitted buildings [37]. They determined that the addition of a polystyrene, when applied to a building façade, has little (1 dB) or no effect on the airborne sound insulation. Instead, changes in the types and materials used for windows have a more important and positive effect (4–5 dB increase in sound insulation) on the façade sound insulation. Weber et al. studied the influence of wall construction on the acoustical behaviour of ETICS [38]. ETICS with extruded polystyrene and mineral fibre on supporting walls of different thickness made from solid lime-sand brick and vertical coring brick was investigated in their research. They found that the improvement of sound insulation by ETICS can strongly depend on the construction of the supporting wall and for light walls with low transmission loss, the improvement of sound insulation seems to be greater than that achieved for heavy ones. The improvement for lightweight wall adding EPS was 19 dB and mineral fibre – 14 dB, respectively. Nurzynski investigated the additional thermal lining effect on the acoustic performance of a wall [39]. He used ETICS with expanded polystyrene and mineral wool on a massive wall constructed from calcium silicate blocks, and also on lightweight cellular concrete and hollowed ceramics, respectively. He also used ETICS with elastic expanded polystyrene on the lightweight cellular concrete wall, and special mineral wool on the hollowed ceramics wall. His research showed that the application of lightweight thermal insulation linings is beneficial from the perspective of energy conversion, but for heavyweight constructions, it produces an adverse side effect by decreasing the sound insulation (up to 7 dB) of a wall. Only for lightweight constructions, it has positive effect on sound insulation (increases it up to 8 dB). Semprini et al. tried to find a correlation between the acoustic and thermal performance of building structures [40]. In their research, they investigated walls with external insulation (expanded polystyrene foam, mineral wool, mineral fibre, wood fibre, glass wool). The results showed that the weighted sound reduction index increases 2–8 dB of ceramic hollow bricks wall with wool, but with EPS do not changes. Parati et al. studied the acoustic aspects of retrofitting structures [41]. They tested two different types of walls: light aggregate concrete block and lightweight brick respectively, with high density uncoated and coated mineral wool; uncoated and coated EPS. The test results showed that sound insulation improvement of lightweight external walls are more affected by the ETICS than heavy walls respectively up to 19 dB and up to 12 dB. A study associated with the balancing of thermal and acoustic insulation performance in the envelope design of buildings was performed by Di Bella et al. [42]. The results of this study showed that thermal and acoustic design optimization have to take into account field transient conditions, as well as structural joints, because a simple

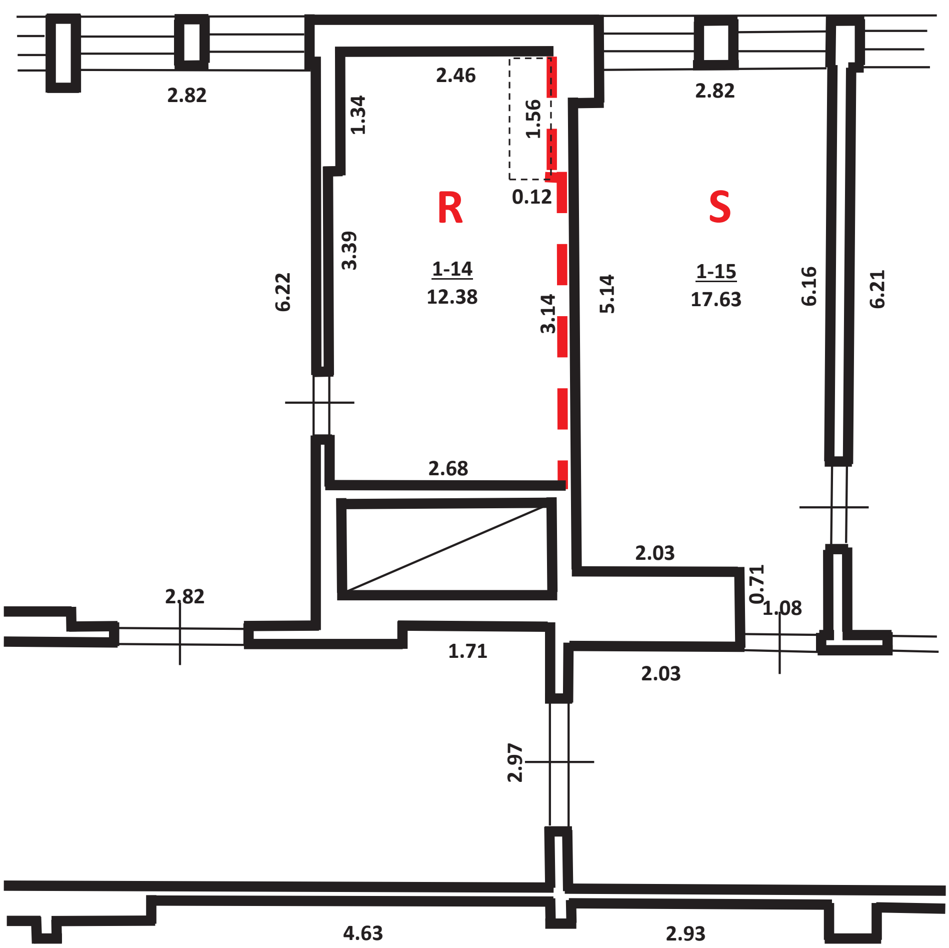

Fig. 1. Fragment of the building plan. S – source room; R – receiving room. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)