# Sound Insulation of New Wood-based Curtain Wall System

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## Abstract

This paper is dealing with the acoustic behavior of new wood-based curtain wall system. This new lightweight facade module system can be used for the replacement of old metallic curtain walls as well as for new buildings with non-bearing envelopes. It has low primary energy consumption compared to standard metallic facades, low carbon footprint and low heat transfer coefficient (U-value). Prefabricated wood-based panels also allow integration of active elements like photovoltaic and heat recovery units.

The results of laboratory measurements of airborne sound insulation are presented and discussed in this paper for different wall compositions (including freestanding front walls). The solution for high sound insulation is also described together with appropriate sound insulation data.

## Introduction

The main structural parts of the new curtain wall system are made of wood based materials. Each facade panel has a wooden supporting frame, filled with wood fibre thermal insulation. The interior side of the frame is covered with OSB boards and the exterior side with dense wood fibreboards – see Table 1 and Figure 1. Panels can be precisely prefabricated in factory, transported to a building site and easily mounted to an independent load bearing structure of the building. This construction technique is similar to that used for common modern glass and metal curtain walls, but the new system is significantly more environmentally friendly. The carbon footprint is only 6 $kg_{CO2,eqv.}/m^2$ compared to 168 $kg_{CO2,eqv.}/m^2$ of standard metallic building envelopes and the primary energy consumption is by about 70% lower [4]. The heat transfer coefficient is also very low – only 0,13 $W.m^{-2}.K^{-1}$. Beside the standard (non-transparent) panels, a special facade panels with wooden triple glazed windows (4-18-4-18-4) were also developed and tested. Expansion joints between panels are sealed with two-stage rubber gaskets which are inserted between panels during the installation. Finally, the new curtain wall system can be used with various facades. The most recommended are double-skin ventilated facades with wooden laths or tile cladding, but external thermal insulation composite systems can also be used [2, 4].

**Table 1:** Composition of standard (non-transparent) panel

| Description | Density [$kg.m^{-3}$] | Thickness [mm] |
|---|---|---|
| Oriented strand board | ≥ 620 | 15 |
| Wood fibre insulation board | 50 | 240 |
| Vapour-permeable wood fibreboard | 625 ± 25 | 15 |


**Figure 1:** Scheme of the curtain wall consisting of wood-based panels [4].

## Development and testing

The new curtain wall system described in this paper was developed in the University centre of energy efficient buildings of the Czech technical university in Prague by a multidisciplinary team of experts in structural design, thermal insulation, life cycle assessment, fire resistance, acoustics and air tightness.

Many tests and measurements have already been done (and the results were used for the development and optimization), but some long-term tests are still ongoing. These tests are primarily focused on durability and thermal and moisture related problems. However, this text is focused only on acoustic behaviour of the new facade system.

## Acoustic performance

Airborne sound insulation of facade system was measured in acoustic laboratory according to EN ISO 10140-2 and EN ISO 10140-4.

**Figure 2**: Test specimen consisting of 4 standard panels.

All tests were performed on a typical segment of facade, consisting of four panels. This arrangement ensured that the measured sound insulation was affected by the structural crossing between horizontal and vertical expansion joints. Acoustically, this is probably the weakest part of facade. Two upper panels (see Figure 2) were supported by a horizontal beam element during the test to simulate the same installation conditions as in the building. This prevented unfavorable compression of horizontal joint between panels and allowed to adjust its thickness. A view of the test specimen is in Figure 2 (non-transparent panels) or Figure 4 respectively (1 panel with window).

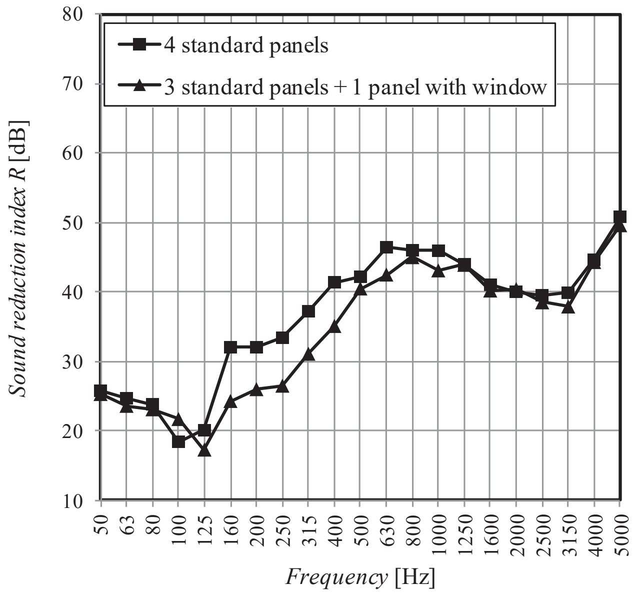


**Figure 3**: Measured airborne sound insulation, 4 standard panels - $R_w$ ($C$; $C_{tr}$) = 41 (-2; -6) dB, 3 standard panels + 1 panel with window - $R_w$ ($C$; $C_{tr}$) = 38 (-2; -5) dB.

The measured results are summarized in Figure 3. It can be seen that the sound reduction index of facade with window is somewhat lower than that for non-transparent variant in almost all frequency bands between 100 Hz and 3 150 Hz. However, the difference is not dramatic and, compared to the current legislation in the Czech Republic, both variants can be used in almost all areas where the limits of traffic noise aren´t exceeded. Typically, this is the case of suburban areas.

**Figure 4**: Test specimen consisting of 3 standard panels and 1 panel with window.

In the city centers, improved robust solution must be used. This wouldn´t be a problem because the curtain wall system will be always used together with independent wall lining on interior side. It has several reasons, but the most important one is the fire protection of building. Therefore, following structure has been also tested:

- 240 mm basic construction (four non-transparent panels).
- 25 mm air gap.
- 50 mm steel studs (CW50) + mineral wool.
- 12.5 mm plasterboard (9 kg.m$^{-2}$).

It should be mentioned here that the thickness of wall lining is acoustically insufficient. Especially in the low frequency region (below 100 Hz), the mass-air-mass resonance would therefore have a negative effect on sound reduction index (see Figure 5). At the present time, when this region is not included into the weighted indices of sound insulation, it is not a significant problem. However, if the rating system is changed in the future, it will be necessary to optimize the thickness of wall lining.

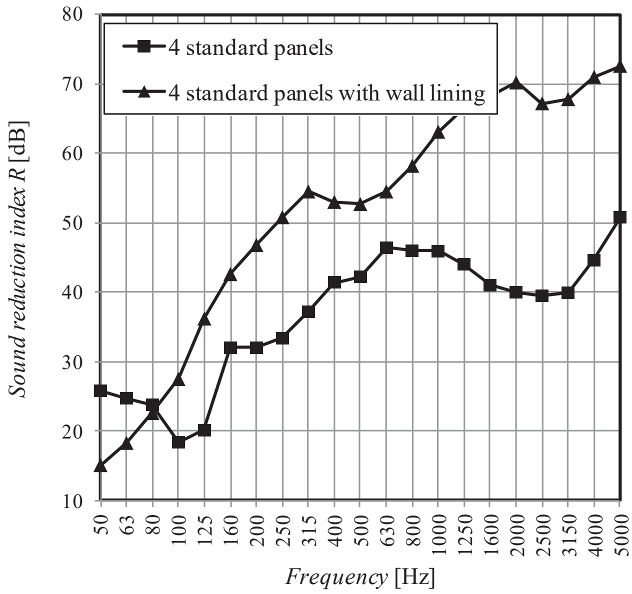


**Figure 5**: Measured airborne sound insulation, 4 standard panels - $R_w$ ($C$; $C_{tr}$) = 41 (-2; -6) dB, 4 standard panels with wall lining - $R_w$ ($C$; $C_{tr}$) = 57 (-3; -11) dB.

Measured sound reduction index of facade system with and without the wall lining is shown in Figure 5. The improvement is significant in all frequency bands above 100 Hz. Increase of $R_w$ is 16 dB, but delta $R_w$ + $C_{tr}$ is only 11 dB. This indicates that the airborne sound insulation is less for traffic noise than for other common sounds (with frequency spectrum close to pink noise).

Regarding the current quantity $R_w$, the facade system with wall lining reaches similar values as traditional heavyweight building envelopes. Acoustically, it can be considered as adequate (and environmentally friendly) alternative to masonry or concrete walls.

## Optimization of acoustic properties

The measured sound reduction index of standard panels was analyzed and compared with calculations using several models, but for clarity the details are not discussed in this paper. However, in Figure 6 a simple comparison with the mass law prediction is shown, which is also very interesting. It can be seen that the measured curve and calculated line are similar, although the measured sound reduction index is still somewhat higher. It indicates that the curtain wall tends to behave like a double structure, but due to a rigid frame connection between face sheets and stiff fibre insulation core inside panels, the attenuation caused by double character of wall is poor. There are also two big dips in *SRI* curve – one in the low frequency region and the second, caused by the coincidence effect, at high frequencies.

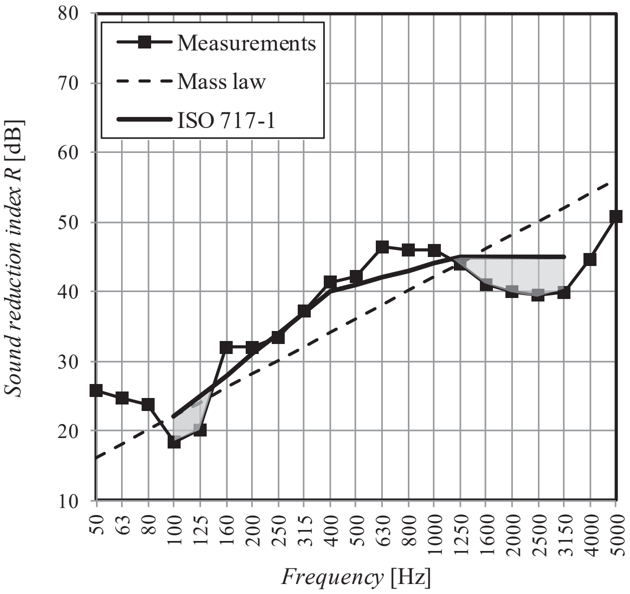


**Figure 6**: Airborne sound insulation, 4 standard panels (measured) - $R_w$ ($C$; $C_{tr}$) = 41 (-2; -6) dB, mass law (calculated) - $R_w$ ($C$; $C_{tr}$) = 40 (-1; -5) dB.

To suppress these dips and improve the sound reduction index, one layer of insulation board consisting of cardboard and sand was added to interior side of panels. The effect is shown in Figure 7. The weighted sound reduction index $R_w$ increased by 9 dB (from 41 dB to 50 dB) and $R_w + C_{tr}$ by 11 dB. The second result is the same as for standard panels with independent wall lining, but in this case only 15 mm thick board was added to basic structure, compared to 85 mm of free standing front wall. It should be also noted that the increase of 9 dB was achieved with the structure which has surface mass only by about 30% higher than the original one (approx. 45 kg.m$^{-2}$ compared to 30 kg.m$^{-2}$). Such surface mass is still very low taking into account that for single homogeneous structures the surface mass of 250 to 300 kg.m$^{-2}$ is needed to achieve $R_w$ around 50 dB. The shape of *SRI* curve is very similar to ISO 717-1 curve. This indicates that the airborne sound insulation is optimized.

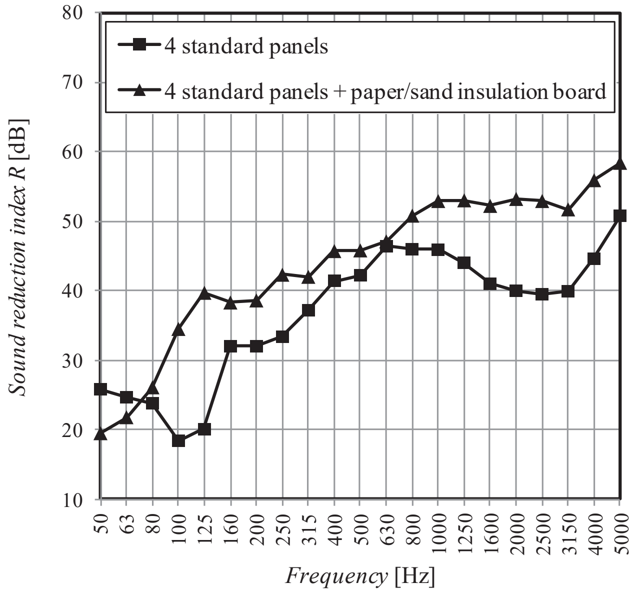


**Figure 7**: Measured airborne sound insulation, 4 standard panels - $R_w$ ($C$; $C_{tr}$) = 41 (-2; -6) dB, 4 standard panels with paper/sand insulation board - $R_w$ ($C$; $C_{tr}$) = 50 (-1; -4) dB.

## Conclusions

The new curtain wall system described in this paper represents environmentally friendly solution for lightweight building envelopes. The results of initial measurements and testing show that it can compete with conventional glass and metal facades as well as heavyweight walls. The further work will focus on long-term durability tests and (regarding acoustics) on in-situ measurements of facade sound insulation, investigation of flanking transmission and evaluation of influence of different types of facades.

## Acknowledgments

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## Literature

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