BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul LX (LXIV), Fasc. 2, 2014
Secţia
CONSTRUCŢII. ARHITECTURĂ

SOUND REDUCTION EFFECTS OF PLASTERED ROCK WOOL SLAB FACADE THERMAL INSULATION SYSTEMS (II)

BY

Lajos Kocsis*

University of Pécs, Hungary

Received: March 31, 2014
Accepted for publication: April 14, 2014

Abstract. Insulating the exterior walls subsequently is one of the most important tasks at energy efficient modernization of old buildings. Depending on their material and structural design, the new layers can increase or decrease the sound reduction ability of the original supporting wall. If due attention is given for the protection against noise during the design, the plastered rock wool (RW) slab facade thermal insulation systems can result better sound insulation performance for the exterior walls in some cases, so they can increase the acoustic comfort in the rooms of buildings exposed to exterior ambient noise (coming usually from road transport). On the basis of the relevant features of the components of the complete outer wall, with the available detailed calculation method, the paper defines how the weighted sound reduction index of the original supporting wall can change, considered also the spectrum adaptation term suitable for road traffic noise. With help of praxis oriented characteristic structural parameters, it examines the options of the acoustic optimization, and the values of $\Delta(R_w + C_{tr,50...5000})$ which are available during energy and noise conscious construct.

The first section described the acoustic model, the calculation method, and the modifying effect under standard conditions. This second part of the paper analyzes the role of each ingredient, and the changes of sound reduction at characteristic structural solutions.

All formulas presented in this paper were developed by L. Weber in a semiempirical model based on a large number of measurements in building

*Corresponding author: *e-mail*: kocsis@pmmik.pte.hu

acoustic laboratories (Weber, 2013). The eqs. adopted in the paper lean on this source, however, modify the original relations somewhat.

Key words: building structure; exterior wall; facade heat insulation; rock wool slab; protection against noise; sound insulation; sound reduction.

1. The Sound Reduction Effect of the Specific Flow Resistance of the Rock Wool Slab

The calculation method does not take into account the effect of the specific flow resistance of the RW (rock wool) slab between the standard conditions, so a separate correction factor must be applied. To its determining serves the following relationship:

$$C_{sfr} = 0.12\mathrm{r} - 3.7, \qquad (1)$$

where: C_{sfr} is the specific flow resistance correction factor, [dB] (C – correction factor, $_{sfr}$ – specific flow resistance); r – the specific flow resistance of the RW slab, [kPa.s/m^2].

According to measurements, the r characteristic of RW slabs for plastering is usually formed between 20...64 kPas/m^2, and it can be calculated with 32 kPas/m^2 as a characteristic average value (Weber, 2013). Based on the latter parameter, the specific flow resistance correction factor happens to C_{sfr} = 0.1 dB. This does not affect the expressions $\Delta(R_w + C_{tr,50\ldots5000})_s$ data fixed to standard conditions substantially, however, the positive effect of this specific material property can be already 3.5 dB *e.g*. in case of r = 60 kPa.s/m^2 (Table 1).

Table 1
Values of the Specific Flow Resistance Correction Factor (C_{sfr})
in Case of RW Slabs with Specific Flow Resistance of r = 20…60 kPa.s/M^2

No.	Specific flow resistance of RW slab, r, [kPa.s/m^2]	Specific flow resistance correction factor, C_{sfr}, [dB]
1	20	−1.3
2	30	−0.1
3	40	1.1
4	50	2.3
5	60	3.5

Based on the data of the Table 1, it can be ascertained that it is expedient to build in a RW slab with greater specific flow resistance – if it is available from supply of manufacturers – for the sake of larger sound reduction of the updated wall (Fig. 1).

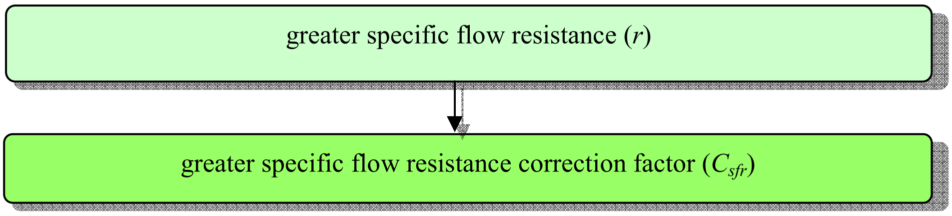

Fig. 1 – Model of obtaining greater specific flow resistance correction factor (C_{sfr}).

2. The Sound Insulation Effect of the Supporting Wall

The estimation method takes 53 dB weighted sound reduction index of supporting wall as a basis between the standard conditions, so when the original outer wall has a performance different from this, it is necessary to apply a particular supporting wall correction factor (C_{sw}). Its size depends partly on the resonance frequency of the new complete wall (f_0), partly on the weighted sound reduction index of the old supporting wall ($R_{w,sw}$) ($_{sw}$ – supporting wall).

The exact value of the C_{sw} can be calculated by the following relation:

$$C_{sw} = (1.3\lg f_0 + 3.4)(R_{w,sw} + 53) \qquad (2)$$

where: C_{sw} is the supporting wall correction factor, [dB]; lg – the base of 10 logarithm; f_0 – the resonant frequency of the originally single leaf massive wall provided with plastered RW slab thermal insulation system, [Hz]; $R_{w,sw}$ – the weighted sound reduction index of the supporting wall, [dB].

It could be seen from the previously analyzed structural solutions that the resonance frequency is f_0 = 54…90 Hz if the RW slab is 16…20 cm thick, and the surface mass of its plaster is 10…22 kg/m^2. In the case of such f_0 values, the supporting wall correction factor spreads from 10.3 dB to –6.9 dB if the weighted sound reduction index of the supporting wall moves between $R_{w,sw}$ = = 44…59 dB, namely

a) the maximum C_{sw} = 10.3 dB follows from f_0 = 54 Hz and $R_{w,sw}$ = = 44 dB (*i.e.* with 20 cm thick RW slab, with 22 kg/m^2 plaster, and with a supporting wall having a relatively small $R_{w,sw}$ parameter);

b) the smallest (C_{sw}= 6.9 dB) can be calculated by f_0 = 54 Hz and $R_{w,sw}$ = = 59 dB (consequently also by d_{RW} = 20 cm and m_p = 22 kg/m^2 structural features, but by a supporting wall being capable of big sound reduction);

c) the smaller the resonance frequency is, the greater the effect of the weighted sound reduction index of the old supporting wall is usually (Table 2).

Table 2

Representative Values of the Supporting Wall Correction Factor (C_{sw}) *Depending on the* f_0 = 54...90 Hz *Resonance Frequency and on the* $R_{w,sw}$ = 44...59 dB *Weighted Sound Reduction Index of the Massive Wall Provided with Plastered RW Slab Thermal Insulation*

No.	Resonance frequency, f_0, [Hz]	The weighted sound reduction index of the supporting wall, $R_{w,sw}$, [dB]					
		44	47	50	53	56	59
		The supporting wall correction factor (C_{sw})					
		Favourable			Neutral	Unfavourable	
1	54	10.3	6.8	3.4	0	–3.4	–6.9
2	60	9.8	6.5	3.3	0	–3.3	–6.5
3	80	8.3	5.6	2.8	0	–2.8	–5.6
4	90	7.7	5.2	2.6	0	–2.6	–5.2

For the sake of better sound insulation of the massive wall provided with plastered RW slab thermal insulation system, the supporting wall correction factor itself can be so better if

a) the supporting wall having smaller than 53 dB weighted sound reduction index is coupled with small resonance frequency,

b) in case of a supporting wall of $R_{w,sw}$ > 53 dB performance, the f_0 value is large (Fig. 2).

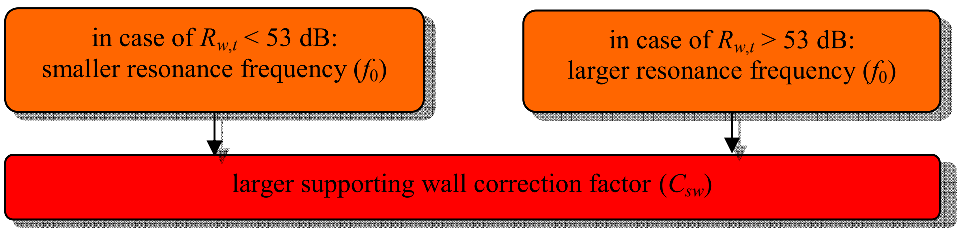

Fig. 2 – Model of obtaining larger supporting wall correction factor (C_{sw}).

3. The Acoustic Effect of the Adhesive Mortal

The sticking gives the first fixing of the insulation during the building. According to recommendation of the system owners, the adhesive mortar must cover the back of the rock wool slabs in a surface ratio of at least A = 40% in built-in state. By such a degree according to measurements, the adhesive mortar behaves as an additional spring in acoustic sense, witch decreases the dynamic stiffness and the resonance frequency consequently (Weber, 2013). However, increasing the gluing rate has generally an unfavorable sound insulation effect. The estimation model reckons with A = 40% between the standard conditions, so it must be applied an adhesive mortar correction factor (C_{am}) at structural solutions different from this. The C_{am} value can be determined by the following formula:

$$C_{am} = 1.7 - 0.043A \quad (3)$$

where: C_{am} is the adhesive mortar correction factor, [dB] ($_{am}$ – adhesive mortar); A – the surface ratio of the adhesive mortar, [%].

The Table 3 shows what adhesive mortar correction factors can be calculated by different gluing surface ratio. In case of A = 40...100 %, the correction of the sound reduction is between 0 dB and 2.6 dB according to standard condition system. The less the A-value exceeds the 40%, the smaller the lowering effect is.

Table 3
Values of the Adhesive Mortar Correction Factor (C_{am}) Depending on the Surface Ratio of the Adhesive Mortar

No.	Surface ratio of the adhesive mortar, A, [%]	Adhesive mortar correction factor, C_{am}, [dB]
1	40	0
2	50	–0.4
3	60	–0.9
4	70	–1.3
5	80	–1.7
6	90	–2.2
7	100	–2.6

The gluing can be contributed to greater weighted sound reduction index of the external wall provided with plastered RW slab thermal insulation system ergo so that it is made on lower surface, met the stability requirements (Fig. 9).

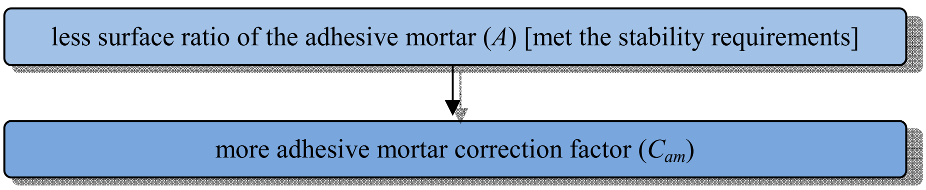

Fig. 3 – Model of obtaining more adhesive mortar correction factor (C_{am})

4.The Sound Reduction Effect of the Plug Anchors

The rock wool slabs must be fastened also with plug anchors to the supporting wall. Depending on tensile load capacity of the plug anchor (on its structure and on material of the supporting wall) furthermore on its position on the supporting wall (on its wind suction stress), the required quantity of the plug anchors is usually approx. 4...6 db/m^2 on intermediate parts of the facade, while about 6...14 db/m^2 on its two lateral and upper 1...2 m outside stripes. These mechanical fixings prevent the vibration of the insulation system, so dampen its acoustic effect: they reduce the positive sound reduction improvement and mitigate (can mitigate) the negative deterioration of value. The estimation procedure takes all of this into account that it determines the sound reduction modifying effect of the plastered RW slab thermal insulation system with standard conditions and without plug anchors and with application of the necessary correction factors, which it halves roughly with a constant factor, then it moderates forth by subtracting a constant value:

$$\Delta(R_w + C_{tr,50...5,000}) = 0.54\Delta(R_w + C_{tr,50...5,000})_{wpa} + 1.2 \quad (4)$$

where: $\Delta(R_w + C_{tr,50...5,000})$ is the modifying effect of the plastered RW slab thermal insulation system for the weighted sound reduction index of the single leaf massive supporting wall, with considering the $C_{tr,50...5,000}$ spectrum adaptation term, [dB]; $\Delta(R_w + C_{tr,50...5,000})_{wpa}$ – the modifying effect of the plastered RW slab thermal insulation system for the weighted sound reduction index of the single leaf massive supporting wall, with considering the $C_{tr,50...5,000}$ spectrum adaptation term, without plug anchors ($_{wpa}$), [dB].

5. Conclusions

The Table 4 shows the sound reduction modifying effect (the $\Delta(R_w + C_{tr,50...5000})$ values) of plastered RW slab thermal insulation systems, depending on the resonance frequency and on the weighted sound reduction index of the supporting wall, to characteristic cases, when

a) the dynamic elasticity modulus of the RW slab is E_d = 0.5 MN/m^2;

b) the thickness of the RW slab are d_{RW} = 16...20 cm (0.16...0.20 m);

c) the surface mass of the plaster of the RW slab are m_p = 10...22 kg/m^2;

d) the specific flow resistance of the RW slab is r = 32 kPas/m^2 (so the specific flow resistance correction factor is C_{sfr} = 0.1 dB);

e) the surface ratio of the adhesive mortar of the RW slab is A = 40% (so it is not necessary applying adhesive mortar correction factor, C_{am} = 0 dB);

f) the weighted sound reduction index of the supporting wall are $R_{w,sw}$ = = 44...59 dB (Kocsis, 2007, 2008).

Based on the data of the Table 4, according to the estimation procedure, in case of the above characteristic material properties and structural solutions, it can be proved that the plastered RW slab thermal insulation system

a) affects the sound reduction of the original external wall in measure of between 3.4 dB and 5.8 dB;

Table 4
Representative Values of Sound Reduction Modifying Effects of Plastered RW Slab Thermal Insulation Systems [$\Delta(R_w + C_{tr,50...5000})$], *Depending on the Resonance Frequency and on the Weighted Sound Reduction Index of the Supporting Wall*

No.	Resonance frequency (f_0)	The weighted sound reduction index of the supporting wall ($R_{w,sw}$)					
		44 dB	47 dB	50 dB	53 dB	56 dB	59 dB
		$\Delta(R_w + C_{tr,50...5000})$ [dB]					
		Favorable		Neutral	Unfavorable		
1	54 Hz (d_{RW} = 20 cm, m_p = 22 kg/m^2)	3.4	1.6	–0.3	–2.1	–4.0	–5.8
2	60 Hz (d_{RW} = 16 cm, m_p = 22 kg/m^2)	3.4	1.7	–0.1	–1.8	–3.6	–5.4
3	80 Hz (d_{RW} = 20 cm, m_p = 10 kg/m^2)	3.4	2.0	0.5	–1.0	–2.6	–4.1
4	90 Hz (d_{RW} = 16 cm, m_p = 10 kg/m^2)	3.4	2.1	0.7	–0.7	–2.1	–3.5

b) its acoustic role is usually favorable at supporting walls having less than 50 dB weighted sound reduction index, however, over this it is typically disadvantageous;

c) it results the biggest improvement effect (3.4 dB) by supporting walls of $R_{w,sw}$ = 44 dB (which have a relatively low acoustic power);

d) the value of $\Delta(R_w + C_{tr,50...5000})$ = 3.4 dB is formed with constant character also by d_{RW} = 16...20 cm insulation thicknesses and m_p = 10...22 kg/m^2 plaster surface masses;

e) the new layers do not influence the original sound insulation potential at supporting walls of $R_{w,sw}$ = 50 dB essentially (the change is smaller than 1 dB);

f) it must be calculated on the most unfavorable data of $\Delta(R_w + C_{tr,50...5000})$ = 5.8 dB if the supporting wall has a $R_{w,t}$ = 59 dB weighted sound reduction index, the RW slab is d_{RW} = 20 cm thick, and the surface mass of its plaster is m_v = 22 kg/m^2.

However, it must be also taken into account that the accuracy of the method is ± 2.2 dB (since the standard deviation of the differences between the data measured in building acoustic laboratories and the ones calculated with the estimation procedure has such a value; the mean of the differences is equal to zero).

REFERENCES

Cziesielski E., Vogdt F.U., *Schäden an Wärmedämm-Verbundsystemen*. Fraunhofer IRB Verlag, Stuttgart, 2007.

Kocsis L., *EPS homlokzati hőszigetelések léghanggátlási hatása*. Építés Spektrum, **9**, *3*, 26-31 (2010).

Kocsis L., *Új hangszigetelési követelmények 2*. Magyar Építéstechnika, **46**, *1*, 16-17 (2008).

Kocsis L., *Új hangszigetelési követelmények*. Magyar Építéstechnika, **45**, *10*, 22-24 (2007).

Metzen H.A., *Wärmedämm-Verbundsysteme zum Thema Schallschutz,* Fachverband WDVS e. V., Baden-Baden, 2003.

Weber L., Brandstetter D., *Einheitliche schalltechnische Bemessung von Wärmedämm-Verbundsystemen*, Fraunhofer IRB Verlag, Stuttgart, 2004.

Weber L., *Einheitliche schalltechnische Bemessung von Wärmedämm-Verbundsystemen – Ergänzung des Berechnungsverfahrens*, Fraunhofer IRB Verlag, Stuttgart, 2005.

Weber L., *WDV-Systeme zum Thema Schallschutz*, Fachverband WDVS e. V., Baden-Baden, 2013.

* * * *Bevonatréteggel ellátott, többrétegű, ragasztott táblás hőszigetelő rendszerek (ETICS-THR) kialakítása. Műszaki irányelv*. Magyar Építőkémia- és Vakolatszövetség (MÉSZ), MÉSZ, Budapest, 2012.

EFECTELE DE REDUCERE A ZGOMOTULUI ALE SISTEMELOR DE IZOLARE TERMICĂ A FAŢADELOR ALCĂTUITE DIN PLĂCI DE VATĂ MINERALĂ (II)

(Rezumat)

Izolarea termică a pereţilor exteriori reprezintă o fază importantă în procesul de modernizare energetică eficientă a unei clădiri existente. În funcţie de materialele utilizate şi de proiectarea structurii de rezistenţă, noile straturi puse în operă pot mări sau micşora capacitatea de izolare acustică a pereţilor existenţi. Considerarea în faza de proiectare a utilizării plăcilor din vată minerală pentru izolarea termică a pereţilor exteriori poate avea ca rezultat o mărire a protecţiei la zgomot, mărindu-se astfel nivelul de confort acustic în cazul clădirilor expuse la zgomot ambiental exterior (provenit în mod normal din traficul rutier). Pe baza caracteristicilor straturilor componente ale peretelui exterior, utilizând o metodă disponibilă de calcul detaliat, lucrarea de faţă defineşte cum indicele de reducţie sonoră al peretelui existent poate suferi schimbări, luând de asemenea în considerare factorul de corecţie a spectrului caracteristic

zgomotului rezultat din traficul rutier. Cu ajutorul parametrilor structurali caracteristici, sunt analizate opţiunile de optimizare acustică şi valorile pentru $\Delta(R_w + C_{tr,50...5,000})$.

Prima parte a lucrării descrie modelul acustic, metoda de calcul, precum şi efectul de modificare în cazul condiţiilor standard. Cea de-a doua parte va analiza rolul acustic al fiecărui element şi schimbările reducerii zgomotului pentru soluţiile structurale caracteristice.

Toate formulele folosite în această lucrare au fost dezvoltate de L. Weber într-un model semiempiric bazat pe un număr mare de măsuratori efectuate în laboratoare acustice (Weber, 2013). Ecuaţiile adoptate se bazează pe această sursă, modificând într-o anumită măsură relaţiile originale.