Acoustic Performance of the External Thermal Composite Insulation Systems Influence in Slovakia

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Introduction

Thermal insulation systems are an essential part of new as well as reconstructed buildings in the aim to reduce their heat use to achieve the criteria of EU energy policy to 2020 [1].

The systematic integration of the additional thermal insulation systems in the building envelopes in Slovakia began in year 1992. Nowadays architects commonly design thermal insulation with thickness about 120 mm. Predictions of EAE (European Association for External Thermal Insulation Composite Systems) for year 2021 shows, that, the requirements for thickness of thermal insulation of wall claddings will exceed 210 mm. Recent trend on requirements on building envelope may lead to additional insulating of already insulated walls. In Slovakia, around 52% of flats in dwelling houses and 33% of family houses were thermally insulated before year 2011. The most of buildings in Slovakia were insulated by all kinds of External Thermal Composite Systems (ETICS). In European Union (EU), towards the end of year 2011, there were about 358 valid European technical approvals (ETA) for ETICS producers, from which about 45 ETA were and 22 Technical certificate (TO) were registered in Slovakia. Majority of the systems here are based on EPS (expanded polystyrene) [2], which have a strong impact on the sound insulation of the wall claddings. In some cases, even decreasing of the facade sound insulation properties is very evident.

State of the art of acoustics performance of ETICS

ETAG004 document [3] does not provide criteria for ETICS in terms of acoustics. It refers to the current technical standards, which provide only a ways of measuring the acoustic properties of separating structures [4-7]. There are different approaches in assessment of the acoustic properties of external wall claddings in different EU countries. It reopens discussion on the assessment of separating structures in terms of the type of noise source again [8, 9]. The impact of ETICS on acoustic properties of external walls has been already examined. Probably the most fundamental research was carried out in Germany (Weber) [10-15]. The effect of thickness and dynamic stiffness of ETICS, as well as mass of external plaster, on decreasing of wall sound insulation was demonstrated [16, 17]. Here the mass spring mass resonances (m-s-m) were manifested, in case of massive external wall with ETICS. Realization of ETICS increases the sound insulation of walls in mass dependence frequency range (about 12dB/oct). However, ETICS resonances decrease sound insulation in low frequencies, which become very prominent in traffic noise situation. Mentioned resonance can be changed by "tuning" of external plaster or ETICS mass [18]. It has been shown, that the same insulation system may change the sound insulating properties in different ways, depending on the character of the “main” wall, related to mass of the “main wall" and its resonance and coincidence frequencies. Recommendations for single number evaluation of improvement of sound insulation due to ETICS have been also developed.

Currently, we also face the problem of subjective assessment of sound insulation of separating structures. The main problem to this respect is that the type of the sound source (traffic, railway, shipping or aviation noise) is not completely taken into account. If the ETICS resonances are above f>200 Hz, weighted sound reduction index R_w will be always lower. Acoustic bridges in ETICS and its impact on flanking sound insulation has been examined just partially. Recommendations have been introduced, that should help in correction factors for improvement of single number quantities. (the specific flow resistance correction factor C_{sft}, the supporting wall correction factor C_{sw}, the adhesive mortar correction factor Cam, the effect of the plug anchors C_{wpa}) [19, 20].

Case study

The evaluation of sound insulation of walls and floors against excessive noise can play a role also thermal insulation in ceilings above unheated garages [21].

The case study presented in this paper deals with a case in which a usage of a wrong ETICS applied on ceilings in garage in the basement of the apartment house. A case study shows results of measurements, the measurement methodology, the way the defect was found and the design of acoustic improvement and its validation by acoustic measurements.

Description of measured construction

The construction of interest (ceiling above the garage) is located in the new apartment building. Garage contains 26 parking places, and its floor area is 262 m^2. The acoustic problem was discovered during the building inspection and it has been decided, that the additional of system layers will be placed.

Figure 1: Composition of the ceiling structure before the acoustic measure. 1) wear layer; 2) floor layers with a total thickness 100 [mm]; 3) Reinforced concrete slab thickness of 250 mm (650 [kg/m^2]); 4) Polystyrene EPS 140+ light mortar; 5) light mortar with reinforcement mesh+ finish plaster (m'_2 = 4 [kg/m^2], s'=40 [MN/m^3]);

Measurement description

The acoustic measurements were carried out in accordance with the standard ISO 16283-1:2014 [22]. Source signal was pink noise generated from omnidirectional loudspeaker. In accordance to STN EN 61672 [23], the measurements were carried out by sound analyzers of class 1 (Fig. 2) and the measuring system was calibrated before and after the measurements.

Figure 2: The airborne sound insulation measurement of ceiling structure above the garage.

Measurements results and data analysis

The measurement of the airborne sound insulation of the original ceiling (R'_w = 54 (-2;-4) dB) shows, that the measured building structure does not meet the requirements of standard STN EN 73 0532:2013 (required value R'_w = 57 dB) [24]. Results shows a decrease of sound insulation around 500Hz. Theoretical calculation confirms the measured values (1) [10]

$$f_0 = 160 \cdot \sqrt{s' \cdot \left(\frac{1}{m'_1} + \frac{1}{m'_2}\right)} \qquad \text{(Hz)} \quad (1)$$

Where

m'_1 mass of based wall [kg/m^2]

m'_2 mass of ETICS [kg/m^2]

s' dynamic stiffness of ETICS [MN/m^3]

The theoretical resonance frequency of the original structure is $f_{0,theor.1}$ = 507 Hz (Fig. 4). This is a consequence of the low mass of ETICS. The ceiling construction showed relatively low sound insulation properties itself, resulting in unacceptable acoustic properties of whole construction.

In order to increase the mass of ETICS and so to achieve suitable ETICS resonances, additional thermal insulation based on mineral wool with a thickness of 50 mm has been proposed. This sollution helped to increase the mass of insulation system to m'_2 = 10 kg/m^2 with a result of shifting the resonance frequency to 300 Hz ($f_{0,theor.2}$ = 322 Hz). Resulting weighted sound reduction index of ceiling with acoustic measures of R'_w = 57 (-3;-6) dB has been reached (Fig. 5).

Figure 3: Solution of ETICS mass increasing ETICS.

Shift of resonance frequency was achieved from 500 Hz to 300 Hz ($f_{0,theor.2}$ = 322 Hz). Resulting weighted sound reduction index of ceiling with acoustic measures was R'_w = 57 (-3;-6) dB (Fig. 5).

Given example has shown in which manner it is possible to use ETICS to reduce or to increase the final single number rating according to the STN EN ISO 717-1 [25].

In Slovakia, the assessing frequency range for sound insulation is between 100 and 3150 Hz. As well known, this doesn't cover all sounds, that might be transmitted to the apartments form exterior noise or neighbor's noise.

In case of ceiling above the garage, the habitants usually complain about the disturbance by noise cause by the closing of the car doors, producing broad band noise with frequencies below the 100 Hz. Furthermore, the low frequency noise in case of the garage is also amplified by longer reverberation time of the space at low frequencies [26].

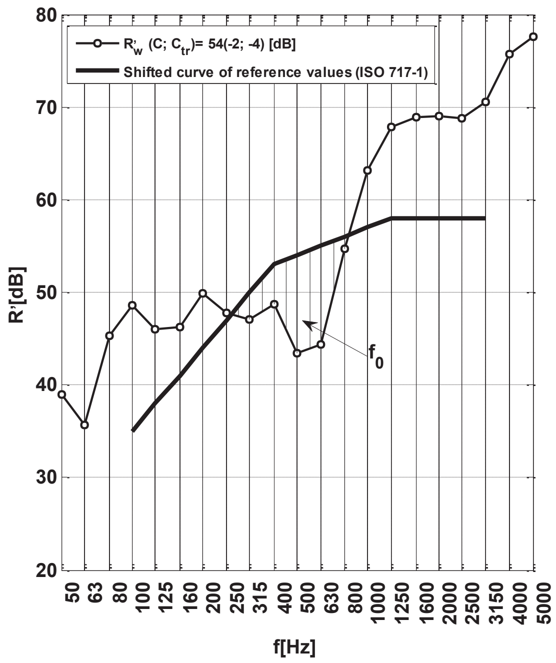

Figure 4: Measured air borne sound insulation of ceiling with ETICS of initial mass.

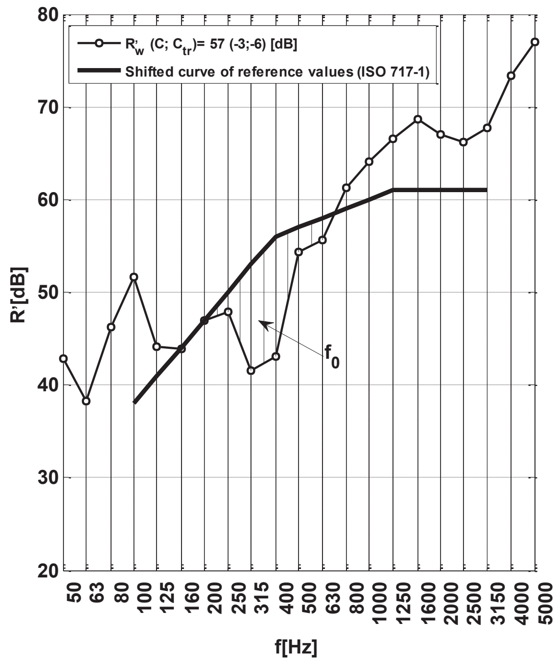

Figure 5: Measured air borne sound insulation of ceiling after increasing the mass of ETICS.

Conclusions

This article has shown an example of an improvement of airborne sound insulation properties of an ETICS system by "tuning" the resonance frequency. Increasing the mass of the ETICS by application of 5 cm mineral wool with 10 kg/m^2 in term of R_w with 3 dB.

In the future, the main focus should be given to the interaction between ETICS and light weight walls, since theses were until now examined only very marginally [27]. Wall thermal insulation behaviors in the high frequency range is still not completely clear. Many questions about the impact of ETICS on flanking sound transmission must be answered. Another issue is, that ETICS acoustic properties must be taken into account in building classification system. [28]. The impact of noise from road, rail and air traffic need to be included in the assessment of acoustic quality of walls in terms of revision of adaptation coefficients C and C_{tr} or by proposal of new single number quantity method, validated through listening tests [29].

Improvements in ETICS anchoring in detail, will require progressive measuring methods such as acoustic camera and/or laser vibrometry scanning[30, 31].

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