Sound insulation of external thermal insulation composite systems (ETICS)

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Introduction

External thermal insulation composite systems are used to improve the thermal insulation of heavy, solid walls. They are composed of a thermal insulation layer, fixed to the outside of the basic wall, and covered with a layer of plaster (fig.1). In most cases polystyrene is used as insulation material with thicknesses between 6 and 20 cm or even more. If elastified, the dynamic stiffness per unit area goes down to 5 MN/m³. Otherwise, the stiffness will be 50 MN/m³

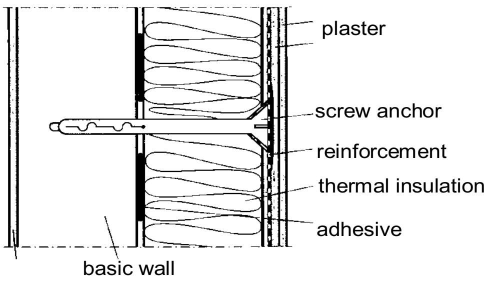

Figure 1: Elements of an ETICS

or more. With elastified polystyrene, the range of resonance frequencies of ETICS extends from about 80 to 160 Hz. If mineral fibre material is used for insulation, the stiffness is higher by reason of stability, and the resulting resonance frequencies extend from about 150 to 400 Hz and more. The plaster usually is between some millimeter and a few centimeter thick with a surficial mass from 10 to about 40 kg/m². If ETICS cannot be tightly applied to the basic wall, it is fixed with screw anchors or aluminium profiles. Together with the basic wall ETICS constitute a mass-spring-mass system and therefore can influence the sound reduction index of the basic wall either in a positive or in a negative way. This is valid not only for the direct sound transmission through the external wall and consequently the insulation from outdoor noise, but also – which often is even more importent - for the flanking transmission along the external wall to the neighbour (fig.2). The acoustic behaviour in the two cases is different if not opposed.

Direct transmission: model and measurement

Direct transmission through an external wall with ETICS was simulated with a mass for the basic wall, a medium performing longitudinal waves for the insulation layer, and another mass for the plaster (fig.3). Fig.4 shows a typical result of the sound transmission loss for ETICS. At low frequencies the sound reduction of the basic wall is reduced by the thickness resonance, where the two masses oscillate one against each other with the insulation as a linear spring in between. Above this resonance frequency, the sound reduction index would be increased by an ideal ETICS by 12 dB/octave. With real ETICS further resonances will occur, in the example given at 1000 and 2000 Hz, due to the inertia of the insulation material and thickness resonances in the material. Studies with this model show the following: The mass per unit area of the basic wall does not have much influence on the sound reduction improvement due to ETICS, when the basic wall is solid and considerably heavier than the ETICS. (Further theoretical investigation has shown another effect of the basic wall: the sound reduction improvement due to ETICS may be reduced below the coincidence frequency of the basic wall [1].) Increasing dynamic stiffness of the insulation layer will shift both the mass-spring-mass resonance to higher frequencies – a negative effect – and the first thickness resonance of the insulation layer – a positive effect. The density of the insulation influences the position of the thickness resonances within the insulation and should therefore be small. A high damping factor of the insulation material is always positive. A heavy plaster layer increases

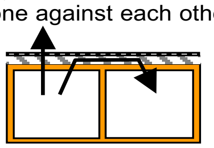

Figure 2: Transmission paths influenced by the ETICS

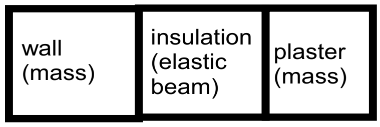

Figure 3: Model for direct sound transmission

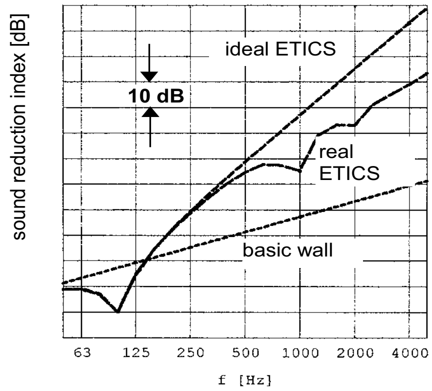

Figure 4: Sound reduction index of a solid basic wall with ideal and real ETICS

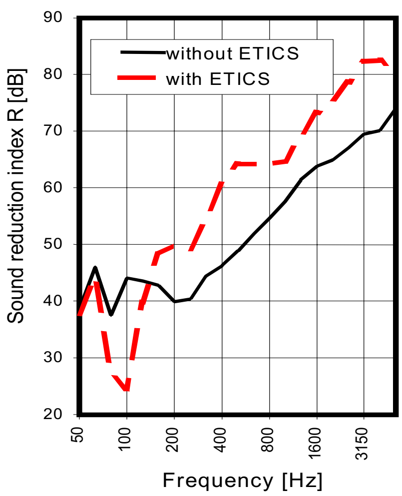

Figure 5: Sound reduction index of a masonry wall without and with ETICS.
Without: R_w = 53 dB, R_w+C_{tr} = 49 dB,
with: R_w = 61 dB, R_w+C_{tr} = 44 dB

the sound reduction improvement by lowering the mass-spring-mass resonance without negative effects on the thickness resonances within the insulation layer.

Fig.5 shows the measured sound reduction index of a solid basic wall without and with ETICS. There is a distinct reduction of the sound insulation by the ETICS around 100 Hz, which is a typical problem of acoustic linings. At higher frequencies, the improvement is obvious. One should be careful when evaluating the effects as a whole. The weighted sound reduction index R_w increases due to the ETICS from 53 dB to 61 dB. Nevertheless the 'improved' wall will be perceived as 'louder' with e.g. road traffic outside. Taking the spectrum adaptation terms C and C_{tr} into account yields the result that the sound reduction in terms of (R_w+C_{tr}) falls off from 49 dB to 44 dB, which subjectively can be better understood. That way a stiffer

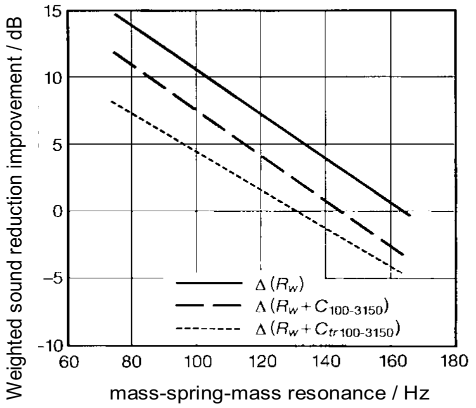

Figure 6: Weighted sound reduction improvement of ETICS on heavy-weight masonry walls as a function of the mass-spring-mass resonance of the system

system with a poor improvement at higher frequencies but a moderate dip at low frequencies might be the better solution. Fig.6 sums up a series of measurements, showing the sound reduction improvement due to ETICS on a heavy wall as a function of the mass-spring-mass resonance of the system. It should be kept in mind, that acoustic bypasses (e.g. windows) may reduce considerably the influence of ETICS.

Flanking transmission: model and measurements

To estimate the effect of ETICS on flanking transmission, three variations of a mass-spring-mass model were investigated according to three different building situations: (1) an ETICS on a continuous and (2) on an interrupted basic wall, and a similar insulation system on the inside of a flanking basic wall for comparison. Fig.7 shows calculated results. The inner insulating system yields the worst deterioration below 300 Hz, followed by ETICS, when the basic wall is interrupted (e.g. in terrace houses). In the latter case, ETICS is a sound bridge between the separated parts. The 'normal' situation in multi dwelling houses with continuous ETICS on continuous flanking walls reveals a moderate effect on flanking transmission, even with areas of improvement of the sound reduction around the mass-spring-mass resonance of the system. Measurements in laboratories and in situ show the same findings.

New measuring standard for acoustic linings

A new standard is being prepared for the laboratory measurement of sound reduction improvement by acoustic linings to which ETICS belong. This will be part 16 of ISO 140. In principle it is a combination of ISO 140-3 (laboratory measurement of sound insulation) and ISO 140-8 (laboratory measurement of impact sound reduction improvement of floor coverings). Only the direct transmission has been considered so far. To measure the sound reduction improvement due to a lining, it is fixed to a reference wall (or floor) and the sound reduction index is taken without and with lining. The improvement ΔR is the difference R_{with} – $R_{without}$. It is a characteristic of the lining, if the basic construction is acoustically 'neutral', such as heavy-weight homogeneous walls and floors. Besides these, a light masonry (75 kg/m²) and a wooden joist floor according to draft standard ISO 140-11 are proposed as additional basic constructions, which are widespread. In this case, the results cannot be transferred to other basic constructions, but different linings can be compared on the same basic construction. A single number value for the improvement, ΔR_w, will be obtained by applying the measured improvement ΔR to the reference curve of the corresponding basic construction and subtract the weighted sound reduction indices of the reference curve with and without improvement by the lining.

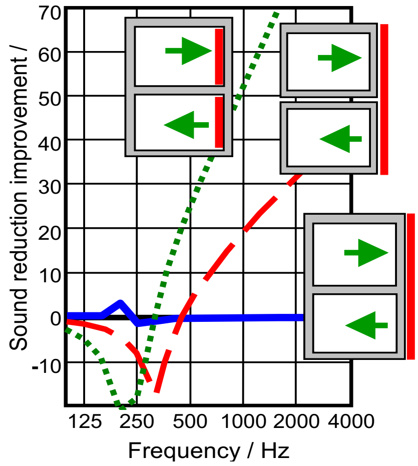

Figure 7: Flanking sound reduction improvement by ETICS or an internal acoustic lining

Summary

ETICS influence the direct as well as the flanking transmission of external walls. Acoustic optimization is subtle, because many features are important. Direct and flanking transmission do not react in the same way. Drawbacks at low frequencies might destroy considerable improvements at higher frequencies. The improvement of ETICS on a light-weight structure will often be less than on a heavy, homogeneous structure. A new ISO standard will help make comparable measurements of the sound reduction improvement.

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