Short report of the research project
Sound insulation of external thermal insulation composite systems

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Title

Sound insulation of external thermal insulation composite systems

Motive / Starting point

Besides improving the thermal insulation external thermal insulation composite systems (ETICS) strongly affect the acoustic properties of outer walls. In the Fraunhofer Institute for Building Physics in the years 2002 - 2005 reliable methods for prediction of the sound insulation were developed. Since that time, however, new constructions and designs have established, so that the models have to be adjusted and complemented.

Subject of the research project

The main focus of the research project was to investigate the effect of new constructions on the sound insulation of outer walls covered with ETICS. The investigations mainly comprised measurements in a building acoustic test facility (measuring setup a with reduced test area of about 1.7 m^2) under exactly defined architectural conditions. Apart from base walls consisting of hollow bricks or build as timber frame construction also ETICS with increased insulation thickness and double-layer ETICS were investigated. As foundation for calculation of the sound insulation an existing semi-empirical model was used, which was based on former investigations in the Fraunhofer Institute for Building Physics and have proved successful in practice. To adapt this model to the new building systems it was synchronized with the measured test results and supplemented, where necessary.

Usually the acoustic assessment of ETICS is performed using the improvement of the weighted sound reduction index of the base wall ΔR_w. In practice, however, $\Delta(R_w + C_{tr,50\text{-}5000})$ - where $C_{tr,50\text{-}5000}$ means the spectrum adaptation value for traffic noise - often is a much better assessment scale for human auditory impression. Since it was so far not possible to predict $\Delta(R_w + C_{tr,50\text{-}5000})$, a calculation model was developed for this purpose. Furthermore comprehensive measurements of traffic noise were performed in order to clear existing uncertainties in the application of C_{tr}.

The last part of the project concentrated on the development of planning instructions for improvement of planning security and prevention of deficiencies in sound insulation. In addition the actual state of knowledge concerning the sustainability of ETICS (energetic and ecological balance of the systems) was collected.

The main results of the project can be summarized as follows:

- For ETICS with increased thickness of the insulation layer (the investigations comprised thicknesses of up to 400 mm) the sound insulation can be calculated in the same way as for common systems.
- For calculation of the sound insulation of double-layer ETICS (consisting of a second ETICS subsequently mounted on an already existing system) a fictitious single-layer system is considered, that results from notionally removing the inner ETICS and the attached adhesive mortar from the construction. From the

result calculated for the fictitious system afterwards a correction in the amount of 2 dB to 4 dB have to be subtracted.

- The calculation method for the sound insulation of ETICS, which was originally developed for solid walls, can likewise be applied to walls consisting of hollow bricks without impairment of accuracy.
- If ETICS are attached to lightweight constructions such as for instance wooden wallboards their acoustic behaviour completely differs from the behaviour on solid walls. For the development of a reliable prediction method for this type of construction further comprehensive investigations are required. Temporary the sound insulation can be estimated by means of a provisional model developed in the ift Rosenheim.
- A new calculation model, that was developed within the scope of the research project, enables the prediction of $\Delta(R_w + C_{tr,50-5000})$ with good accuracy (the standard deviation between measurement and calculation amounts to 2,1 dB).
- The acoustic design of ETICS should be performed considering the spectrum adaptation value $C_{tr,50-5000}$. In practice this can be realized by shifting the resonance frequency of the ETICS to a value in the range of about 100 Hz to 160 Hz. In this way the transmission of external noise (mostly traffic noise) into the building can be prevented most effectively.

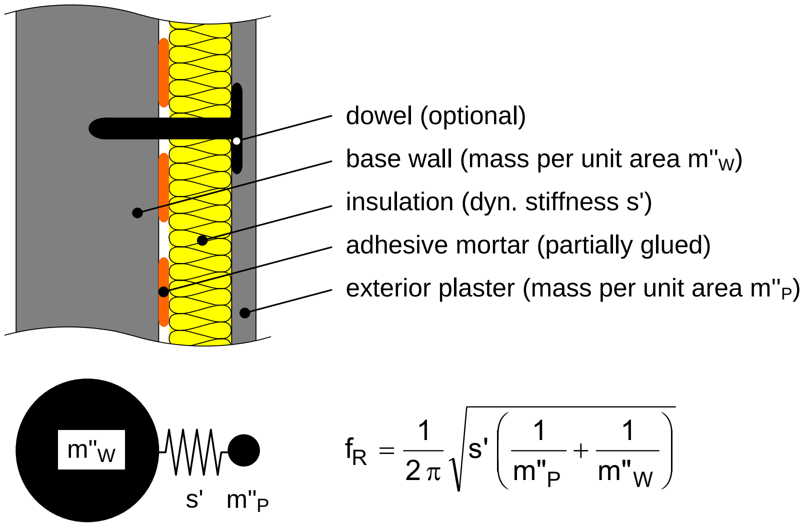
In the research project many open questions could be clarified and the planning security for outer walls with ETICS could be considerably improved. Some aspects, however, still require comprehensive acoustic research. In particular this applies to lightweight walls in timber frame construction, which gain increasing importance in practice whereas their acoustic properties in conjunction with ETICS are mostly unknown.

Conclusion

The main goal of the project was the enhancement of the existing calculation models for the sound insulation of ETICS, in order to enable the application of the models to new constructions, such as ETICS attached to walls consisting of hollow bricks or timber, ETICS with increased insulation thickness and double-layer ETICS. This aim has been fully met, so that uncertainties in planning are minimized. Furthermore the new calculation model for $\Delta(R_w + C_{tr,50-5000})$ provides an useful tool for the acoustic planning of outer walls. In conjunction with the performed measurements of traffic noise it allows the aurally accurate design of ETICS. Significant demand for research, however, still exists in the field of timber walls with ETICS.

Basic data

Short title: Sound insulation of ETICS
Scientist / Project leader: Dr. Lutz Weber
Total costs: 172.500,00 €
Part of federal subsidy: 80.000,00 €
Project duration: 16 months



$$f_R = \frac{1}{2\pi}\sqrt{s'\left(\frac{1}{m''_P}+\frac{1}{m''_W}\right)}$$

Fig. 1: Schematic sketch of a solid outer wall with ETICS. The lower part of the figure shows the acoustic principle of operation (mass-spring-mass system) with the resonance frequency f_R.

Fig. 2: Insulation board coated with adhesive mortar prior to attachment to the base wall (portion of the coated area 40 %). In order to reach exactly equal conditions for all measurements, the mortar was applied using a stencil.

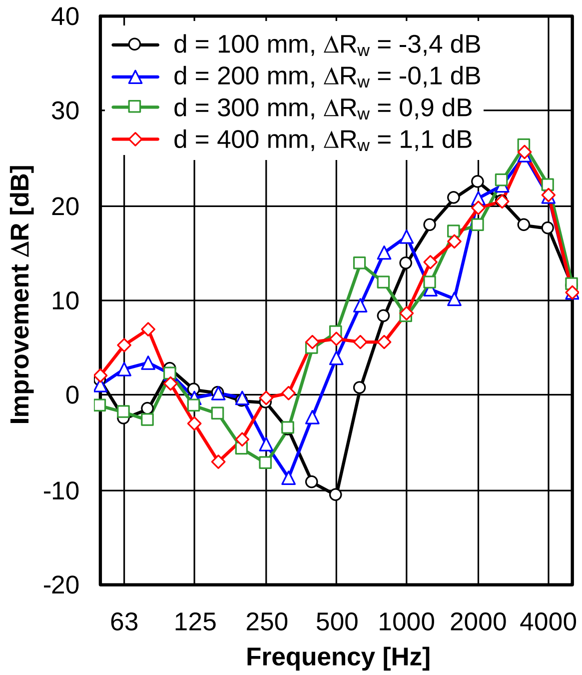


Fig. 3: Improvement of the sound insulation by an ETICS as a function of the thickness of the insulation layer d. Apart from the insulation thickness all other conditions were equal. With increasing thickness of the insulation layer the resonance of the ETICS (minimum in the curve shape) shifts to lower frequencies.

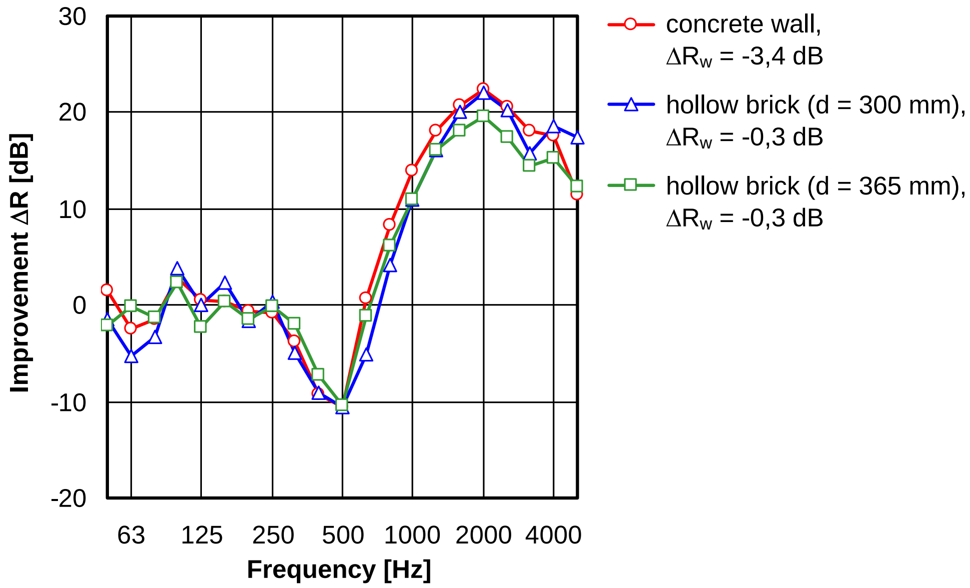


Fig. 4: Behaviour of the same ETICS on three different solid walls (a concrete wall and two walls consisting of hollow bricks). The figure shows the improvement of the sound insulation as a function frequency.

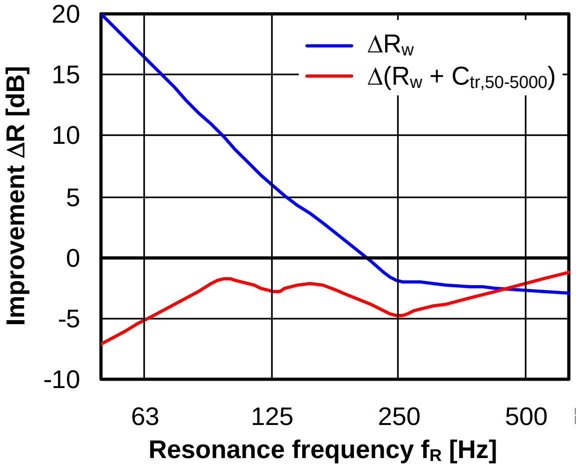


Fig. 5: Improvement of the sound insulation of a base wall by an ETICS as a function of the resonance frequency. The calculation was exemplary performed for an insulation system made of polystyrene (adhesive area 40%, without dowels) and a base wall with R_w = 53 dB.

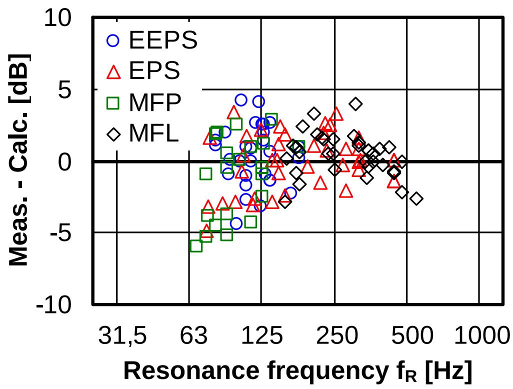


Fig. 6: Difference between measurement and calculation for the developed model for prediction of $\Delta(R_w + C_{tr,50\text{-}5000})$. The different symbols represent various types of insulation materials (altogether about 130 measured values). The standard deviation amounts to σ = 2,1 dB.