Short report of the research project
Acoustic efficient adhesives and sealants for the application in buildings

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Title

Acoustic efficient adhesives and sealants for the application in buildings

Motive / Starting point

Adhesives and sealants are used in nearly all fields of civil engineering. Although their effect on the sound insulation in buildings is often rather strong, their acoustic properties have so far only rarely been investigated. Thus, the aim of the research project was to enhance the state of knowledge concerning the acoustic properties of adhesives and sealants, to develop optimised products and to test them under practical conditions.

Subject of the research project

Because of the large variety of materials and applications the investigations on adhesives and sealants must be exemplary concentrated on joint seals with the ability to reduce the transmission of structure-borne sound. The acoustic effect of such seals is characterized by their insertion loss D_e (i. e. the reduction of sound transmission due to elastic decoupling of the connected building elements). Further important parameters are the dynamic modulus of elasticity E_{dyn} und the loss factor η of the used sealant.

In the first step of the project new measuring systems for the required acoustic tests were developed and assembled. An example for one of these systems is shown in Fig. 1. Since the insertion loss is a function of frequency (see Fig. 2), it was necessary to merge the measured frequency spectrum in a single number value. The developed single number value, called weighted insertion loss $D_{e,w}$, enables a direct comparison between different seals regarding to the efficacy of sound insulation.

The second step of the project comprised an acoustic inventory of commercial sealants. According to the measuring results presented in Fig. 3 the investigated materials differ strongly from each other (range of values 2 dB $\leq D_{e,w} \leq$ 20 dB). The performed measurements were used as foundation for the development of a calculation model, with the aim to predict the insertion loss of seals from the material properties of the sealant. In this context the dynamic modulus of elasticity of the sealant turned out to be the most important acoustic parameter, whereas the loss factor has only minor importance (see Fig. 4).

Based on the previous results the third step of the project constituted the starting point for the development of acoustically optimised sealants. The aim of the optimisation process was to create a practicable material with a preferably small modulus of elasticity and – as far as possible – low value of loss factor. Under the leadership of the involved industrial partner, Henkel AG, this aim was achieved to a large extent. The new sealant on the basis of acetate silicon has a modulus of elasticity about 70% smaller than best material so far been tested, resulting in an improvement of the weighted insertion loss by more than 2 dB.

In addition to the dynamic modulus of elasticity the sound insulating properties of elastic seals strongly depend on the geometry of the seal. The larger the relation between height and width, the smaller the insertion loss of the seal. To take account of the effect of geometry a suitable correction was developed based on the results of experimental investigations. It must be added to the insertion loss calculated for a seal with standard dimensions (seal with a quadratic cross section of 10 mm x 10 mm). The correction is shown in Fig. 5.

Elastic joint tapes provide an effective measure to ensure an acoustic favourable geometric shape of seals during the process of production (see Fig. 6). Since the joint tape remains in the gap after finishing of the seal an excessive compression of the tape must be avoided. Otherwise the band will behave as an additional transmission path and can considerably reduce the insulation of structure-borne sound.

Apart from elastic seals a further topic of research was the impact sound reduction of floor coverings attached to the ground by means of an elastic adhesive. The investigations concerning this topic were concentrating on an inventory of commercial elastic adhesives combined with different types of floor coverings. The required measurements were performed by means of a simplified experimental setup. The measuring results clearly show that in the case of direct adhesion between covering and floor the use of an elastic adhesive is offering no acoustic advantage. To reach an effective impact sound insulation the floor covering must be laid on an impact sound insulating pad. In this context double-sided adhesive tape with a core of flexible foam turned out to be a multifunctional and effective product for sound insulation.

Conclusion

Concerning sound insulating elastic seals the research project was brought to a successful conclusion. The acoustic important parameters are identified and the developed tools for acoustic analysis and design are applicable in product engineering as well as in the practice of construction work. By means of the developed improvement measures the weighted insertion loss of elastic seals can be increased by about 5 - 8 dB compared to the present state of the art.

For the attachment of floor coverings by means of elastic adhesives no appreciable improvement of impact sound insulation could be detected. In this field further investigations are necessary.

Basic data

Short title: Acoustics of adhesives and sealants
Scientist / Project management: Dr. Lutz Weber
Overall costs: 190.000,00 €
Ratio of federal subsidy: 115.000,00 €
Runtime of the project: 18 months

Pictures / Drawings

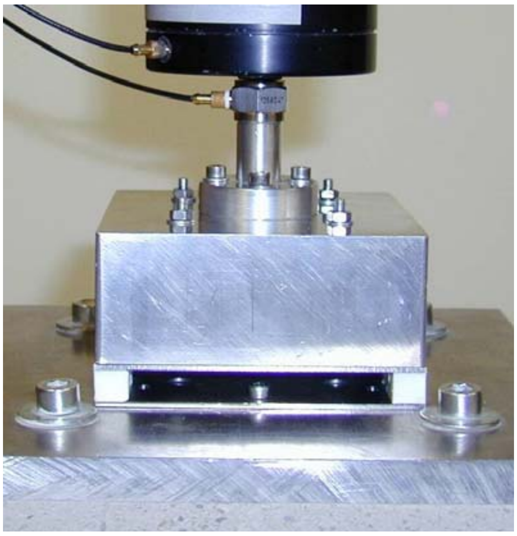

Fig. 1: Experimental setup for measurement of the insertion loss of elastic seals. The used samples (here white silicon) were made of sealant strips with quadratic cross section (l x w x h = 100 mm x 10 mm x 10 mm).

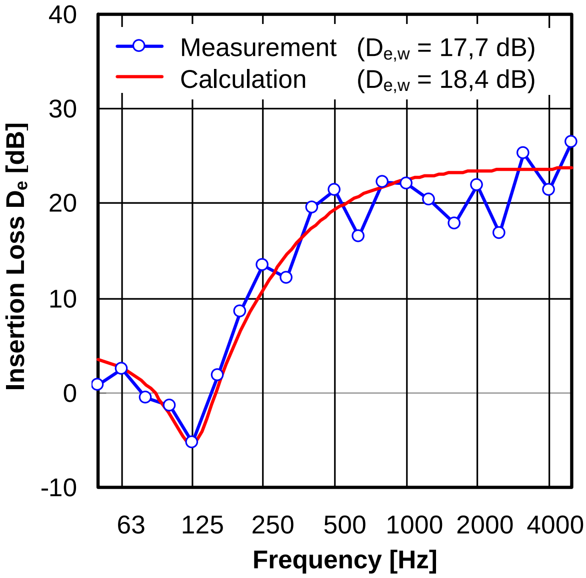

Fig. 2: Insertion loss of a typical joint seal used in the sanitary area under common construction conditions. Comparison between measuring data and predicted values calculated by means of the developed forecast model. The corresponding values for the weighted insertion loss $D_{e,w}$ are shown in brackets.

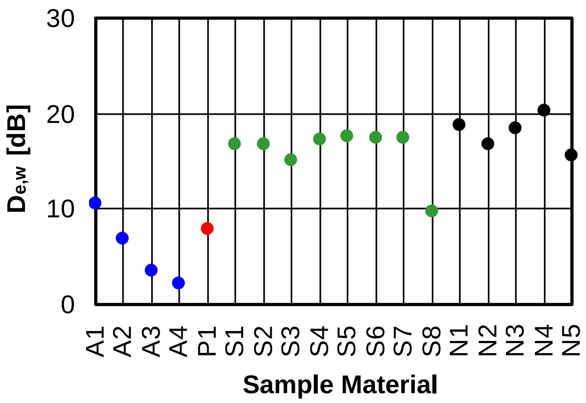

Fig. 3: Weighted insertion loss of commercial sealants (for a seal with a quadratic cross section of 10 mm x 10 mm). The colour of the measuring points characterizes the type of sealant (blue for acrylic, red for polyurethane, green for acid cross-linking silicon and black for neutral cross-linking silicon).

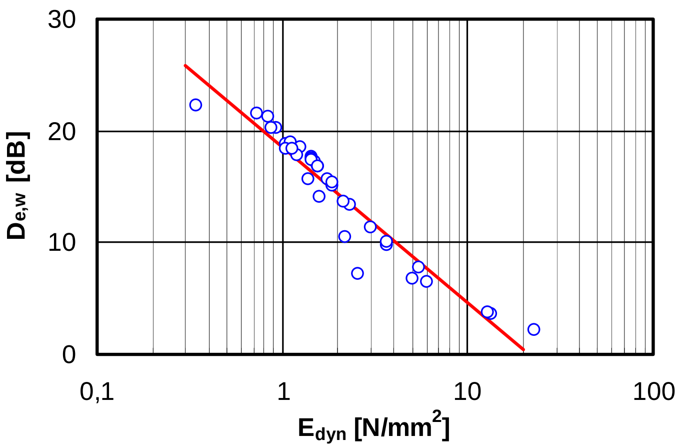

Fig. 4: Weighted insertion loss of all investigated sealants (altogether 36 different products) as a function of the dynamic modulus of elasticity. The formula for the included regression line is given by $D_{e,w}$ = [-14,0 × lg (E_{dyn}) + 18,6] dB, where E_{dyn} has to be inserted in the unit N/mm² into the formula.

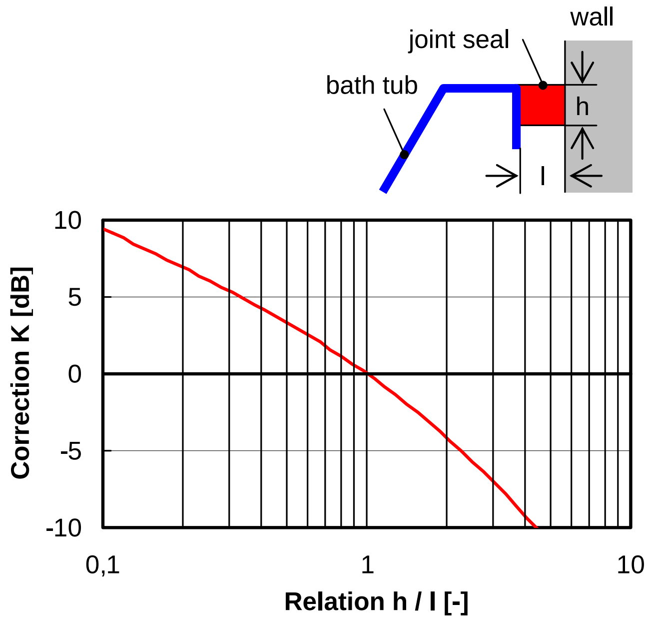

Fig. 5: Correction for consideration of the effect of seal geometry on the resulting value of the weighted insertion loss. The correction refers to a seal with rectangular cross section (with height h and width l).

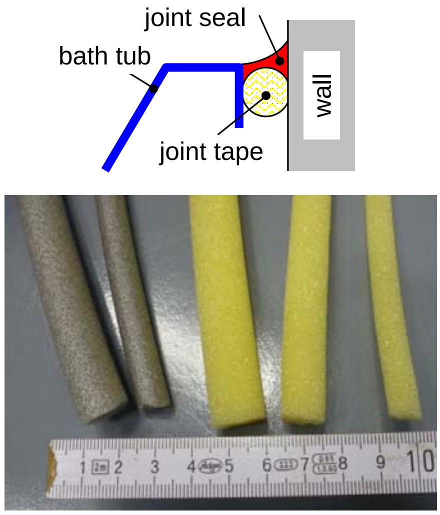

Fig. 6: Improvement of the structure-borne sound insulation of an elastic joint seal by a joint tape made of soft foam plastics. The tapes are available in building materials trade. They mostly have circular cross section (diameter about 10 - 30 mm).