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TRANSMISSION LOSS CALCULATION FOR DOUBLE-WALL CONSTRUCTIONS OF INDUSTRIAL BUILDINGS USING SEA

P Geissler (1), J Gilg (1) & M Gerhardt (2)

(1) Mueller-BBM, Planegg, Germany, (2) Hochschule fur Architektur und Bauwesen, Weimar, Germany

1. INTRODUCTION

The question underlying this paper was: can Statistical Energy Analysis (SEA) be used to predict the transmission loss of a given double wall construction with an acceptable accuracy? Usually the transmission loss has to be measured in standard acoustical testrooms in order to quantify the effect of constructional details and to find the optimized design of double wall constructions.

The transmission loss R of a wall separating two rooms is defined as 10 log (P_1 / P_2) where P_1 is the incident sound power in a sending room and P_2 the sound power radiated into a receiving room. It can be written as

$$R = L_1 - L_2 + 10\log\left(\frac{A_2 c}{24 f \eta_2 V_2}\right) \tag{1}$$

where L_1 and L_2 are the sound pressure levels in the sending and in the receiving room, A_2, V_2 and η_2 are the surface area, the volume and the damping loss factor in the receiving room, f is the frequency and c is the speed of sound in air.

SEA has been successfully applied by Price & Crocker [1], Craik & Wilson [2] and other authors to calculate the transmission loss of homogeneous double panels. Bremner [3] has shown how this approach can be extended to „real" structures by the addition of non-resonant connectors and the integration of „trim" material into the SEA concept. Encouraged by these results, it was attempted to use a commercial SEA-program [4] to calculate the transmission loss of three double wall constructions used in industrial buildings and to compare the results with measured data obtained in standard acoustical testrooms some years earlier [5, 6].

2. DOUBLE-WALL CONSTRUCTIONS INVESTIGATED

In a typical construction (fig. 1) aluminium sheets with trapezoidal corrugations are screwed onto the „C" of C-shaped steel sheets filled with absorption material.

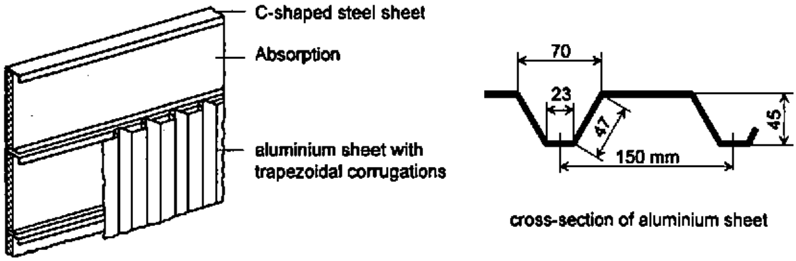

Fig. 1. Typical double wall construction für industrial buildings

The parameters of the three constructions investigated (fig. 3) were as follows: Construction A was built up of C-shaped steel sheets (1,5 mm thick, m" = 17.4 kg/m^2) filled with mineral wool (100 mm thick) and aluminium sheets with trapezoidal corrugations (1 mm thick, m" = 3.69 kg/m^2). Construction B was identical to A but with mineral wool 200 mm thick. Construction C was filled with mineral wool 240 mm thick. The aluminium sheets were 1.2 mm thick in this case (m" = 4.43 kg/m^2) and attached with additional z-profiles made of steel (1.5 mm thick).

The density of the absorption material (ISOVER SPF 1) was 50 kg/m^3, the flow resistance was specified to be greater than 12 kNs/m^4.

The constructions were tested in the frequency range 63 - 3150 Hz according to DIN 52210, part 4. The area between the two rooms was 3 m (height) x 4.14 m (width).

3. SEA MODELS

The SEA-network (fig. 2) was based upon the „classical" model built up of five coupled subsystems: room - panel - cavity - panel - room.

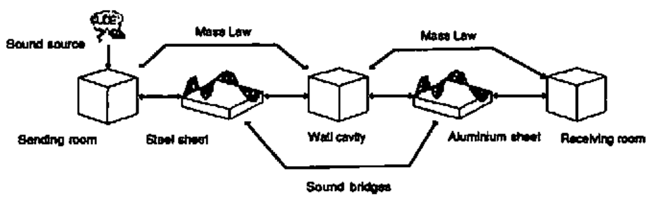

Fig. 2. SEA-Network

The rooms and the cavity were modelled as 3D-cavities for which the volume, the surface area and the perimeter define the modal density and the wavenumber. The sound pressure level in the sending room was forced to be constant for all third-octaves in the frequency range of interest. In the receiving room the damping loss factor was set to $\eta = a/f$, where a was calculated so that the third term in equation (1) was zero. The damping loss factor in the cavity was calculated from the given flow resistance and thickness of the absorption material. The panels were modelled as flexible plates defined by their lengths, widths and thicknesses. Their loss factors were set to $\eta = 0.001$.

The resonant coupling between the panels and the 3D-cavities was defined by the surface areas and the perimeter lengths of the panels. These parameters included the extended area and perimeter length due to the ribs of the aluminium panel. The stiffening effect of the ribs was not considered in the calculations.

The non-resonant coupling between the steel sheets and the aluminium sheets was defined by the number of screw connections. The non-resonant mass-law coupling between the cavity and the rooms included the complete masses of the panels and the trim.

4. RESULTS AND CONCLUSIONS

The transmission loss and the weighted apparent sound reduction index R_w' calculated for the three SEA-models are shown in fig. 3 together with the measured results. The maximum deviation is 5 - 6 dB for single third-octave values, the calculated R_w' come as close as 1 - 2 dB to the measured ones.

The accuracy of the calculation is acceptable taking into account the complexity of the construction and the relative small effort necessary to build the network. SEA is considered to be a promising design tool to develop and optimize double wall constructions. Currently it is still necessary to validate the SEA-calculation at least for the baseline and the optimized construction in standard test procedures. However, with increasing modelling experience the importance of standard testing will certainly get smaller.

REFERENCES

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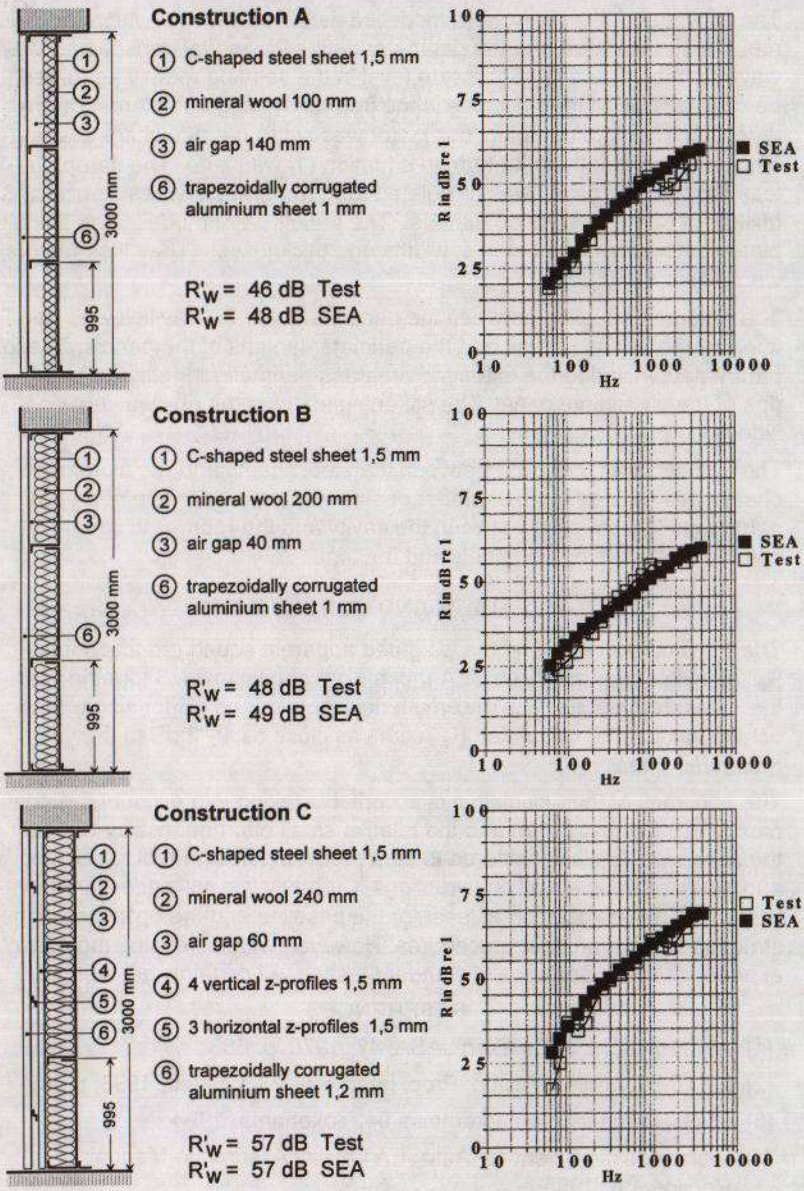

Fig. 3. Cross-sections and measured and calculated transmission losses of the three double wall constructions investigated