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SOUND VELOCITY AND ATTENUATION IN ANISOTROPIC GLASS WOOL

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ABSTRACT
The energy absorption coefficients for plane waves hitting a plane wall covered with a 100 mm thick layer of glass wool has been calculated. The calculation was based on experimentally measured wave numbers for plane sound waves in glass wool. Movements of fibres were taken into account. For glass wool of density 30 kg/m^3 at the frequency 300 Hz the energy absorption coefficient was 0.83 when the glass fibres were parallel to the wall, and 0.73 when the plane of fibres directions was perpendicular to the wall. The d.c. flow resistivity for the glass wool in the two case were 15000 and 9000 kg m^{-3} s^{-1}.

1 - INTRODUCTION
The glass wool studied in this paper contains thin glass fibres with a diameter of 7 micro metre with a standard deviation of 2 micro metre. The fibres are glued together with a phenol resin. In a microscope one can see a very irregular lattice of glass fibres. The glass wool studied was produced in the form of slabs measuring 100 × 600 × 900 mm.
Measurements of the sound attenuation in thick layers of glass wool have shown that the sound velocity and attenuation is anisotropic. These measurements will be reported elsewhere. The acoustic measurement in the frequency range $50 - 10\ 000$ Hz can be explained approximately, when one assumes that the fibres are oriented in a plane parallel to the big surface of the manufactured slabs. I this plane the fibres are randomly distributed. This is also confirmed by measurements of the mechanical elastic moduli of the glass wool. The latter are needed because the movements of the fibres contribute significantly to the acoustical properties, as was shown in ref. [1].

2 - ELASTIC MODULI
We assume that the fibres all are parallel with one plane and their direction in this plane are randomly distributed. For plane waves propagating perpendicular to the fibre plane the stress σ_1 in the fibre skeleton is proportional to the strain $u_{\ 1}$. Thus $\sigma_1 = c_{11} \cdot u_1$, where c_{11} is an elastic modulus. Only two moduli are needed, one for fibre plane parallel to wall and one for fibre plane perpendicular to the wall. For glass wool of density 30 kg/m^3 the values found were $c_{11} = 16\ 000$ Pa and $c_{\ 22} = 330\ 000$ Pa. The glass wool is very soft in the direction perpendicular to the fibres.

3 - COMPUTATION OF ENERGY ABSORPTION COEFFICIENT
We are considering an infinite plane rigid wall on which is placed a 100 mm thick layer of glass wool of density 30 kg/m^3. The glass wool is hit by a plane sound wave perpendicular to the surface, and a wave is reflected into the air. We what to compute the fraction of incoming energy absorbed.
One needs the wave number to calculate the absorption coefficient. The wave number can be computed from the effective mass density and compressibility. A method of extrapolating between the experimental data was described in ref. [1].
It is necessary to take into account the movements of the fibre skeleton. This was done in the manner of Biot. Two waves can exist: an acoustic one and a mechanical one. The mechanical wave is exited from the viscous drag on the fibres by the moving air between fibres. The details of the computation is presented in ref. [1].

From the knowledge of the complex wave numbers and a specification of the boundary condition at the wall on can computed the acoustic impedance at the outer surface of the glass wool. The acoustic impedance then gives the energy absorption coefficient.
The result is shown in figure 1, where the absorption coefficient is given for fibre plane parallel and perpendicular to the surface. It is assumed that the fibres can move freely at the wall − a small air gab is assumed between glass wool and wall.
The d.c. resistivities were extrapolated from the dynamic ones used to calculate the energy absorption. For air velocity perpendicular to the fibre plane the result was 15 000 kg m^{-3} s^{-1} and parallel 9 000 kg m^{-3} s^{-1}.

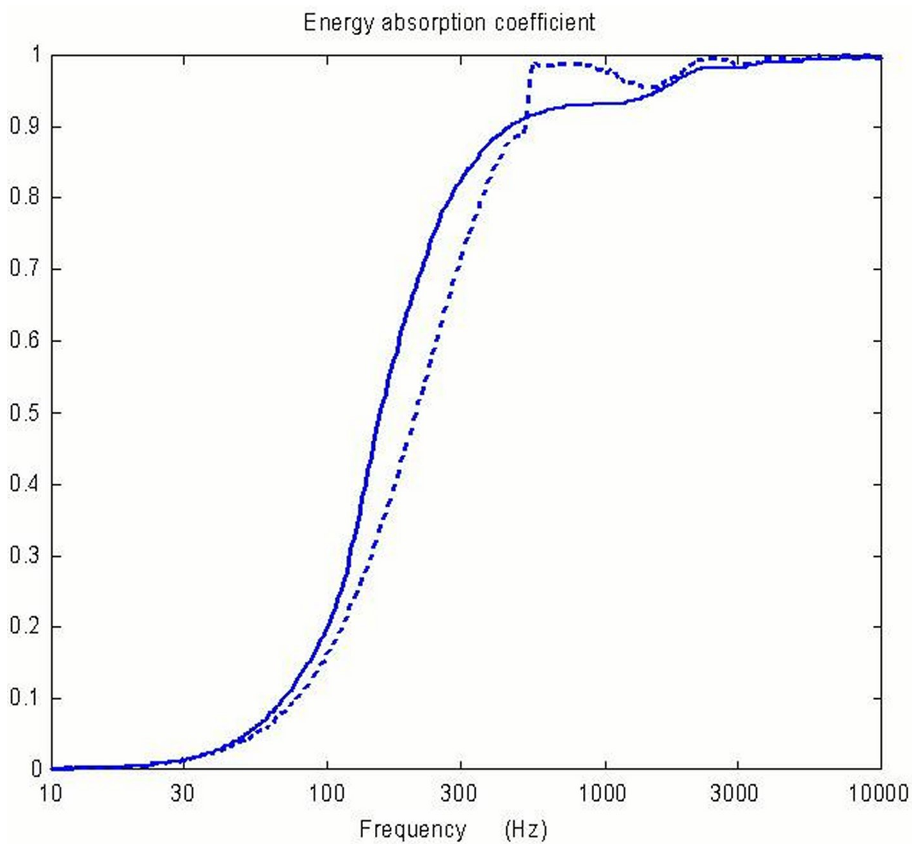

Figure 1: Energy absorption coefficient for 100 mm glass wool on rigid wall; the full line is for fibres parallel to the wall; the doted line is for fibre plan perpendicular to wall.

REFERENCES

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