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ABSORPTION OF ELASTIC FRAMED POROUS MATERIALS IN COMBINATION WITH IMPERVIOUS FILMS: EFFECT OF BONDING

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ABSTRACT
The absorption characteristics of elastic framed absorbers in combination with impervious films has been investigated. The effect of bonding the film to the absorber and the absorbers to their rear surface was examined experimentally and theoretically. The absorption of a foam with a film bonded to its top surface is much more sensitive to the rear surface bonding condition than if the film is simply placed on the top surface of the foam. The results demonstrate that test data used to predict absorption performance need to reflect the absorber mounting conditions.

1 - INTRODUCTION
The absorption of materials is typically measured according to ISO R354:1988 [1]. Surface mounted absorbers commonly placed on walls, ceilings and floors are usually tested on the floor of a reverberation room. However, when elastic framed materials (acoustic foams) are installed they are often bonded with adhesives to the mounting surface. In some cases the absorption is significantly different when bonded to the mounting surface (as installed) rather than when simply placed on the surface (as tested).

The absorption of an open cell foam with a polyester surface film was investigated by Masiak [2]. It was found that the films shifted the maximum absorption peak to lower frequencies while reducing the absorption at higher frequencies. Empirical equations describing the impedance of impervious and perforated synthetic films combined with porous backing material layers were developed by Voronina [3]. The films were examined as placed on the backing material layer. Lauriks et al [4] have modelled layered porous materials with impervious screens. The oblique incidence surface impedance of the layered materials was predicted using a matrix representation of the acoustical properties. The films studied were bonded to the porous backing material and the backing material was bonded to the hard rear surface.

In this work the effect of rear surface bonding conditions on the absorption of elastic framed porous materials in combination with impervious films was investigated. The use of an established modelling method was verified by the measured results with attention paid to simulating the impervious film bonding condition and the rear surface bonding condition.

2 - PROCEDURE
The materials were tested in a reverberant room of volume 217 m ^{3}. Each test specimen comprised four sheets of 1.2×2.4 m absorber. A Bruel and Kjaer sound analyser, type 2260B with building acoustics software, type BZ 7204 was used for reverberation time measurements. Absorption coefficients were calculated from the averaged reverberation times of the empty room and averaged reverberation times with a test specimen present according to ISO R354:1988.

The foam absorber used was a combustion modified partially reticulated polyurethane foam of the polyether type. It typically has cells / 25 mm and a bulk density of 43 kg/m^3. The film used was

Mylar™ , a thin (25 μm) metallised polyester film with a surface density of 35 g/m^2. The gypsum board used was 9.5 mm thick and was painted with an enamel paint.
The elastic frame theory used to predict the absorption coefficients was based on the work by Biot [5] who developed a theory for the propagation of elastic waves in fluid-saturated porous materials. The general method of Brouard et al [6] was used with a correction for edge effects according to Thomasson [7] to predict the measured results.

3 - RESULTS

The measured and modelled absorption coefficients of a film faced foam absorber are shown in figure 1. The film was bonded to the porous layer while the porous layer was placed on (i.e. not bonded) to the floor of the reverberation room. The layer of foam was decoupled from the hard rear surface in the model by including a thin layer of air between the two materials. The foam parameters used in the model are shown in table 1 and were used throughout the modelled results. Figure 1 shows the good agreement between the measured and modelled results.

Thickness	**Tortuosity**	**Frame Density**	**Flow Resistivity**	**Porosity**	**Complex Shear Modulus**	**Poissons Ratio**	**Form Factor**
t	ks	ρ_1	R	h	N	ν	c
(mm)		(kg/m^3)	(mks rayls/m, or Ns/m^4)		(N/cm^2)		
24	2.85	43	22000	0.98	20+10i	0.3	4

Table 1: Parameters used for the modelled results in figure 1.

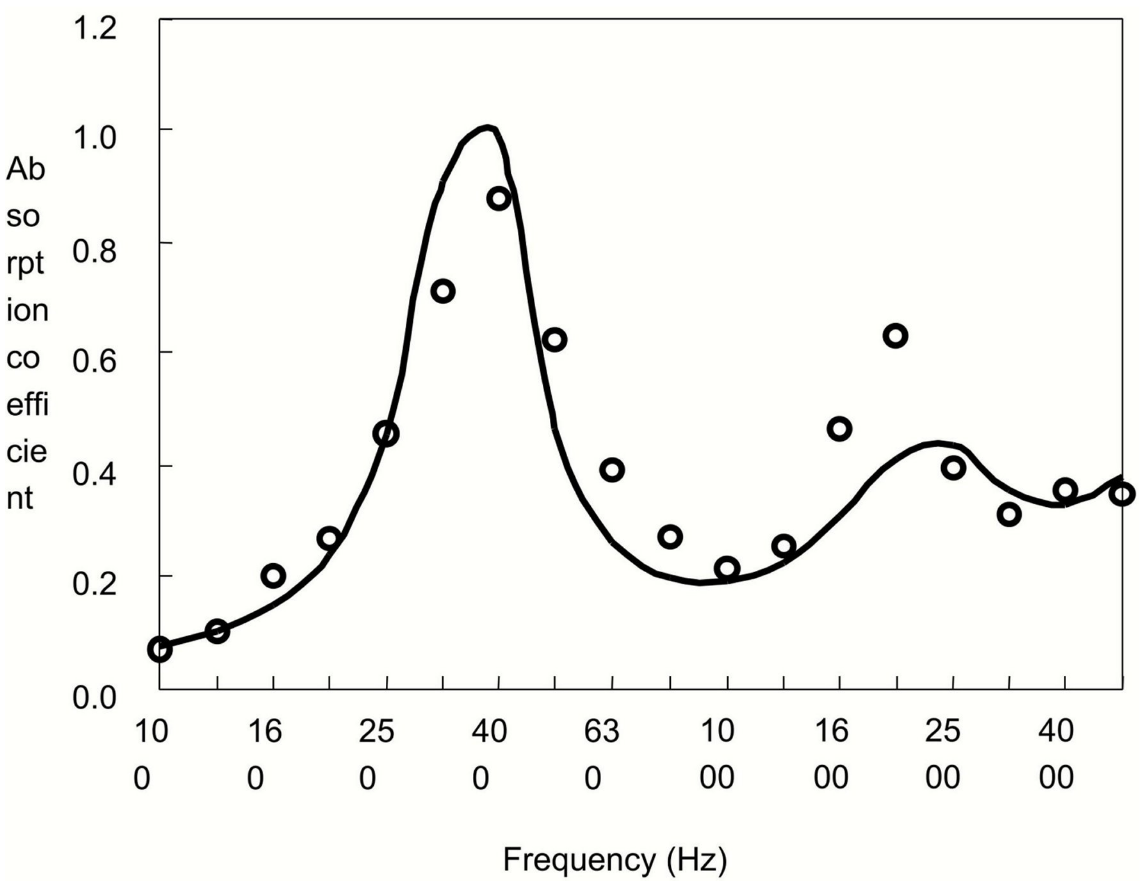

Figure 1: Measured [o] and modelled [−] absorption of film faced foam of 24 mm thickness; foam was placed on rear surface (floor of reverberation room).

The same film faced foam absorber was then bonded to a layer of gypsum board and tested. The board was used to simulate a wall in a gypsum lined room. The measured and modelled absorption coefficients for this system are shown in figure 2. The film faced foam in figure 2 was modelled with the film bonded to the foam layer and the foam layer bonded to the hard rear surface according to Lauriks et al [4]. The large difference in absorption trends between figures 1 and 2 show that the absorption of the film faced foam is quite sensitive to the rear surface bonding condition.

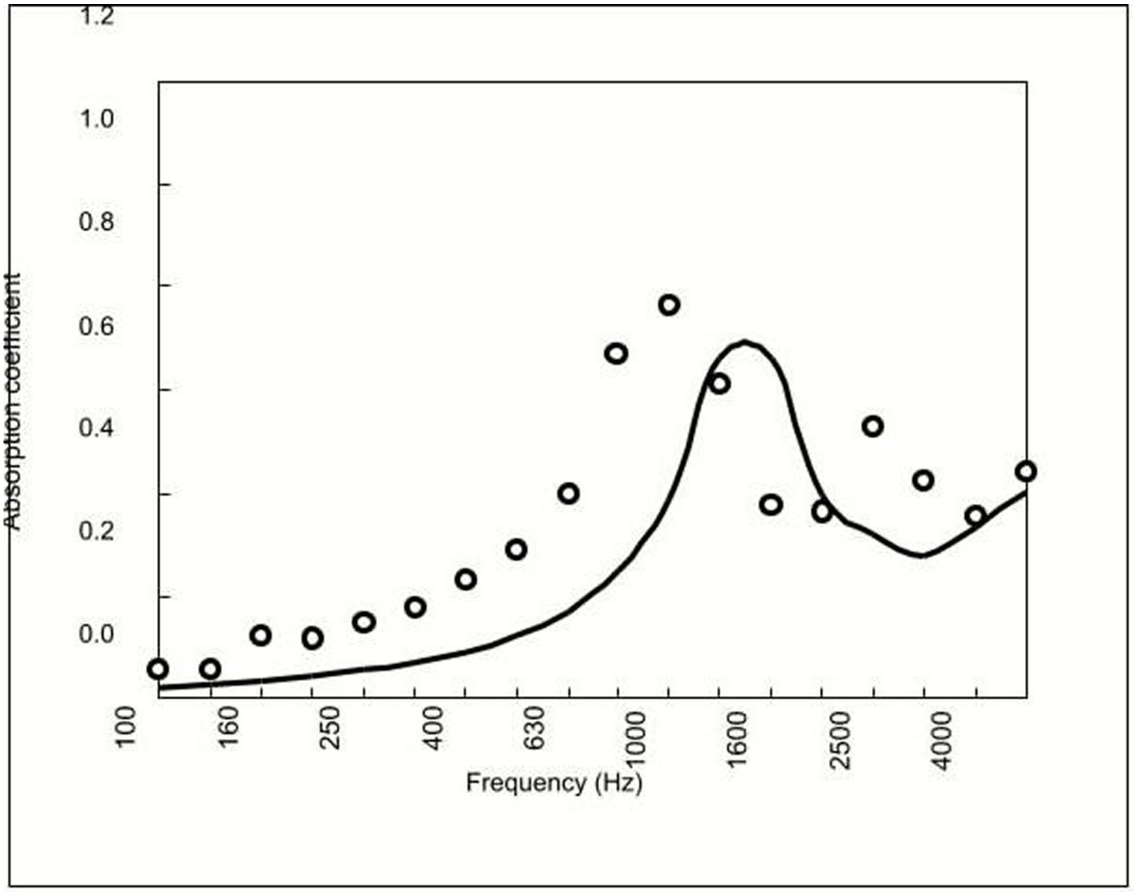

Figure 2: Measured [o] and modelled [−] absorption of film faced foam of 24 mm thickness; foam was bonded to rear surface (gypsum board).

The absorption of a loose-laid film on the foam layer (rather than a bonded film) was also investigated using the model. The results are shown in figure 3 below. The loose-laid film on foam absorber system is less sensitive to the rear surface bonding condition than the film faced absorber as shown in figures 1 and 2.

4 - CONCLUSIONS

The effect of the rear surface bonding condition of elastic framed porous materials in combination with impervious films has been investigated. The absorption of a film faced foam was measured in a reverberation room and predicted using established modelling methods. This absorption was found to be very sensitive to the rear surface bonding condition − placed against the hard backing surface or bonded to it.

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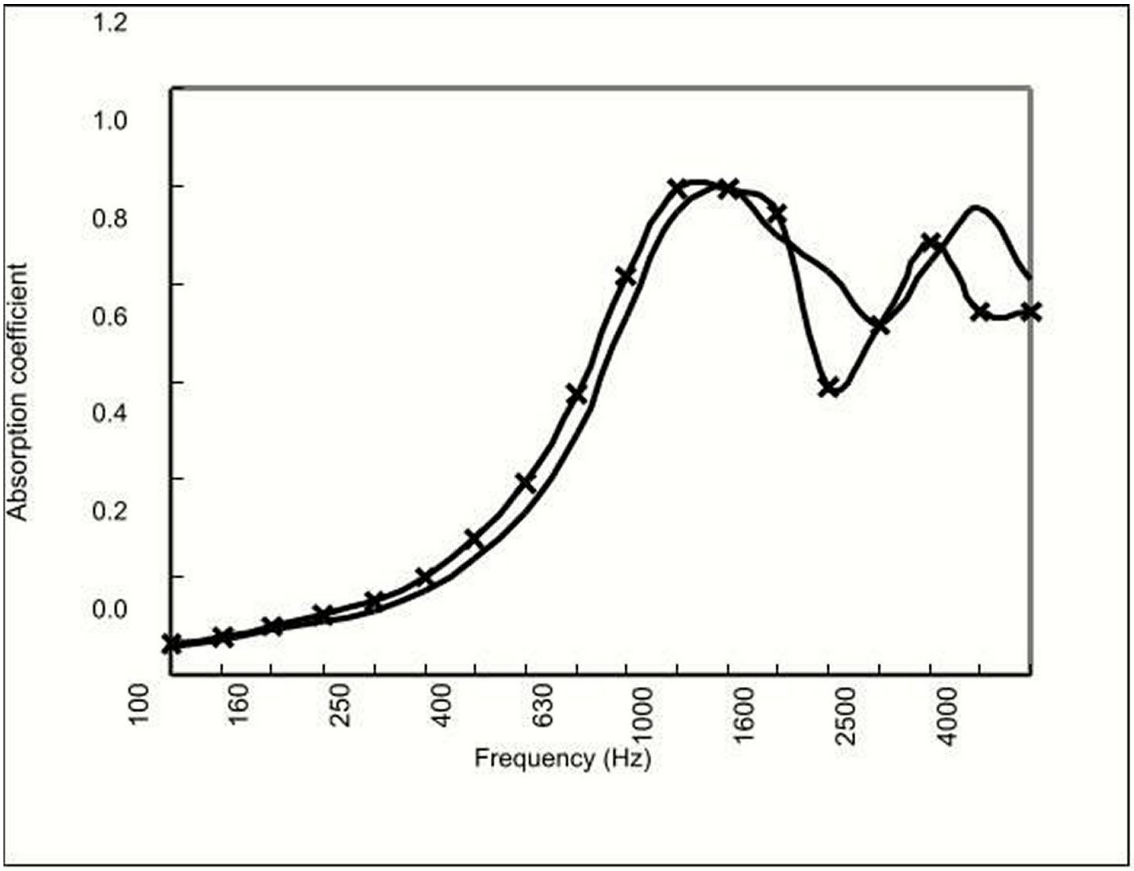

Figure 3: Predicted results of a loose-laid film on foam of 24 mm thickness with [x−x] foam bonded to rear surface and [−] foam placed on rear surface.

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