EFFECT OF PERFORATED FACING ON SOUND ABSORPTION OF POLYESTER FIBRE MATERIAL

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Aim of the work

The perforated facing used in lined ducts or absorbing panels to protect the porous sound absorbing material from dust or grazing flow, or simply as a rigid support for the porous material, can affect the behaviour of the “backing” material, so modifying the acoustical performance of the porous layer.

In the present work, the effect of perforated facings on sound absorption characteristics of samples made by polyester fibre has been experimentally investigated in the frequency range 500 - 2500 Hz. The polyester (PET) fibre material had bulk density of 30 kg/m^3 and melting point at 260°C. The analysis has been performed for sample thicknesses equal to 50 mm and 100 mm.

The acoustical behaviour of unfaced polyester fibre samples was firstly characterized by measuring flow resistivity, R_1, and sound absorption coefficient at normal incidence, α, by means of the standing wave ratio (SWR) method. Flow resistivity was measured according to ISO 9053:1991 standard, direct airflow method (method A), and resulted to be equal to 4285 Pa·s/m^2, that is a typical value for this material and density.

Then the same samples were faced by means of different metal plates perforated with circular holes (Fig. 1). The holes diameter was equal to 2 mm for all facings but the percent open area, σ (σ = perforated area/total area) was varied from 15% to 30%.

Metal plates were 1 mm thick and in close contact with the polyester fibre material. Normal incidence sound absorption coefficients were measured for all facings and compared both each other and with the results for the unfaced samples.

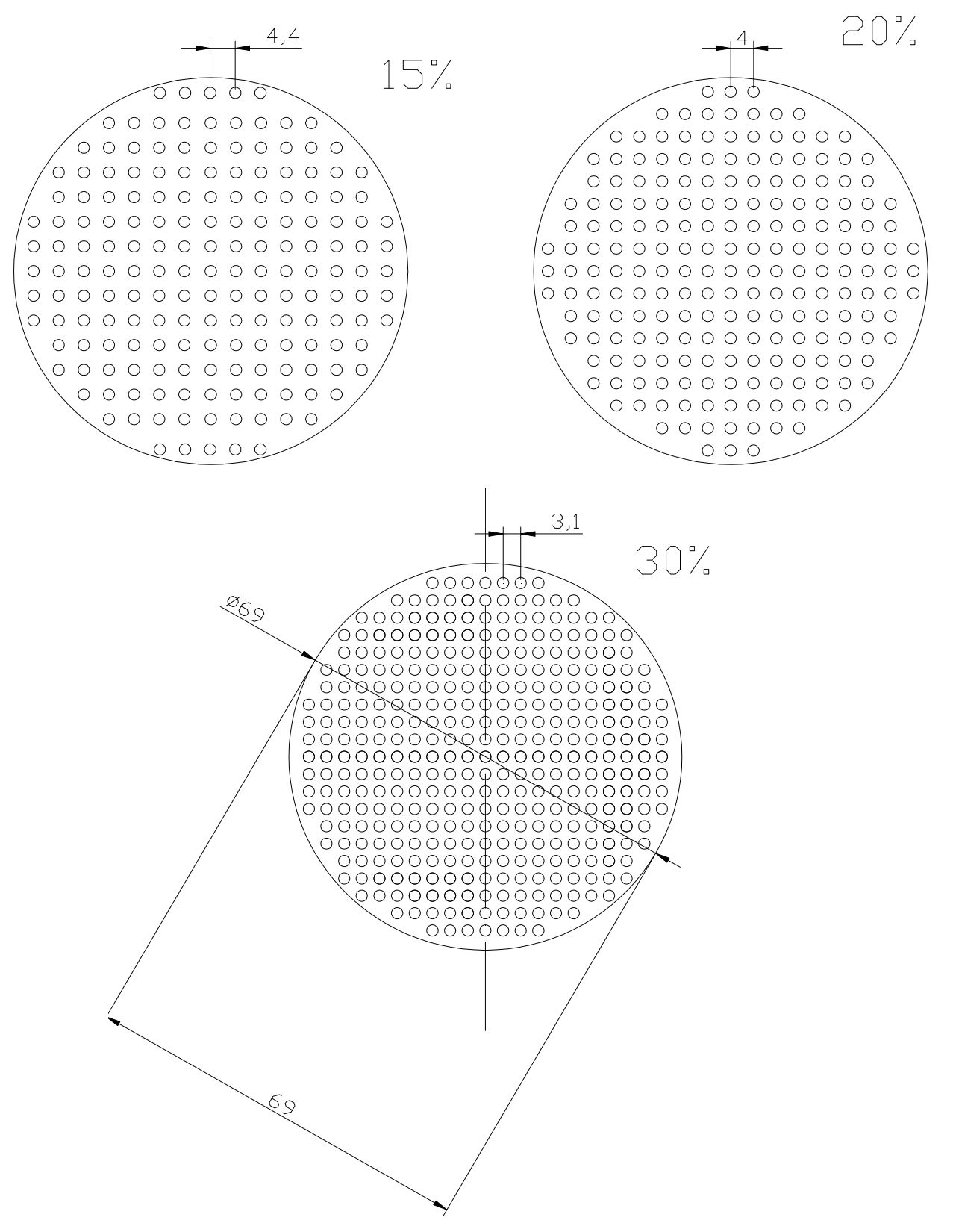

Fig. 1. Sketch of metal sheets used in the experiments.

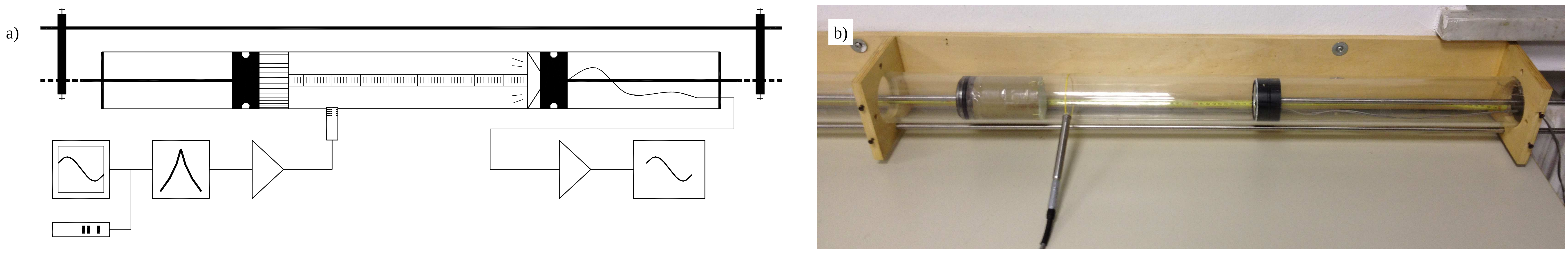

Fig. 2. SWR tube: a) sketch; b) picture.

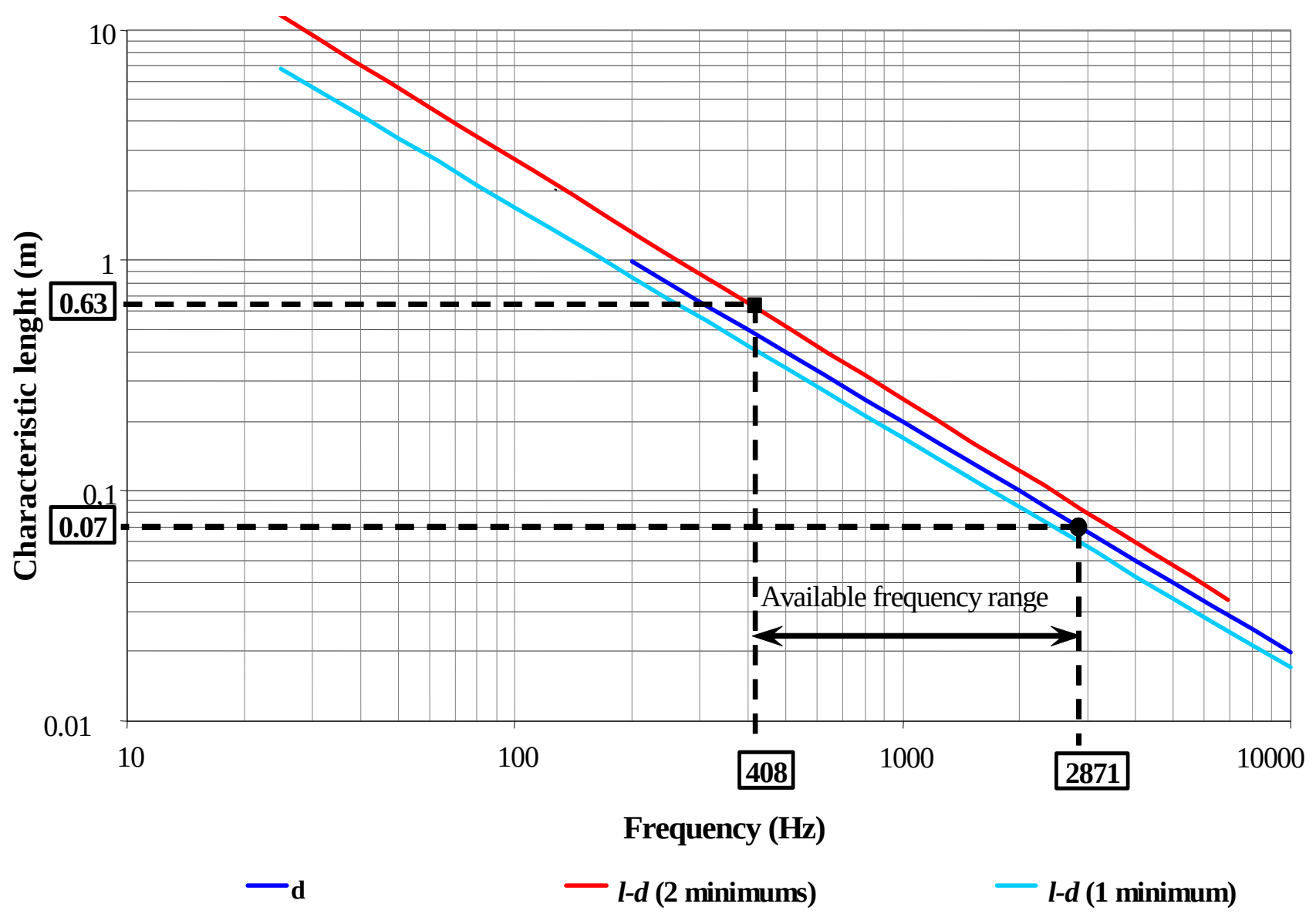

Fig. 3. Available frequency range.

Experimental setup

Sound absorption coefficients were measured in accordance with ASTM C384-04 standard: the experimental set-up consisted in a horizontal cylindrical Kundt’s tube made of PMMA, with an inner diameter of 70 mm and an effective length of 630 mm (Fig. 2). This equipment has been realized adopting a variable length test section with the microphone in a fixed position.

According with ASTM C384-04, to include the effects of attenuation in the calculation two minimums were used, so that the lower frequency of the range is given by:

$$f > 0.75\frac{c}{l-d}$$

The upper limit of the usable frequency is imposed by the need for plane waves in the tube. According to Rayleigh, this condition is verified if the sound source operates at frequencies such that the wavelength is greater than 1.707 times the diameter of the tube, so:

$$f < 0.586\frac{c}{d}$$

The frequency range available for the experiments is reproduced in Figure 3.

Experimental data were firstly obtained for unfaced polyester fibre samples of thickness 50 mm and 100 mm. Those data were compared with literature correlations from Delany-Bazley, Dunn-Davern and Pompoli-Garai, which is especially intended for polyester fibre material (Fig. 4). The comparison showed a good agreement between measured and calculated values for both sample thicknesses; in this way the accuracy of the experimental set-up and of the operating procedure were validated.

Results

In Figure 5 the sound absorption coefficient curves in one-third octave band for the samples faced with the different perforated screens are shown in comparison with the unfaced sample. The analysis of the results indicates that, in general, when σ rises, the α curves for faced and unfaced samples tend to be closer, that is the effect of facing reduces meanwhile the open area increases. In particular, when the percent open area is equal to 30%, for both porous material thicknesses the effect of perforated facing is negligible. For percent open area 15% faced samples tend to behave quite differently from unfaced ones for both thicknesses, and the curves for faced materials are separate, thus indicating a different acoustical behavior of the lined duct or of the absorbing panel on which the facing is applied.

The comparison of diagrams (a) and (b) in Figure 5 suggests that, even if local α values change, the facing effect is similar for both thicknesses. In other words, the thickness of porous material influences its acoustical performance, but 50 mm and 100 mm thick samples are anyhow sensitive in a similar way to the presence of the perforated plates. This conclusion applies to porous material with the same thickness but different density, too.

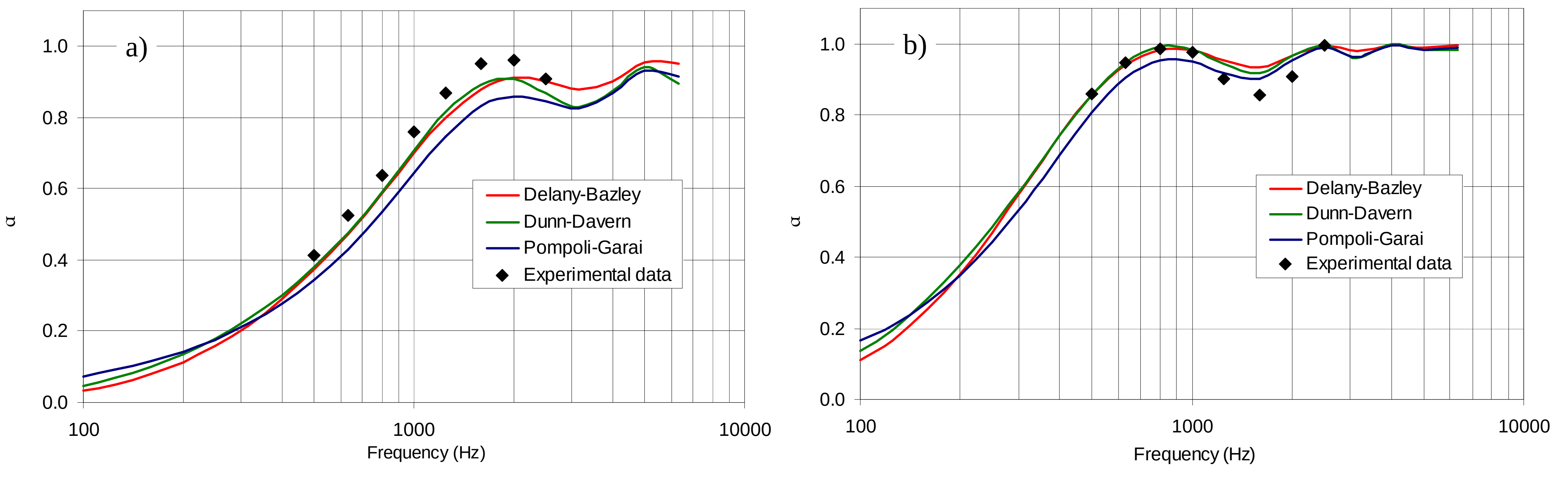

Fig. 4. Sound absorption coefficient curves for unfaced sample with thickness equal to: a) 50 mm; b) 100 mm.

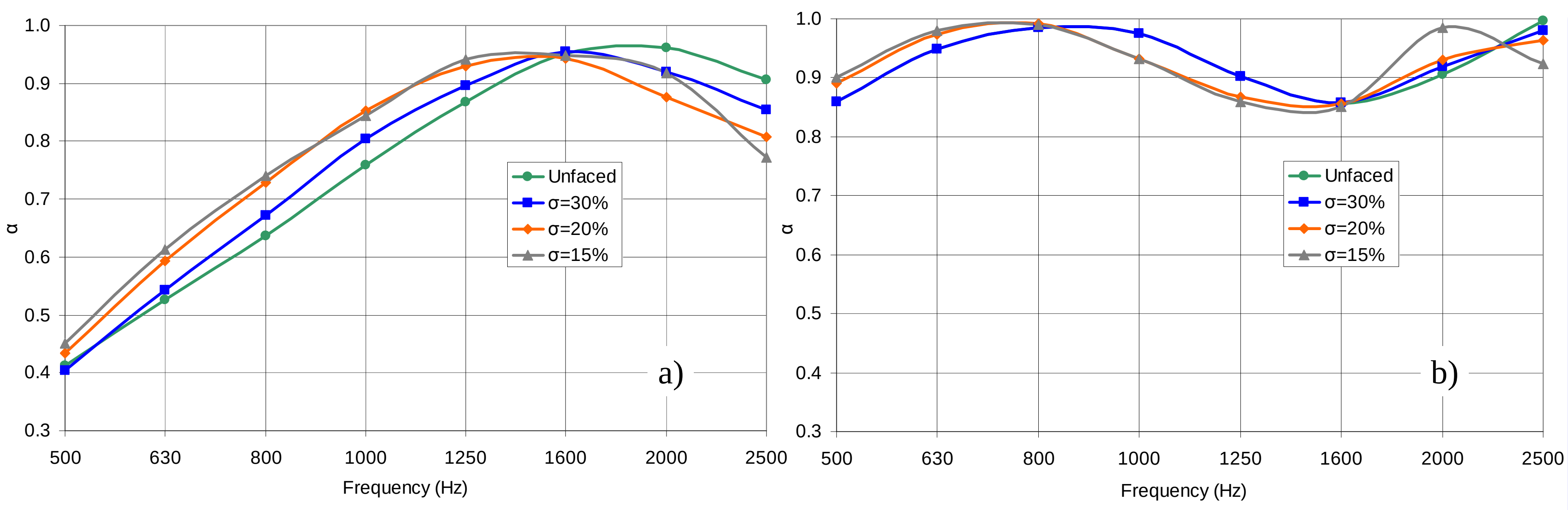

Fig. 5. Sound absorption coefficient curves for samples faced with different perforated plates: a) sample thickness 50 mm; b) sample thickness 100 mm.

Conclusions

Present experimental data essentially agree with literature results.

Munjal and Thawani at the end of their theoretical analysis, conclude that for highly porous fibrous material a thin perforated of 34.9% percent open area is practically as good as 100% percent open area whereas a 4.9% percent open area affects absorbing behavior at high frequencies, and suggest that about a 10% percent open area is a good design compromise between acoustical performance and mechanical strength.

Similarly in Ingard, where the effect of a perforated panel with a percent open area of 7.7% is theoretically analyzed and a considerable effect on absorption coefficient curves of porous materials is predicted.

Those conclusions are substantially confirmed by the present study, i.e. protective layers may have a dual function, which is to work like a mere support to the porous sound-absorbing material or to operate like a real absorbent panel according to the open area.

The different intended use therefore depends on the percentage of perforation: in the event that it is equal to or greater than 20% of the surface of the facing, this assumes the only function of supporting and protecting the sound-absorbing material.