Application of microperforated panel absorbers to room interior surfaces

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Microperforated panel (MPP) absorbers are promising as a basis for the next generation of sound absorbing materials. A microperforated panel absorber is backed by an air cavity with a rigid back wall, and its typical use is for a sound-absorbing ceiling. However, MPPs have some limitations and disadvantages. MPPs are typically made of a thin metal or plastic panel. Such a thin panel is often not suitable for an interior finish because thin limp panels do not have enough strength. In particular, an interior finish of room walls requires appropriate strength. This problem prevents practical applications of MPPs as an interior finish of room walls. In order to solve this problem, the following treatments were considered and their acoustical effects are discussed: (1) the thickening of an MPP to make it firmer, (2) the use of an elastic support to stiffen an MPP, and (3) attaching a honeycomb structure to MPPs to stiffen the construction.

1. INTRODUCTION

A microperforated panel (MPP) is promising as a basis for the next generation of sound absorbing materials. Since the pioneering works by Maa,[1–3] many studies have been conducted on the application of MPPs for various purposes, such as attenuating noise in small rooms and for duct silencing, etc.[4–6] Application of thin MPP films in acoustic window systems has recently been studied by Kang and Brocklesby.[7] Application of the multiple-leaf transparent MPP absorber to noise barriers is also recently reported by Asdrubali and Pispola.[8] However, since MPPs are typically made of a thin metal panel or film, they do not have enough strength and are, in many cases, not suitable for an interior finish, especially for finishing room walls. The use of a thin panel to make an MPP is not only useful to facilitate the manufacturing process, but also is important to offer an appropriate range of its acoustic resistance. Also, MPPs have been made out of different materials, such as a thin plastic film or a thicker acrylic panel. However, for finishing room walls, it should be thicker than at least 10 mm to make the panel stiff enough. If MPPs can be made stiffer, they would be more widely used for a sound absorbing finish in buildings.

Strong MPPs are needed for room interior surfaces. However, if a thick material is used to make MPPs strong, the acoustical performance will be deteriorated due to its excess acoustic resistance and reactance. Thin MPPs are advantageous to produce optimal acoustic resistance and reactance. Thus, it is important to make MPPs strong enough without deteriorating the acoustic performance.

For this purpose, the following treatments can be considered, and their acoustical effects need to be discussed: (1) thickening an MPP to make it firm enough, (2) using an elastic support to stiffen an MPP, and (3) attaching a honeycomb structure to MPPs to stiffen the construction. In this paper, first, regarding the thickening of MPPs, acoustical problems with thick MPPs are pointed out and discussed. Then the main results of our experimental study on a trial production of thick MPPs to improve their acoustical performance are reviewed.[9] Secondly, the effect of an elastic support to stiffen a thin MPP on its absorption characteristics is discussed with a simple model calculation. Lastly, the effect of a honeycomb structure, attached behind a thin MPP to stiffen it on its acoustical performance, is discussed through experimental results. Also, the effects are interpreted with an electro-acoustical equivalent circuit model analysis.

2. PROBLEMS OF THICK MPPS AND THEIR IMPROVEMENT

MPPs are usually made of thin panels. This is mainly for manufacture ease since making submillimetre perforations in thick panels is quite difficult. Besides, small perforations in a thick panel tend to produce too much acoustic resistance. In this section, problems with thick MPPs are discussed, and in an attempt to improve their acoustical performance, the results of an experimental study with a trial production are reviewed.[9]

Figure 1 shows an example of absorption coefficient of a thick MPP panel, calculated by Maa's theory.

According to Maa's revised formulae, the impedance of an MPP, $z = r - i\omega m$, is given by the following equations[3] :

$$r = \frac{32\eta}{p\rho c}\frac{t}{d^2}\left(\sqrt{1+\frac{x^2}{32}}+\frac{\sqrt{2}}{32}x\frac{d}{t}\right) \tag{1}$$

$$\omega m = \frac{\omega t}{pc}\left(1+\frac{1}{\sqrt{1+\frac{x^2}{2}}}+0.85\frac{d}{t}\right), \tag{2}$$