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Experiments on absorption characteristic of micro-perforated stretch ceiling backed by honeycomb

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ABSTRACT

As an efficient and decorative sound absorption material, the micro-perforated stretch ceiling is easily destroyed for the lack of frames supporting in the back cavity when it is installed on the wall or someplace vulnerable to be forced. To serve as the supporting structural element and improve the sound absorption performance, micro-perforated stretch ceiling absorption structures backed by honeycombs are proposed in this paper. Then, their absorption performances were experimentally studied. The experiments showed that the sound absorption coefficients of micro-perforated stretch ceiling (MPSC) and double-leaf micro-perforated stretched ceiling (DLMPSC) backed by honeycomb were similar to the structures without honeycomb. However, the effect of honeycomb inserting in DLMPSC is notable. In this case, the honeycomb provides the air-cavity structure supporting the membrane as well as improving the sound performance. This design provides guidance for the application of micro-perforated stretch ceiling.

Keywords: Micro-perforated stretch ceiling, Honeycomb, Support
I-INCE Classification of Subject Number: 35

1. INTRODUCTION

Micro-perforated stretched ceiling, as a practicial sound absorption material [1], can be designed into decorative space sound absorber. This membrane absorber is usually installed below the ceilings or in front of the rigid surfaces, which can help form a Helmholtz resonator with a air cavity [2-3]. However, it is easily destoryed for the lack of frames supporting in the back cavity when it is installed on the wall or someplace vulnerable to force.

As the theories for the membrane absorbers have been well developed [4-7], Sakagami et al. [8-10] applied the honeycomb structure attached behind an MPP to stiffen it and enhance its absorption performance. Then, the Helmholtz-kirchhoff integral formulation was used to analyze the sound absorption performance of MPP absorber backed by honeycomb. The theoretical results accorded with the experimental

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results [11]. Furthermore, the effect of honeycomb was theoretically analyzed, which should be designed to improve the sound absorption performance of the panel-type [12]. The researches applying the honeycomb to the double-leaf MPP space sound absorber showed that the the honeycomb could enhance the resonance peak and shift it to lower frequencies [13].

In this paper, the honeycomb structures are placed in the back cavity behind the micro-perforated stretch ceiling (MPSC) and double-leaf micro-perforated stretched ceiling (DLMPSC). And the absorption coefficients of these structures are experimentally studied. The honeycomb provides greater range extension application of micro-perforated stretch ceiling.

2. EXPERIMENT

In this experimental study, the normal incidence sound absorption coefficient of the MPSC and DLMPSC structures backed by honeycomb are measured according to the ISO10534-2 in the impedence tube. The parameters of the micro-perforated stretch ceiling membrane is shown in the Table 1. And the aramid paper honeycomb (shown in the Table 2) is attached behind the MPSC and DLMPSC in the air cavity.

Table 1-Parameters of the micro-perforated stretch ceiling

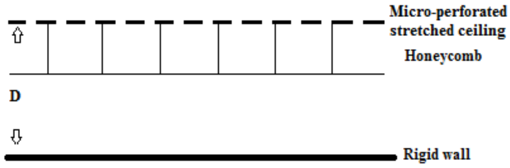
	Hole diameter (mm)	Perforation ratio (%)	Thickness (mm)
Micro-perforated stretch ceiling	0.2	0.13	0.2

Table 2-Parameters of the Aramid paper honeycomb

	Hole diameter (mm)	Side length (mm)	Thickness (mm)
Aramid paper honeycomb	3.2	1.83	10

2.1 Micro-perforated stretched ceiling backed by honeycomb

Firstly, a honeycomb is attached behind a single-leaf MPSC, which is shown in Figure 1. The sound absorption coefficients (with depth of air cavity D = 10 mm, 30 mm, 50 mm) are measured to compare with the single-leaf MPSC without honeycomb in the air cavity (Figure 2). The thickness of honeycomb is included in D.



(a) (b)

Figure 1 – Model of the MPSC *structures without and with honeycomb*
(a. structure without honeycomb; b. structure with honeycomb)

when D is equal to the thickness of honeycomb, the peak frequency become lower by inserting a honeycomb in the air cavity. The sound absorption bandwidth is narrowing slightly as D becomes larger, while the resonance frequency is invariant. The increase of absorption performance attaching a honeycomb behind single-leaf MPSC is not remarkable, but it really can provide the sufficient strength as a supporting structure.

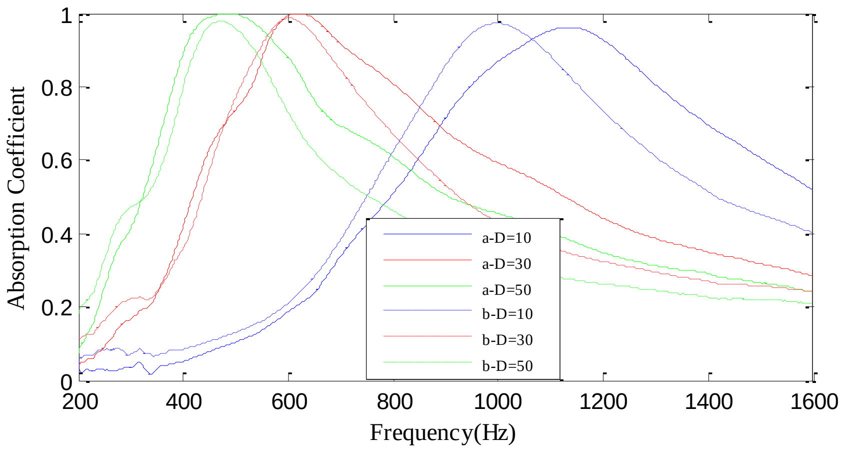


Figure 2 –The comparison of sound absorption coefficients of the MPSC without and with honeycomb

2.2 Double-leaf micro-perforated stretched ceiling backed by honeycomb

Secondly, a honeycomb is inserted into the air cavity between the membranes of the DLMPSC structure (Figure 3).

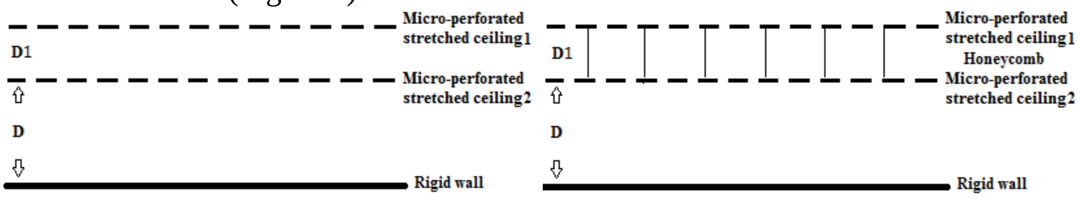


Figure 3 – Model of the DLMPSC structures without and with honeycomb between the membranes (a. structure without honeycomb; b. structure with honeycomb)

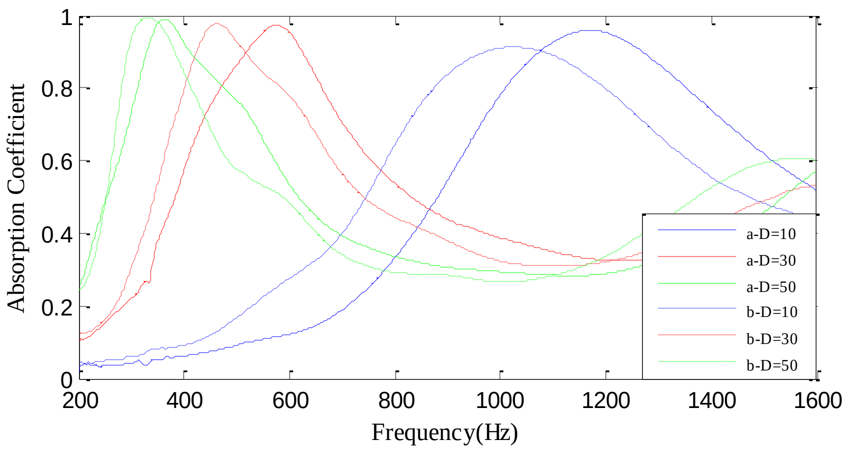


Figure 4 –The comparison of sound absorption coefficients of the DLMPSC without and with honeycomb between the membranes

Figure 4 shows the difference in the sound absorption coefficients of DLMPSC without and with honeycomb between the membranes. The depth of air cavity between the membranes (D1) is equal to the thickness of honeycomb. The resonance frequency shifts to the lower frequency slightly, while other absorption characteristics keep agreement with the condition in Figure 3(a). Hence, replacing the air cavity between the membranes of the DLMPSC with honeycomb can help improve the stress tolerance and slightly change the absorption performance of the DLMPSC structure.

Then, the honeycomb is attached behind the structure shown in Figure 3(b). Figure 5 shows the model of the sandwich structure (DLMPSC with honeycomb between the membranes) backed by honeycomb. In this sitution, the depth of air cavity D are designed as 10 mm, 30 mm, 50 mm, while D1 is 10 mm.

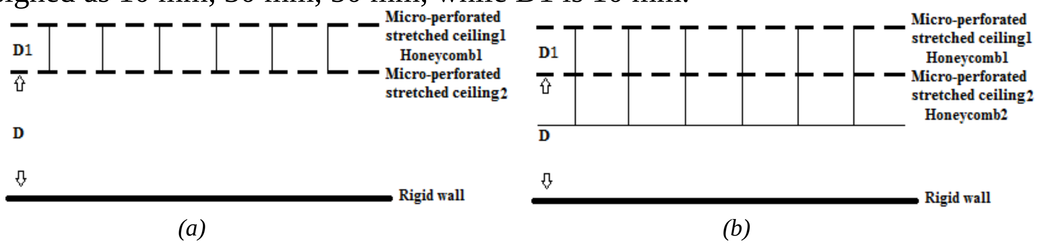


Figure 5 – Model of the DLMPSC structures backed by honeycomb
(a. structure without honeycomb; b. structure with honeycomb)

Figure 6 shows a similiar phenomenon with the condition that single-leaf MPSC is backed by honeycomb. Attaching a honeycomb behind the structure to improve the acoustic performance is not as effective as that inserted in the air cavity between the membranes of the DLMPSC.

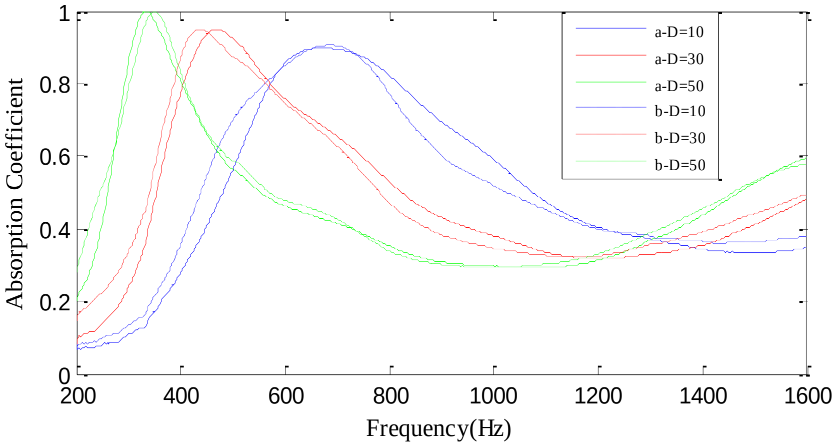


Figure 6 –The comparison of sound absorption coefficients of the DLMPSC without and with honeycomb

3. CONCLUSIONS

In this paper, three cases of inserting the honeycomb are designed. The sound absorption characteristics of micro-perforated stretch ceiling absorption structure backed by honeycomb are experimentally analyzed. To some extent, inserting a honeycomb into the air cavity between the membranes of the DLMPSC is notable in achieving a lower frequency. Honeycomb in these conditions can support the micro-perforated stretch ceiling as a effiective absorption structure with sufficient strength, which help the micro-perforated stretch ceiling be applied more freely.

4. ACKNOWLEDGEMENTS

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