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Experimental Studies on Acoustic Curtain

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Acoustic curtains, which are widely used in room acoustic projects, are a kind of fire resistance porous organic-fiber material with many advantages such as adjustable sound-absorption, easy installation, decoration effect, etc. The absorption of curtains is affected by both the properties of the textile, such as density, thickness, and the conditions of fixing or on another word of the air space between the wall and the curtain, the frills, the extending areas. To further study the acoustic properties of acoustic curtains, a series of test were conducted in different conditions. In many room acoustic projects, for example the adjustable curtain in Shanghai Grand Theatre, the outer acoustic drop scene in Shanghai People's Grand Stage and the hidden adjustable curtain in Guangxi Wuzhou Culture Center; acoustic curtains show a great advantage. This paper focuses on the acoustic performance of acoustic curtains through experiment measurements

Key words: acoustic curtain sound-absorption performance adjustable acoustic

1. Introduction of acoustic curtain

Acoustic curtain is a porous sound-absorbing material in a special sound-absorbing structure. It is not only the oldest, but also the most modern sound-absorbing measure. In 1930s when the sound films was in its embryonic stage, the recording studio began to use multi-layer fabric curtain as sound-absorbing material. In 1940s acoustic curtains were used in some anechoic chambers as a strong absorption material. Therefore, we could say acoustic curtains is the most primitive and the oldest sound-absorbing material. But in modern concert halls and sound recording/broadcasting studios, in order to separate spaces or adjust reverberation time, etc., acoustic curtain is widely used. So acoustic curtains is the most modern sound-absorbing material. [1]

The basic characteristics of acoustic curtain:

A Fire resistance ability: an ordinary curtain has not been applied fire proof treatment, so it's easy to burn; while absorbing curtains is usually applied fire proof treatment so it's more liable to meet the fire proof requirement..

B Variable acoustic properties: sound absorption is easy to be adjusted by changing acoustic curtain covered area.

C Easy Installation: acoustic curtain is made by fabric so it is very easy to be installed in different ways and adjusted..

D Decoration: As a fabric, obviously acoustic curtain has a good decoration effect..

When the non-fold curtain attached to the wall without space, the sound absorption is not very significant; the sound absorption is increased when there's a space between the curtain and wall, at the same condition, the sound absorption

of a fold curtain is better than a non-folding curtain because folds increase the area density of the curtain. The function of folds is similar to wedges in an anechoic room.

2. The factors that affect the acoustic absorption curtain

2.1 The space between the wall and curtains

Experiment material: WX-L-type fire resistant high-performance wide-band acoustic curtains, it's fully expanded area (without fold) is 22.56 m²; area density is 1.46kg/m². After being folded, the curtains fully covered area is 10.08 m² and absorption coefficient calculated area is 10.08 m².

Experiment plan: WX-L-type fire resistant high-performance wide-band acoustic curtains completely cover the 10.08 m² test area (folded), then measure absorption coefficient in 5 status: the space between the wall and curtains is none, 100mm,200mm,300mm, 400mm respectively.

Note: The curtain is installed on the wall of the reverberation room, surrounded by 40mm thickness reinforced concrete envelope which inner area is 10.08 m².

Table 1: Sound absorption coefficient data [2]

Space	none	100mm	200mm	300mm	400mm
The average absorption coefficient	0.69	0.80	0.83	0.86	0.90
NRC	0.75	0.90	0.95	0.95	0.95

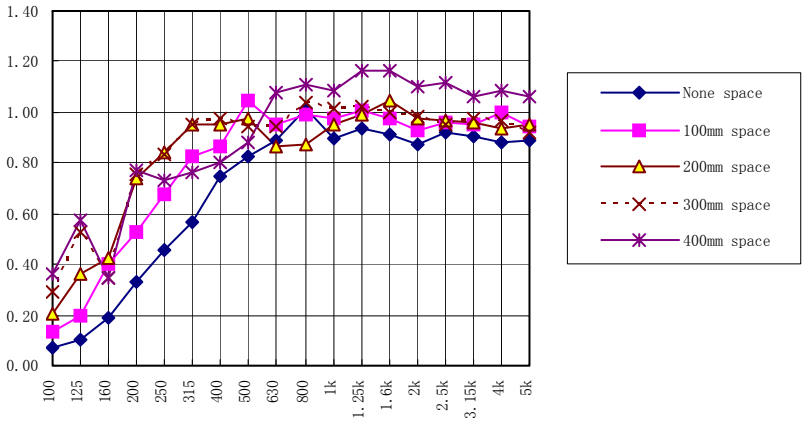


Figure 1: Absorption coefficient curve [2]

From Table 1 and Figure 1, it can be seen that, as the space increases, the sound absorption of acoustic curtain in the full band is improved. None space, NRC increases from 0.75 at none space to 0.95 at 400mm space. From Table 1 we can see the most significant improvement happened in the low-frequency. For instance, the absorption coefficient of none space in 100Hz is 0.07, while the 400mm-space is 0.36. Thus, the space plays a significant role to increase the absorption coefficient in low frequency. From Table 1, it can be seen that, with the space increases, the curtains of the sound absorption performance increases. Therefore, increasing the space can greatly improve the acoustic performance

of the curtains, especially in low-frequency.

2.2 The adjustable acoustic curtains

Experiment material: WX-L-type fire resistant high-performance wide-band acoustic curtains, its fully expanded area (without fold) is 22.56 m², area density: 1.46 kg / m².

A．1/2-open status: After being folded, the curtains covered area is 5.04 m², and absorption coefficient calculated area is 10.08 m², so the curtains cover 1/2 area.

B．1/3-open Status: After being folded, the curtains covered area is 3.36 m², and absorption coefficient calculated area is 10.08 m², so the curtains cover 1/3 area.

C． Fully close status: After being folded, the curtains covered area is 10.08 m², and absorption coefficient calculated area is 10.08 m², so the curtains cover fully area.

D． Fully open status: After being folded, the curtains covered area is 1.44 m², and absorption coefficient calculated area is 10.08 m², the curtains is put at both sides of the concrete envelope.

Experiment Plan: WX-L-type fire resistant high-performance wide-band acoustic curtains completely cover the 10.08 m² test area (folded), with the 400mm-space., then measure absorption coefficient in 4 status: 1/2-open,1/3 open, Fully close and Fully open.

Note: Same as 2.1

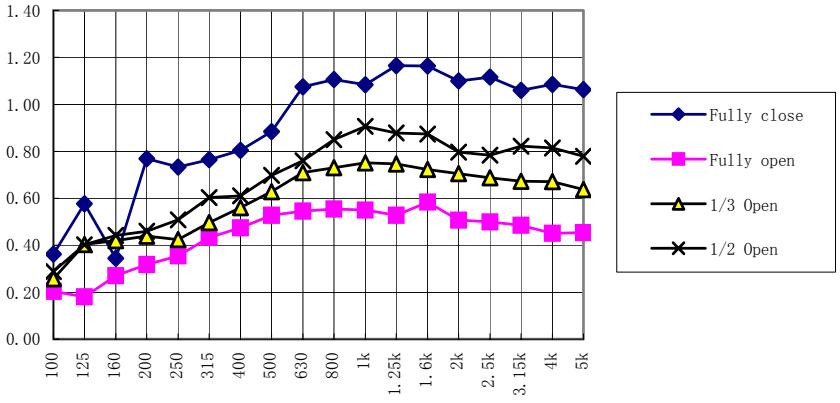
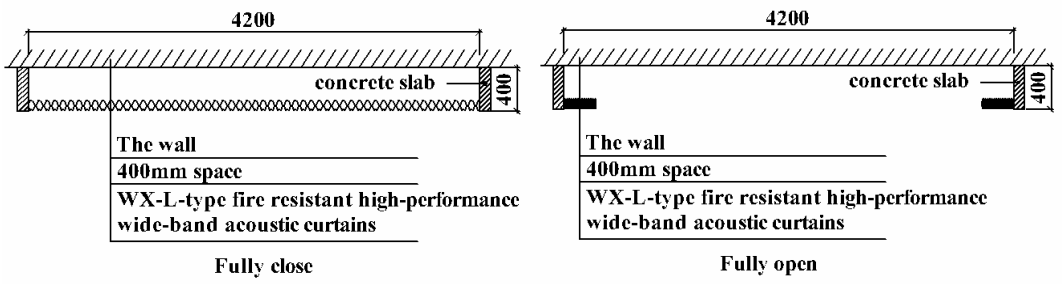


Figure 2: 400mm-space absorption coefficient curve[2]



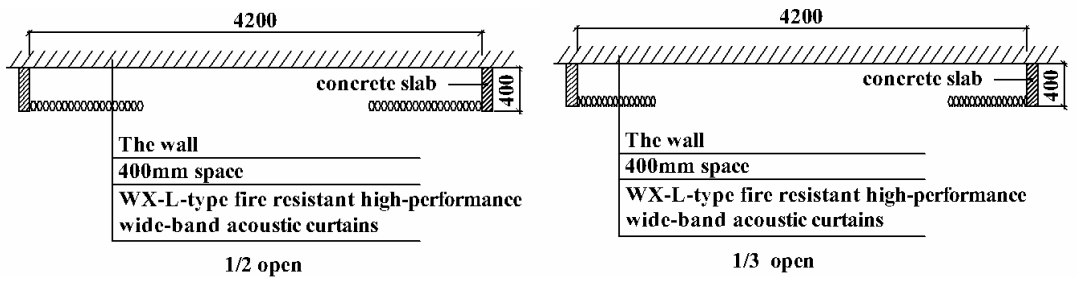


Figure3: Experiment sketch [2]

It can be seen in Figure 2 that the absorption curves in these four states have obvious differences, especially in high-frequency.

Table 2 shows the absorption properties in different status.

Table 2: Data comparison table[2]

Status	Fully close	Fully Open	1/2 Open	1/3 Open
The average absorption coefficient	0.90	0.44	0.68	0.59
NRC	0.95	0.50	0.75	0.65

Using additional sound absorption can not only reduce reverberation time, increase the music transparency and speech clarity, but also change the structure of early reflections. To significantly change reverberation time, there should be a large requirement of additional sound absorption [2].

2.3 Area density on the acoustic effects

Experiment Materials:

A WX-L-type fire resistant high-performance wide-band acoustic curtain, its fully expanded area (without fold) is 22.56 m², area density: 1.46 kg / m². After being folded, the curtains fully covered area is 10.08 m²

B FD type adjustable acoustic curtain, area density: 0.89 kg / m²

C FPP type adjustable acoustic curtain, area density: 0.38 kg / m²

D FU type adjustable acoustic curtain, area density: 0.49 kg / m²

Experiment Plan: with the 300mm-space, and the curtains fully covered area is 10.08 m², each of these four kind curtains is tested.

Note: The four kind curtains were installed in the reverberation room, same as 2.1.

Table 3: Data Comparison Table[2]

Curtain Type	WX-L-type 1.46 kg / m²	FD type 0.89 kg / m²	FPP type 0.38 kg / m²	FU type 0.49 kg / m²
The average absorption coefficient	0.86	0.88	0.40	0.70
NRC	0.95	0.95	0.40	0.70

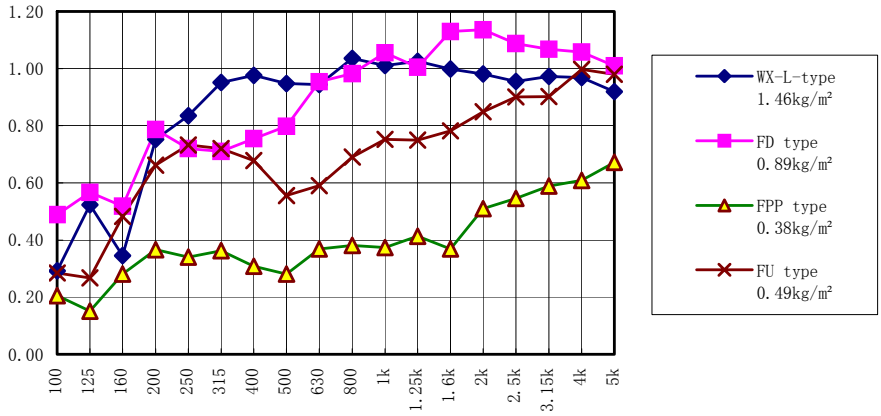


Figure 4: Absorption coefficient curve[2]

It can be seen in Table 3, the larger the area density of the curtain, the higher the NRC value is. That means a larger area density produce a higher NRC value.

Comparing the WX-L-type with FD type of which the area densities are larger, they have the same NRC value; however, the average absorption coefficient is decreased with the area density increasing. From Figure 4 we can see the WX-L-type and FD type curves, from 100Hz to 200Hz the absorption coefficient value of the FD is a little higher than that of the WX-L-type; from 200Hz to 630Hz the absorption coefficient value of the WX-L-type is much higher than that of the FD ; but from 1250 Hz to 5000 Hz the absorption coefficient value of the FD is much higher than that of the WX-L-type. It can be inferred that the absorption properties of the curtains is not improved with the increase of area density at all the frequency band.

Comparing the other two kind curtains, the NRC and the average absorption coefficient can be increased with the area density increased in whole frequency band, especially in high-frequency

From the above comparison, it can be derived that there should be an optimal area density acoustic curtain.

Folding the curtains is one of the applications of the area density influence on the acoustic properties. It is increasing the apparent area density, so the absorption properties can be improved.

3. Conclusion

Through the experiment researches on acoustic curtains, it can be derived that the expanding rate, the space and the area density can influence the absorption properties of the curtain:

1, With a larger space, the sound absorption performance of the curtain can be improved. When the space moves from 200mm to 300mm, the sound absorption properties of the curtain can only get a small improvement, but when the space is up to 400mm, there is a very significant increase, especially in low frequency.

2, The larger the area density of the curtain, the better absorption of the full band can be achieved, especially in the high frequency but there is an optimal area density.

3, Depending on the actual needs of different function halls, people can use acoustic curtains expanding rate to adjust the reverberation time.

References

[1] Xiang Duanqi ed. " *Practical Building Acoustics* "

[2] Articles used in the experimental data refer to the Center for Building Environment Test, Tsinghua University

Testing number is: 04048,04088,04092,04096,04100,04098,04099,04101,03091,03089,03090 of the test report.