Proceedings of 20th International Congress on Acoustics, ICA 2010

23-27 August 2010, Sydney, Australia

A Study of Sound Absorption Characteristics on Air Layer with Irregular Shape

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PACS: 43.55.EV

ABSTRACT

Air layer with irregular shape in sound absorbing structure is formed by different structure mode of materials. With building multiform interior space by materials and structure mode, it makes the shape of air layer between the facing and the structure of building to be irregular shape.

According to related study of absorbing structure, it shows less information about the influence of air layer with irregular shape. The factors of sound absorption of absorbing structure were focused on absorbing structure which facing paralleled structure of building in past research. For searching the influence of sound absorption of absorbing structure caused by the air layer with irregular shape, the subject in this study is set as the air layer with irregular shape which facing tilts with single-axis. The factors of air layer with irregular shape are the angle between tilting facing and horizontal face, the length of span of tilting facing, and if the setting is that the air layer is divided into several parts not to be interlinked. By these factors the sound absorption characteristics of air layer with irregular shape are shown.

The results of the measurement in the study are displayed in two parts. One is the influence of absorption coefficient caused by irregular shape, and the other is the influence of absorption coefficient caused by setting of air cavity. The effects of absorption coefficient caused by irregular shape mainly divided to influences of angle and span of tilting facing. In the variation of angle of tilting facing we concern, it exerts a more obvious influence on panel structure backed air layer with irregular shape, and the absorption coefficient increases as the increasing of the angle, and the effects are mainly revealed below frequency 250 Hz. In the other side of effects from span of tilting facing, the perforated panel structure is influenced remarkably at high frequencies. Furthermore, as the increasing of the span of tilting facing, the absorption of air layer with irregular shape back to the panel becomes lower. On the contrary, the absorption of the perforated panel shows less difference. In additional, the absorption of the perforated panel structure reveals relative high values to the panel structure at middle and high frequency in condition of same angle and span of tilting facing.

In the other point of effects of absorption coefficient causing by setting of air cavity, both panel and perforated panel structure the influences are influenced mainly at low frequency, especially at 200 Hz. Whether the air cavity is set or not, the panel structure reveals less influences and the absorption coefficient reduces as increasing of span at low frequencies.

Keyword: Irregular shape, absorbing structure

INTRODUCTION

Design of reve**r**beration time is situated at extremely important position of interior acoustical design. Due to the suitable reverberation time makes performers' voices to obtain the best display, design of reverberation time would be the critical foundation for design of interior decoration and the choice of materials. Because of the accuracy of the reverberation time estimate in planning step, the accuracy of the acoustical absorption from each material and structure is certainly an indispensable condition. However, the designer usually takes lack of accuracy of reverberation time estimate due to the relative data about acoustical absorption of materials and structures.Especially in present day the interior space is designed with continuously renewed design technique as applying the variation of interior decoration materials. According to this conversion, the original air layer parallel to the face of structure (air layer with regular shape) become to the air layer with irregular shape.There is less study about the effects of air layer with irregular shape setting.

From the above-mentioned motives, this study categorize relative factors of absorbing structure backed with air layer and choose factors which influence the air layer with irregular shape as studying variables, and with panel and perforated facing the sound characteristics of air layer with irregular shape would be shown.

THE OBJECT OF STUDY

The definition of air layer is "the air layer between the facing material and the back material." The definition of the air layer with irregular shape in this study is "the air layer formed by being between the facing material and the back material with the facing of absorbing structure in unparallel setting to the facing of building structure or the back material." As this definition, the diagram of air layer with irregular shape is shown as below Figure 1:

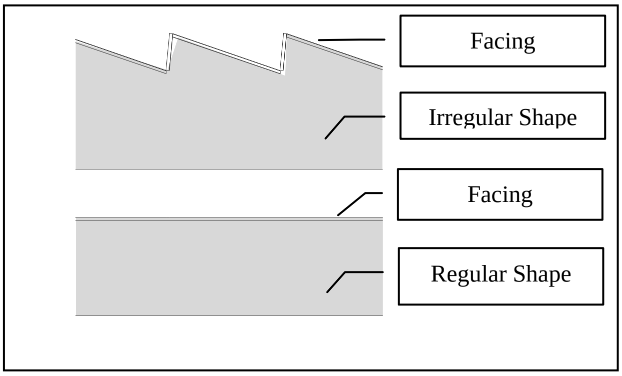


Figure 1 Air Layer with Irregular Shape and Regular Shape

RANGE AND FACTOR

This study takes account of the internal common structure which include panel structure and perforated structure as the range to study in. The variables are base on the relative factors of air layer with irregular shape. The variables entries is shown as below Table1.

This study focuses on air layer with irregular shape, formed by tilting the facing with single axis, as a study object. It contains two entries which are the shape and the thickness of the air layer, and further more the factors which influences entries would be chosen and identified. The factors of the shape of the air layer contain the angle of the tilting facing, the span of the tilting facing, and the air cavity of the air layer, and the factors of the thickness of the air layer contain the average of the thickness of the air layer and the minimum of the thickness of the air layer. By these factors the multi-shapes of the air layer with irregular shape can be identified. The factors are illustrated as below Table1.

In the part of variable factors, the angle of the tilting facing would be limited in 20° according to concern with the feasibility of measuring and the maximum of the angle of the tilting facing in practical setting. The span of the tilting facing changes with a multiple as the size of the facing material. In the part of fixed factors, steel panel and perforated steel panel are chosen as the facing materials. The standards of variable and fixed factors are shown as below Table 2,Figure3:

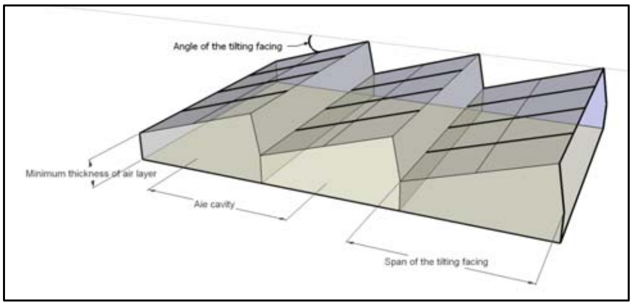


Figure 2 Factors of sound characteristics of air layer

EXPERIMENT METHOD

This study uses CNS A 3165 “Method for Measurement of Sound Absorption Coefficients in a Reverberation Room” to measure the absorption of samples. The laboratory is the reverberation room of Acoustical Laboratory in Department of Architecture, National Cheng Kung University, Taiwan. The measure of area is 32.8 m^2, and the volume is 171.6 m^3, and The area of the sample is 8.64 m^2.

Table 1 Factors of sound characteristics of air layer

Entry	Factor	Definition	Explanation	Option
Shape of Air Layer	Angle of Tilting facing	The Angle between the tilting facing and the horizontal facing	Controlling the shape of air layer with irregular shape by variation of tilting degree of the tilting facing.	Using the angle of tilting facing as one variable factor
	Span of Tilting facing	The projective length of the tilting facing.	Controlling the module size of air layer with irregular shape by variation of span length of the tilting facing.	Using the span of tilting facing as one variable factor
	Air Cavity	Each air part back to the tilting facing set as independent cavity by partitions, or note.	Controlling the tilting module as independent or whole cavity by setting the air cavity or not.	Using whether setting air cavity or not as one variable factor
Thickness of Air Layer	Average Thickness of Air Layer	The average thickness of air layer from the total volume of air layer divided by the projective area of tilting facing.	Use average thickness of air layer to fix the total air volume.	Using Average thickness of air layer as the contrastive factor to angle of tilting facing
	Minimum Thickness of Air Layer	The minimum of the thickness of air layer between the tilting facing and the back material layer.	There must be basic thickness of air layer between the facing and back materials to make sure absorbing ability of air layer practicable.	Using single minimum thickness of air layer as fixed factor.

Table 2 Variable factor and Fix factor

factor	Entry		Factor	Value
Variable factor	Air Layer with Irregular Shape	Shape of Air Layer	Angle of Tilting facing	5°
				10°
				15°
				20°
			Span of Tilting facing	60 cm
				120 cm
				180 cm
				360 cm
			Air Cavity	Setting
				None
	Facing	Characteristic	perforated	0 %
				8.55 %
Fix factor	Air Layer with Irregular Shape	Thickness of Air Layer	Minimum Thickness of Air Layer	10 cm
	Facing	Characteristic	Material	steel
			Thickness	0.06 cm

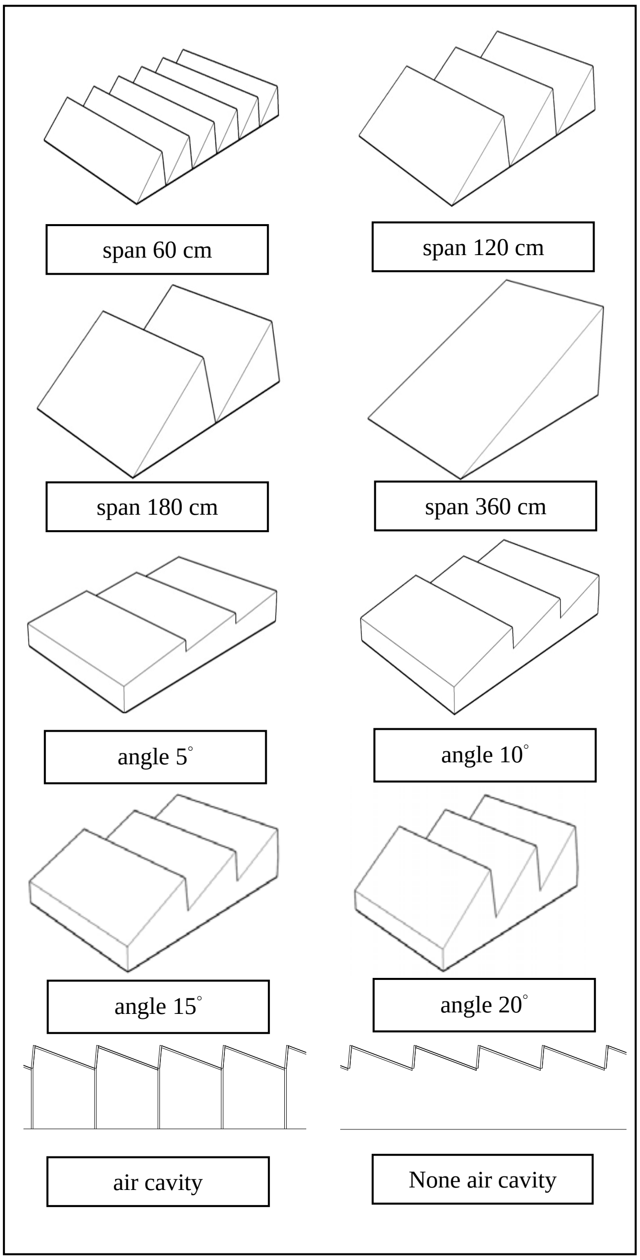


Figure 3 Variable factor

EXPERIMENTAL RESULTS

The compare of the measuring result from samples of angle from 5° to 20° and span as 60 cm displays several trends as following. Absorption of air layer with irregular shape back to the steel panel shows relative high values to the one with regular shape back to the steel panel below frequency 250 Hz. In the part of the perforated steel panel, the absorption of air layer back to the perforated steel panel shows less difference in each frequency between air layer with irregular and regular shape at angle 5°, and the one with irregular shape shows relative high to the one with regular shape values above frequency 800 Hz at angle 10°, and the one with irregular shape shows relative high to the one with regular shape values below frequency 250 Hz at angle 15°, and the last one with irregular shape shows relative high to the one with regular shape values below frequency 250 Hz and above frequency 800 Hz at angle 20°. Otherwise, as increasing of the angle, the absorption of air layer with irregular shape back to perforated steel panel reveal a trend of increasing values at low frequency.。(Figure 4, Figure 5)

As the span 120 cm, absorption of air layer with irregular shape back to the steel panel shows relative high values to the one with regular shape back to the steel panel at frequency 400 Hz from angle 5° to 15°. In the other hand, it reveals main effects of air layer with irregular shape back to the perforated steel panel at low and high frequency.(Figure 6, Figure 7)

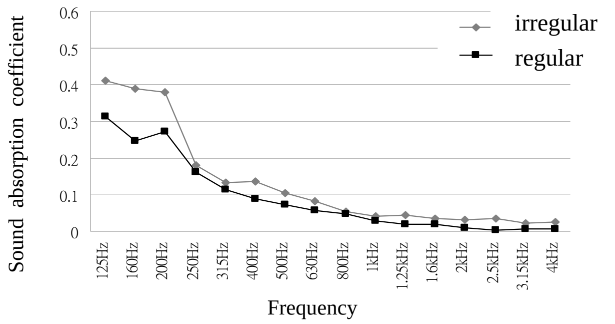
As the span 180 cm, absorption of air layer with irregular shape back to the steel panel shows relative high values to the one with regular shape back to the steel panel, especially at low frequency. However, absorption of air layer back to the perforated steel panel shows more obvious difference at low and high frequency. Through comparing measuring results of absorption of air layer back to the steel panel and the perforated steel panel, absorption of air layer with regular shape shows relative high values to the one with irregular shape at frequency 3150 Hz and 4000 Hz. (Figure 8, Figure9)

As the span 360 cm, absorption of air layer back to the steel panel and the perforated steel panel all shows almost no difference between irregular and regular shape at angle 5°. According to compare measuring results of absorption of air layer back to the steel panel and the perforated steel panel at angle 10° and 15°, absorption of air layer with regular shape shows relative high values to the one with irregular shape at low frequency. (Figure10, Figure11)

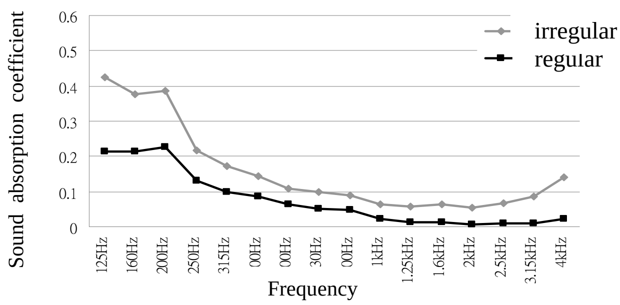
At span 60 cm, absorption of air layer back to the perforated steel panel reveals no obvious difference whether air layer is with air cavity or not. In the other one back to steel panel, the difference of absorption between air cavity and no air cavity displays at low frequency. (Figure12)

At span 120 cm, absorption of air layer with air cavity back to the steel panel reveals relative high values to the one without air cavity at all angles at frequency 200 Hz, and the other one back to the perforated steel panel shows obvious differences at low and middle frequency. (Figure13)

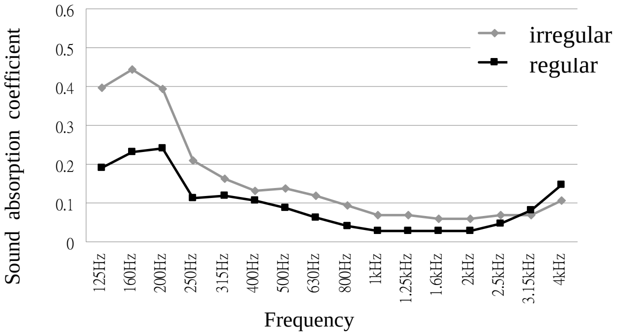
At span 180 cm, except to the absorption of air layer back to the perforated steel panel at angle 5° at frequency 125 Hz and at 10° at frequency 160 Hz and 200 Hz, the differences of absorption between air layer with air cavity or not shows no obvious. (Figure14)



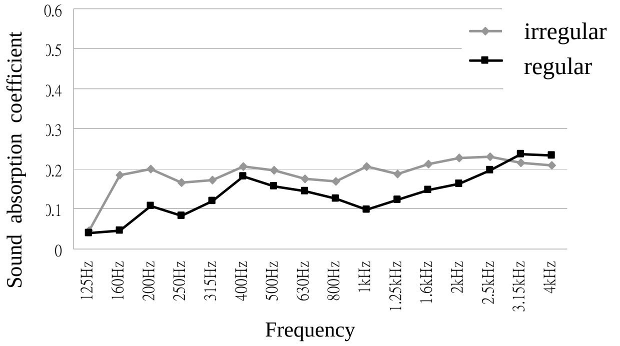
(a)span 60cm,angle 5°,steel panel



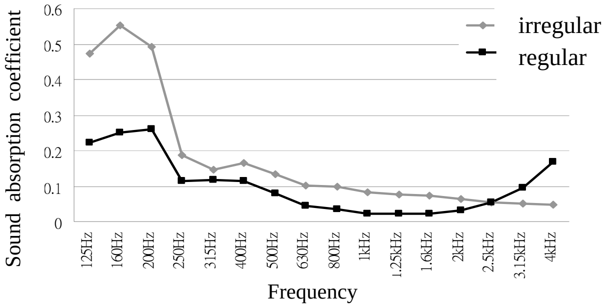
(b)span 60cm,angle10°,steel panel



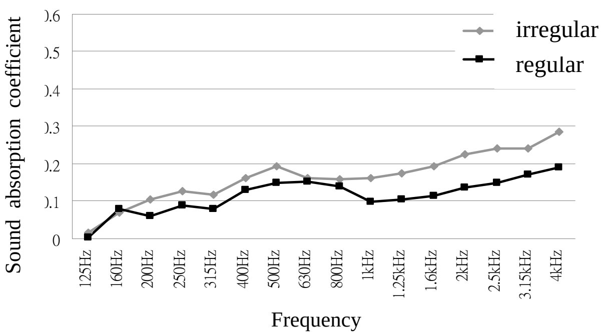
(c)span 60cm,angle15°,steel panel



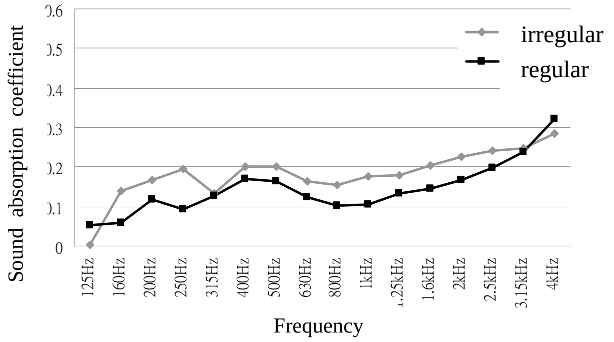
(d)span 60cm,angle20°,steel panel
Figure4 span 60cm,steel panel



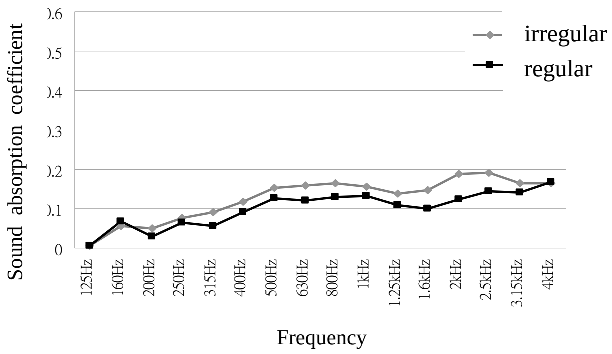
(a)span 60cm,angle 5°,perforated steel panel



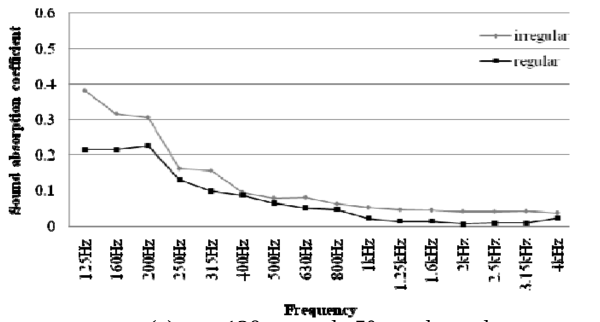
(b)span 60cm,angle 10°,perforated steel panel



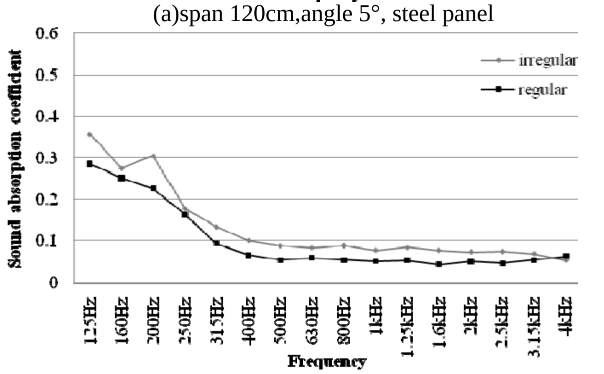
(c)span 60cm,angle 15°,perforated steel panel



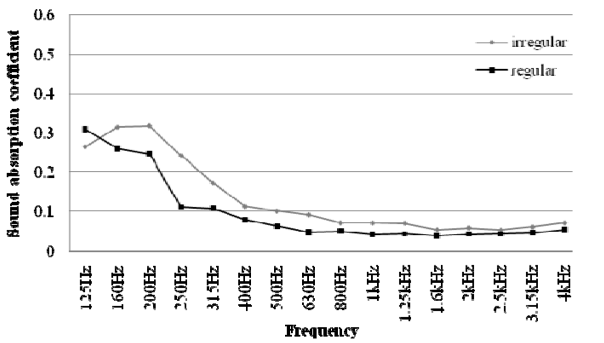
(d)span 60cm,angle 20°,perforated steel panel
Figure5 span 60cm, perforated steel pane



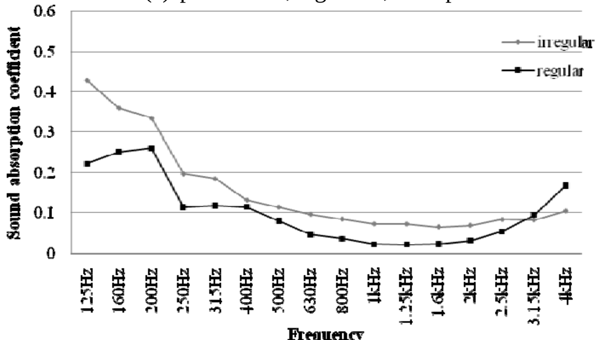
(a)span 120cm,angle 5°, steel panel



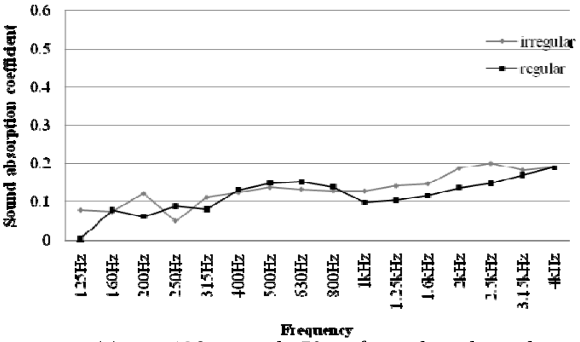
(b)span 120cm,angle 10°, steel panel



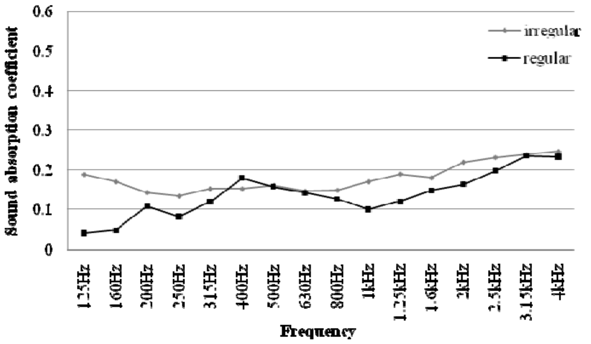
(c)span 120cm,angle 15°, steel panel



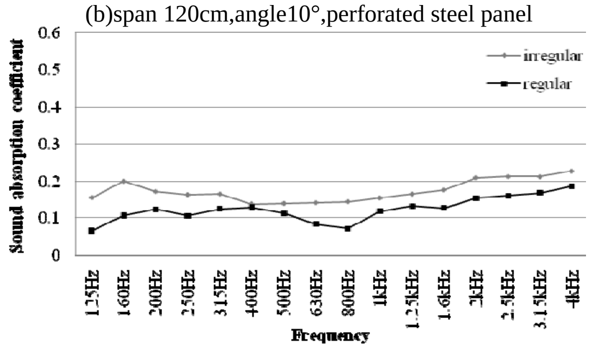
(d)span 120cm,angle 20°, steel panel
Figure6 span 120cm, steel pane



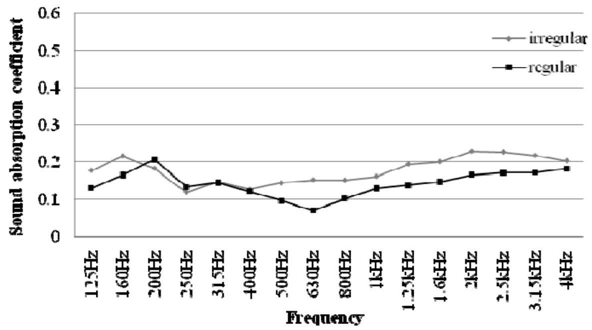
(a)span 120cm,angle 5°,perforated steel panel



(b)span 120cm,angle10°,perforated steel panel

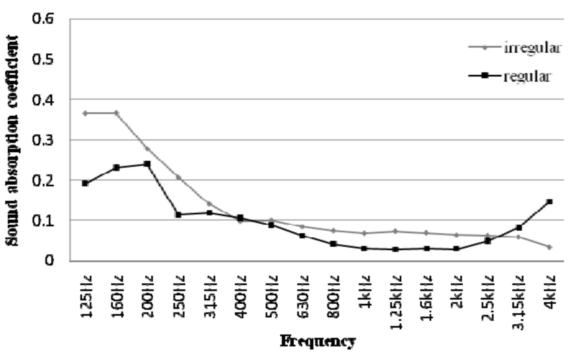


(c)span 120cm,angle 15°,perforated steel panel

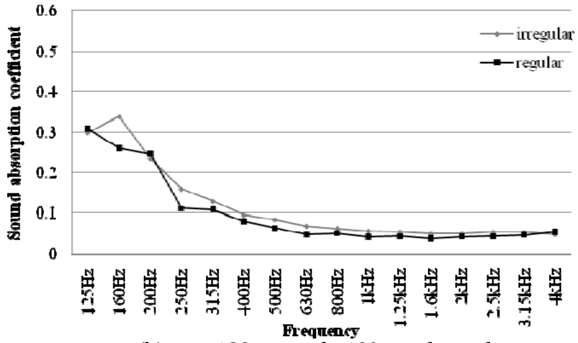


(d)span 120cm,angle 20°,perforated steel panel

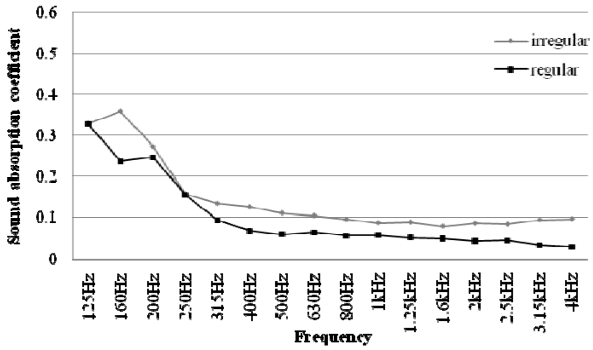
Figure7 span 120cm, perforated steel pane



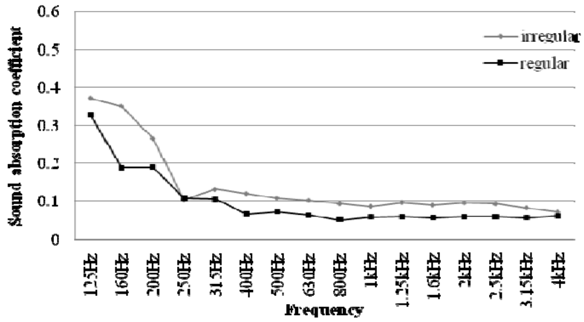
(a)span 180cm,angle 5°, steel panel



(b)span 180cm,angle 10°, steel panel

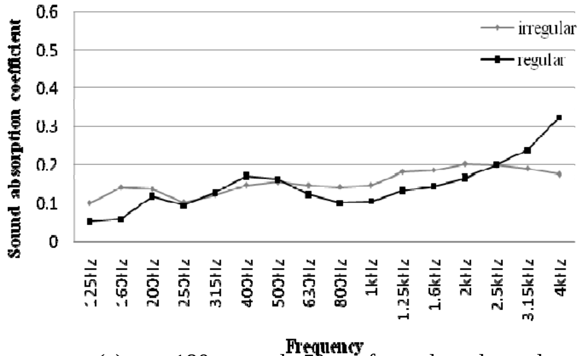


(c)span 180cm,angle15°, steel panel

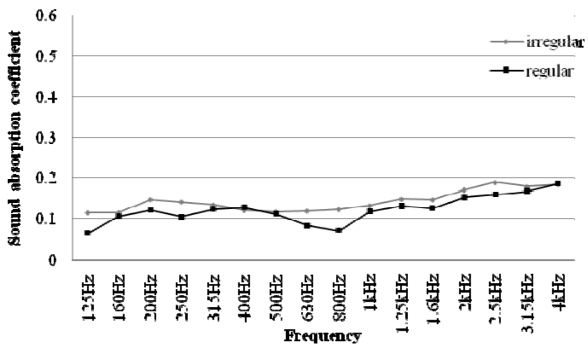


(d)span 180cm,angle20°, steel panel

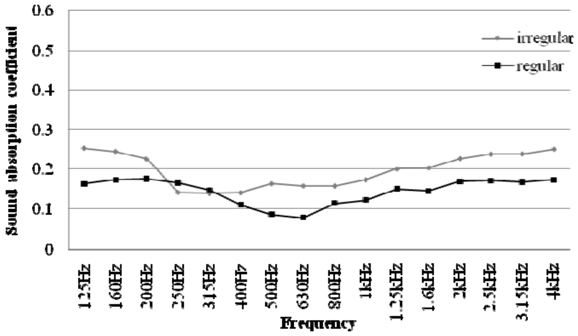
Figure8 span 180cm, steel pane



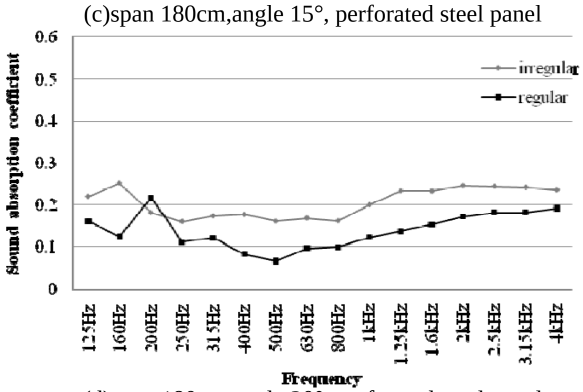
(a)span 180cm,angle 5°, perforated steel panel



(b)span 180cm,angle 10°, perforated steel panel

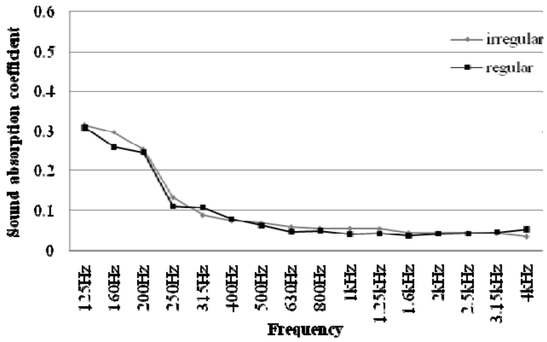


(c)span 180cm,angle 15°, perforated steel panel

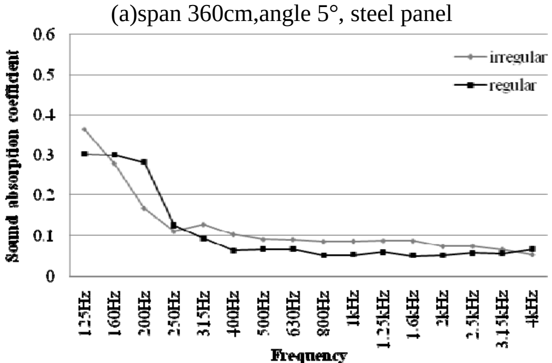


(d)span 180cm,angle 20°, perforated steel panel

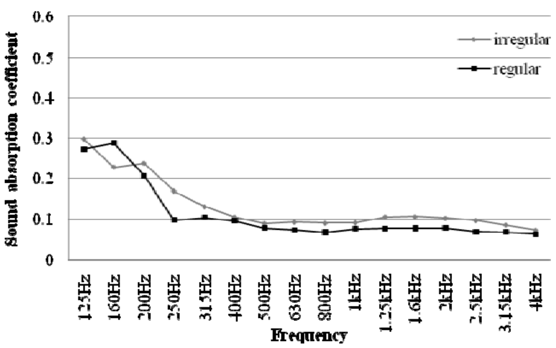
Figure9 span 180cm, perforated steel pane



(a)span 360cm,angle 5°, steel panel

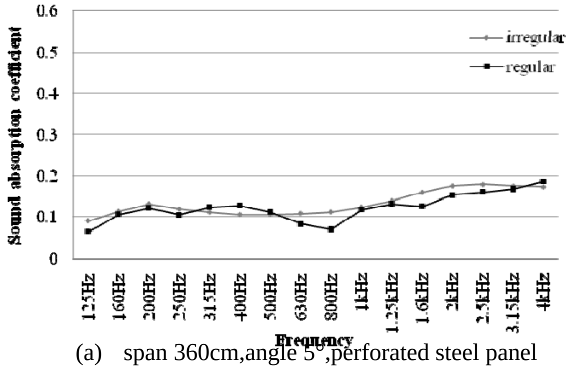


(b)span 360cm,angle 10°, steel panel

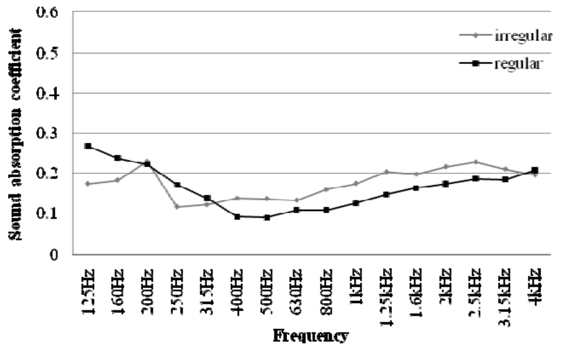


(c)span 360cm,angle 15°, steel panel

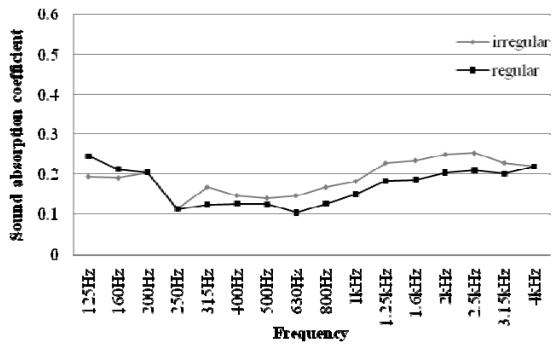
Figure10 span 360cm, steel pane



(a) span 360cm,angle 5°,perforated steel panel

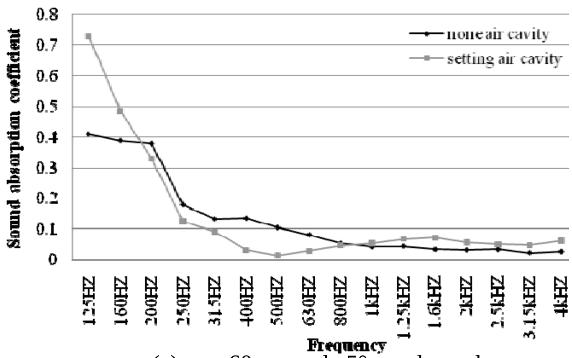


(b)span 360cm,angle 10°,perforated steel panel

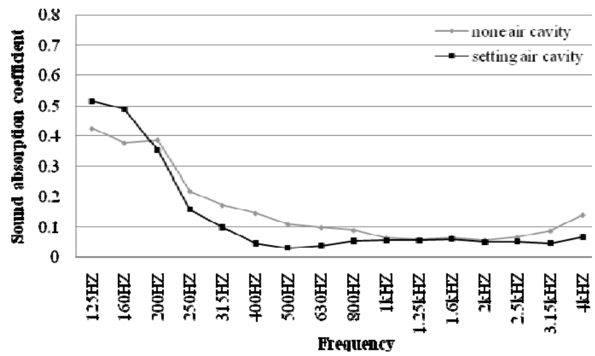


(c)span 360cm,angle 15°,perforated steel panel

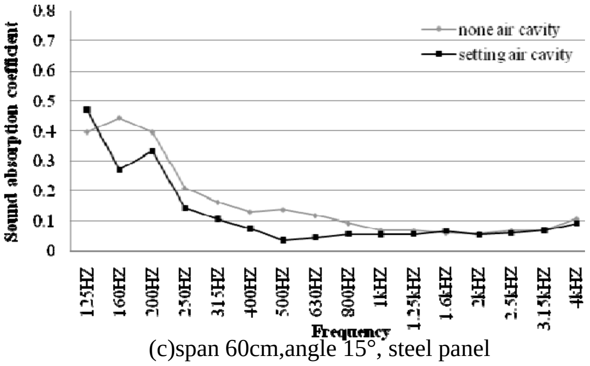
Figure11 span 360cm, perforated steel pane



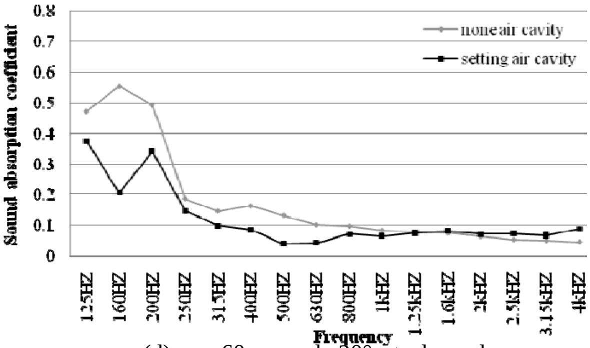
(a)span 60cm,angle 5°, steel panel



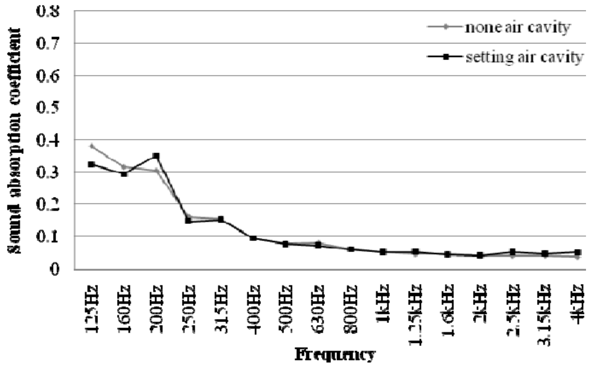
(b)span 60cm,angle 10°, steel panel



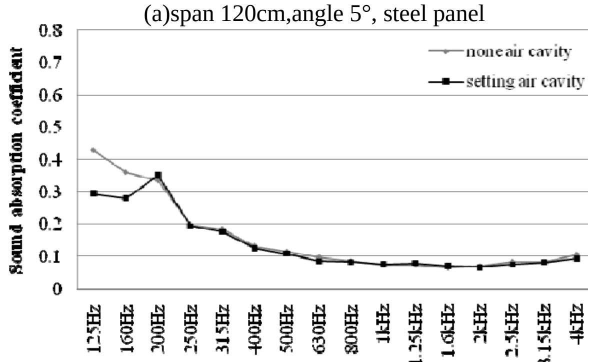
(c)span 60cm,angle 15°, steel panel



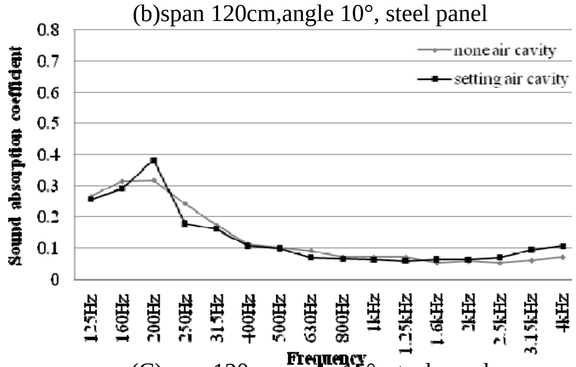
(d)span 60cm,angle 20°, steel panel
Figure12 span 60cm, steel pane



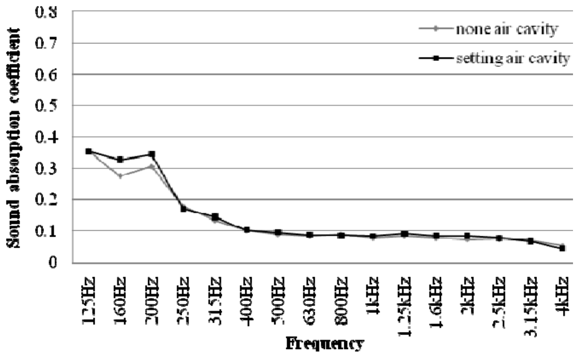
(a)span 120cm,angle 5°, steel panel



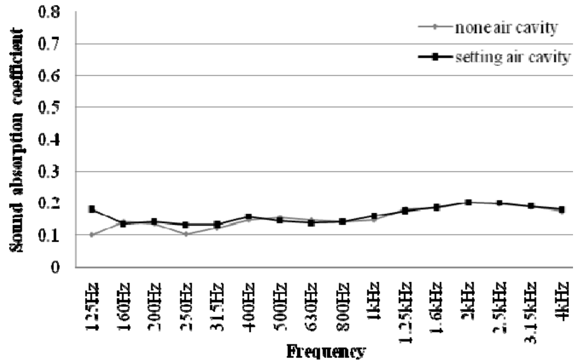
(b)span 120cm,angle 10°, steel panel



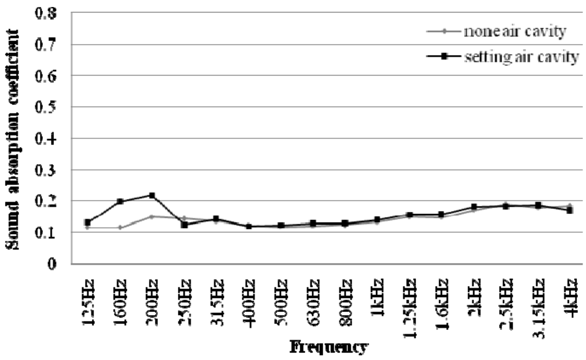
(C)span 120cm,angle 15°, steel panel



(d)span 120cm,angle 20°, steel panel
Figure13 span 120cm, steel pane



(a)span 180cm,angle 5°, perforated steel panel



(b)span 180cm,angle 10°, perforated steel panel
Figure14 span 180cm, perforated steel pane

CONCLUSIONS

1. The setting of air layer with irregular shape in panel structure would exert an influence on absorption of structure which increase as the increasing of the angle, and the effects are mainly revealed below frequency 250 Hz.
2. For the perforated panel structure, The effects by variation of the span of tilting facing are revealed at high frequency.
3. As the increasing of the span of tilting facing, the absorption of air layer with irregular shape back to the panel becomes lower. On the contrary, the absorption of the perforated panel shows less difference.
4. In condition of same angle and span of tilting facing, the absorption of the perforated panel structure reveals relative high values to the panel structure at middle and high frequency.
5. The influences of setting air cavity or not are revealed mainly at low frequency, especially at 200 Hz.
6. The panel structure reveals no influence from setting air cavity or not, and the absorption reduces as increasing of span at low frequency.

DISCUSSION

This study confers the air layer with irregular shape back to the absorptive structure with the steel panel. It is found that the absorption coefficient of air layer with irregular shape indeed is with relative high value to the one with regular shape. Besides, the difference of the facing perforated or not is resulted at different frequencies. In the future the demands of interior acoustics can be basis for the interior design to consider the angle, span of the tilting facing of decoration materials, and the need of the perforated facing. These measures are all as a result of making the reverberation time of space to reach more ideal goal.

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