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Investigation On The Role of Cavity and Slit of Cavity Resonators to Sound Absorption Behavior

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ABSTRACT

Slit resonator and also perforated resonator are few kind of room interior finishing. They act as sound absorbers. Generally, they are constructed of at least three basic types of absorbers, such as porous, membrane and cavity components.These types of room surface finishing should acoustically provide aural quality for audience and even architecturally contribute aesthetic value for interior finishing. To attain a well performance of interior finishing, composition of surfaces, textures and colors, motivate designers to explore slit and also perforated resonator as frequent choices. Configuration, dimension, composition and form of cavity or slit may give different and specific sound absorption behavior as well as sound absorption ability and quality. Research that has been done leads to the objective to study the role of slit and cavity resonators as sound absorbers through experimental method in a reverberant chamber.

BACKGROUND

Reverberation time is an important parameter in acoustical room performance. As in case of auditorium; when it is for music purpose, the reverberation time surely must longer than for speech purpose. In order to catch this quite important acoustic requirement, a designer face up many kind of sound absorbing materials which one of these that has been investigating further is a slit resonator. Slit resonator has an advantage as it can be explore by a designer to many variants by exploring its thickness, spacing, and depth to perform an aesthetic as good as acoustical performance in a room.

THEORETICAL APPROACH & HYPOTHESES

The Reverberation Time (RT) of a room is defined as the time for sound pressure level in the room to decrease by 60 dB. RT is then expressed in second(s).

As the decay rate depends on the amount of absoption value in room, change in absorption value in the same room will effect the change of reverberation time of the room. By finding changes in the absorption value in room (by measuring the change of the reverberation times in an empty room compare to condition after introducing the test specimen into the room) the absorption coefficient of the test specimen can be determined. A reverberation chamber is used for the tests.

A simple RT formulae will be used for calculating the absorption coefficient of test specimens.

The increase in equivalent absorption area, ΔA, is defined by

$$\Delta A = 55.3\ V\ (\ 1/RT_2 - 1/RT_1) / c \qquad [2]$$

where V = volume of the room, c = the velocity of sound, RT1 = the reverberation time of the room before the test specimen in introduced, and RT2 = the reverberation time of the room after the test specimen is introduced).

Then, the absorption coefficient αs of the test specimen is determined by

$$\alpha s = \Delta A/S \text{ (where S is the area of the test specimen)} \qquad [2]$$

Since the objective of this experiment is just to study the effect of variation in configuration of the test specimen components (and not the absolute value of their absorption coefficients) the above simple formulae is considered as sufficient.

Slit resonator components being studied are width of slit (gap) between woodslats, thickness of woodslats, and depth of the air space behind the layers. Does its coefficient of absorption increase when its depth increase ? Or the larger its gap may provide higher absorption coefficient ? And in what frequency bands ?

RESEARCH PURPOSES AND LIMITATION

This research conducted in order to study the role of slit resonator for the following purposes:

- To get the absorption value (α) of woodslats in variative composition/ configuration .

- To conclude which different configuration got advantages compared to others as a sound absorbing materials.
- To give a spesific information to acoustic designers in considering which configuration will be suitable to their acoustic design problem.

This research was held by some limitations:

- the using interior finishing are that commonly available in the building materials market;
- the frequency used for the tests are 1octave band frequencies i.e. 125 Hz, 250 Hz, 500 Hz, 1kHz, 2k Hz and 4k Hz;
- the laboratory to conduct this research is the reverberation room of Architecture Department Petra Christian University with room dimension of 4.26m X 3.80m x 3.3m; with all its limitation.

RESEARCH METHOD

This research conducted by experiment in a reverberation room that follow ISO/R 354 as the guidance. Many variative composition/configuration made in order to get an objective findings, that applicable for a designer to judge which composition will suitable for their acoustical room design problems.

Measurement conducted by measuring the reverberation time with the material configuration within, compared to the empty room condition (without the test specimen overlay). This result is then being calculated by Sabine formula to get the absorption value (α) of each material configuration.

Mentioned accordingly, RT of the empty reverberation room condition (before introducing the test specimen) at 125 Hz was 4.2 second, 250 Hz was 4.8 second, 4.7 second at 500 Hz, 3.9 second at 1k Hz, 3.4 second at 2k Hz, and 2.9 second at 4k Hz. These data are acceptable for the RT standard of Australian Standard [1], which given at least 5 second for low frequency (125-250 Hz) and at least 2 second for high frequency (4k Hz).

Devices

In conducting this research, besides the reverberation room itself, the devices used are: a noise generator ex RION, power amplifier and loudspeaker ex PANASONIC, a 13mm condenser microphone ex RION, a callibrated sound level meter equipped with octave band filter ex RION, level recorder, a roll of recording printing paper ex RION, and a reverberation time protractor.

Material test specimen and Compositions

The material used are woodslats made of plywood that commonly used for wall and ceiling finishing materials and are available in market; in pieces of dimension : 7cm width and 1.8m length in different thickness; laying in different compositions/configurations in the reverberation room as in figure below.

Figure 1. A test specimen

Variables

In composing the materials, some variables explored are *the thickness, the spacing and the depth* of the plywood configured. From the available materials in the market, ***the thickness*** chosen are 9mm, 12mm, 18mm and 24mm; ***the spacing*** are 0mm, 3mm, 6mm, 9mm, 12mm and 15mm; while ***the depth*** are 0mm, 40mm and 80mm.

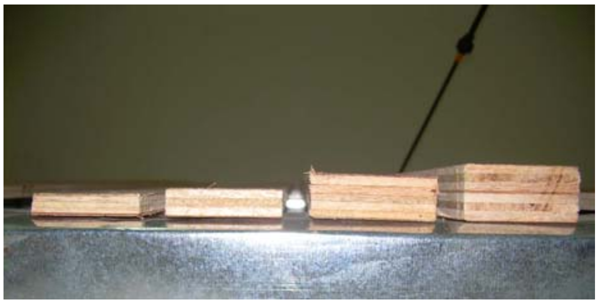


Figure 2. Thicknesses: 9mm, 12mm, 18mm, 24mm

Figure 3. Spacings: 0mm, 3mm, 6mm, 9mm, 12mm, 15mm

Figure 4. Depths: 0mm, 40mm, 80mm

DISCUSSION AND CONCLUSION

The role of thickening the wood slats plywood

From the experimental results found that thickening the thickness of plywood as facing layers are effective to increase the absorption coefficients.

The best results are at the low (125 Hz and 250 Hz) and high (1kHz, 2kHz and 4kHz) frequency; while at 500Hz the absorption coefficient are averagely persistent.

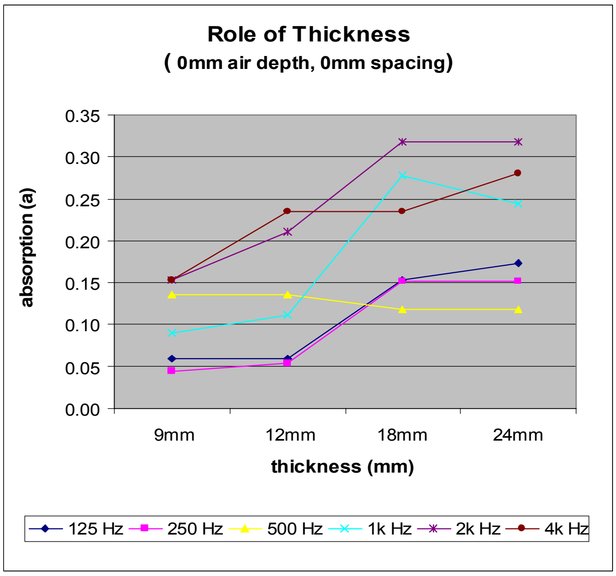


Figure 5. The thickness variables

The role of Spacing and Air Depth

It can be found that widening the spacing (gap) will not thoroughly increasing the absorption coefficients. From the charts can be seen the increases and decreases trend of absorption coefficients are different at spacing toward every frequency. This is considering caused by a depth to height (d/h) ratio; that needs to be explored further.

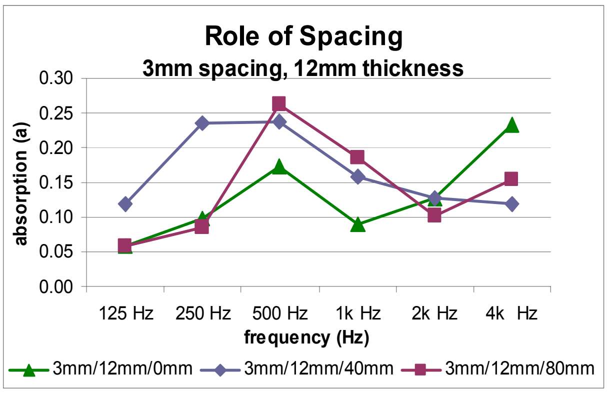


Figure 6a

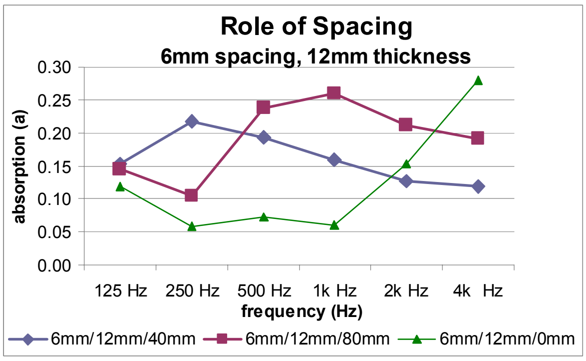


Figure 6b

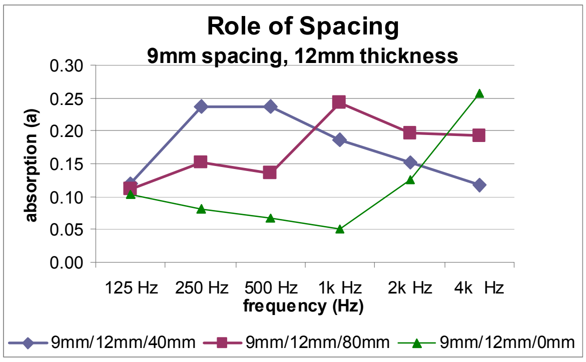


Figure 6c

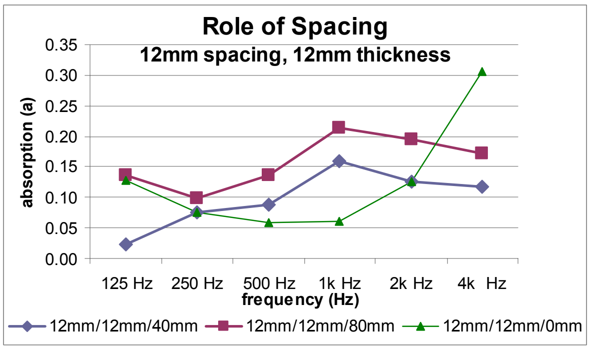


Figure 6d

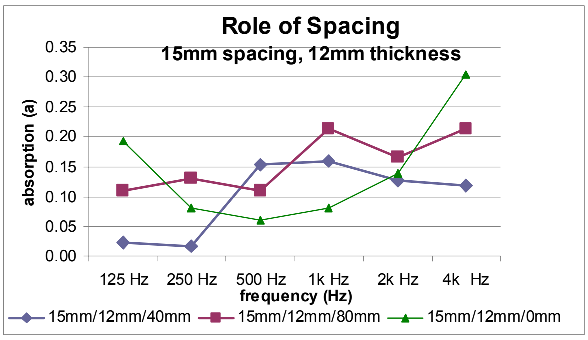


Figure 6e

Figure 6a-e. Role of Spacing at 12mm thickness

Later on, for the mid frequency (500Hz and 1kHz) the deeper air depth gives the better absorption coefficient. Also, by the graphs can be seen that the 0mm placement has different behavior amongst other air depths (40mm and 80mm). While for 4k Hz frequency the results rather unsignificant (need later more readings).

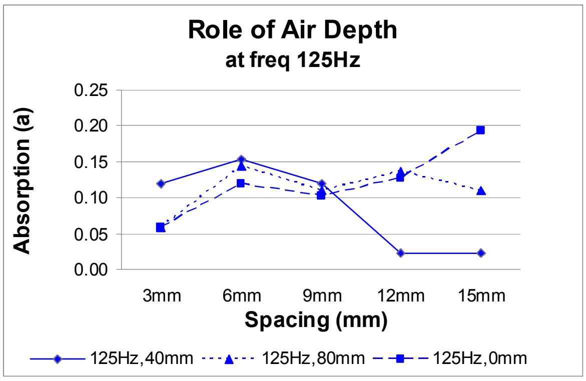
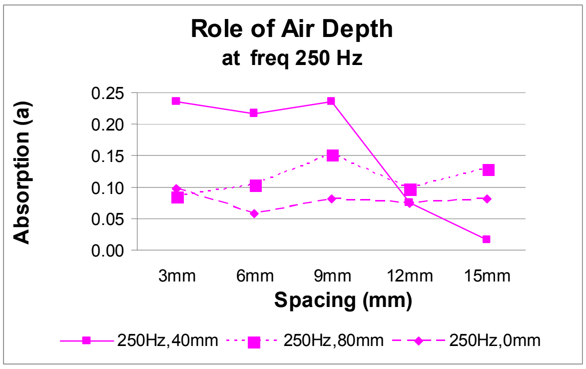


Figure 7a



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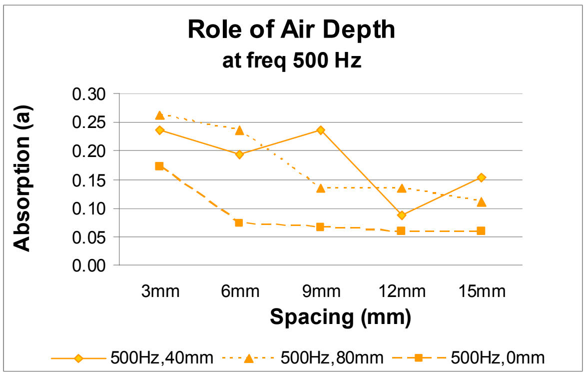

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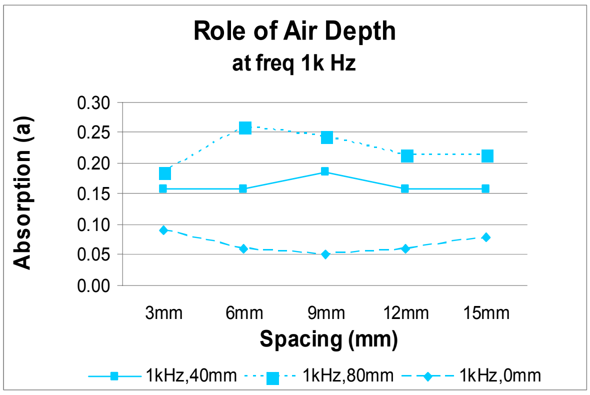

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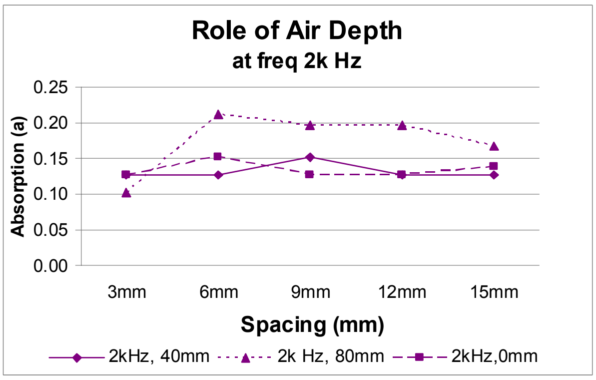

Figure 7e

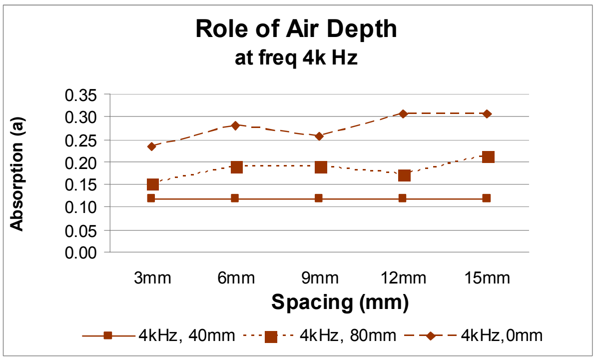

Figure 7f

Figure 7a-f. Role of Air Depth at 12mm thickness

An important note to be informed is that all the results shown here are by three times reading of reverberation time protractors; it is still need at least three more times further readings to conclude this investigation [3]. Besides, not include in this experiments are porous sound absorbing material which is commonly inserted in the air space behind the plywood. Following experiments should be taken to enrich the results.

REFERENCES

1. AS 2460, Acoustics – “Method for The Measurement of Reverberation Time in Enclosures” ,(1981)
2. Bruel & Kjaer, “Acoustic measurements according to ISO Standards andRecommendations: ISO/R354 Measurement of Absorption Coefficients in a Reverberation Room”,(n.d.)
3. Bruel & Kjaer, “Measurements in Building Acoustics” (Booklet),(n.d.)