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Gypsum Board And Cement Board As An Acoustic Material For Building

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Abstract:

In the design of the building, the architect must think of acoustic requirements with the same serious attention and concern poured in thinking about other requirements. Acoustics includes a very broad range, and touch nearly all facets of human life. Thus it is obvious; the acoustics are architectural elements in control of the environment both inside and outside spaces [4]. In the last of half-century, architects and designers are all looking for a new acoustic product which are versatility and economical.
The use of solid wood and composite wood materials as acoustics has long been known. Generally of wood used as acoustic panels and placed as floor (including the floor floating), walls, and ceiling. Gypsum board which is a wood processed has been used as an acoustic materials to made a space become soft and comfortable. Gypsum board is very strategic for noise insulation in the room was dominant uses a glass and the concrete wall. Meanwhile, cement board which is also a product of wood composite made from wood particles or other lignocelluloses materials with cement as its glue adhesive; it can provide solutions for architecture acoustics issue.

Keywords: acoustics, gypsum board, cement board, noise absorption

1. INTRODUCTION

The word of sound has two definitions: (1) physical, sound are pressure deviation, shifting of particles in an elastic medium such as air (referred as objective sound); (2) the physiologically, sound is a sensation of hearing caused by deviation of physically (referred as subjective sound). More precisely, sound are the sensation of hearing passing ears and arises because air pressure deviations. This distortion is usually caused by some object that vibrates, for example string guitar picked or a tuning fork is struck [9]. There is no distinct definition about acoustics, but it can be said acoustic to be closely associated with sounds and noise. The acoustic more emphasis on environment controlling of sound, and making it comfortable for aural.

More details, acoustics related to artificial environment which created for superior than natural conditions, such as concerts or radio studio with sound control will generate an acoustic environment that is not available in natural [1]. Controlling sound in architectural has two goals: (1) providing the state of being most favored production, propagation, and acceptance of the desired sound in a room used for the various purposes of hearing, or in the open air; (2) counteraction and reduction of noisy (unwanted sounds) and vibrations in sufficient amounts [4]. Solid wood and wood composite can be used as material absorbs acoustic because of its ability in a number of sounds. Wood as an acoustic material very flexible usage in a given space, which can be used as a component of ceiling, wall, floor, or any other components accordance with the needs of the building [3]. The efficiency of sound absorption and reflection from the wooden material depends on structure, surface treatment, mounting, geometry, etc [2]. For example, plywood or particle board can absorb noise in the low frequency (< 500 Hz), while the porous wood (fiber board) can absorb sound in the medium to high frequency of (2000 - 8000 Hz).

2. MATERIAL AND METHOD

2.1. Material and Instrument

Material used is a gypsum board undersized 120 x 240 x 0.9 cm^3 and cement board undersized 122x 244 x 1.5 cm^3. An instrument used for sound absorption testing is the sound level meter, unit of sound sources, computer/laptop, software tool for sound frequencies, and a stopwatch.

2.2. Research Method

2.2.1. <u>Making of Objects Test</u>

Gypsum boards and cement board made into a box with three sizes namely 36 x 12 x 12 cm^3; 24 x 12 x 12 cm^3; and 12 x 12 x 12 cm^3; henceforward box of gypsum board and cement board are referred to as test objects.

2.2.2 <u>Acoustics Testing</u>

Acoustic testing on the object test is the sound absorption testing by using software of sound tool. Software is connected to the sound source unit that has been programmed on a PC/laptop. Then the sound source unit (speakers) connected with sound receiver that is placed in objects test; and read on the magnitude of sound was accepted at the measurement frequency to get noise reduction index and transmission loss (Figure 1).

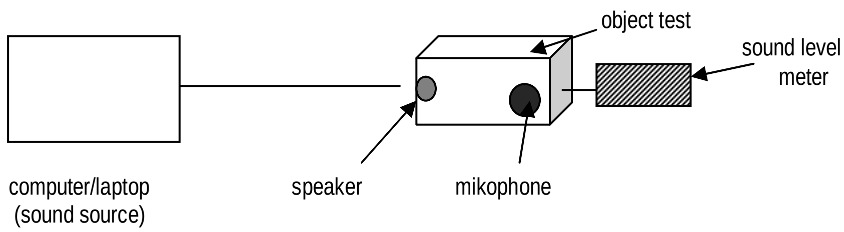

Figure1. The testing scheme on object test

The measurement of frequency at this testing is 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz and 8000 Hz; as an important measure in acoustics. In addition, was also performed by measurements of reverberation time on each measurement of frequency to obtain an absorption coefficient. Each frequency measurements will be performed five times repeats on each object test. Before the measurement of sound absorption of the object test, sound absorption measurements done without any object test.

2.2.3. <u>Calculation of Sound Absorption</u>

- Noise reduction index

Noise reduction index is a reduction of sound strength on acoustic board obtained based on ratios among the difference of the sound of (sound source is subtracted sound reflected) with the value of a sound from the sound source, namely:

$$NRI = \{(Ee - Er)/Ee\} \times 100 \qquad (1)$$

where: NRI = *noise reduction index*
Ee = source of sound energy (dB)
Er = reflected sounds energy (dB)

- Transmission loss

Transmission loss is the transmission medium to inhibit sounds and different on every frequency. This research was lost in transmission obtained based on the results of observations, but can also be calculated by an equation:

$$TL_f = 18 \log M + 12 \log f - 25 \text{ dB} \qquad (2)$$

where: M = wall mass (kg/m²)
f = frequency, Hz

- Absorption coefficient

Absorption coefficient is a measure of the absorption of power per unit area of a surface. Absorption is the comparison between the energy which is not reflected back and overall sound energy coming. Meanwhile, an absorption coefficient is the ability of an ingredient to quell the coming sound, calculated in percent or fractions. Calculation of absorption coefficients determined by the reverberation time from the ingredients being tested, namely:

$$\alpha = (0{,}16\ V)/(T_R\ S) \qquad (3)$$

where: α = absorption coefficient
V= volume of room, m^3
T_R = reverberation time
S = energy of sound absorption (dB)

3. RESULT AND DISCUSSION

3.1. Noise Reduction Index

The result showed that a reduction of sound strength on a cement board higher than gypsum board. Noise reduction index on a gypsum board between 0.14 - 0.23 dB; whereas on a cement board between at 0.24 - 0.30 dB. The research also shows that the bigger of wooden box; hence noise reduction index also higher. Meanwhile, when viewed from the data obtained, there is no difference in noise reduction index on each tested frequency, it is explained that the magnitude of the frequency does not affect the noise reduction index (Figure 2).

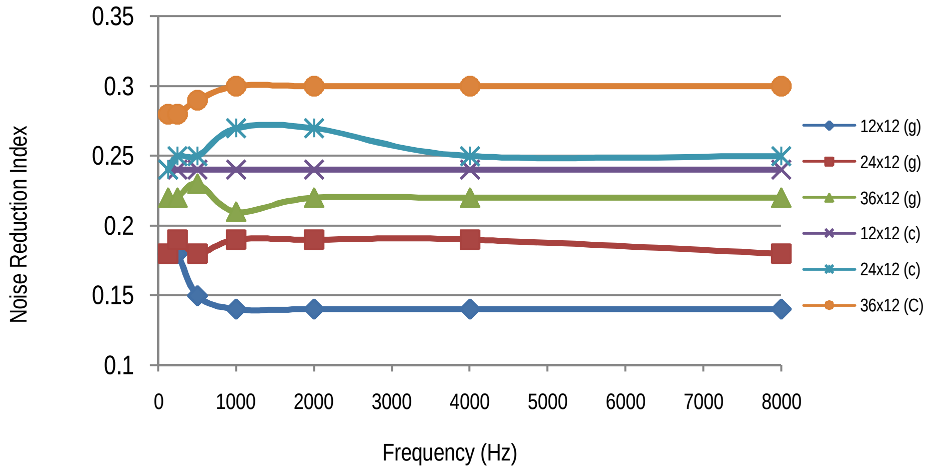

Figure 2. Noise reduction index on gypsum board (g) and cement board (c).

Noise reduction index on gypsum board are lower than cement board; this happens because the cement board is a clone board that uses cement as its adhesive, while gypsum board contains elements of paper. In this case, the pores on the cement board more closer, which in effect results the noise reduction index, is also steeper than gypsum board. In other words, the existence of elements of cement as adhesive on cement board have resulted in better soundproofed properties, even though gypsum board had considered also as material for acoustics.

No occurrence of a significant change in noise reduction index for different frequencies, showed that noise reduction index fixed for all sound frequencies. Meanwhile when viewed the data, there is an increase of noise reduction index seen reduction with the greater volume of the box either on gypsum board or cement board (Figure 2); shows noise caused by the sound can be reduced. The bigger faintly room is getting better; because the traveled distance of sound pressure range is long enough, so that it will dampen the sound during the journey [7].

3.2. Transmission Loss

The result showed that transmission loss on a box of gypsum boards sized 12x12x12 cm^3 between 15.6 – 27.6 dB; box of 24x12x12 cm^3 between 16.1 – 28.6 dB; and box of 36x12x12 cm^3 between 16.7 – 29.4 dB. Meanwhile, transmission lose on a box of cement boards sized 12x12x12 cm^3 between 11.2 – 20.1 dB; box of 24x12x12 cm^3 between 12.6 – 21.6 dB; and box of 36x12x12 cm^3 between 14.1 – 23.7 dB (Figure 3). From the obtained data showed that the lowest of transmission loss occurred at the frequency of 125 Hz and the highest occurred at the frequency of 8000 Hz. It showed that the higher of sound frequency, so it also greater transmission loss happened.

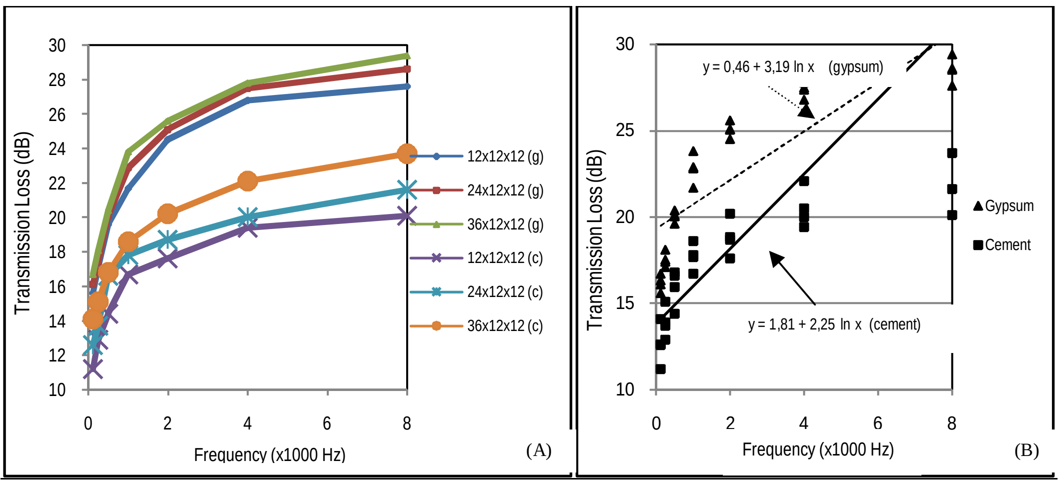

Figure 3. (A) Transmission loss on box of gypsum (g) board and box of cement (c) board, and (B) Graphic of relationship between frequency (Hz) and transmission loss on box of gypsum board and box of cement board.

Meanwhile, the results of calculation using the equation (2) (see Material and Method), shows a different result with the observations in this research. Based on equation (2) is obtained that the box of cement board greater loss of sound transmission compared to the box of gypsum board (Table 1). This happens because the wall mass in the equation is calculated. Masses of gypsum board wall box (7.30 - 8.02 kg/m^2) smaller than the box of cement board wall (18.45 – 18.70 kg/m^2). As mentioned earlier, the thickness of the gypsum boards box only 0.9 cm, and the thickness of the cement board box 1.5 cm. Thus it is clear that the mass of the wall box from gypsum board is smaller than a box of cement board, so the equation cannot be used to get the magnitude of sound transmission loss for the box of cement board.

Table 1. Transmission loss on gypsum board and cement board (based on calculation of transmisson loss equation)

Board box	Transmission Loss (dB)						
(cm^3)	125	250	500	1000	2000	4000	8000
Gypsum							
12x12x12	15.6	19.3	22.9	26.5	30.2	33.8	37.4
21x12x12	16.0	19.6	23.1	26.8	30.4	34.0	37.6
36x12x12	16.4	20.0	23.6	27.3	30.9	34.5	38.1
Cement							
12x12x12	23.0	26.6	30.2	33.8	37.4	41.0	44.6
24x12x12	23.2	26.7	30.4	33.9	37.5	41.2	44.9
36x12x12	23.5	27.1	30.7	35.0	37.8	42.0	46.1

3.3. Absorption Coefficient of Sound

The results showed that absorption coefficient of sound on the box of the gypsum board sized 12x12x12 cm^3 between 0.23 - 0.39 dB; box of 24x12x12 cm^3 between 0.25 – 0.41dB; and box of 36x12x12 cm^3 between 0.30 - 0.48 dB. Meanwhile, absorption coefficient of sound on the box of cement board sized 12x12x12 cm^3 between 0.17 - 0.31 dB; box of 24x12x12 cm^3 between 0.22 - 0.33 dB; and box of 36x12x12 cm^3 between 0.25 - 0.36 dB (Figure 4). From obtained data, shows that the lowest absorption coefficient of sound occurs at a frequency of 8000 Hz and the highest occurs at a frequency of 125 Hz; except for box of gypsum board sized 36x12x12 cm^3 is the highest sound absorption coefficient occurs at a frequency of 250 Hz. Generally, this indicates that the higher of sound frequency, so the sound absorption coefficient will lower.

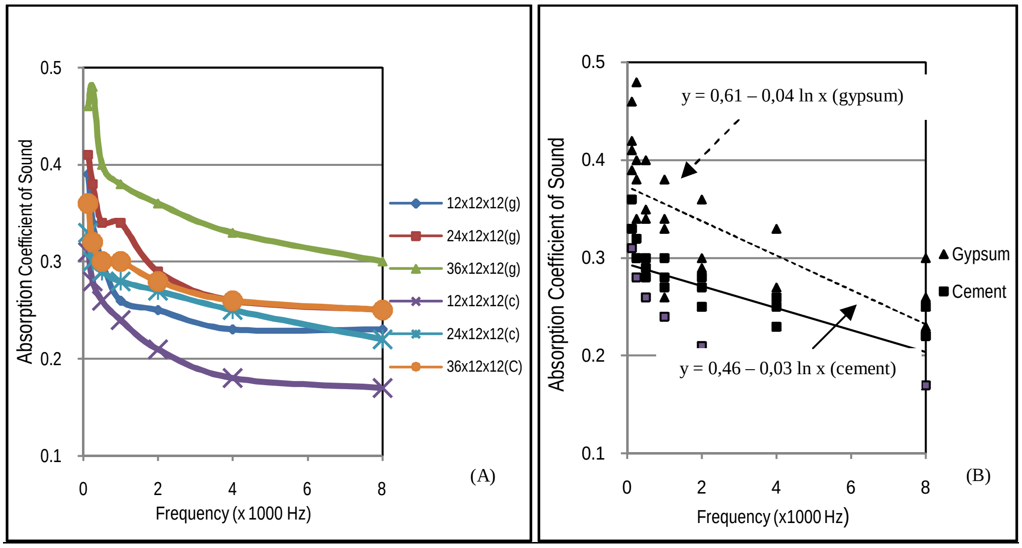

Figure 4. (A) Absorption coefficient of sound on box of gypsum board (g) and box of cement board (c), and (B) Graphic of relationship between frequency (Hz) and absorption coefficient of sound on box of gypsum board and cement board.

Sound absorption is the ability of a material to quell the sound which comes [8]. Absorption coefficient of sound calculated in percent, or a fractional value between $0 \leq \alpha \leq 1$ [6]. From this research is it appears that box of gypsum board has a greater sound absorption coefficient compared with a box of cement board, though no real difference. From this research, it turns out that the sound absorption coefficient of gypsum board and cement board are good, so both these materials can be used as acoustic material. The results also indicated that the size of a box less impact on absorptions coefficients of sound, it is probably caused size of the box less/not too different (Figure 4). Nevertheless, the existence of a raw standard not found for sound absorption coefficient for the particular material. Generally the required standard in the sound absorption is designation for a room or building, for example, acoustics needed for a classroom are different with studio room, or between the worship houses with the auditorium building [5].

CONCLUSION

No occurrence of a significant change in noise reduction index for different frequency showed that noise reduction index fixed for all sound frequencies. Meanwhile, when viewed that there was increased of noise reduction with the greater volume of box either on gypsum board and cement board; showing that the larger volumes of the box then noise caused by sound can be reduced.

Transmission loss of sound in the box of gypsum board and the box of cement board that shows increasing with the increasing of sound frequency; it also shows that there is a positive linear relationship between the sound frequencies with the transmission loss. Meanwhile, the opposite happened on a absorption coefficient of sound. The sound absorption coefficient on the box of gypsum board and the box of cement board that showed decreasing with increasing of sound frequency; and it also shows that there is a negative linear relationship between the sound frequency of the with a absorption coefficient of sound.

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