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The soundproofing efficiency of gypsum board in masonry cavity wall

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ABSTRACT

Noise pollution is a globally recognized problem impacting public health and quality of life. This study aimed to investigate effective noise-blocking methods using a soundproofing masonry cavity wall filled with gypsum boards. The experiments were conducted using small-scale built rooms, where sound was sourced and received to measure soundproofing efficiency. Various setups were assessed, including different thicknesses of gypsum boards combined with mineral wool and air gaps. The results revealed that adding gypsum boards can improve soundproofing; however, the improvement is marginal unless combined with additional materials. However, the combination of materials within the cavity, such as gypsum boards, mineral wool, and air gaps, provided better soundproofing, particularly in the frequency range of 500-8000 Hz. This integrated approach to filling the cavity proved more effective than using gypsum boards or air alone, offering a solution for noise reduction in masonry structures.

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1. Introduction

Noise pollution is a common but frequently overlooked environmental stressor that can potentially have serious consequences for human health. Excessive noise exposure, whether from sources such as traffic, construction, industrial operations, or disturbing neighbors and fit-out works, can result in a range of adverse reactions affecting both physical and emotional well-being. Noise pollution's impact extends beyond mere annoyance and discomfort, potentially contributing to serious health issues. The influence of noise on human health, its wide-ranging consequences, and the potential health risks connected with prolonged or intense noise exposure, including noisy activities both within and outside a building. Research has shown that noise-induced sleep disturbance can lead to impaired mood, increased daytime sleepiness, and cognitive performance deficits (Basner et al., 2014). Long-term exposure to traffic-related air pollution, often associated with noise, has been linked to increased mortality (Beelen et al., 2008). The World Health Organization (WHO) has conducted a systematic review of environmental noise and its effects on sleep, emphasizing the need for noise reduction strategies (Basner & McGuire, 2018). Noise exposure has been associated with adverse cardiovascular effects, including hypertension, stroke, and coronary heart diseases. Noise exposure is also associated with mental health problems, including anxiety, depression, and cognitive dysfunction. The sleep disturbances caused by noise are comparable to those found in endogenous sleep disorders (Halpérin, 2014). The detrimental effects of noise on sleep can also contribute to hearing loss (Basner et al., 2014). Noise annoyance and sleep disturbance have been reported to have a significant impact on mental health and quality of life. Noise exposure has been associated with gastrointestinal disturbances and adverse pregnancy outcomes. Noise-related sleep disturbances have also been shown to weaken immune function. Studies have examined the effects of noise from specific sources such as wind turbines and aircraft. Wind turbine noise has been found to cause annoyance, self-reported sleep disturbance, and psychological distress (Bakker et al., 2012). Aircraft noise has been associated with sleep disturbances and cardiovascular morbidity and mortality (Basner et al., 2006; Halonen et al., 2015). As well as road traffic noise has been linked to increased cardiovascular morbidity and mortality, hypertension, and sleep disturbances (Sørensen et al., 2011; Stansfeld, 2015). In conclusion, noise from sources such as traffic, construction, or neighboring disturbances and fit-out works can have a wide range of negative effects on health. These effects include stress, sleep disturbances, cardiovascular effects, hearing loss, cognitive impairment, mental health issues, gastrointestinal disturbances, adverse pregnancy outcomes, impaired immune function, and increased mortality. Addressing and mitigating noise pollution is crucial to protect public health and well-being.

One study in Lithuania by Jagniatinskis et al. (2017) focused on the classification scheme for labeling buildings based on their sound insulation performance. The researchers highlighted the importance of using multiple descriptors to regulate sound insulation in dwellings. Their findings emphasized the need for a comprehensive approach to address the specificities and advantages of different sound insulation materials and techniques.

The effect of wall construction on satisfaction with sound insulation in residential dwellings was investigated by (Hongisto et al., 2015). The researchers explored the relationship between different wall constructions and occupants' satisfaction with sound insulation. Their findings highlighted the importance of considering wall construction materials and techniques in improving sound insulation and enhancing occupants' comfort.

The importance of soundproofing has significantly increased following the COVID-19 pandemic. According to a FlexJobs and Global Workplace Analytics study in 2019, only 3.4% of the U.S. workforce worked remotely regularly (Buffer, 2019). However, the COVID-19 pandemic has significantly increased the prevalence of remote work. During the early stages of lockdown in Europe, data from 29 European countries showed that knowledge workers were forced to work from home, highlighting the shift in work dynamics Ipsen et al. (2021). In the United States, remote work participation rose from 16% in 2019 to 23.7% following the COVID-19 pandemic (Jackson, 2022).

Furthermore, achieving optimal soundproofing results requires encompassing soundproofing solutions from the initial stages of the project. Soundproofing strategies should be integrated during the preliminary architectural design phase.

Soundproofing involves employing various techniques to impede the transmission of sound waves through structures or barriers. These techniques are based on fundamental acoustic principles that aim to minimize the energy of sound waves and prevent their propagation. The main principles of soundproofing are mass, decoupling and damping, and tightness

Mass is a critical factor in soundproofing efficiency (Beranek & Ver, 1992). Heavier materials are generally better at blocking sound than lighter materials. This is because heavier materials are more resistant to vibration, which is what sound waves are made of (Fahy, 2000). When sound waves hit a heavy material, they have more difficulty causing the material to vibrate, and as a result, less sound is transmitted through the material (Kinsler et al., 2000).

The formula for mass is $m = \rho V$, where ρ is the density of the material and V is the volume of the object.

As per the given formula, there are two ways to increase the mass, increase the density of the material, or increase the volume of the element.

Decoupling is a fundamental principle in soundproofing that involves separating two sound-transmitting surfaces to prevent them from vibrating together (Beranek, 2017) The effectiveness of decoupling is based on the principle that sound waves are transmitted through materials due to their vibration (Kinsler et al., 2022). When two surfaces are coupled, or in physical contact, they can vibrate together, effectively transmitting sound waves from one surface to the other. By separating the surfaces, the ability of sound waves to transfer between them is significantly reduced (Beranek, 2017). Damping is a critical aspect of soundproofing that involves dissipating vibrational energy within a material, reducing the transmission of sound waves (Beranek, 2017). While mass and decoupling are effective at blocking sound waves, damping focuses on converting vibrational energy into other forms, such as heat, preventing it from propagating further.

Gaps, even small ones, can have a significant impact on soundproofing effectiveness. A study by the National Research Council (NRC) found that a gap of just 1/8 inch (0.3 cm) around a door can allow up to 10 decibels (dB) of sound to pass through (NRC, 2003). A gap of 1/4 inch (0.6 cm) around a door can allow up to 20 dB of sound to pass through. A gap around a window can allow up to 15 dB of sound to pass through. Another study, by the National Institute of Standards and Technology (NIST), found that gaps can significantly reduce the soundproofing effectiveness of walls. For example, a 4-inch (10 cm) gap between a wall and a ceiling can reduce the soundproofing effectiveness of the wall by up to 10 dB (NIST, 2010). Holes in walls, ceilings, floors, or other structural elements can greatly influence the efficiency of soundproofing measures. A study by the Institute of Acoustics (IOA) found that a hole in a wall with a diameter of 1/4 inch (0.6 cm) can allow up to 20 dB of sound to pass through (IOA, 2009). A hole with a diameter of 1 inch (2.5 cm) can allow up to 30 dB of sound to pass through. Another study, by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), found that holes can significantly reduce the soundproofing effectiveness of doors and windows. For example, a 1-inch (2.5 cm) hole in a door can reduce the soundproofing effectiveness of the door by up to 15 dB (ASHRAE, 2017).Openings, such as vents, ducts, and electrical outlets, can also allow sound to leak through, bypassing the soundproofing materials and reducing their overall effectiveness. A study by the NRC found that an open vent can allow up to 30 dB of sound to pass through (NRC, 2003). An open duct can allow up to 40 dB of sound to pass through. An open electrical outlet can allow up to 20 dB of sound to pass through. Another study, by the Building Research Establishment (BRE), found that openings can significantly reduce the soundproofing effectiveness of walls. For example, a 4-inch (10 cm) opening in a wall can reduce the soundproofing effectiveness of the wall by up to 10 dB (BRE, 2008).

Loosely fitting building components, such as loose floorboards, rattling windows, or improperly sealed drywall joints, can also reduce soundproofing effectiveness. A study by the NRC found that loose floorboards can transmit vibrations and noise, reducing soundproofing effectiveness by up to 10 dB (NRC, 2003). Another study, by the IOA, found that rattling windows can allow up to 15 dB of sound to pass through (IOA, 2009). Improperly sealed drywall joints can allow up to 20 dB of sound to pass through.

Absorption is a crucial element of soundproofing that involves converting sound energy into other forms, such as heat, preventing it from reflecting into the room (Beranek, 2017). Absorption focuses on dissipating the energy of the sound waves, reducing the overall sound level within a space. The absorption coefficient specifically refers to the extent to which a material absorbs sound energy. Materials exhibiting high absorption coefficients tend to transform sound energy into heat, thereby diminishing the transmission of sound through the material. (Chung et al., 2002).

This absorption capability directly contributes to improved STC (Sound Transmission Class) rating The impact of the absorption coefficient on STC rating is multifaceted and depends on several factors, including the material's thickness, density, and frequency range of the sound (Fahy et al., 2003). Thicker materials with higher absorption coefficients tend to have higher STC ratings. This is because thicker materials provide a longer path for sound waves to travel, increasing the likelihood of absorption. Additionally, materials with higher absorption coefficients are more effective at converting sound energy into heat, further reducing sound transmission. However, the relationship between the absorption coefficient and STC rating is not always straightforward. At high frequencies, sound waves tend to interact primarily with the surface of the material, making the absorption coefficient more dominant in influencing STC rating. However, sound waves penetrate more deeply into the material at lower frequencies, causing the material's thickness and density to play a more significant role in determining STC rating (Everest, 2001). Table 1 presents the absorption coefficients of different materials.

To increase the effectiveness of the soundproofing system, adding more mass, decoupling, and damping of structural elements needed, filling the openings and gaps, avoiding looseness, and including absorption layers are needed.

An airborne sound insulation test was conducted in Lithuania using assemblies such as masonry leaf-cavity-masonry leaf. (Jagniatinskis, 2019). This study employs a comprehensive approach, integrating both theoretical and experimental methods. The investigation focuses on utilizing a multi-layer wall with a cavity as an alternative to a homogeneous masonry wall. Samples of walls are shown in Table 2. The test reflects the impact of choosing of material (can be considered as mass variation, because all materials have different densities) and cavity width on STC rating.

Table 1. Acoustic Absorption Coefficients of Various Materials in the Frequency Range

Material	Absorption coefficient	Frequency Range	Reference
Acoustic foam	0.90	250 Hz to 4 kHz	Beranek, L. L. (2017)
Fiberglass	0.85	250 Hz to 4 kHz	Fahy, F. J., (2017)
Perforated panels	0.75	500 Hz to 2 kHz	Kinsler, L. E., (2022)
Slotted absorbers	0.65	500 Hz to 2 kHz	Beranek, L. L. (2017)
Gypsum board	0.10	250 Hz to 4 kHz	Fahy, F. J., (2017)
Concrete	0.05	250 Hz to 4 kHz	Kinsler, L. E., (2022)
Brick	0.03	250 Hz to 4 kHz	Beranek, L. L. (2017)

Table 2. Properties of taken samples and testing results

Displays the weighted apparent sound reduction index (R′w) along with the corresponding standard deviation (R′w st. dev). (Jagniatinskis, 2019)

Masonry element	Total/cavity width [mm]	Surface mass [kg/m2]	R′w [dB]	R′w st. dev. [dB]
(w)Silicate bricks	358/120	415	58	1.16
(s)Silicate bricks	358/120	415	51.9	0.95
(s)Silicate bricks	346/140	360	53.2	0.71
(w)Hollow silicate blocks	450/70	500	61.2	0.79
(s)Hollow silicate blocks	450/70	500	55.5	0.97
(w)Hollow silicate blocks	420/150	280	57.3	1.33
(s)Gypsum blocks	320/100	212	57.6	1.46
(w)Gypsum blocks	320/100	212	52	0.95
(s)Gypsum blocks	285/85	170	54.2	0.94
(w)Gypsum blocks	285/85	170	49.9	1.16
(s)Gypsum blocks	230/70	155	51.9	0.92
(s)Aerated concrete blocks	335/100	172	54	0.95
(w)Aerated concrete blocks	325/75	170	49.1	1.04
(w)Aerated concrete blocks	280/100	127	43	1.01

Structures with strong support are marked by adding the lowercase letter 's' to the identifier, while those with weaker support are the lowercase letter 'w' appended. Furthermore, a simplified and standardized methodology based on ISO standards 12354-1:2017 and compared with experimental results.

Rw = 37.50 lg (m' /m'0) - 42.0, if m'>150 [kg/m2],

Where is:

Rw: is the weighted sound reduction index

m' represents the mass distributed across each square meter of the tested partition, measured in kilograms per square meter (kg/m²).

m'0 is a reference surface mass of 1 kg/m², also measured in kilograms per square meter (kg/m²).

Similar standardized regression formulas for computing the weighted laboratory sound reduction index for single-leaf walls are employed in Austria (1), France (2), UK (3), and Italy (4) (Jagniatinskis, 2019).

1. Rw = 32.40 lg (m' /m'0) - 26.0, if m'>100 [kg/m2],
2. Rw = 40.00 lg (m' /m'0) - 45.0, if m'>100 [kg/m2],
3. Rw = 21.65 lg (m' /m'0) - 2.3, if m'>50 [kg/m2],
4. Rw = 20.00 lg (m' /m'0), if m'>80 [kg/m2],

The results indicate that standardized models for uniform walls can reliably predict the weighted apparent sound reduction index for cavity walls, especially those with comparatively high surface mass, surpassing 350 kg/m². For cavity walls with a surface mass below 350 kg/m², the R'w outcomes demonstrate approximately 3–8 dB higher values compared to the predictions of standardized models, particularly in instances of robustly supported cavity walls. Furthermore, one more test of air-borne sound insulation was carried out.

Table 3: presents the adjusted weighted sound reduction index incorporates corrections for pink noise and traffic noise for the walls. Correction values for pink noise (C) and traffic noise (Ctr) are applied.

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The initial structure, labeled as "ClB–HB4," comprised a lightweight clay block (ClB) with a thickness of 140 mm, both external faces plastered, a 100 mm air cavity filled with 50 mm thick mineral wool, and a 40 mm hollow brick (HB4) wall with one face plastered serving as the inner leaf. The second structure, denoted as "CoB–HB4," featured a 150 mm thick lightweight concrete block (CoB) with both faces plastered as the external leaf, a 100 mm air cavity filled with 50 mm thick mineral wool, and a 40 mm thick hollow brick (HB4) wall with one face plastered as the inner leaf. The third structure, named "PB–HB7," included a 110 mm thick perforated brick (PB) with both external faces plastered, a 100 mm air cavity filled with 50 mm thick mineral wool, and a 70 mm thick hollow brick (HB7) wall with one face plastered as the inner leaf. In this case, the thickness of the inner brick leaf was increased from 40 to 70 mm due to the maximum allowed wall thickness being 300 mm (Guillen, 2008).

Table 3. Measured results of samples

	ClB-HB4	**CoB-HB4**	**PB-HB7**	**ClB-GB**	**CoB–GB**	**PB–GB**
R_w [dB]	55	54	49	61	61	58
C [dB]	−1	−1	0	-1	-1	-2
C_{tr} [dB]	−5	−3	-2	-6	-6	-9

The experiment is intended to evaluate the proposed building soundproofing system's performance comprehensively

2. Research Methodology and Framework

2.1 Methodology and Setup

This study employs a quantitative approach to explore the Sound Transmission Loss (STL) of masonry cavity walls and the usage of gypsum boards as a filling material. The investigation involves an airborne sound transmission test.

The focus is on assessing the efficiency of the proposed soundproofing system for buildings

Walls are made of concrete blocks 100 mm thick and laid without mortar. Cement sheets are utilized to cover these walls and make holistic rooms. Each layer is 18 mm thick. 2 layers of sheets will be installed manually without fixation with each other without any binding material. The overall thickness of the cement boards sheets cover is 36 mm. The density of all materials utilized is in Table 4. Connected to the phone via Bluetooth audio speaker and iPhone 6 as microphone are installed inside the first room. iPhone 15 is installed inside the second room. Both iPhones measured sound through the "dB Meter" application (see Figure 1).

The comprehensive acoustic test was performed according to ISO 16283-1:2014. (Airborne sound insulation, 2014). The audio speaker was installed 500 mm from the side walls, 250 mm from the back, and 600 mm from the floor. iPhone 6 was installed 200 mm from the side wall, 200 mm from the tested wall, and 600 mm from the floor. The iPhone 15 was installed 500 mm from the side wall, 300 mm from the back wall, and 600 from the floor.

Sound is generated within the frequency range 125 Hz – 8000 Hz:

On 125 Hz, 160 Hz, 200 Hz, 250 Hz, 315 Hz, 400 Hz, 500 Hz, 630 Hz, 800 Hz, 1000 Hz, 1250 Hz, 1600 Hz, 2000 Hz, 2500 Hz, 3150 Hz, 4000 Hz, 8000 Hz.

Table 4. Density of used materials

Name of the material	Density [kg/m^3]
Concrete blocks	2074
Cement sheets	1383
Mineral wool	41.7
Gypsum boards	511

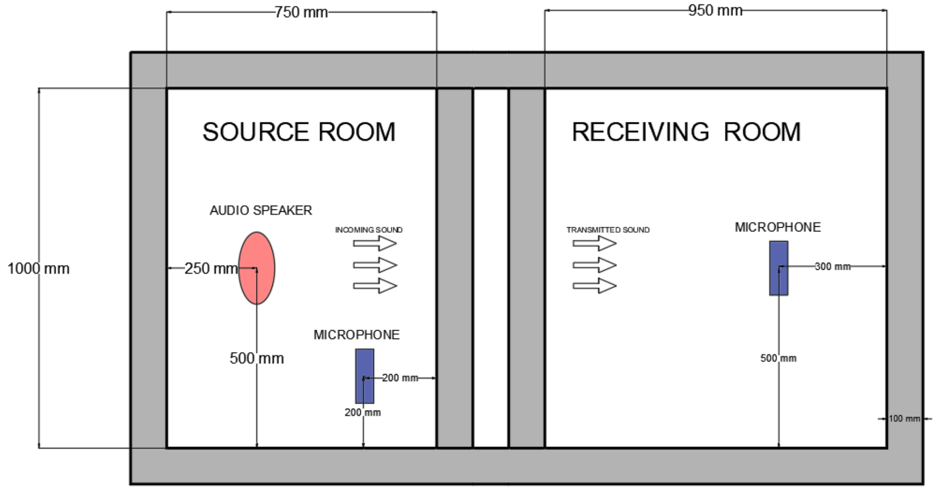

Figure 1 - Layout design for setup

Dimension of the sourcing room is length – 1000 mm, width – 750 mm, and height – 1200 mm (without cover). The dimensions of the receiving room are length – 1000 mm, width – 950 mm, and height – 1200 mm (without cover). The total size of the block structure is Length – 2200 mm, Width 1200 mm, and Height 1200 mm (without cover). The total height of the cover is 1250 mm.

Figure 2 reflects the layout of the experimental setup. The green color is indicated by the variable part of the testing wall. Figure 3 shows the elevation and height of concrete blocks without the thickness of cement sheets' top cover. Figure 4 illustrates a 3d view of the entire structure.

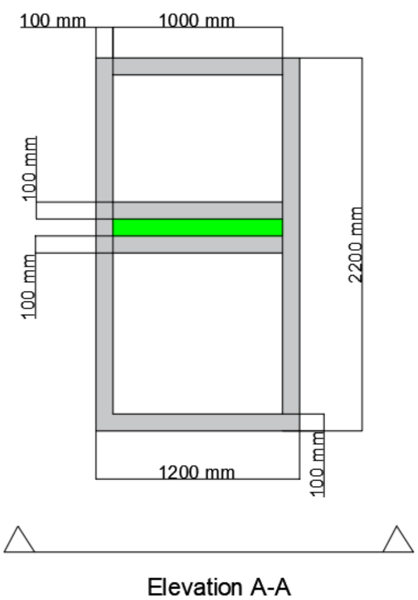

Figure 2 – Layout experimental setup

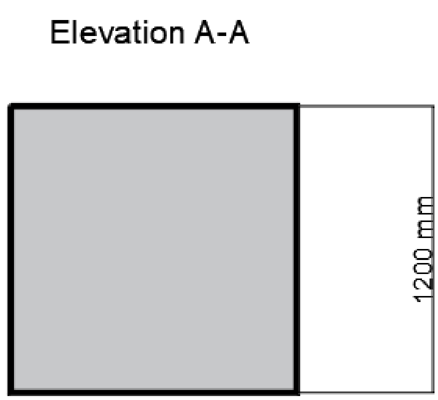

Figure 3 – Elevation of Experimental setup

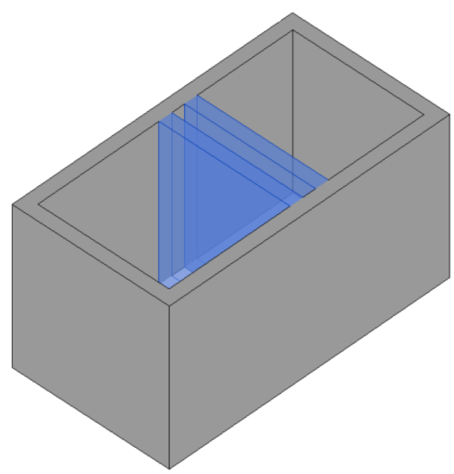

Figure 4- 3D view of experimental setup

2.2 Samples

For the comprehensive test, 4 types of samples. Each sample has a different selection of materials and their thicknesses. Table 5 indicates the properties of tested samples. Figure 5 (a,b,c,d) reflects the layout of the real experimental setup

Table 5. Samples and layers of materials used

Sample name /Layer material and thickness	Layer 1st	Layer 2nd	Layer 3rd	Layer 4th	Layer 5th
Sample 1 (a) Figure 5 (a)	Concrete block - 100 mm	Air gap – 100 mm	Concrete block- 100 mm	-	-
Sample 2 (b) Figure 5 (b)	Concrete block 100 mm	Air gap – 87.5 mm	Gypsum board – 12.5 mm	Concrete block 100 mm	-
Sample 3 (c) Figure 5 (c)	Concrete block 100 mm	Air gap – 75.0 mm	Gypsum board – 25.0 mm	Concrete block 100 mm	-
Sample 4 (d) Figure 5 (d)	Concrete block 100 mm	Air gap – 37.5 mm	Mineral wool – 50.0 mm	Gypsum board – 12.5 mm	Concrete block 100 mm

Figure 5 (a) – Layout of the experimental setup of Sample 1

Figure 5 (b) – Layout of the experimental setup of Sample 2

Figure 5 (c) – Layout of the experimental setup of Sample 3

Figure 5 (d) – Layout of the experimental setup of Sample 4

Table 6 includes the detailed and enlarged assembly of wall samples

Table 6. Detailed assembly of the experimental setup

Samples name	Detailed assembly of the experimental setup
Sample 1	
Sample 2	
Sample 3	
Sample 4	

3. Results and Analysis

Recording results from each sample test are illustrated in Table 7. Rows are frequencies (Hz), and columns are Sound Pressure Levels (dB). Results are illustrated for all 4 samples.

Table 7. Measured results for each frequency

Frequency [Hz]	Sample 1		Sample 2	
	Sound from source room [dB]	Sound from receiving room [dB]	Sound from source room [dB]	Sound from receiving room [dB]
125	78.1	60.1	77.2	63.1
160	81.5	63	80	69.4
200	90	60.8	90.2	64.5
250	95	59.4	95.2	68.4
315	90.2	61	89.7	68
400	84.7	60.6	75.7	62.2
500	88.7	65.5	89.2	60.7
630	92.4	64.4	93.2	65.1
800	92.3	64.1	93.2	60.3
1000	102.4	68.5	103.9	62.3
1250	97.7	69.1	97.1	63.3
1600	97.9	70.3	101.4	61.6
2000	100.8	65.1	100.6	61.4
2500	98.1	62.7	96.2	60.5
3150	99.4	61	97.4	59.6
4000	89.3	57.5	90.3	54.9
8000	82.6	49.7	77.8	45.1

Frequency [Hz]	Sample 3		Sample 4	
	Sound from source room [dB]	Sound from receiving room [dB]	Sound from source room [dB]	Sound from receiving room [dB]
125	74.9	59.5	77.2	63.1
160	77.9	64.2	80	69.4
200	73.8	62.6	90.2	64.5
250	91.4	67.8	95.2	68.4
315	87.9	69.3	89.7	68
400	72.6	63.9	75.7	62.2
500	85.8	62.8	89.2	60.7
630	90	71.9	93.2	65.1

800	89.2	67.7	93.2	60.3
1000	101	70.6	103.9	62.3
1250	93.8	68.6	97.1	63.3
1600	97.6	69.2	101.4	61.6
2000	97.3	66.3	100.6	61.4
2500	94.2	63.1	96.2	60.5
3150	92.5	58.8	97.4	59.6
4000	86.9	56.2	90.3	54.9
8000	76.2	40.2	77.8	45.1

To compare the efficiency of samples the approach of calculating Sound Transmission Loss (STL). The formula is STL= Psourced – Ptransmitted . Psourced is a measured sound from the sourcing room (dB) and Ptransmitted is a measured sound from the receiving room (dB). Calculated numbers are shown in Table 8.

Table 8. Calculated Sound Transmission Loss for each frequency

Frequency (Hz)	Sample 1	Sample 2	Sample 3	Sample 4
	Sound Transmission Loss [dB]	Sound Transmission Loss [dB]	Sound Transmission Loss [dB]	Sound Transmission Loss [dB]
125	18	14.1	15.4	14.1
160	18.5	10.6	13.7	10.6
200	29.2	25.7	11.2	25.7
250	35.6	26.8	23.6	26.8
315	29.2	21.7	18.6	21.7
400	24.1	13.5	8.7	13.5
500	23.2	28.5	23	28.5
630	28	28.1	18.1	28.1
800	28.2	32.9	21.5	32.9
1000	33.9	41.6	30.4	41.6
1250	28.6	33.8	25.2	33.8
1600	27.6	39.8	28.4	39.8
2000	35.7	39.2	31	39.2
2500	35.4	35.7	31.1	35.7
3150	38.4	37.8	33.7	37.8
4000	31.8	35.4	30.7	35.4
8000	32.9	32.7	36	32.7

Results from each sample test are illustrated in the Figure 6 graph chart using the octave method, The X-axis shows Frequency (Hz), and the Y-axis shows Sound Pressure Level (dB). At the end, one combined graph demonstrates a comparison of all measured curves. Points illustrate maximum peaks of measured sound. The outcomes are assessed and chosen as the best wall configuration. X axis is logarithmic. The pink line indicates sample 1. Sky blue line – sample 2. Dark blue – sample 3. Green line – sample 4

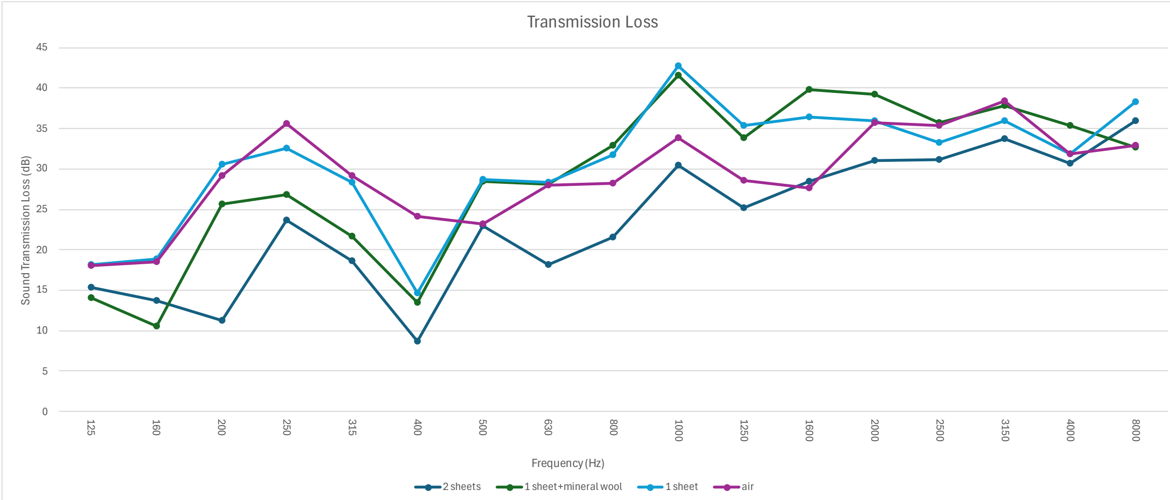

Figure 6. Transmission Loss graph chart.

Results of sample 1 – filled by air has a little increment of soundproofing efficiency from 125 to 160 Hz, and significant growth from 160 Hz to 250 Hz, then it declines until 500 Hz. After that, It has growth for 1000 Hz. However, after that, it decays until 1000 Hz. After that there is an improvement to 3150 Hz with maximum efficiency of 38.4 dB and after that falls ending at 8000 Hz.

Results of sample 2 – filled by 1 gypsum sheet has a little augmentation of soundproofing efficiency from 125 to 160 Hz, and good progress from 160 Hz until 250 Hz, then it rapidly declines until 400 Hz. After that, it has trended to growth until maximum efficiency picks up at 1000 Hz reaching 41.6 dB. Nevertheless, after it mainly declines until 4000 Hz only with a slight increase at 3150 Hz and a higher increase at 8000 Hz.

Results of sample 3 – filled with 2 gypsum sheets show a little decrease in soundproofing efficiency from 125 to 200 Hz and huge growth from 200 Hz to 250 Hz, then it sharply declines until 400 Hz. After there is an increment to 500 Hz. Then it has trended to growth with outstanding pick at 1000 Hz and maximum efficiency pick at 8000 Hz reaching 36.0 dB.

Results of sample 4 – filled with 1 gypsum sheet and mineral wool show a little decrease in soundproofing efficiency from 125 to 160 Hz, and huge growth from 160 Hz to 250 Hz, then it sharply decreases until 400 Hz. After that, there is sharp growth till 1000 Hz with a maximum pick at 41.6 dB. Then it declines to 1250 Hz and grows to 1600 Hz. After that, it has a trend to decrease to 8000 Hz

4. Conclusions

The following conclusions can be drawn:

• The use of gypsum board in masonry cavity walls does not result in significant efficiency gains in soundproofing.

• Increment of gypsum board thickness two times (from 12.5 mm to 25 mm) does not improve soundproofing effectiveness.

• Filling the cavity with air improves soundproofing effectiveness to a higher extend than mineral wool or gypsum board for the frequency range from 125 Hz – 500 Hz.

• Filling the cavity with 1 gypsum board (12.5 mm thickness) and 1 layer of mineral wool (50 mm thick) on a frequency range from 500 Hz – 8000 Hz gives only a small increase in soundproofing efficiency.

• To benefit from the application of gypsum board as soundproofing material it shall be considered in combination with other types of materials and shall be based on the evaluation of frequency sound disturbance.

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