TUNKU ABDUL RAHMAN UNIVERSITY COLLEGE

Faculty of Building Environment

BTAR3015 DESIGN PROJECT PUBLICATION

Project 1: Thematic Essay

A STUDY ON AUDITORIUM ACOUSTICAL WALLS

(Semester 3, Year 2021/2022)

PROG./ YEAR/ SEM/ TUTORIAL GROUP : RAR3G3

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0.0 Abstract

A good auditorium design for performances to be enjoyed by the audience required not only visually, but also acoustics. Therefore, this study shows the application of acoustic walls in Auditorium's acoustic design as it is used for the BTAR3028 Design Studio VI subject with a given brief for designing a Performing Arts Centre (PAC) in the area of Wangsa Maju. The design brief shall require an Auditorium space. To achieve clarity in the acoustic wall design, some studies on basic acoustic and sound physics are done along with the existing acoustics products and materials. The methods applied in this study are references from multiple sources and selected case studies of 2 buildings with auditoriums for better understanding of the topic. At the end,the study showed the ideal Auditorium wall design with a combination use of acoustic materials and acoustic products which will be applied in the PAC design.

1.0 Introduction

Auditorium is a space for large meetings, presentations and performances. They are designed to accommodate large groups of audience. Acoustics is one of the major key factors for a good auditorium experience besides visuals. Acoustics is defined as an interdisciplinary science that involves a study of all mechanical waves in different states of matter which includes topics such as vibration, sound, ultrasound and infrasound (Alibaba and Itontei, Int J Adv Technol, 2016). As auditoriums being a part of sound and noise control, sounds played from the stage need to be enjoyed by the audience, complementing existing visuals, especially for auditoriums in the Performing Arts Centre (PAC). There are plenty of criterias to be discussed in order to achieve good acoustics in the space, one of them is the choice of materials within the auditorium. The choice of materials are selected for floors, walls and ceilings. Good selection of materials will ensure a quality audio experience during a performance. Hence, this discussion shall focus on the choice of a study on auditorium acoustical walls.

2.0 What is sound

Sound is produced in waves by vibrations of objects that will reach a listener's ear through different media such as gas,liquid and solid. Regional alternation of air pressure after being pushed by vibrations which travel in air are sound waves.

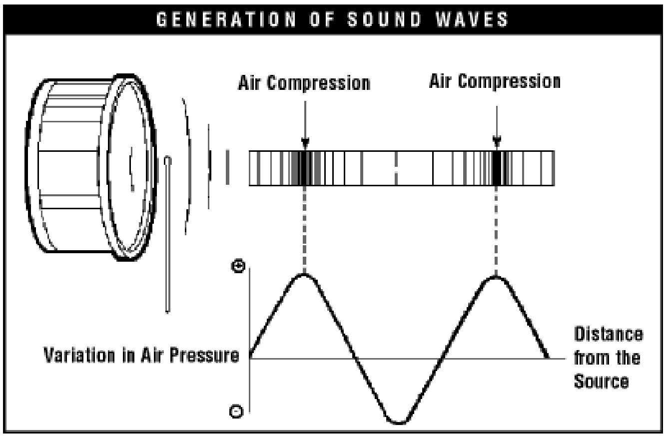


Figure 2.0.1 : Generation of Sound Waves Illustrated

A total number of sound waves produced in a second called frequency of waves. The common unit for frequency is the Hertz (Hz) where 1 Hertz = 1 wave per second. Low frequencies are low pitch around 500Hz or below and give a rumbly sound, whereas high frequencies are high pitched above 2000 which are like crashing cymbals or chirping of birds. Currently, the human ear is able to detect the sound frequency between 20Hz to 20000Hz. Sounds below 20 Hz are infrasound and above

20000 Hz are ultrasound. Low frequency could travel further distance than high frequency due to the size of the wave.

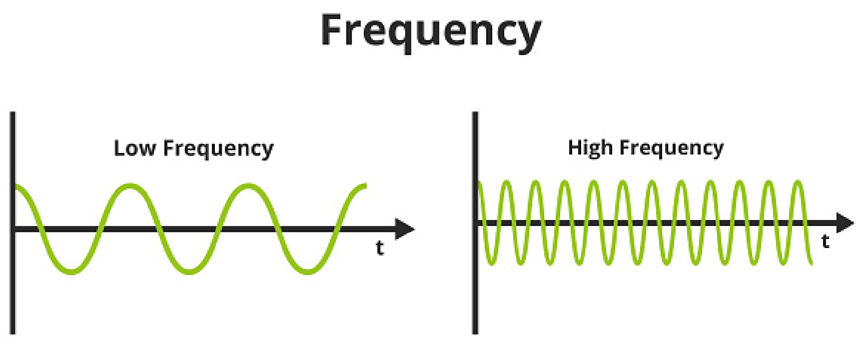


Figure 2.0.2 : difference of low and high frequency

When an incoming sound reaches a medium, it will either be absorbed, reflected and transmitted. Absorption is sound energy dissipated to heat. Next, reflection is sound waves bouncing off from the surface. Furthermore the pass through of sound is transmission.

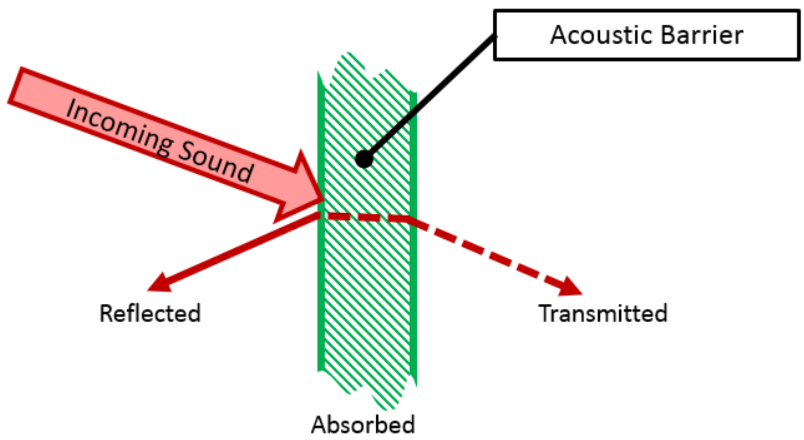


Figure 2.0.3 : difference of low and high frequency

2.1.1 Absorption of sound & Sound absorption coefficient

Referring to the law of physics in which energy could not be created or destroyed but can be transformed and transferred, sound energy is transferred to the medium's molecule to create heat energy through vibrations. Heat energy will dissipate into air when the energy is used up through vibrations.

Sound absorption coefficients or Noise Reduction Coefficient (NRC) are the average of how absorbing each material in different frequencies, often times at 500 Hz, 1000 Hz and 2000 Hz. The NRC rating ranges from 0.0 - 1.0. With the NRC of 0.0 meaning the material reflects sounds and does not absorb whereas the NRC of 1.0 does the opposite. The higher the sound absorption coefficient, the more the sound absorbs. In general, soft and porous materials have much higher sound absorption or NRC value than hard and reflective materials. However the coefficient values vary when it comes to different frequencies, some materials are better in absorbing low frequencies than high frequencies or vice versa.

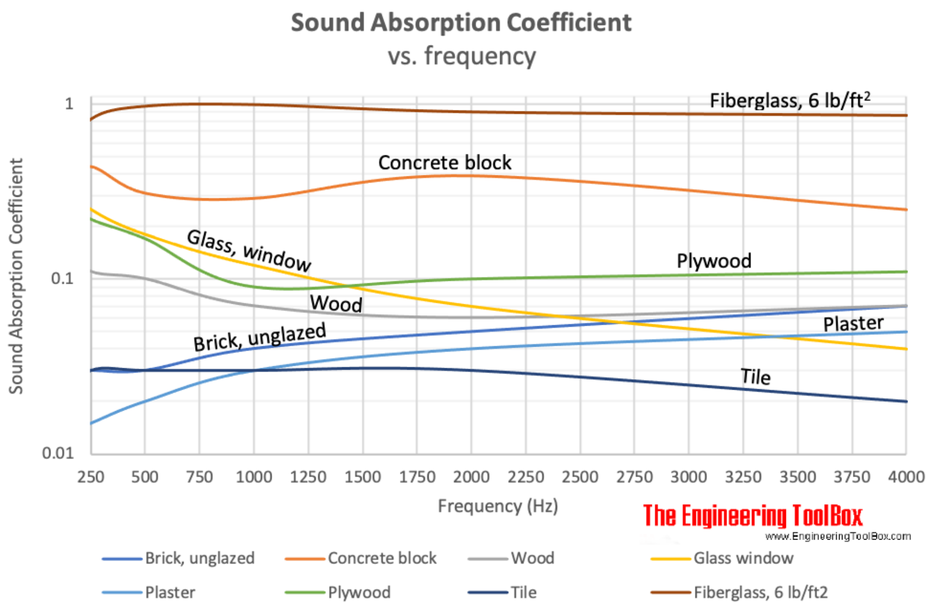


Table 2.1.1 : Sound Absorption coefficient vs frequency between different materials, source from The Engineering ToolBox

2.1.2 Reflection of Sound

Sound can be **reflected** from surfaces with waves bouncing off it. The bounced off sound travels slower as it has a longer travel distance. These sounds are **echos** or **reverberations** of sound. **Reverberations** of sound is when multiple sounds reach the ear within 0.1 seconds within a room dimension of length,width and height of 17 metres. The human brain endures 0.1 second of sound in memory and sound travels at a speed of 340m/s. Based on the formula time = distance travelled / velocity, (34m) / (340m/s) = 0.1s . Thus it explains why reverberation occurs in rooms within a dimension of 17 metres or less. **Echos** are when the second or more sounds arrive in the ear for more than 0.1 seconds after the first sound. When the first sound dies out and the second sound perceived rather than prolonging the first, it is an echo instead of reverberation.

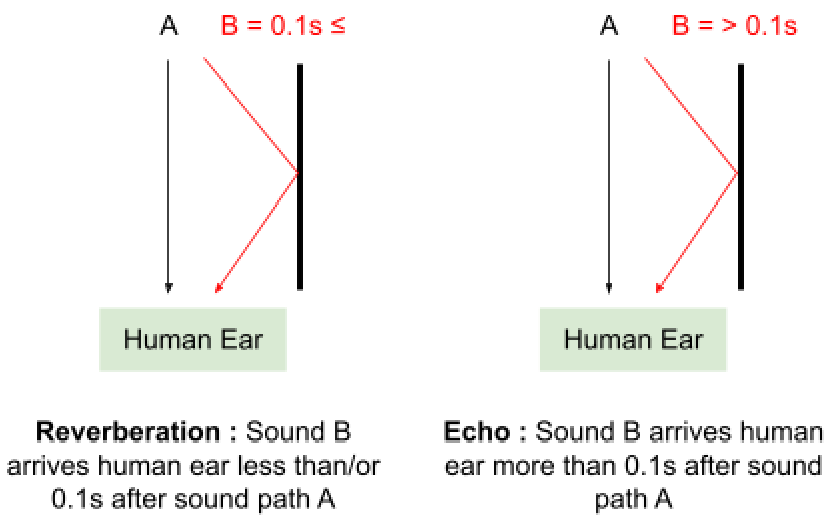


Diagram 2.1.2 : Illustration differentiates reverberation and echo

2.1.3 Transmission of Sound and Sound Transmission Class

Different types of materials allow different intensity of sound passing through. In auditorium design, sounds had to be limited within the space to prevent it from passing through into another room and disrupt the existing ambience. Thus, to determine how well the materials reduce sound transmission, they are rated under Sound Transmission Class (STC).

The basics of STC involves decibels (DB), which is a measurement of sound intensity or loudness of sound. The table below gives an idea of the DB value.

SOUND PRESSURE	SOURCE	SENSATION
130-120 dBa	Jet Aircraft at 100’ Bass Drum at 3’ Auto Horn at 2’	Physical Pain
120-100 dBa	Thunder, Artillery Elevated Train Discotheque	Deafening
100-80 dBa	Loud Street Noise Noisy Factory Police Whistle	Very Loud
80-60 dBa	Cocktail Party Noisy office Average Street Noise	Loud
60-40 dBa	Noisy Home Inside General Office Conversation	Moderate
40-20 dBa	Quiet Radio Private Office Quiet Conversation	Faint
20-1 dBa	Rustle of Leaves Soundproof Room	Whisper
20-1 dBa	Threshold of Audibility	

Table 2.1.3 : List of Intensity between different decibels

In general the higher the STC value, the better the sound transmission reduction is. *(See Appendix 5.5, 5.6 & 5.7 to understand the STC of wall assembly)*

STC	**Track Application**
25	Normal speech can be easily heard and understood
30	Loud speech can be easily heard and understood
35	Loud speech heard, but not understood
40	Loud speech now only a murmur
45	Loud speech not heard, music systems/heavy traffic noise still a potential problem
50	Very loud sounds such as musical instruments or a stereo can be faintly heard
60+	Excellent soundproofing

Table 2..1.4 : List of Sound Transmission Class

2.2 How acoustic works in Auditorium

Auditoriums are spaces for live music or presentations with different acoustical requirements. To achieve the acoustical requirements for these events are having the sound to be natural instead of being too ‘dead’ or too ‘lively’. When the auditorium consists of too many hard, reflective surfaces allowing sounds to reverberate around the room, it leads to too lively sounds. On the other hand when there are too many absorption of sound waves, it will lead to a ‘dead’ room with an unpleasantly quiet room. Therefore, it is required to have a balance of reverberation time in an auditorium to be in between too lively and too dead. For general auditoriums with both speech and music, it is preferred to have a reverberation time between 1.5 to 2.5 seconds as shown in diagram 3 by Nave. However depending on the type of performance, the reverberation time could vary based on table 2.2.2 & table 2.2.3. The reverberation time could be controlled by a strategic use of acoustical products which will be mentioned in this following essay.

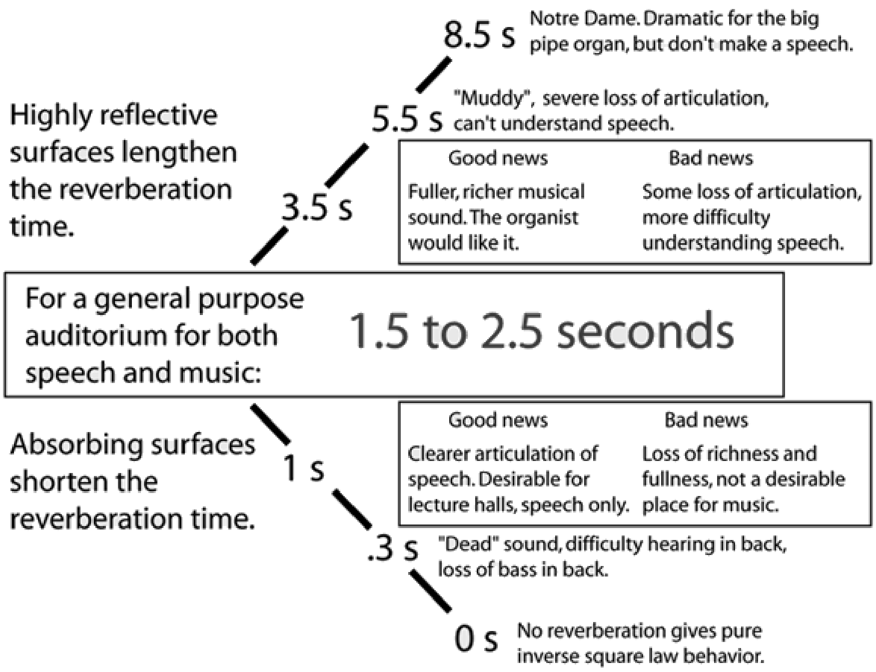


Figure 2.2.1 : Comparison of reverberation times (Nave,1999)

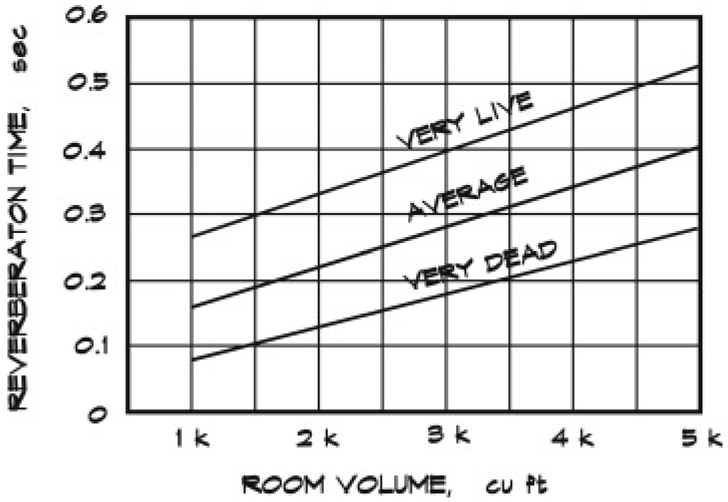


Table 2.2.2 : Suggested Reverberation Times for Rooms (Fierstein, 1979)

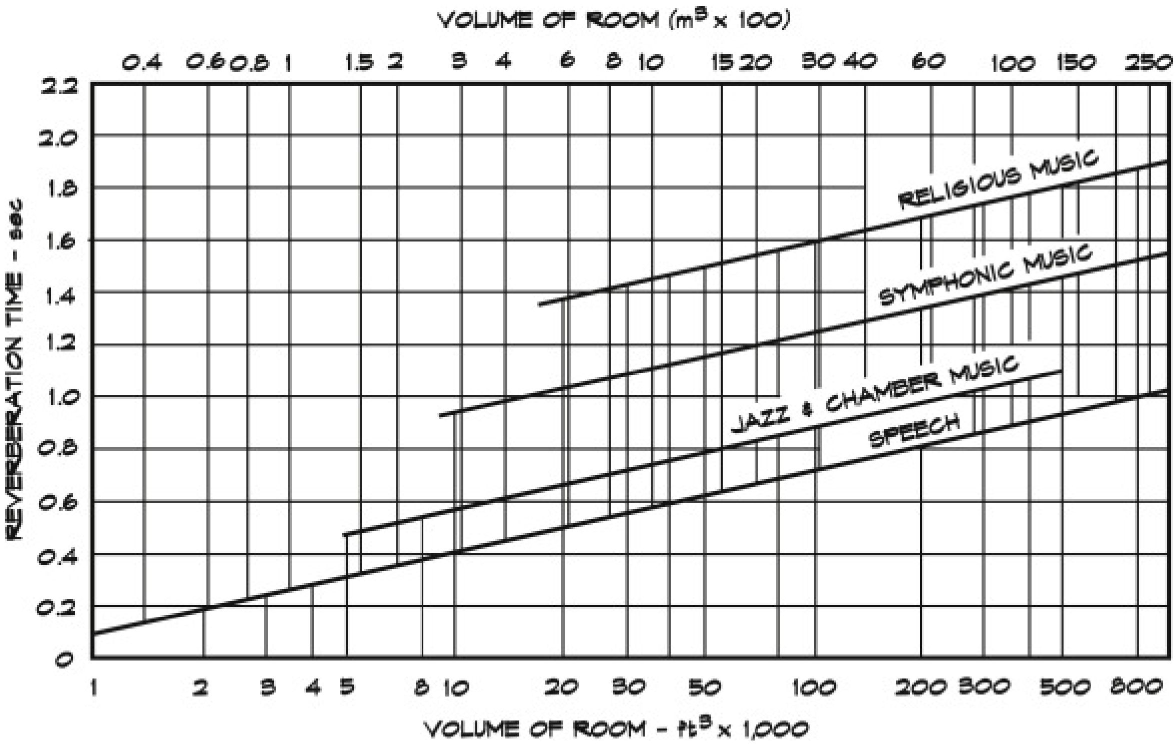


Table 2.2.3 : Reverberation Times for rooms in the 500–1000 Hz Range (Doelle, 1972)

2.3 Acoustic products and types of materials

There are a number of acoustic materials introduced into today's auditorium wall designs. Every material plays a role in acoustical control. The acoustical control devices for walls are categorised into four aspects, which are **absorbers, diffusers, barriers** and **isolators**.

2.3.1 Sound absorbers

Sound absorbers are porous materials which eliminate sound by redirecting sound into many pathways to reduce the energy. An internal sound quality of a space is improved by sound absorbers absorbing incoming echo and reverberation in it. It helps to eliminate most noise and sound volume but does not help to prevent sound transmissions. Figure 2.3.7 illustrates the effects of absorbers. Image 2.3.1 to Image 2.3.6 shows the common absorbers . These materials usually have a high Sound Absorption Coefficient / NRC higher than 0.75. Depending on the frequency emitted, the coefficient values vary. *(See Appendix 5.1 & 5.2)*

 *Image 2.3.1 : Fibreglass*	 *Image 2.3.2 : Rockwool*	 *Image 2.3.3 : open cell polyurethane foam*
 *Image 2.3.4 : cellular melamine foam*	 *Image 2.3.5 : heavy curtain blankets*	 *Image 2.3.6 : thick fabric wall coverings*

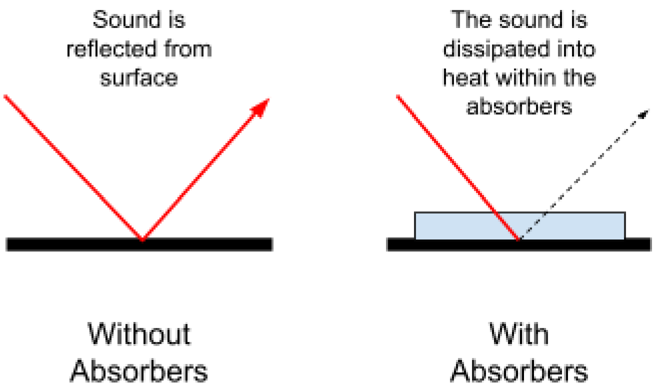


Figure 2.3.7 : Comparison of with or without absorbers

2.3.2 Diffusers

Diffusers are devices that scatter sound over an expanded area rather than eliminating sounds unlike absorbers. The diffusers rely on harder and non porous materials like timber panels, which are relatively reflective. The Sound Absorbing Coefficient / NRC of diffusers are normally as close as 0.0. *(See Appendix 5.1 & 5.2)* Besides, the surfaces of diffusers are commonly uneven with varying depths, causing a focused sound to spread in all directions evenly. The spread of sound could enhance a room's atmosphere, making it more lively and reducing localization.

Image 2.3.8 : Temporal diffusers made of timber

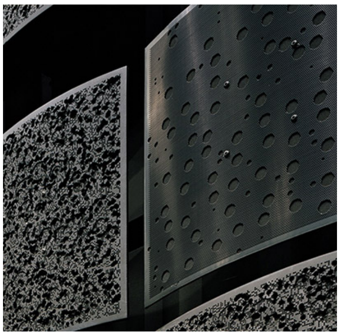


Image 2.3.9 : Perforated Metal diffusers

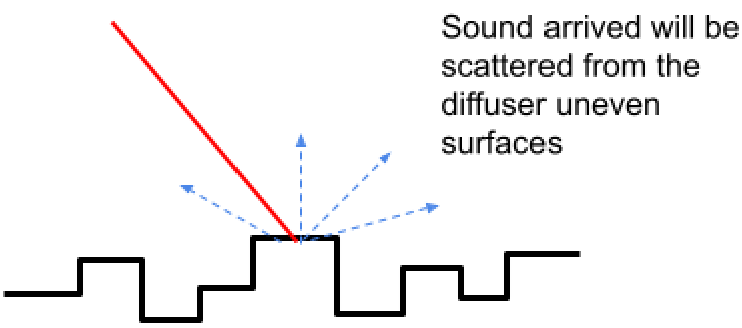


Figure 2.3.10 : Illustration of sound when encounter diffusers

2.3.3 Barriers

Barriers are heavy and dense materials to prevent sound transmissions. The materials suitable to be barriers are drywalls such as gypsum and sheetrock. There are also thin barrier materials which are lead foil and mass loaded vinyl.

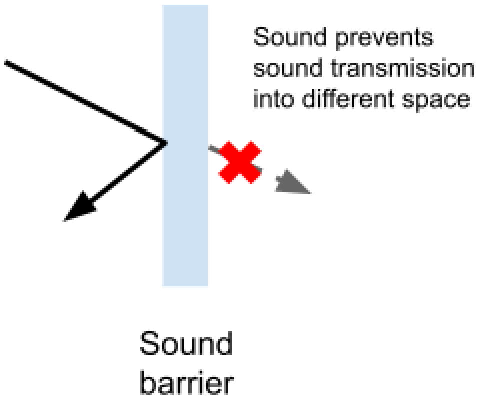


Figure 2.3.11 : Illustration of sound barrier

2.3.4 Isolators

Isolators prevent sound transmission through structure elements and services of a building and causing them to vibrate. The common devices for sound isolators are resilient channels for drywall, isolation pads for floors, decoupling hanger for ceilings and special adhesives for walls with nails and screws. Sound isolations require the attention of details during installation.

Diagram 2.3.12 : Masonry isolator bracket

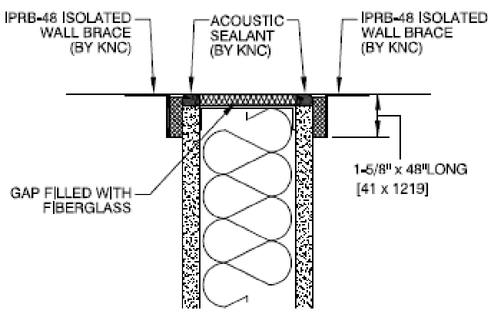


Diagram 2.3.13 : Masonry isolator bracket typical details

2.4 Application of Acoustic Products on Walls

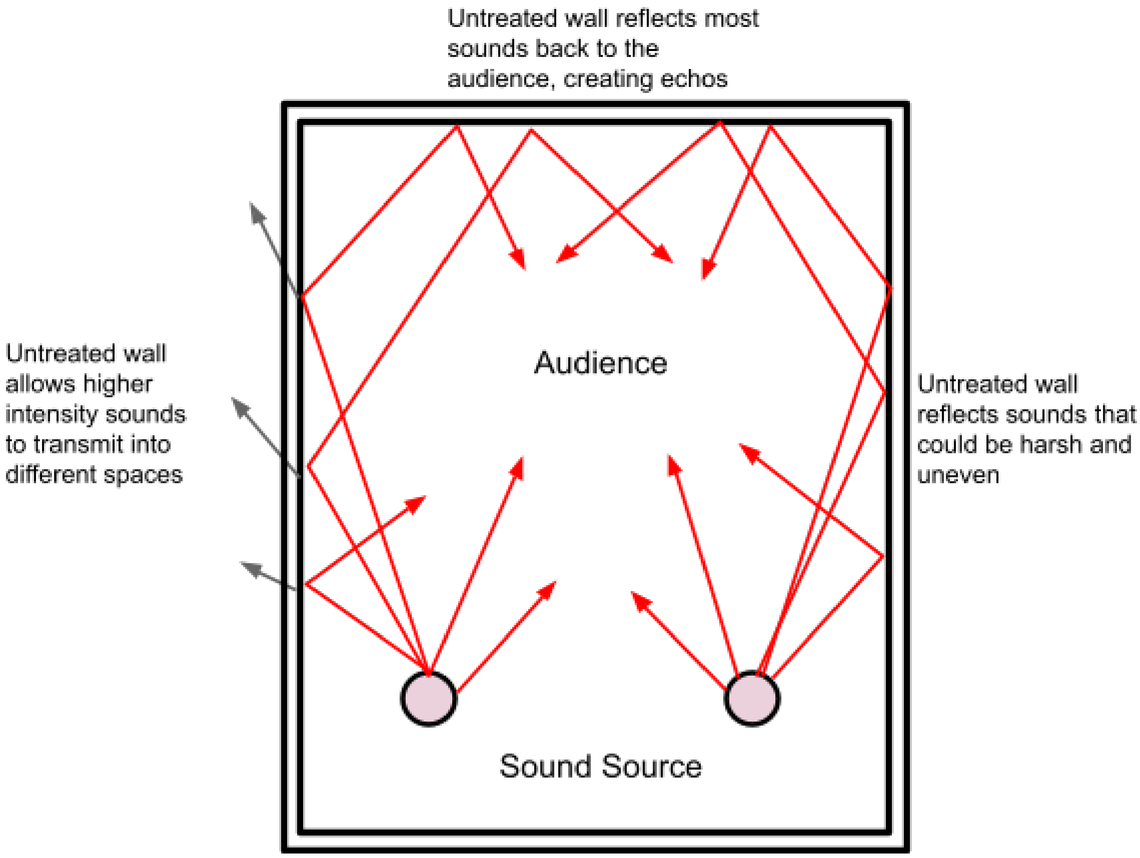
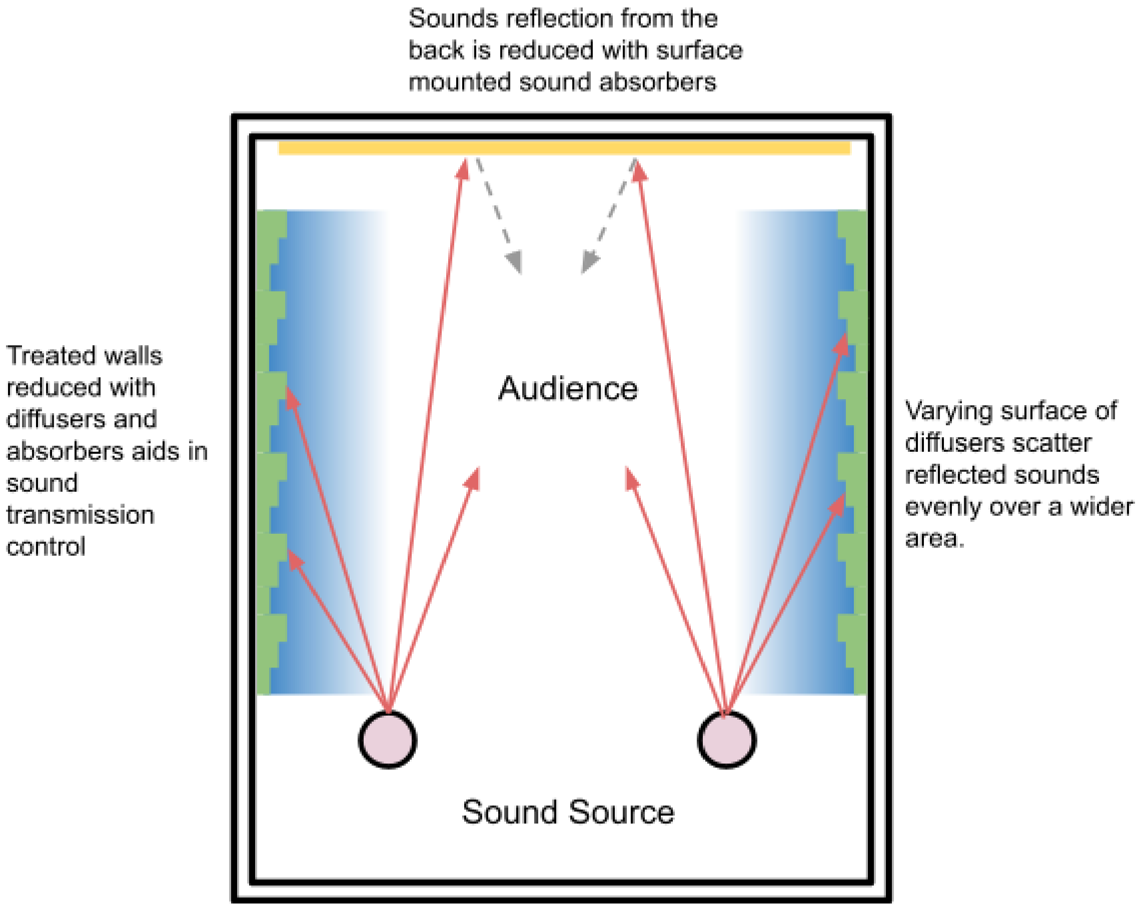


Figure 2.4.1 : Acoustic Issues from untreated walls

Illustrated on figure 2.4.1, an untreated room of masonry wall or drywall creates unwanted sound reflections due to its hard, reflective surface; which creates echoes within the room. Sound or vibration are also able to penetrate out from the walls, intruding other spaces or being intruded by sounds from outside. With the combination of absorbers,diffusers and suitable sound barriers, the effect will be as shown in figure 2.4.2 :



(Figure 2.4.1 : Acoustic solutions from treated walls)

A controlled use of absorbers to prevent space becoming too quiet, an example given from Barron (2015) that the Royal Albert Hall in London with over 5000 seats creates an extreme silent space as seats are absorbers. Given that the auditorium will definitely have seats, therefore the walls should have more diffuser panels to control the reverberation time. The masonry walls could also introduce niches, recesses which give depths on the wall's surface will work well as diffusers too.

Besides, bare masonry walls could also transmit vibrations with sound flanking into the walls and spreading to other spaces. Hence, sound isolation is required on the wall. There are few methods depending on the budget and area. If both criteria are met, decoupling or adding a drywall will create insulation. Decoupling is adding another layer of wall that creates a cavity space which uses air to prevent sound waves penetrating. For a more affordable option will be applying the mass loaded vinyl. Figure 2.4.2 shows the sectional details of an acoustically treated wall.

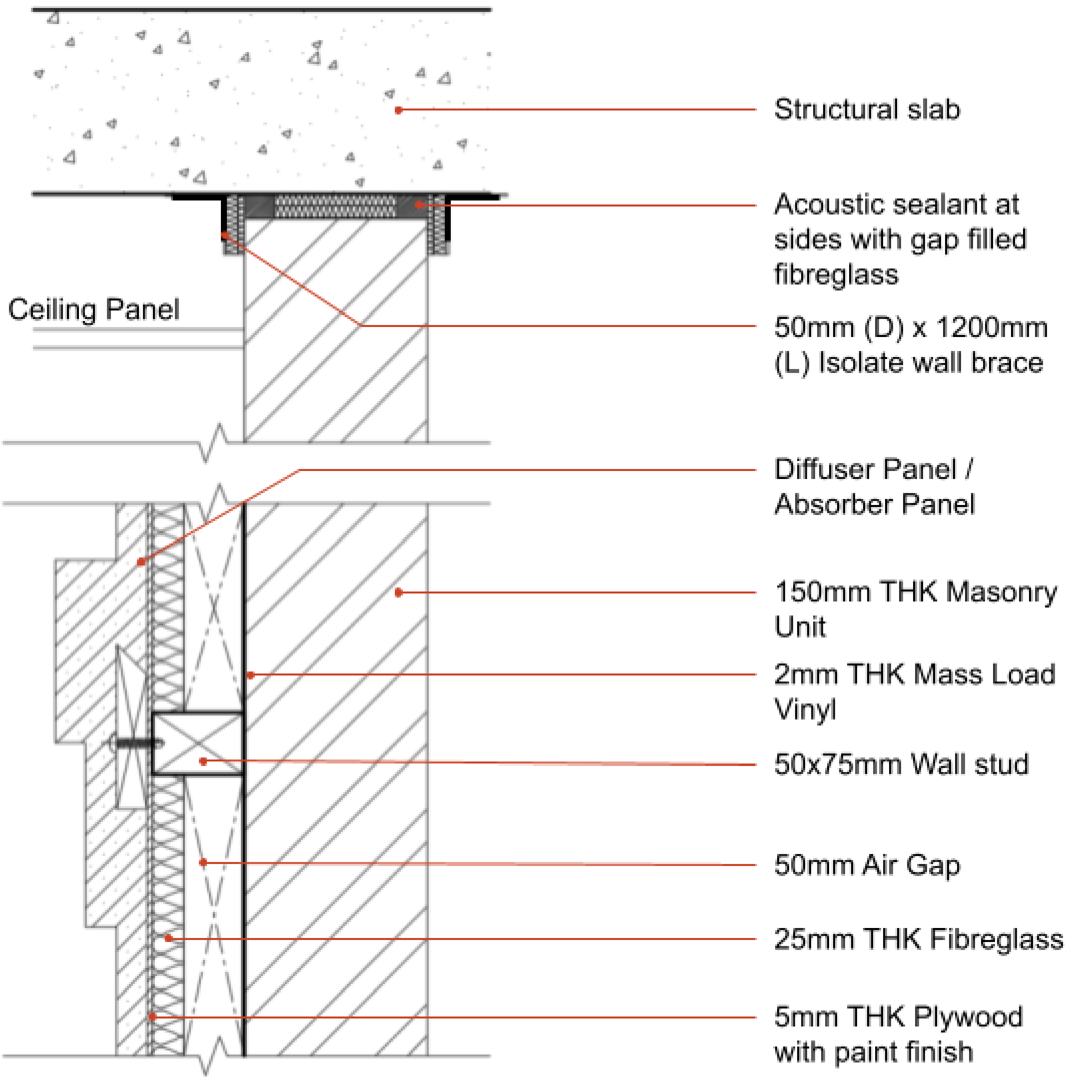


Figure 2.4.2 : Vertical Section of acoustic treated wall

3.0 Case Study

A comparative case study has been done for the analysis of wall acoustic materials. This study shall be looking into 2 auditoriums from different buildings: Institute of Contemporary Art (ICA) in Virginia Commonwealth University in the United States and Kuala Lumpur Performing Arts Center (KLPAC) in Malaysia.

3.1 ICA, VCU

ICA is a building which houses different disciplines of contemporary arts from the students in VCU. The building opens for both students and the public access to experience contemporary art.

Image 3.1.1 : Front facade of ICA, VCU

Looking at the wall panels installed in ICA's auditorium, it is a one sided seated auditorium with the seats at one end ascending down to the stage in a 45 degree gradient.

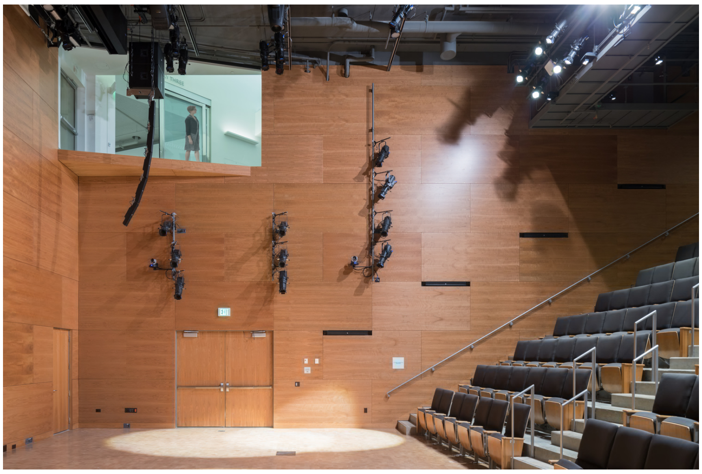


Image 3.1.2 : ICA's Auditorium

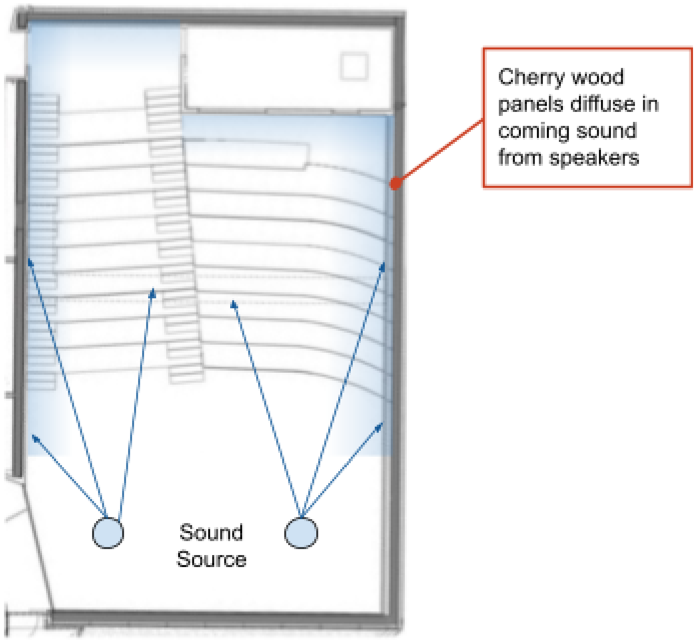


Diagram 3.1.3 : Auditorium Floor Plan

The interior walls around the auditorium walls are cladded with certified cherry wood panels of 4’ x 8’ .

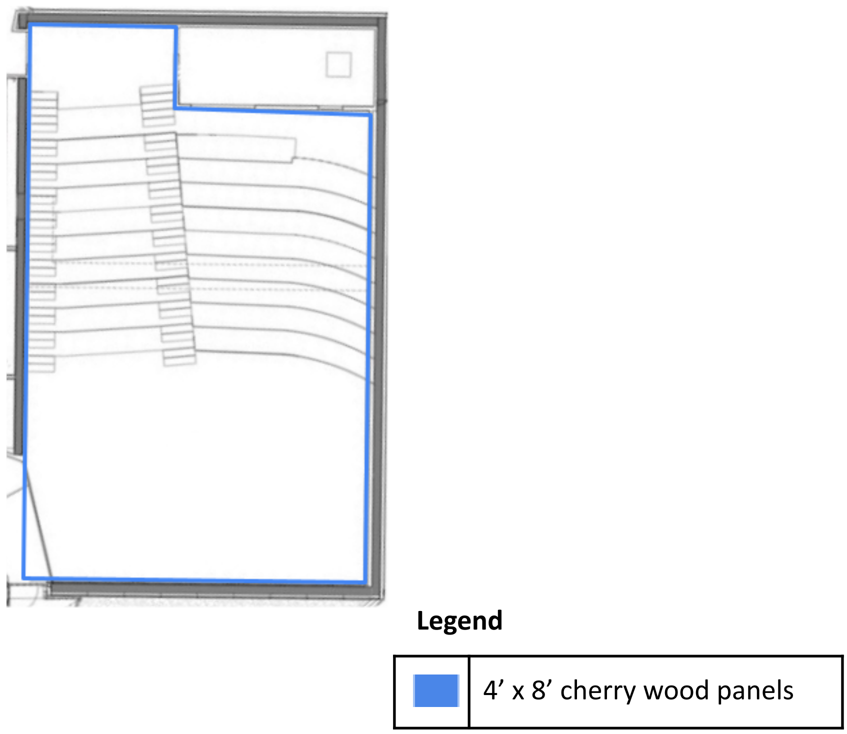


Diagram 3.1.4 : Line indicates the installation of cherry wood panels

Cherry wood panels are timbers. Timber panels are chosen for acoustic purposes in auditoriums because their relative softness cellular structure has different acoustic performance to harder materials such as steel concrete and masonry. Timber tends to absorb sound energy and dampen resonant vibrations; different species of wood will perform differently. In an auditorium, wooden panels generally reflect and absorb low frequencies of (500 Hz or lower) made from the stage area. (Wegst 2006).

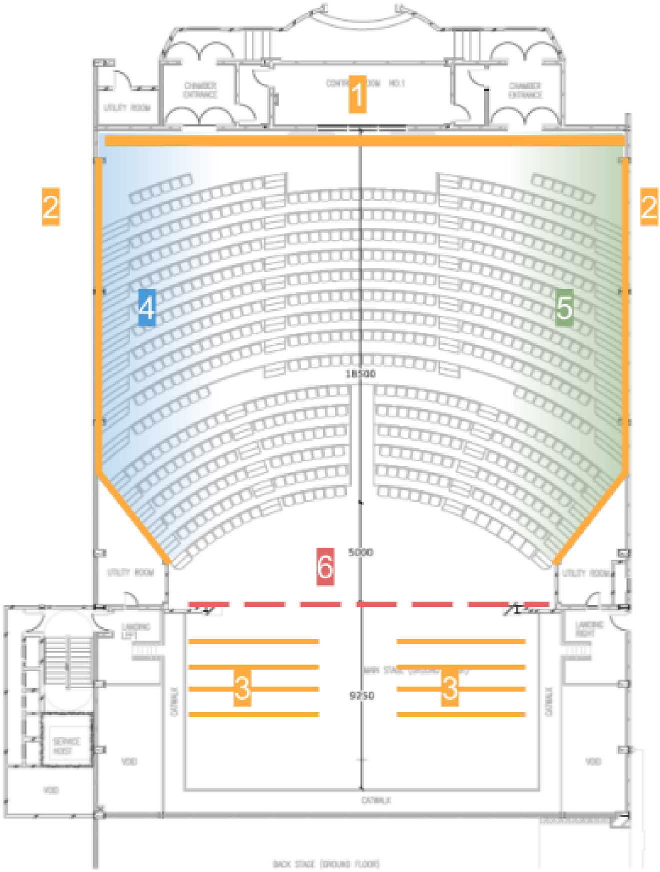
It has long been known that exposure of high frequency noise or loud noises within the audible range will cause hearing loss overtime, however 90 seconds exposure of low frequencies could change the way the human's inner ear works, as the ear could be more prone to damage. (Williams, 2014). Based on this fact, it proves absorption of low frequencies from wooden panels are important in acoustic design.

Besides absorbing low frequency sounds as mentioned, the cherry wood cladding does reflect back higher frequency sounds to prevent sound penetrating out from the auditorium which affects the other spaces due to its low noise reduction coefficient (NRC) of 0.10 to 0.15. The lower the NRC, the higher the reflectivity of noise and vice versa.This means that the auditorium still produces echoes, however the issue is solved with fabric seats and audiences.

3.2 KLPAC

Kuala Lumpur Performing arts centre is an adaptive reuse building which houses 3 different sizes of performing spaces with a main auditorium for general performance (Pentas 1), a black box for experimental use (Pentas 2) and a smaller theatre (Indicine). The study will be mainly focusing on the main auditorium which is Pentas 1.

Image 3.2.1 : KLPAC



Legend

Absorbers	1	Floor to ceiling height Acoustic Panels
	2	1.4m height Fabric soundboard
	3	Back stage drapes
Diffusers	4	PVC Pipes
	5	Wooden blocks
	6	Zinc sheets

(Diagram & Table 3.2.2 : Pentas 2 Layout Plan with indications of acoustic devices)

Around the walls of the auditorium, it uses a varying amount of materials, besides masonry walls, there are recycled materials such as wooden blocks, PVC pipes and zinc sheets.

Legend : 1. Wooden blocks, 2. Zinc sheets, 3. PVC pipes

Image 3.2.3 : Perspective towards stage

The surrounding base walls in Pentas 1 are mainly masonry walls. Masonry walls have a low NRC of average 0.00 to 0.05, which shows it could totally reflect sounds within the space and create unwanted echos. Hence, the recycled materials act as diffusers as their surface properties and their density . They have varying depths on the surface which allows the diffraction of sound. From the arrangement of wooden blocks with different depths and dimensions (NRC 0.36-0.39) , to the undulating profiles of zinc sheets (NRC 0.35-0.54) and PVC pipes (NRC 0.01-0.04) . These materials shall scatter the echos effectively with its surface hardness and levels.

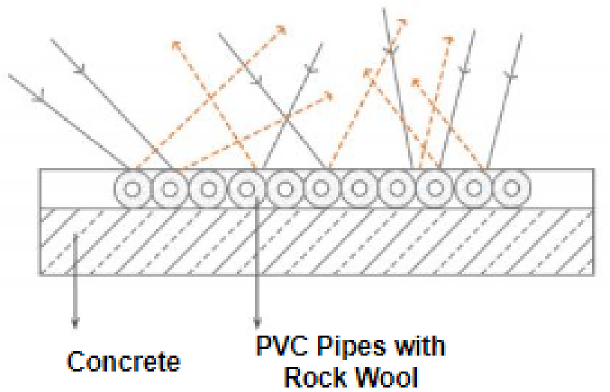


Image 3.2.4 : Sound diffusion details on PVC pipes (Lim,2019)

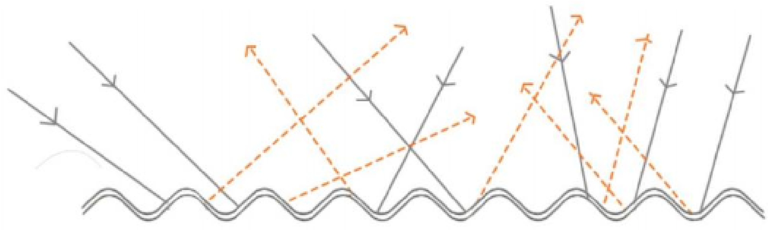


Image 3.2.5 : Sound diffusion details on corrugated Zinc Sheets (Lim,2019)

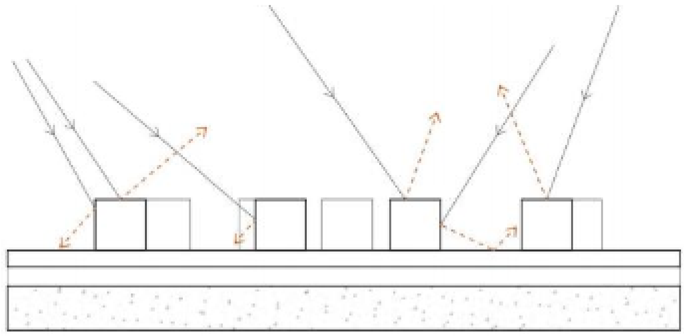


Image 3.2.6 : Sound diffusion details on wooden blocks (Lim,2019)

As for the auditorium's sound absorbers, fabric panels are installed from floor to ceiling at the opposite end of the stage and 1.4m height of soundboard under the diffusers at both sides of the walls. The height of the soundboards along the auditorium 2 sides prevents reflection on echo into the audience during sitting position. Fabric has a high NRC of 0.80 which allows good absorption of most noise. Besides, curtain drapes at the back stage helps in reducing slapback although it does not significantly help in reducing sound transmission *(Lim,2019).*

Image 3.2.7 : Curtain drapes at backstage (Azman,2019)

Image 3.2.8 : Sound absorption on the curtain drapes (Lim,2019)

4.0 Conclusion

Based on the overall study of acoustics in this essay, there are a number of factors to achieve good acoustics in auditorium walls design. The first step shall be determine the type of programs needed in the auditorium. Different programs required different reverberation time as mentioned in figure 2.2.1 in chapter 2.2 by Nave,1999. Speeches had to be clear with low reverberation time and Music will be more sensational with longer reverberation time.

Next, with a basic understanding of sound physics shall help in determining the sound absorption, reflection and transmission issues. A balance of use in acoustic devices compliments each other in achieving desired acoustics. Too much of either one of the devices reduces acoustic effectiveness and alters the overall ambience in audio. The balance between devices also manage to respond against different ranges of frequencies as different frequencies have different absorption and reflection requirements.

Finally, every part of the auditorium from floors, ceilings, seatings, room temperature could affect the overall acoustics besides walls. Strategic use of acoustic devices and materials with the aid of acoustics consultants in the design stage will achieve acoustic comfort without relying too much on audio devices such as speakers. Everyone in the auditorium deserves a good sound quality in every performance.

5.0 Appendix

Reflective wall materials	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
Brick (natural)	0.03	0.03	0.03	0.04	0.05	0.07
Brick (painted)	0.01	0.01	0.02	0.02	0.02	0.03
Concrete block (coarse)	0.36	0.44	0.31	0.29	0.39	0.25
Concrete block (painted)	0.1	0.05	0.06	0.07	0.09	0.08
Concrete (poured, rough finish, unpainted)	0.01	0.02	0.04	0.06	0.08	0.1
Doors (solid wood panels)	0.1	0.07	0.05	0.04	0.04	0.04
Glass (1/4" plate, large pane)	0.18	0.06	0.04	0.03	0.02	0.02
Glass (small pane)	0.04	0.04	0.03	0.03	0.02	0.02
Plasterboard (12mm (1/2") panelling on studs)	0.29	0.1	0.06	0.05	0.04	0.04
Plaster (gypsum or lime, on masonry)	0.01	0.02	0.02	0.03	0.04	0.05
Plaster (gypsum or lime, on wood lath)	0.14	0.1	0.06	0.05	0.04	0.04

Plywood (3mm(1/8″) panelling over 31.7mm(1-1/4″) airspace)	0.15	0.25	0.12	0.08	0.08	0.08
Plywood (3mm(1/8″) panelling over 57.1mm(2-1/4″) airspace)	0.28	0.2	0.1	0.1	0.08	0.08
Plywood (5mm(3/16″) panelling over 50mm(2″) airspace)	0.38	0.24	0.17	0.1	0.08	0.05
Plywood (5mm(3/16″) panel, 25mm(1″) fibreglass in 50mm(2″) airspace)	0.42	0.36	0.19	0.1	0.08	0.05
Plywood (6mm(1/4″) panelling, airspace, light bracing)	0.3	0.25	0.15	0.1	0.1	0.1
Plywood (10mm(3/8″) panelling, airspace, light bracing)	0.28	0.22	0.17	0.09	0.1	0.11
Plywood (19mm(3/4″) panelling, airspace, light bracing)	0.2	0.18	0.15	0.12	0.1	0.1

Table 5.1 : Absorption coefficient of Reflective wall materials

Absorptive wall materials	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
Drapery (10 oz/yd2, 340 g/m2, flat against wall)	0.04	0.05	0.11	0.18	0.3	0.35
Drapery (14 oz/yd2, 476 g/m2, flat against wall)	0.05	0.07	0.13	0.22	0.32	0.35
Drapery (18 oz/yd2, 612 g/m2, flat against wall)	0.05	0.12	0.35	0.48	0.38	0.36
Drapery (14 oz/yd2, 476 g/m2, pleated 50%)	0.07	0.31	0.49	0.75	0.7	0.6
Drapery (18 oz/yd2, 612 g/m2, pleated 50%)	0.14	0.35	0.53	0.75	0.7	0.6
Fibreglass board (25mm(1″) thick)	0.06	0.2	0.65	0.9	0.95	0.98
Fibreglass board (50mm(2″) thick)	0.18	0.76	0.99	0.99	0.99	0.99
Fibreglass board (75mm(3″) thick)	0.53	0.99	0.99	0.99	0.99	0.99
Fibreglass board (100mm(4″) thick)	0.99	0.99	0.99	0.99	0.99	0.97

Open brick pattern over 75mm(3″) fibreglass	0.4	0.65	0.85	0.75	0.65	0.6
Pageboard over 25mm(1″) fibreglass board	0.08	0.32	0.99	0.76	0.34	0.12
Pageboard over 50mm(2″) fibreglass board	0.26	0.97	0.99	0.66	0.34	0.14
Pageboard over 75mm(3″) fibreglass board	0.49	0.99	0.99	0.69	0.37	0.15
Perforated metal (13% open, over 50mm(2″) fibreglass)	0.25	0.64	0.99	0.97	0.88	0.92
Drapery (10 oz/yd2, 340 g/m2, flat against wall)	0.04	0.05	0.11	0.18	0.3	0.35
Drapery (14 oz/yd2, 476 g/m2, flat against wall)	0.05	0.07	0.13	0.22	0.32	0.35
Drapery (18 oz/yd2, 612 g/m2, flat against wall)	0.05	0.12	0.35	0.48	0.38	0.36

Table 5.2 : Absorption coefficient of Absorptive wall materials

Seating Materials	**125 Hz**	**250 Hz**	**500 Hz**	**1 kHz**	**2 kHz**	**4 kHz**
Benches (wooden, empty)	0.1	0.09	0.08	0.08	0.08	0.08
Benches (wooden, 2/3 occupied)	0.37	0.4	0.47	0.53	0.56	0.53
Benches (wooden, fully occupied)	0.5	0.56	0.66	0.76	0.8	0.76
Benches (cushioned seats and backs, empty)	0.32	0.4	0.42	0.44	0.43	0.48
Benches (cushioned seats and backs, 2/3 occupied)	0.44	0.56	0.65	0.72	0.72	0.67
Benches (cushioned seats and backs, fully occupied)	0.5	0.64	0.76	0.86	0.86	0.76
Theatre seats (wood, empty)	0.03	0.04	0.05	0.07	0.08	0.08
Theatre seats (wood, 2/3 occupied)	0.34	0.21	0.28	0.53	0.56	0.53
Theatre seats (wood, fully occupied)	0.5	0.3	0.4	0.76	0.8	0.76
Seats (fabric-upholstered, empty)	0.49	0.66	0.8	0.88	0.82	0.7
Seats (fabric-upholstered, fully occupied)	0.6	0.74	0.88	0.96	0.93	0.85

Table 5.3 : Absorption coefficient of Seating materials

Miscellaneous surface material	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
People-adults (per 1/10 person)	0.25	0.35	0.42	0.46	0.5	0.5
People-high school students (per 1/10 person	0.22	0.3	0.38	0.42	0.45	0.45
People-elementary students (per 1/10 person)	0.18	0.23	0.28	0.32	0.35	0.35
Ventilating grilles	0.3	0.4	0.5	0.5	0.5	0.4
Water or ice surface	0.008	0.008	0.013	0.015	0.02	0.025

Table 5.4 : Absorption coefficient of Miscellaneous surface material

Wall Assembly STC Performance

STC	Assembly Build	Performance
33	Single layer of 1/2" drywall on each side, wood studs, no insulation (typical interior wall)	Poor
44	Double layer of 1/2" drywall on each side, wood studs, batt insulation in the wall	Poor
52	Single 5/8" drywall on one side, double 5/8" drywall and Green Glue on other side wood studs	Good
55	Double layer of 1/2" drywall on each side, on a staggered wood stud wall, batt insulation in the wall	Fair
60	Double 5/8" drywall on either side of a steel stud wall with insulation and 1 load of Green Glue both sides.	Good
62	Double 5/8" drywall on either side of a steel stud wall with insulation and 2 loads of Green Glue on both sides.	Excellent
63	Double layer of 1/2" drywall on each side, on double wood/metal stud walls (spaced 1" apart), double batt insulation	Good

Table 5.5 : Wall Assembly Sound Transmission Class Performance

Nominal unit thickness, in. (mm)	Density, pcf (kg/m³)	STC[A]			
		Hollow unit	Grout-filled unit	Sand-filled unit	Solid unit
4 (102)	85 (1,362)	40	45[B]	44	44
	95 (1,522)	41	46[B]	44	45
	105 (1,682)	42	46[B]	45	46
	115 (1,842)	43	47[B]	46	46
	125 (2,002)	44	48[B]	46	47
	135 (2,162)	45	48[B]	47	48
6 (152)	85 (1,362)	42	51	48	48
	95 (1,522)	43	51	49	49
	105 (1,682)	44	52	50	50
	115 (1,842)	45	52	50	51
	125 (2,002)	45	53	51	52
	135 (2,162)	46	53	51	53
8 (203)	85 (1,362)	44	55	52	52
	95 (1,522)	45	55	52	53
	105 (1,682)	46	56	53	54
	115 (1,842)	47	56	54	55
	125 (2,002)	48	57	54	56
	135 (2,162)	49	57	55	57
10 (254)	85 (1,362)	46	58	55	55
	95 (1,522)	48	58	55	56
	105 (1,682)	49	59	56	57
	115 (1,842)	50	59	57	58
	125 (2,002)	50	60	57	59
	135 (2,162)	51	60	58	60
12 (305)	85 (1,362)	48	61	57	57
	95 (1,522)	49	61	58	58
	105 (1,682)	50	62	58	60
	115 (1,842)	51	62	59	61
	125 (2,002)	52	63	60	62
	135 (2,162)	53	63	60	63

Table 5.6 : Calculated STC Ratings for Concrete Masonry Walls

Furring space condition:	Drywall on:	ΔSTC for furring space thickness[A] (in., (mm)) of:							
		0.5 (13)	0.8 (19)	1 (25)	1.5 (38)	2 (51)	2.5 (64)	3 (76)	3.5 (89)
No sound-absorbing material in the furring space	one side	0.2	0.9	1.6	3.0	4.4	5.8	7.2	8.6
	both sides[A]	-1.0	-0.1	0.8	2.6	4.4	6.2	8.0	9.8
Furring space filled with sound-absorbing material[B]	one side	3.4	4.1	4.9	6.4	7.9	9.4	10.9	12.4
	both sides[A]	-1.8	1.0	3.8	9.4	15.0	20.6	26.2	31.8

Table 5.7 : Increase in STC Ratings Due to Furring Space and Drywall

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