UCSI SCHOOL OF ARCHITECTURE & BUILT ENVIRONMENT

Architectural Acoustic Design

AR 453 Building Science 02

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CASE STUDY 1 : FLAT-PACK AUDITORIUM L'AQUILA , ITALY

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CASE STUDY 2 : KAUFFMAN CENTER FOR THE PERFORMING ARTS

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CONTENT

CASE STUDY 1

CASE STUDY 2

CASE STUDY 3
GREAT AMBER CONCERT HALL

GROUP WORK

INDIVIDUAL

1

Case Study

Flat-Pack Auditorium
L'Aquila , Italy

LOCATION

L'Aquila
Italy

ARCHITECT

Renzo Piano Building Workshop

Architect Renzo Piano has replaced the auditorium destroyed during the 2009 earthquake in L'Aquila, Italy, with a flat-pack building comprising three wooden cubes.

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ORTHOGRAPHIC DRAWINGS

Case Study 1

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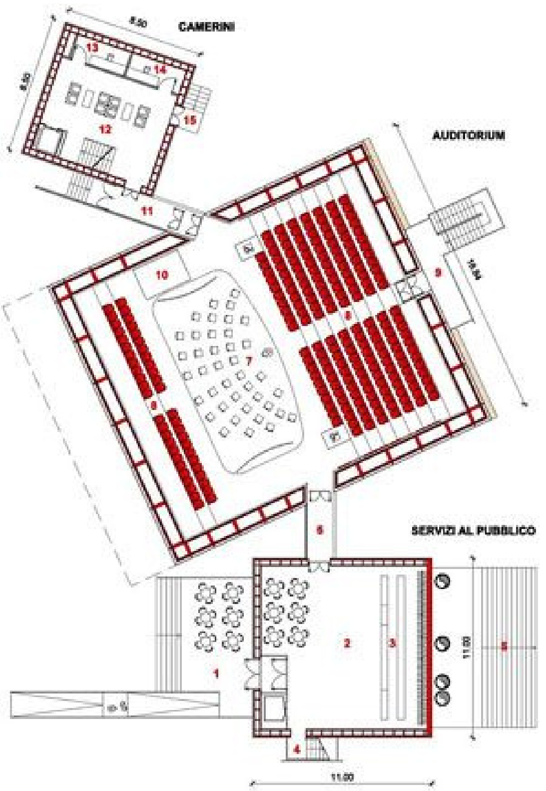


FLOOR PLAN

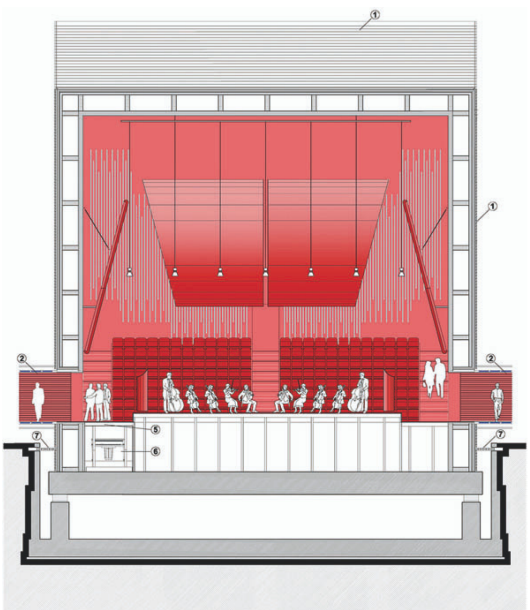
Scale 1:200

BACK ELEVATION

Scale 1:100

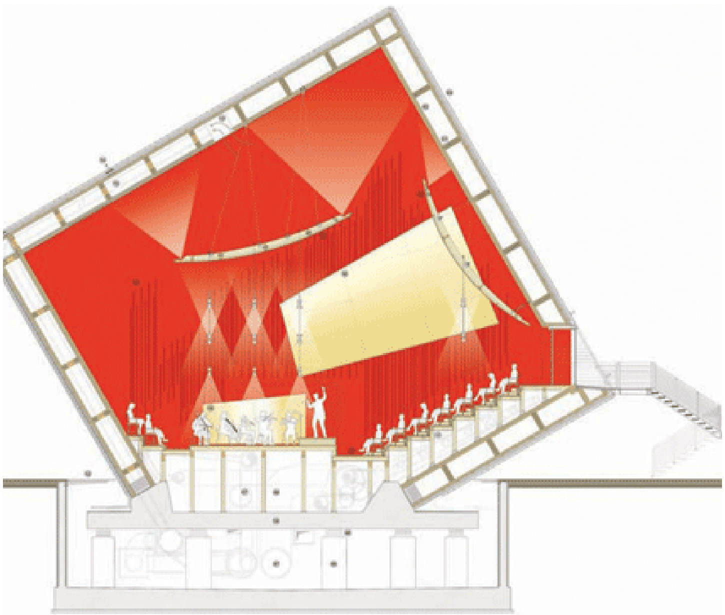
LONG SECTION

Scale 1:200



CROSS SECTION THROUGH AUDITORIUM

Scale nts



LONG SECTION THROUGH AUDITORIUM

Scale nts

CONSTRUCTION DRAWINGS

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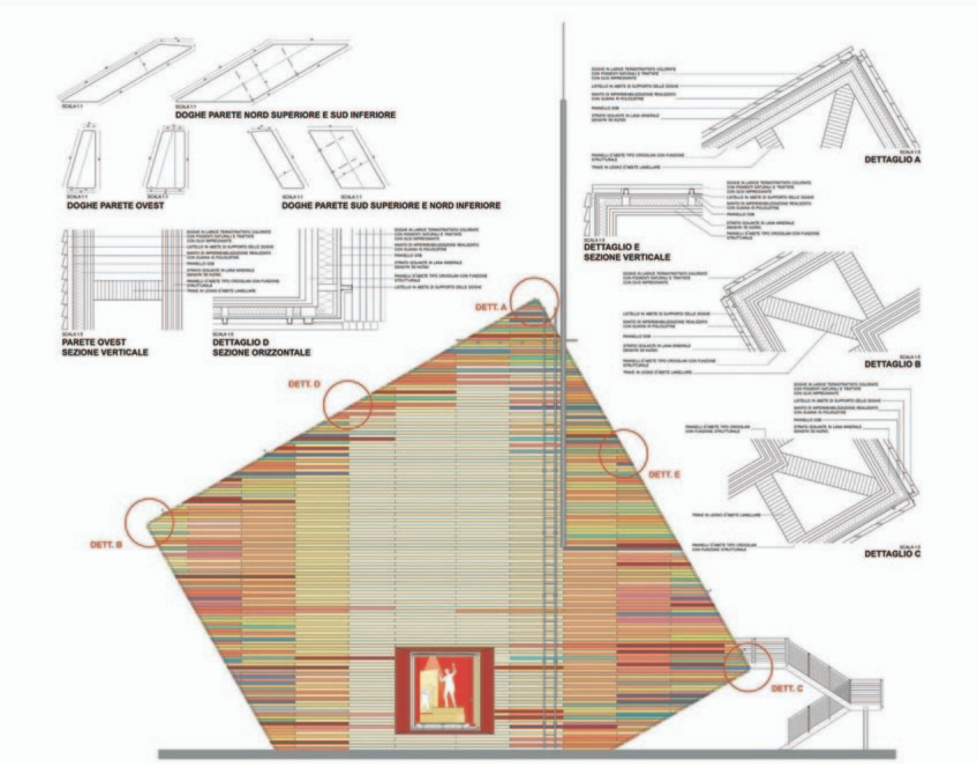
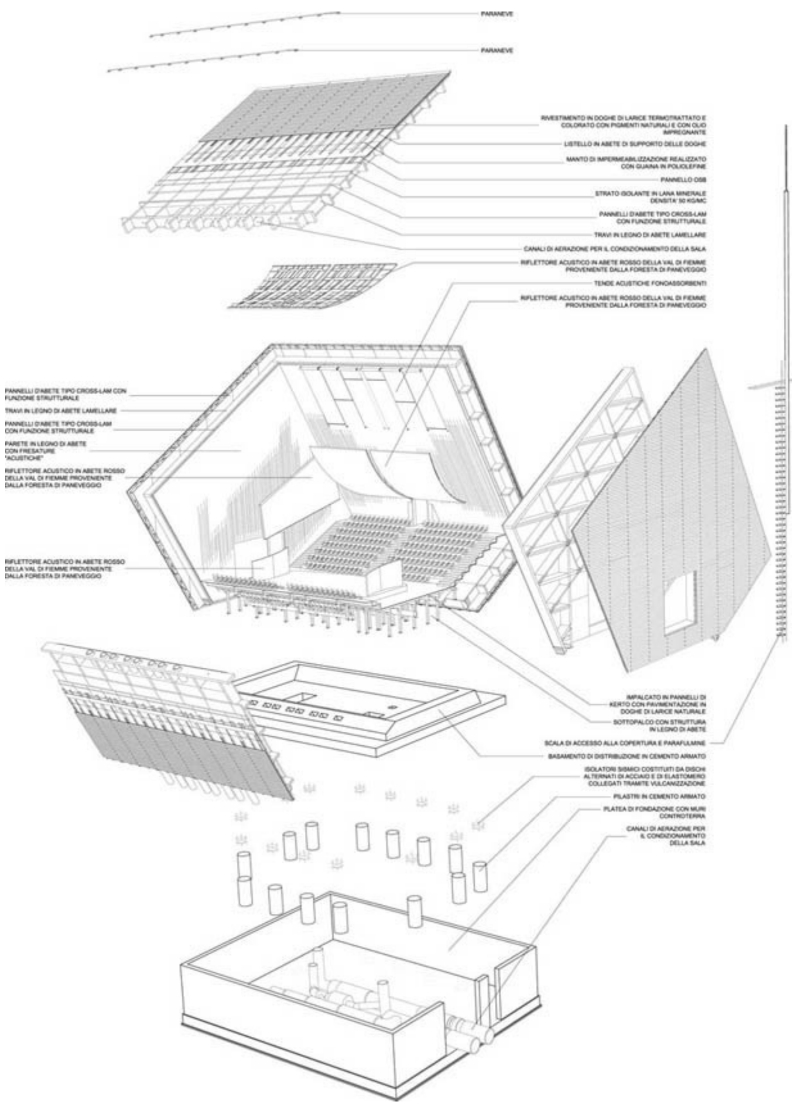


SECTIONAL DETAIL

Scale 1:100

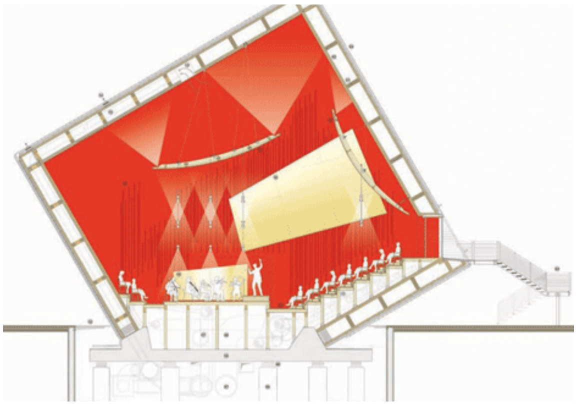
EXPLODED ANXONOMETRIC

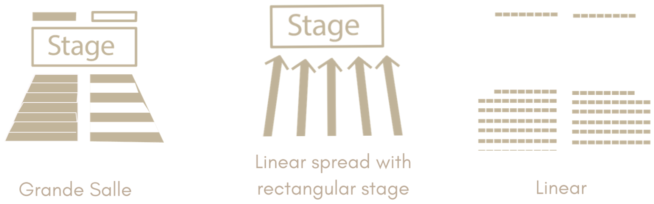
Scale 1:200



ANALYSIS

1. LAYOUT OF SEATING ARRANGEMENT

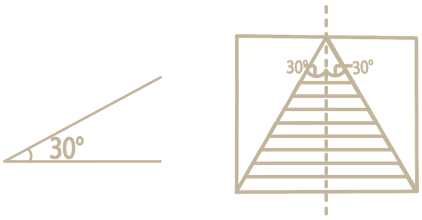


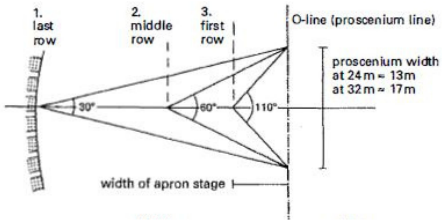


The Flat-Pack Auditorium has a traditional layout of seating arrangement. The rows of spectators positioned in linear, don't have a better alignment toward the stage and to achieve a better perception of each other as it optimizing the view and listening experiences for everyone in attendance compare to fan shape arrangement.

The correct levelling of seats are able to allow sound waves reach to each individual without any interruption. The floor between the seats had a same level as the adjacent aisle at the side to create same angle of receive sound.
On the other hand, the layout of the Auditorium is divided into a central flat area and two opposing sloping areas with a stepped pattern. The central flat area is occupied by the orchestra podium, raised by 40 cm has a nice acoustic experience.

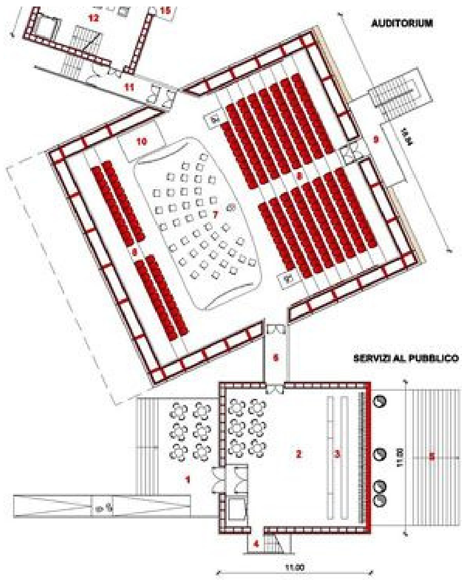
2. ANGLE OF SEATING





The seating features a multi-aisle auditorium layout. This layout produce a good view because without moving head, but light eye movements of approx. 30°.

This feature allows the audience from different height received a uniformly distributed acoustic and visual optical effects.



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3. SELECTION OF MATERIAL

Exterior

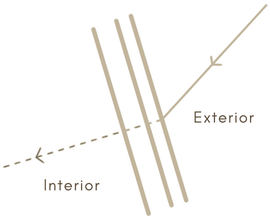
The main structure of this building was connected by steel and timber. The entire building is composed of wood and all of its components were pre-fabricated and then later assembled on site.

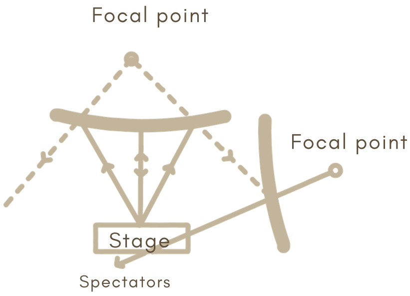
25cm long by 6cm thick larch tiles were used for the unified surface finish it is highly valued and famously used by Cremona's 17th-century master lute-makers, Stradivarius, making the building to perform like a musical instrument.

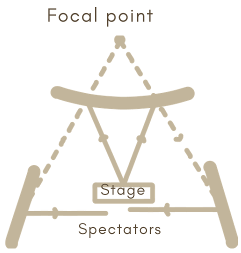
Other than just the aesthetic purposes, wood, the material that all the cubes are made of, is favored here for its unpretentious, rustic and external qualities. Renzo Piano not only chose wood because of the acoustic functions of the building’s program, but also because of its earthquake resistant properties.

Steel

Larch Wood







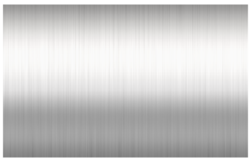
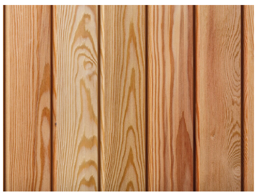
Interior

2 meter wooden panels flank both sides of the stage to reflect sound back to the orchestra. The wooden walls of the auditorium are treated with acoustic wooden panels oriented towards the audience. As for the convex wooden panels used in application where sound reflection is necessary to enhance the auditorium's acoustic.

The cubic-shaped structure of the main hall consists of a lattice of lamellar fir beams - 200 x 720 mm thick and braced on both sides with 95mm 3-ply X-Lam fir panels.

MATERIAL SPECIFICATION

Flat-Pack Auditorium implemented a range of materials from outside to inside.

Material		Absorption Coefficient
Interior		
	Alloy Wall	0.02
	X-LAM FIR	0.5
	Lattice of lamellar fir	0.7
Interior		
	Reinforced concrete	0.03
	Larch timber	0.5
	Asbestos, sprayed 25 mm	0.6 - 0.7

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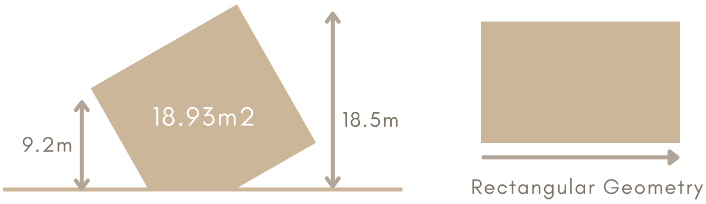
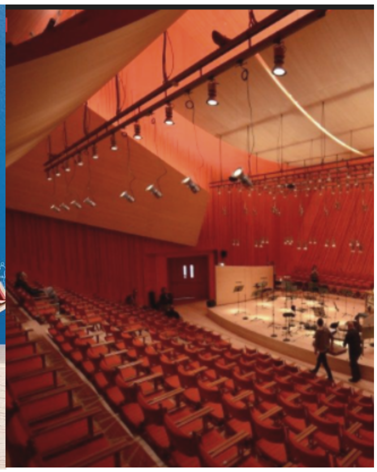
4. VOLUME OF BUILDING



The optimum size of the auditorium depends on the function of the hall and the audience capacity. The auditorium's volume is essentially a toppled cube with 18.5 meter sides. In section, one of the suspended edges is 18.5 meters above ground, while the other is 9.2 meters high. The total volume is 18.93m2. The auditorium is relatively smaller, hence the reverberation time is shorter. Rectangular geometry is suitable for relatively small space which Flat-Pack Auditorium us built to accommodate small audience capacity, which is implemented in this auditorium.

5. SEATING CAPACITY




238


40

The 238-seat auditorium has a stage that can hold around 40 musicians It's slopped, cubic facade supports two stepped seating areas facing each other to accommodate the audience; the larger has 190 seats in front of the orchestra, the smaller, 48 seats behind it. where audiences can choose either seat at the front or at the back of the stage. The rectangular geometry affect the seating capacity.

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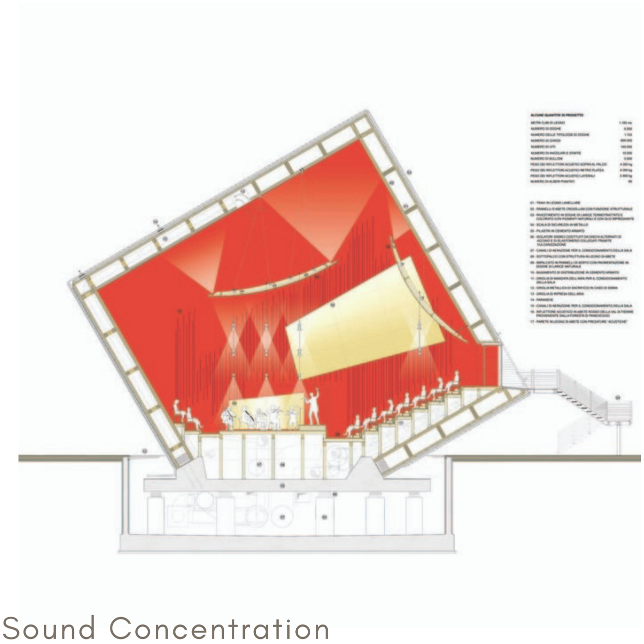
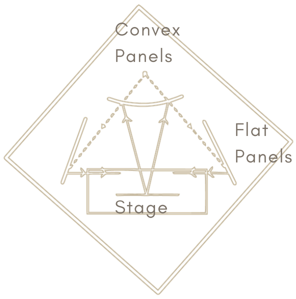
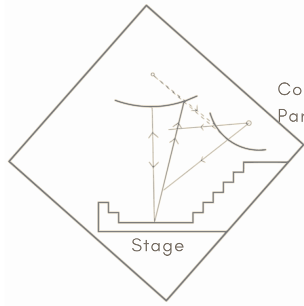
6. SOUND PROPAGATION

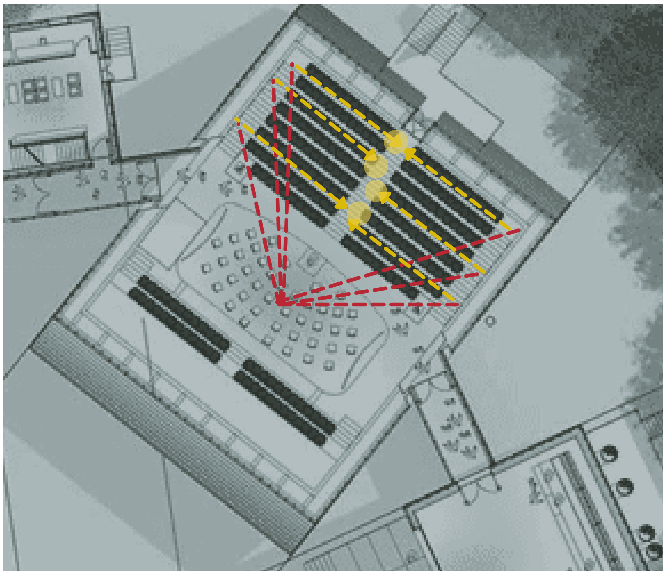




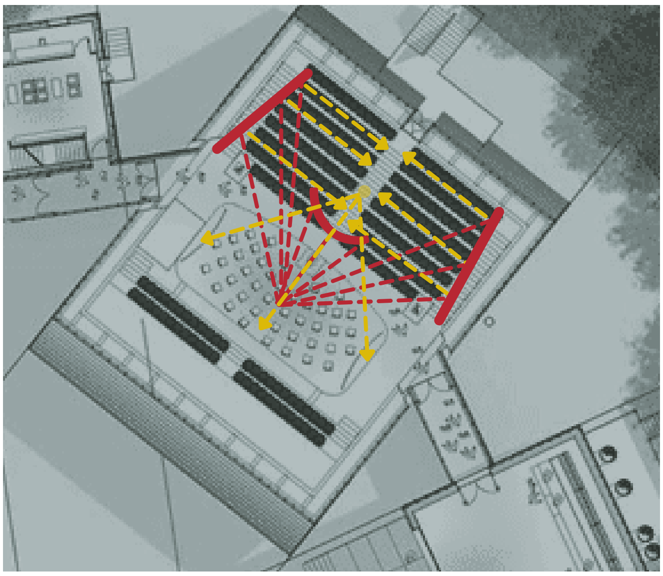


Layout of boundary surface implementing convex shaped ceiling system to reflect the sound from the orchestra podium to the audiences. The panels disperse the sound to create richer quality by enabling the audience to hear sound coming from more than one direction. This benefits more

Sound Concentration



The sound concentration will be affected by the curved and flat panels. The sound concentration will be diffuse because of the materials used on the surfaces which able to absorb just a small amount of sound and reflect to the audiences. Hence, the sound is controlled and provide comfortability.



Sound Reflection

To make it an efficient space, it is necessary to reflect back the sound towards the audiences. The panels act as sound reflector and concentrate waves of sound to a particular point. The placement of sound reflector is arranged in a relatively higher area so that the sound can be distributed evenly without affecting the audiences' comfort.

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Safdie Architects

Kansas City

Kauffman Center for the Performing Arts

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INTRODUCTION

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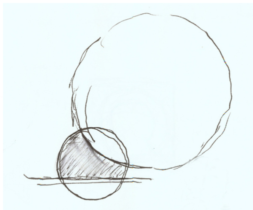
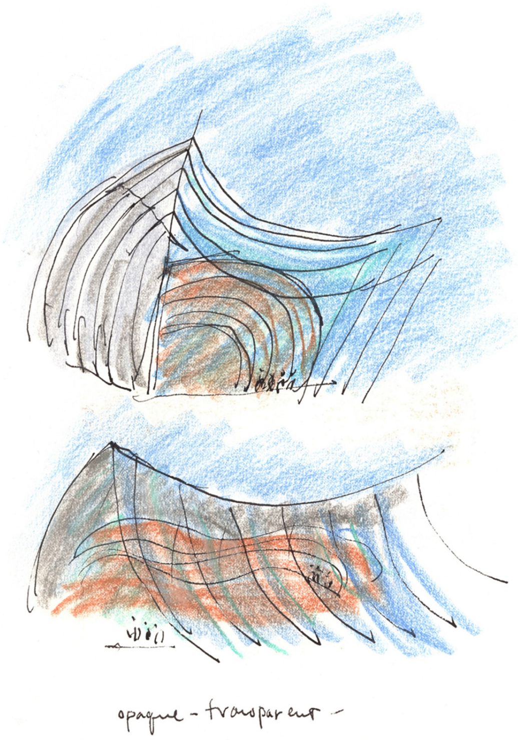
MOSHE SAFDIE

Moshe Safdie is an architect, urban planner, educator, theorist, and author. Over a 50-year career, Safdie has explored the essential principles of socially responsible design through a comprehensive and humane design philosophy. He is most identified with designing Marina Bay Sands and Jewel Changi Airport, as well as his debut project, Habitat 67.



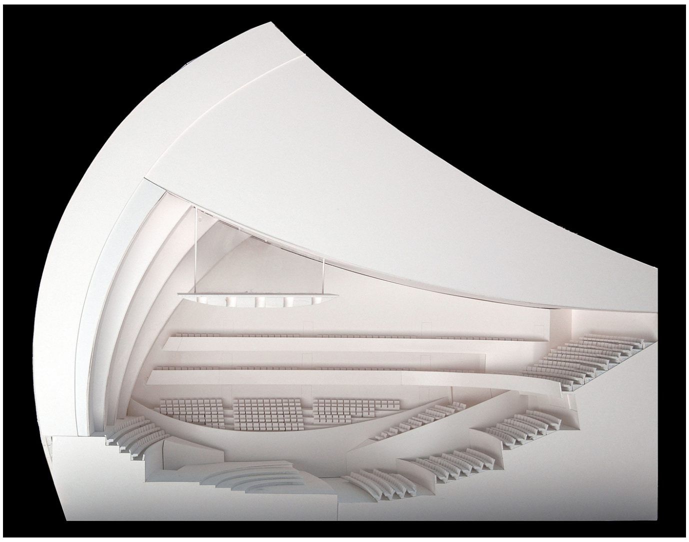


KAUFFMAN CENTER FOR THE PERFORMING ARTS

The Kauffman Center for the Performing Arts, a major new center for music, opera, theater, and dance, will open in downtown Kansas City, Missouri on September 16, 2011.

The Kauffman Center's two performance venues, Muriel Kauffman Theatre and Helzberg Hall, are two distinct structures, each existing in their own acoustical envelope and housed within a dramatic architectural shell.

In this case study we will be focusing Helzberg Hall and analyzing the acoustic properties.



ORTHOGRAPHIC DRAWINGS

Case Study 2

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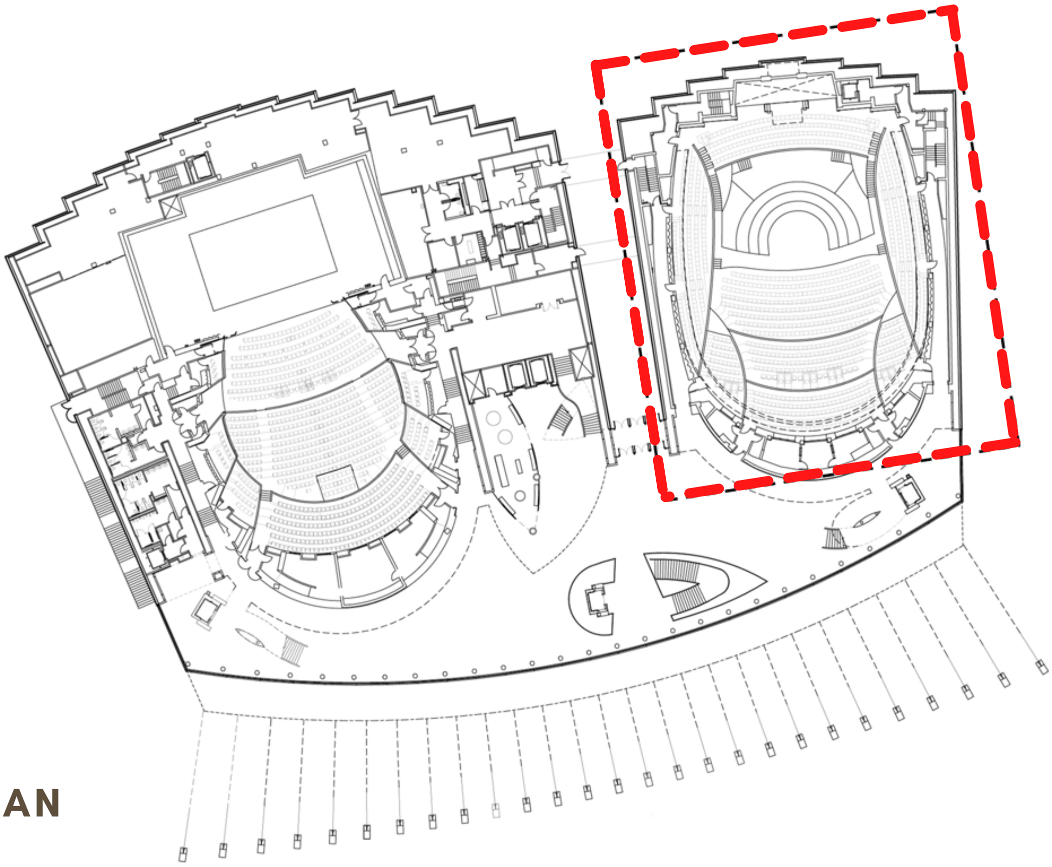
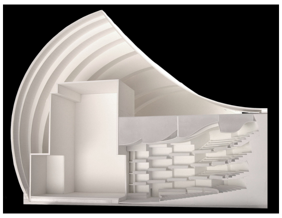
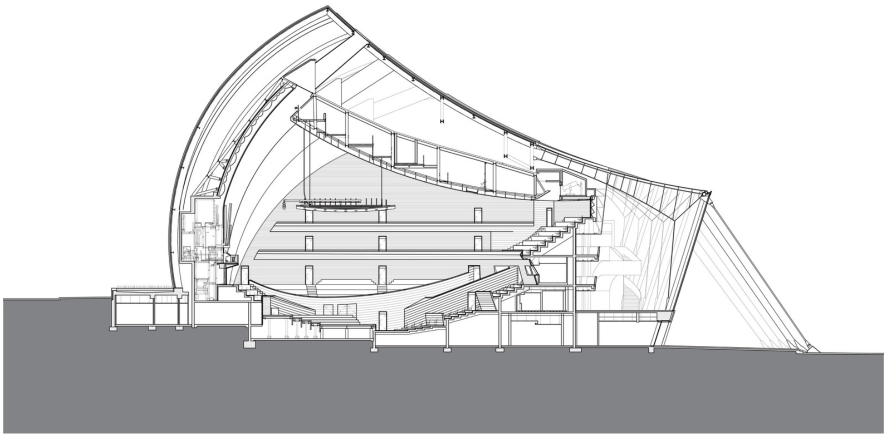


FLOOR PLAN

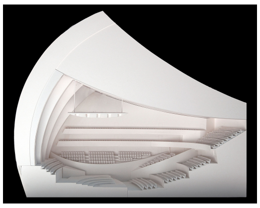
Scale 1:200

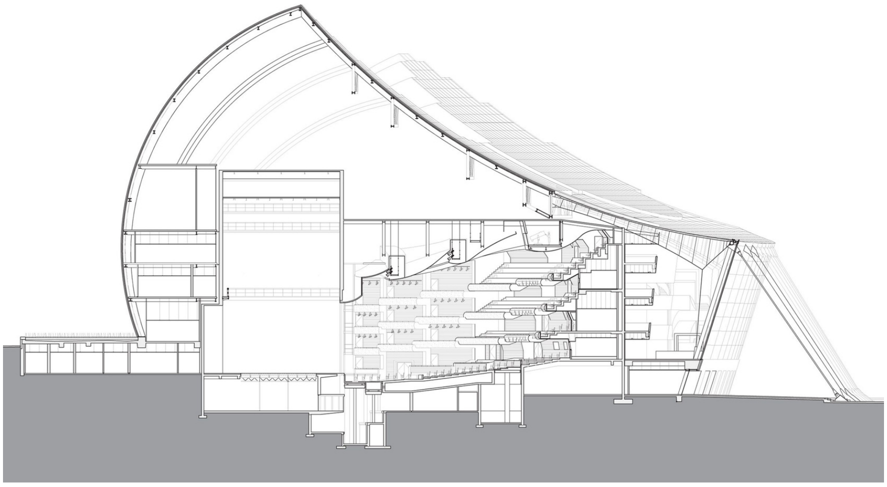




SECTION 1

Scale 1:100





SECTION 2

Scale 1:100

SEATING ARRANGEMENT

Case Study 2

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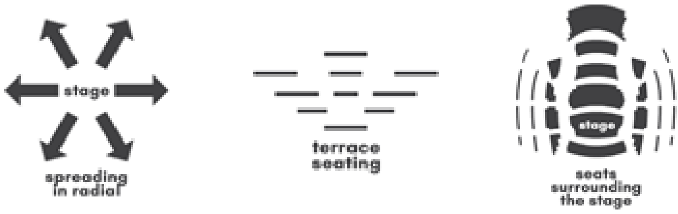
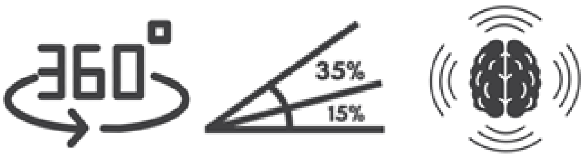
LAYOUT

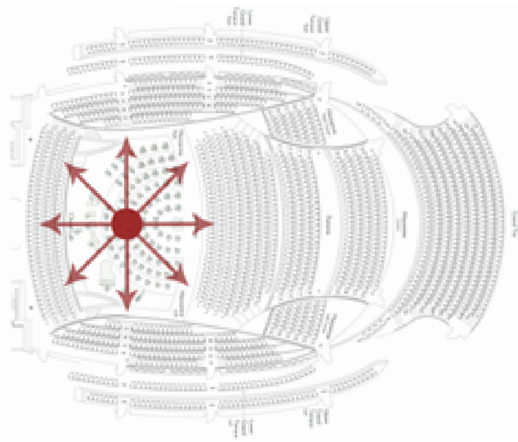


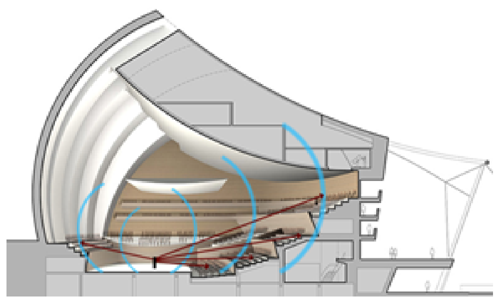
The Helzberg Hall was design in oval shape with vineyard style seating on four sides of the stage arrangement with the sub-division of seating placed in the terrace. The stage extends approximately one-third of the distance into the Hall, by placing 40% of seats alongside or behind the orchestra. As a result, the shape creates an intimate and immersive experience for both artists and audiences to experience the musician perspective during performance. The lower seating numbers are located closer to the center of the stage while the higher seat number placed further away from the center of the stage.

ANGLE & SEATING CAPACITY



The placement of seating are arranged in multidirectional layout which means every corner and angle of hall are surrounded with seating and allow comfortable vertical sightlines for audiences. Since the raked seating are designed with adjustable risers system on stage, the arrangement from lowest slope (near the stage) to highest slope, sound are able to travel all the way to the furthest back row of seating. The rake seating slope for hall are generally approx. 15 degree and maximum rake with steps are 35 degree to avoid positioning against the proscenium. This feature are visually interesting and the irregular pattern of seating allow to avoid acoustic issue such as echoes. The building can accommodate about 1,600 seats but generally the hall can accommodate about 520 audience and 80 orchestra band. The idea of envelope seats radially throughout the stage so that it can distribute the equivalent amount of acoustic quality from the stage to the final row of seats.





SELECTION OF MATERIAL

Case Study 2

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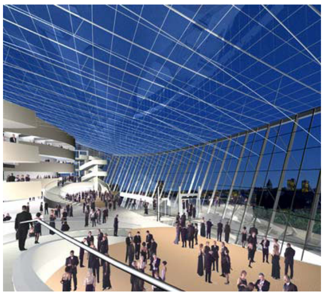
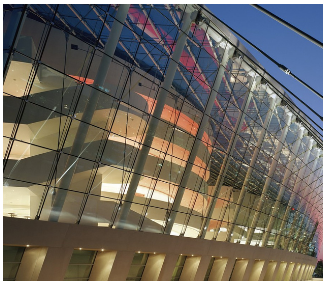
EXTERIOR

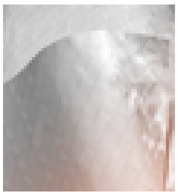





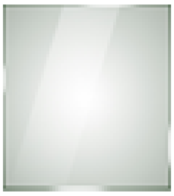
The building is constructed by structural dense concrete wall in curved shape with acit - etched finishes and stainless steel panel as a outer shell to act as a sound barrier to prevent the transmission of sound and vibration from the busy road to penetrate into the hall.

The glass panel enclosure is supported by a cable-supported glass system and steel column to reflects the sky and allow natural daylight in while in the night the glazing inverted so people can see the activities happened inside.Then, a glass atrium is in between the two hall to serve as circlation linkage which also supported by cable system and column free.

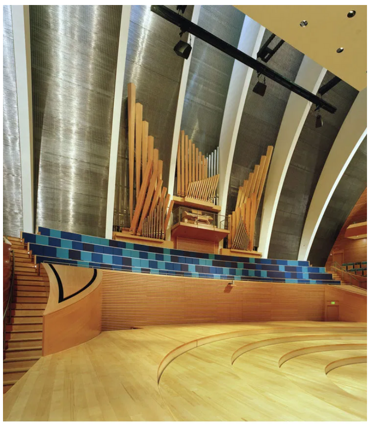

CONCRETE


STAINLESS STEEL REFLECTIVE ' PANEL

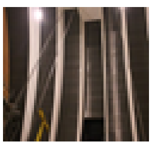

ACIT-ETCHED FINISHES


GLASS PANEL

INTERIOR

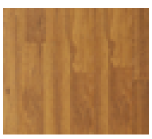



The concert hall employs wood as the main material to increase acoustic system.For instance, The wall is applying solid douglas fir panel with an absorptive layer inside to avoid the transmission of unwanted sound.Then, The floor are using 2 different wood material such as red oak for hall's flooring and alaskan yellow cedar for stage, both chosen for acoutics properties.The Alaskan yellow cedar flooring apply at the 6 lift riser system stage which will help to enhance the acoustics of the hall.The ceiling finishes applys sandblasting plaster for reflecting the sound. Semi cylindrical bump with transparent mesh were installed behind the wall so it will follow the curve shape to improve the acoustic.This wall panel creates high reflective surface which enhance the sound during musical concert.


TRANSPARENT MESH


OAK FLOORING

ALASKAN YELLOW CEDAR


SOLID DOUGLAS FIR PANEL


ABSORPTIVE FABRIC

SIZE AND VOLUME OF SPACE

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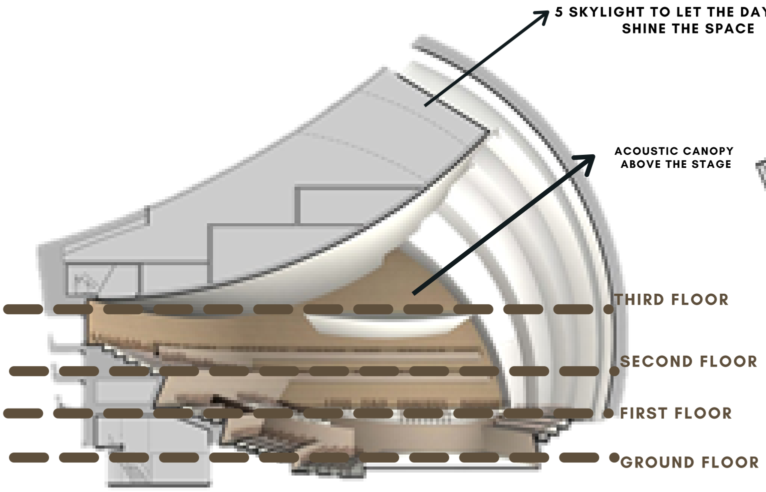
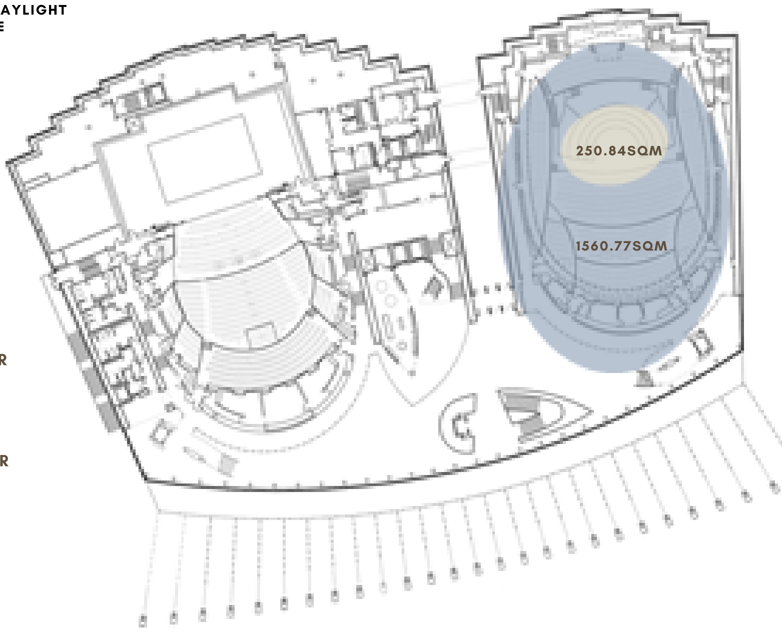
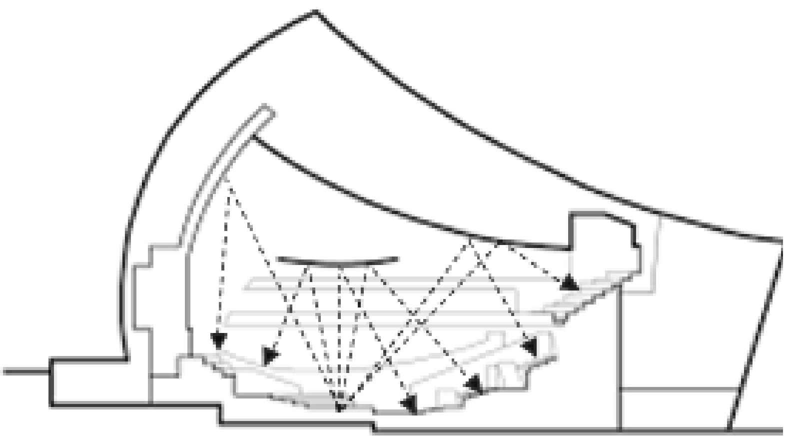
Case Study 2

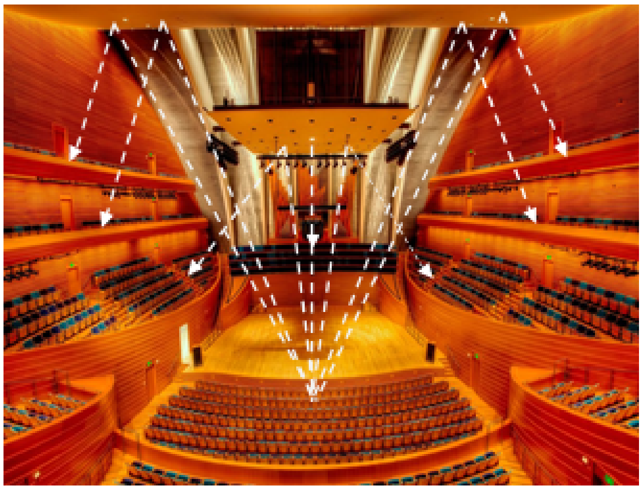




The Helzberg hall is a 4 level high volume concert hall in 19000m^3 with the area of 1560.77 sqm followed by 250.84sqm stage which include 6 lifts in the middle to act as the riser system for musical concert.Then,the large orchestra reflector is approximately 15m above stage while the highest point is 30m above the stage. There are 5 skylight in this hall to allow daylight to penetrate into the space and set an acoustic canopy above the stage to reflect the sound so this hall's reverberation time is longer .

SOUND PROPAGATION





There is a convex reflector placed above the stage which is also right in the middle.The reflector act as a reflective surface to reflect the sound to the seats at both side , middle and upper level.The convex ceiling also helps to reflect the sound to the side at all direction.

Volker Giencke

Liepaja, Latvia

Great Amber Concert Hall

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ARCHITECTURAL DRAWINGS

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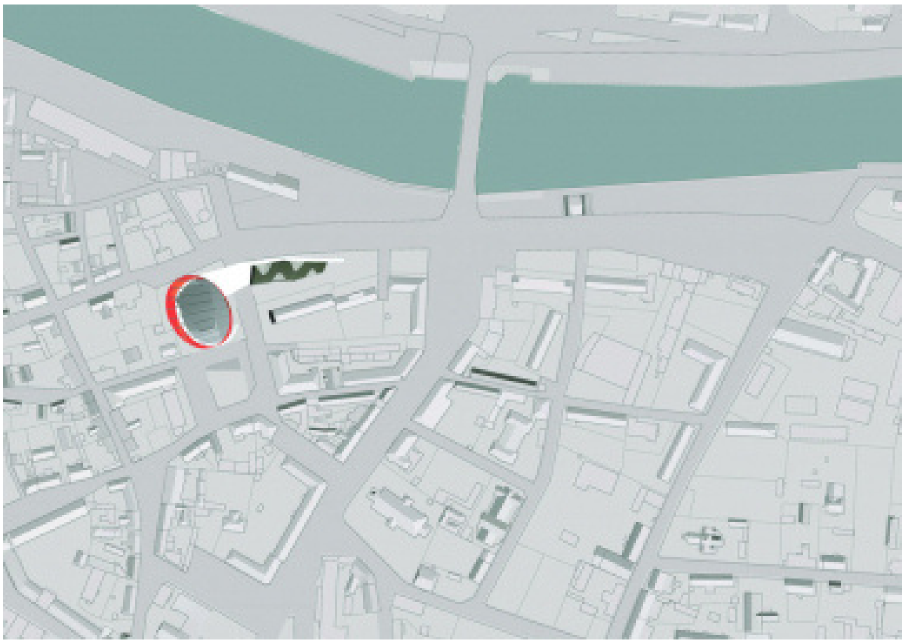
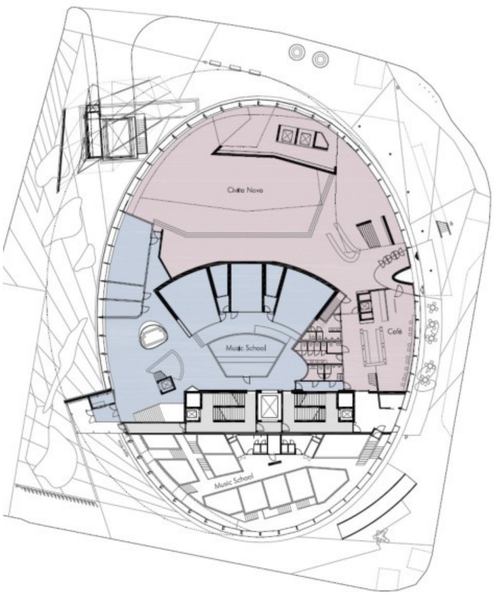
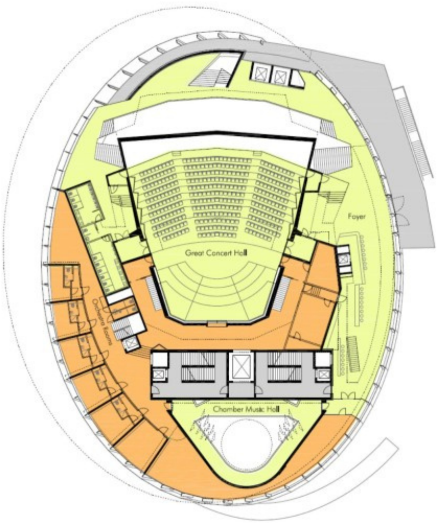


SITE PLAN

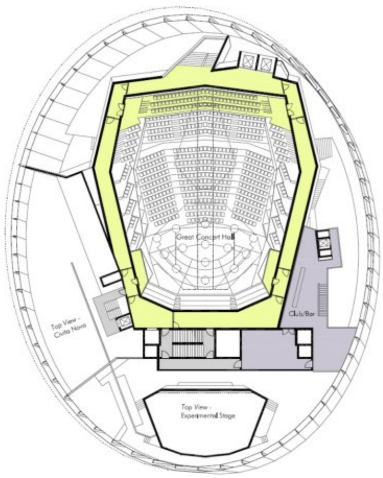
Not to Scale



GREAT AMBER - Ground Floor ±0.00



GREAT AMBER 2nd Floor +6.25



GREAT AMBER 6th Floor +18.90

FLOOR PLAN

Not to Scale

ARCHITECTURAL DRAWINGS

Case Study 3

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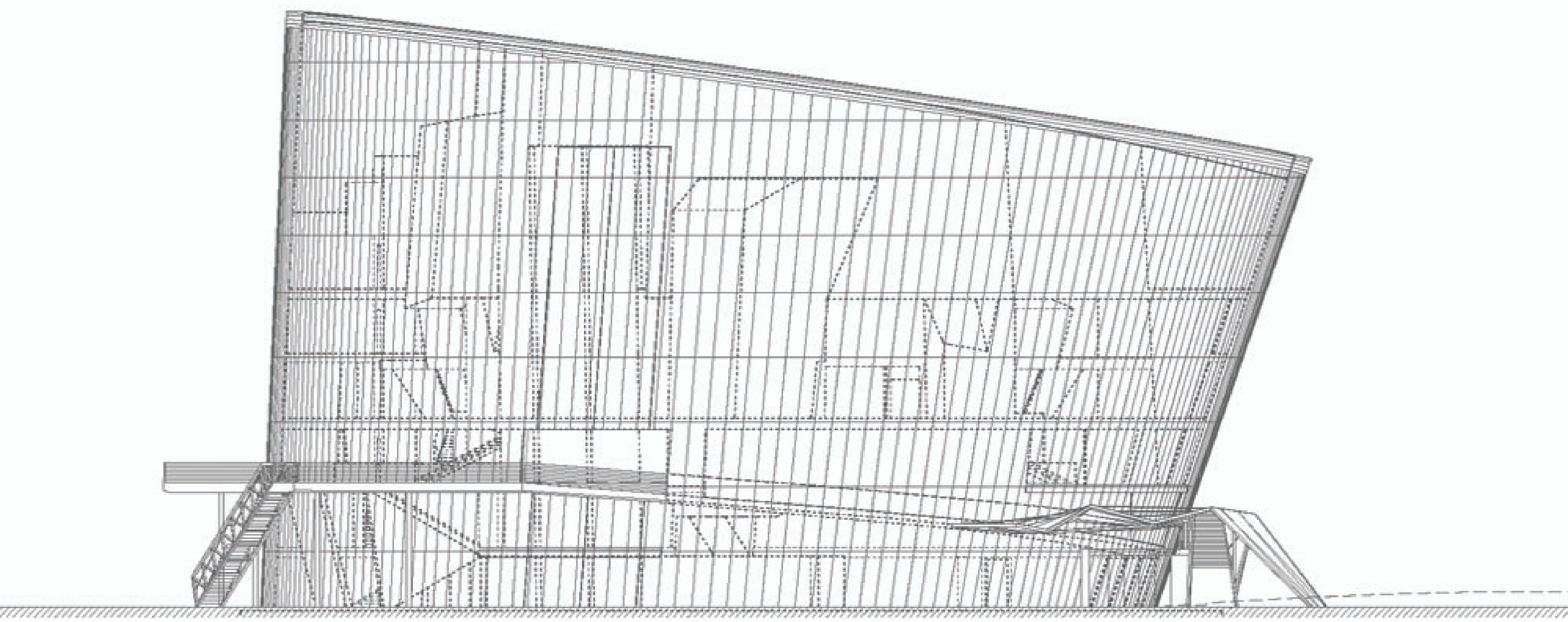
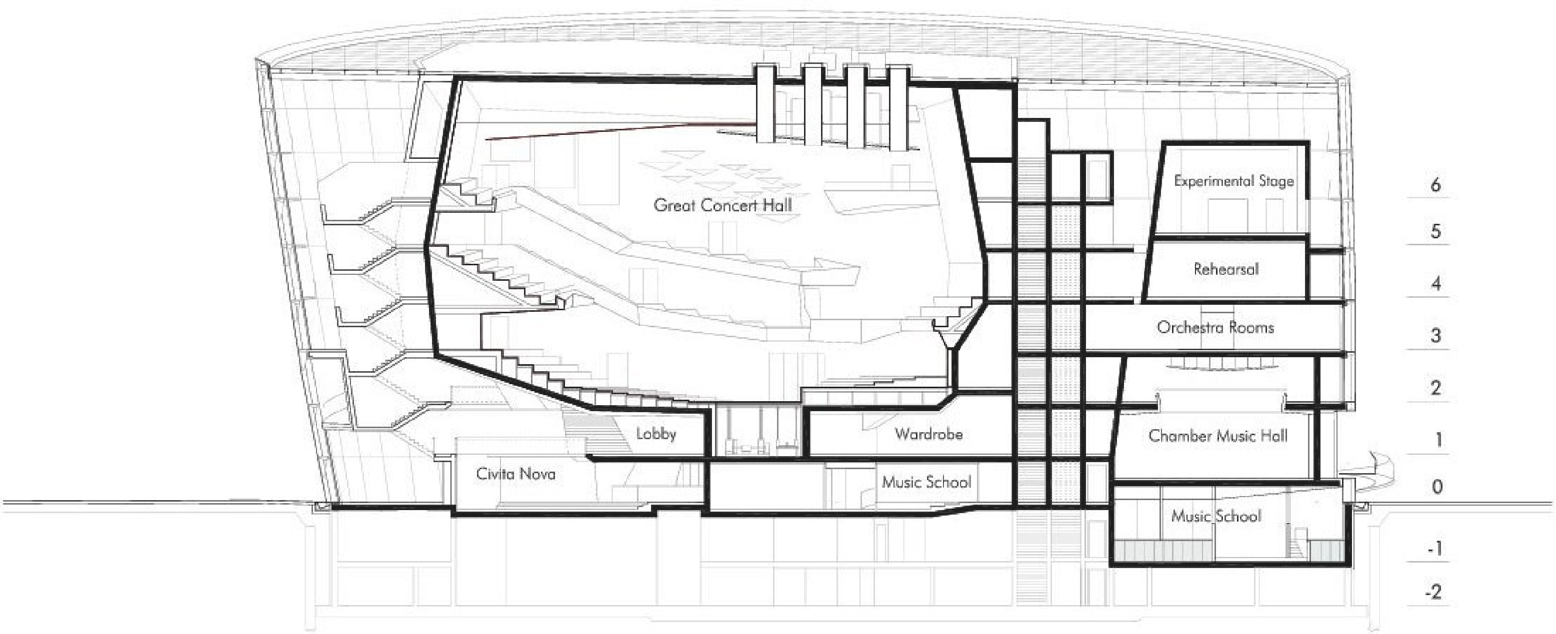
Ng Xin Ru 1001850447



NORTH ELEVATION

Not to Scale



SECTION

Not to Scale

LAYOUT & SEATING ARRANGEMENT

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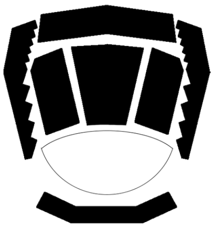
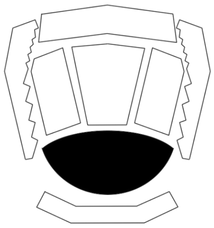
Ng Xin Ru 1001850447

1. LAYOUT

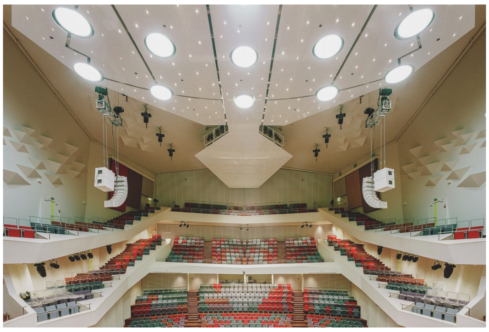


Circular concentric seating scheme



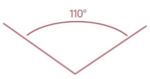
Circular projecting stage

Terraced vineyard pattern

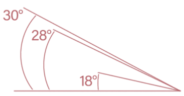


- Concentric seating is more efficient in auditoriums compared to straight linear seating and it gives a sense of belonging to visitors.
- Seating platforms towards the rear of the auditorium is being raised and each floor are stacked vertically above and behind the stalls.
- Its hall type, with the stage across one narrow end is excellent for music or performance where audience can be seated far away and a greater ratio of reverberant sound is desirable.

2. ANGLE & SEATING CAPACITY

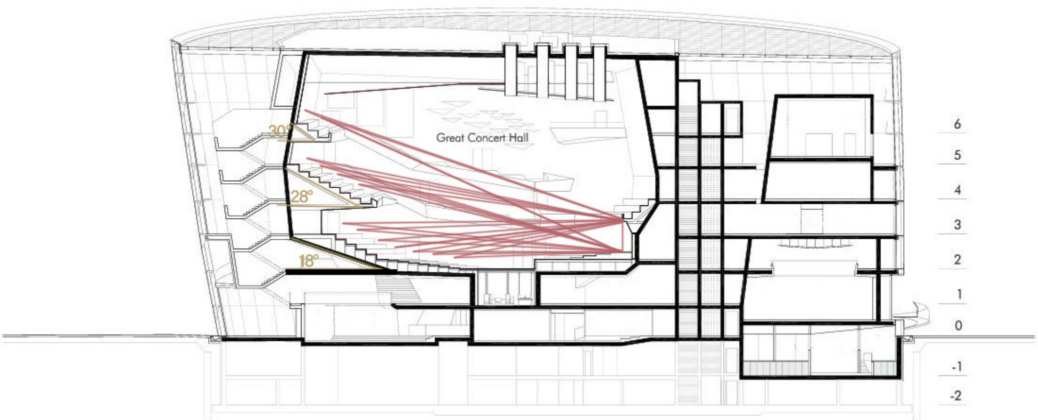


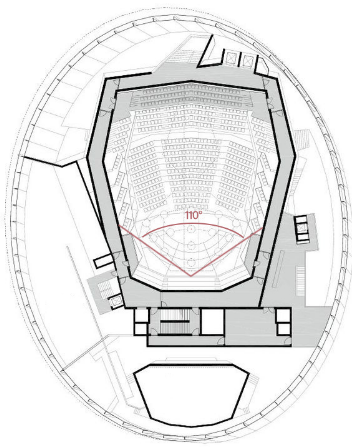
Viewing angle



Sitting slope angle

- The Grand Concert Hall providing seating for 1024 visitors.
- 110° viewing angle which allows all visitor in a concert hall can have good view on stage.
- The sitting slope angle is at 18°, 28°, and 30° respectively from lower to the top terrace which is within the 30° maximum seating slope angle for a comfortable view.





SELECTION OF MATERIAL

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1. Oak wood tongue and groove panels are placed on concrete sub-floor. Floor uses acoustic deck overlay system which helps in sound reduction for separating floors.

2. Upholstered seating with high resiliency polyurethane foam core covered with fabric cover. This helps in sound absorption and dampening sound.

3. Laminated noise-reducing gypsum wallboard is used in acoustic control. It is a single-panel product containing a viscoelastic polymer middle layer applied between two specifically formulated thin layers of gypsum board.

4. 14 aluminum reflective tubes with mirror finish which is mainly used for skylight penetration into Great Amber Concert Hall. Aluminum is a good sound reflector with its hard and dense characteristics while air gap within the aluminum tube is a good sound isolator.

5. Behind plastered covered concrete wall, it is covered with fabric. These sound absorbent curtains are used to reduce long natural reverberation times and together with permanently installed sound reinforcement systems, this type of sound absorption ensures very good speech and consonant intelligibility in both halls.

SELECTION OF MATERIAL

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6. Steel railing has only little effect on sound performance due to its small area but it is a sound reflector.

7. Pyramid shaped acoustic plasterboard is used to increase surface area for sound absorption.

8. Laminated noise-reducing gypsum board is used in acoustic control. It is a single-panel product containing a viscoelastic polymer middle layer applied between two specifically formulated thin layers of gypsum board.

9. Wood veneer solid-core door with high density than baffles the sound with door seal.

SIZE AND VOLUME OF SPACE

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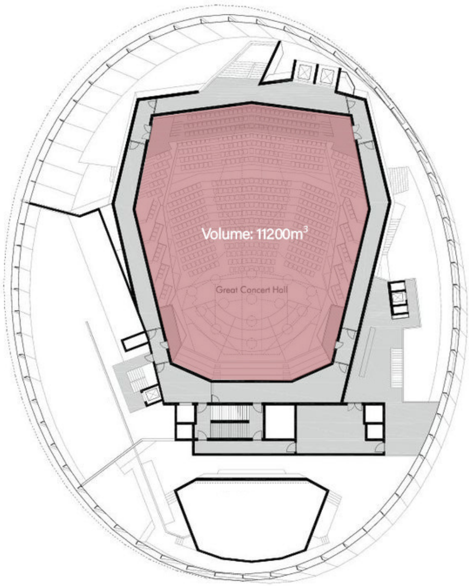
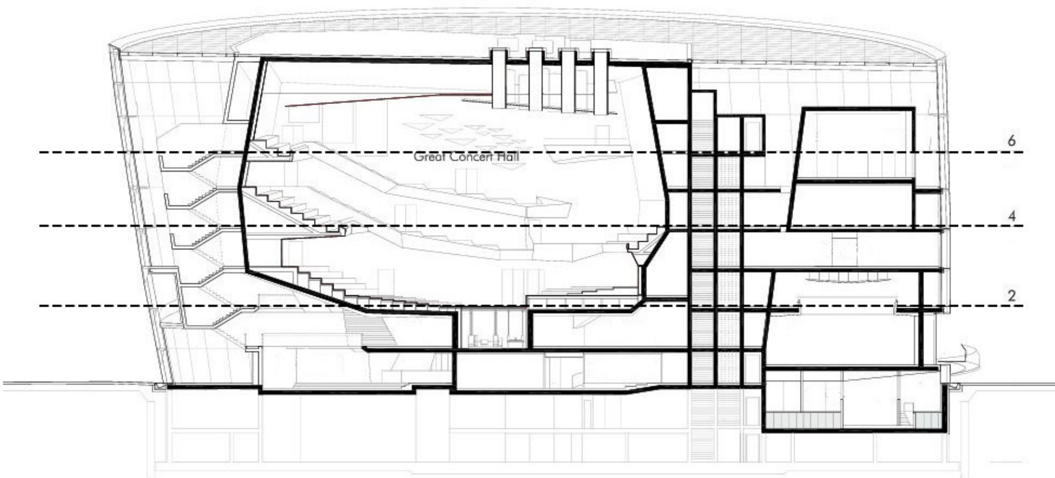
Ng Xin Ru 1001850447

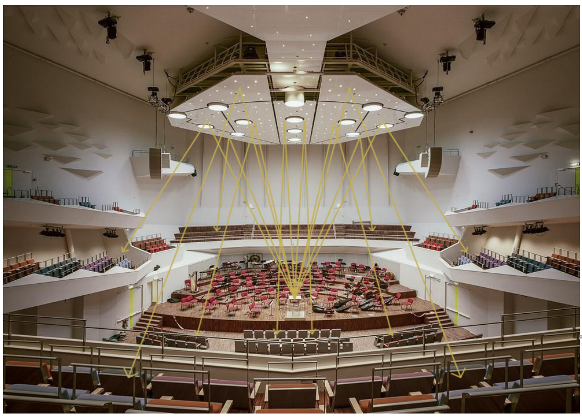
1. VOLUME OF SPACE

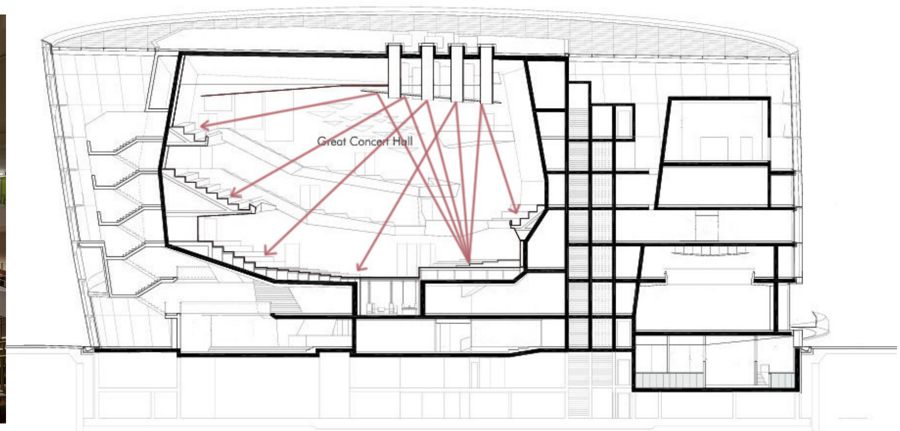




The Grand Concert Hall has a seating capacity of over 1,000. Its acoustically effective volume is around 11,200 m^3. It consists of three floors of the terrace to maximize the seat available for visitors. When the hall and the orchestra podium are fully occupied, reverberation time still reaches 1.8 to 2.0 seconds, increasing again towards the lower frequencies, thus lending the necessary warmth to the sound.

2. SOUND PROPAGATION





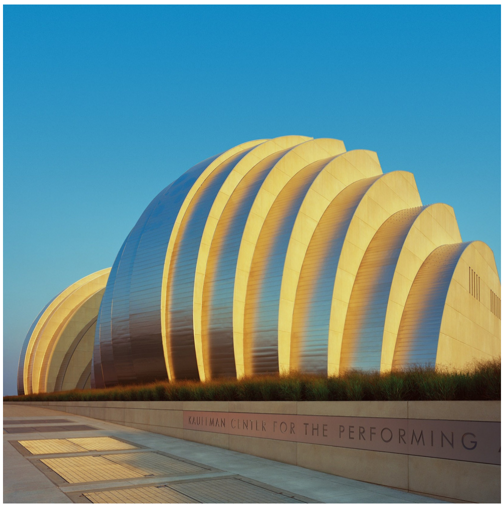
Perfect conditions for classical concert performances. With its tiers and balconies, the form of the hall follows the classic terraced vineyard pattern, thus enabling intimate proximity to the artists on the podium while everyone in the auditorium still enjoys the full spatial acoustics, no matter where they sit. Filigree decorative elements on the ceilings and walls effect a diffuse blend of acoustics for well-balanced sound quality without excessive clarity.

SUMMARY

Case Study 01

Flat-Pack Auditorium L'Aquila , Italy

The Flat- Pack Auditorium has a traditional seating layout and seating angle provide good experience to spectators. The hall is equipped with various sound proofing technology and material both externally and internally. The external wood is highly insulated to prevent noise entry from outside. The architect's choice of materials are not only relevant to the site but also serve the function and the aesthetic purposes. One down side of this auditorium is the arrangement of seating, it might not be suitable to place the 48 seats. It can be better if the panels are designed in concave shape and when it is reflected to the flat panels, sound can be diffused a little to lessen hearing burden.



Case Study 02

Kauffman Center for the Performing Arts
(Helzberg Hall)

From chamber music to full orchestra, from jazz and pop to lectures and recitals, Helzberg Hall will be the performance home of the Kansas City Symphony as well as host to renowned international soloists and ensembles. The 1,600-seat venue is oval in shape, with a vineyard-style seating configuration. The stage extends approximately one-third of the distance into the Hall, thus placing 40 percent of the seats alongside or behind the orchestra. This creates an intimate and immersive experience for both artists and audiences and allows a portion of the audience to experience the musician's perspective during performance. The distance from the stage to Helzberg Hall's farthest seat is just over 100 feet.

Case Study 03

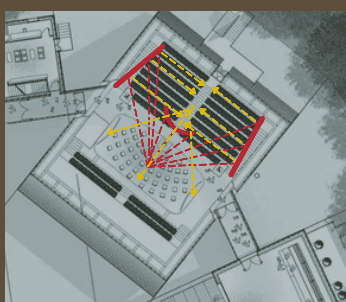
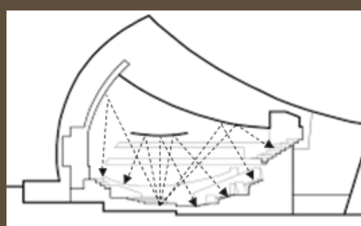
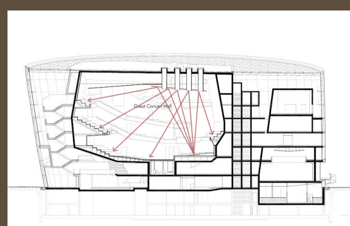
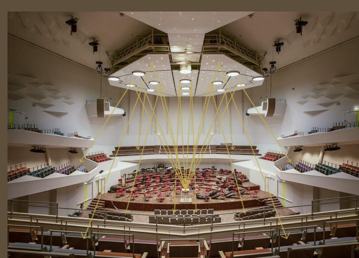
Great Amber Concert Hall Liepāja, Latvia

Great Amber Concert Hall is an icon in the city which has 1024 seat available for various events like concert, performance and talk. Advance daylight technology allows the concert can be light up by daylight during day time. Thick concrete wall as the barrier in between the concert hall and outside and acoustic wall and panel in the concert hall provides best acoustic experience in the region. The exterior facade clad with amber colour glass on a steel frame which makes it stand out in the city.

TABULATION

	Flat Pack Auditorium Case Study 01	**Kauffman Center for the Performing Arts** Case Study 02	Case Study 03
SEATING ARRANGEMENT	Linear seating arrangement with tiers going up. **Pros**: • More preferable to smaller space • Simplest traditional rectangular space **Cons**: • Lesser seating capacity	Design with oval shape with vineyard seating arrangement with sub-division in terrace. **Pros**: • Closer to the center of stage • Higher seating capacity **Cons**: • Complexity of seating arrangement	Design in circular concentric sitting scheme and terrace vineyard pattern. **Pros**: • Every seat focus on centre point • Higher seating capacity **Cons**: • Complexity of seating arrangement
ANGLE OF SEAT	30° Seating angle **Pros**: • Provide a good view without any body movement • Good relationship between occupants and performer • Directly distributed view **Cons**: • Lesser seating capacity • Comparing to 60°, making it less efficient	15° to 35° Seating angle **Pros**: • Provide comfortable vertical sightlines. • Multidirectional layout • Every angle of seating provide direct distributed view • Angle of view are 360° **Cons**: • Irregular angle pattern of seating	18°, 28° and 30° Seating angle **Pros**: • Provide comfortable performance view for visitors. • Every seat provide direct view. **Cons**: • Difference entrance needed • Irregular angle pattern of seating
MATERIAL **EXTERIOR** **INTERIOR**	Choices of materials relate not only to the site context but also aesthetic purposes and functionality. Wide range of meterials used for the interior space as well to perform better experience and comfortability,	Choices of materials provide better acoustic to improve the sound quality such as the stainless steel reflective panel that act as an outer shell helps to prevent the transmission of busy road's sound at the same time decrease the vibration too.	Choices of materials has efficiently reflect and absorb the sound which results in a better acoustic quality. For example, its special feature of triangular shape has enabled sound to be widely and evenly distributed.

TABULATION

	Case Study 01	Case Study 02	Case Study 03
VOLUME	18.93m2 that accomodate lesser amount of people The architect designed the other features based on the volume such as the seating arrangement, angle and etc. **Cons**: • Spaces are cramp hence affect the comfortability of occupants	Concert hall with the volume of $19000m^3$. The area of concert hall is 1560.77 sqm followed by 250.84sqm stage which include 6 lifts in the middle to act as the riser system for musical concert. **Cons:** Reverberation time will be more as the chosen material have better acoustic	Concert hall with volume of $11200m^3$ and have reverberation time 1.8 to 2.0 seconds while fully occupied. **Cons:** • Reverberation time will be more if lesser visitors.
SEATING CAPACITY	238 - Occupants 40 - Musicians **Pros** : • Smaller crowd to enjoy the performance • Lesser noise , obstruction	1520 - Occupants 80 - Orchestra Band **Pros** : • Wide range of seating provided for both audience and band.	1024 - Occupants 50 - Orchestra band **Pros**: • Many sittings for visitors and thus increase sound absorption by visitors. **Cons:** Longer reverberation time if less visitors in hall.
SOUND PROPAGATION	 	 	 

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Case Study 2-Kauffman Centre for the Performing Arts(Helzberg Hall)

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Case Study 3 Flat-Pack Auditorium

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1 Individual Part

Fan Auditorium

Teh Yong Peng 1001954491

FORM AND LAYOUT DESIGN

Teh Yong Peng 1001954491

Fan Auditorium

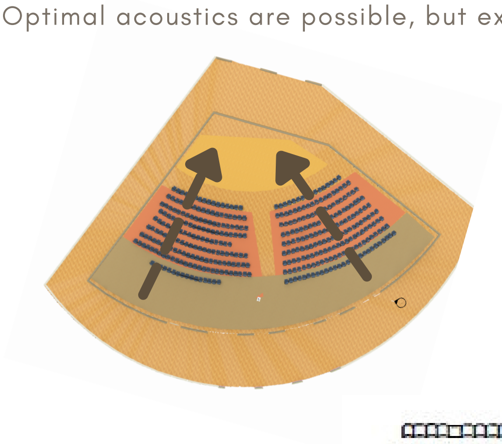
Form

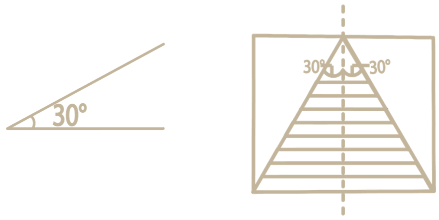
Circle/arc form

Fan-shaped plan

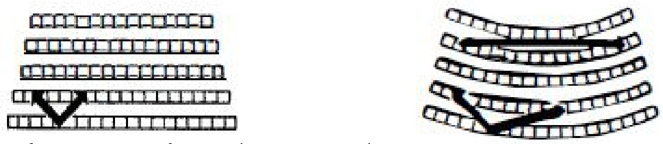
Good view, good direct sound transfer Acoustic disadvantages due to fan-shaped opening of hall

Optimal acoustics are possible, but expensive to create .

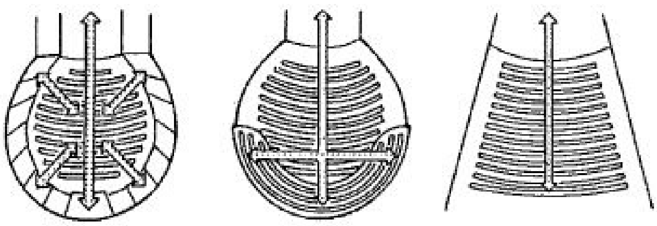




Good view, without moving head, but light eye movements of approx. 30°.

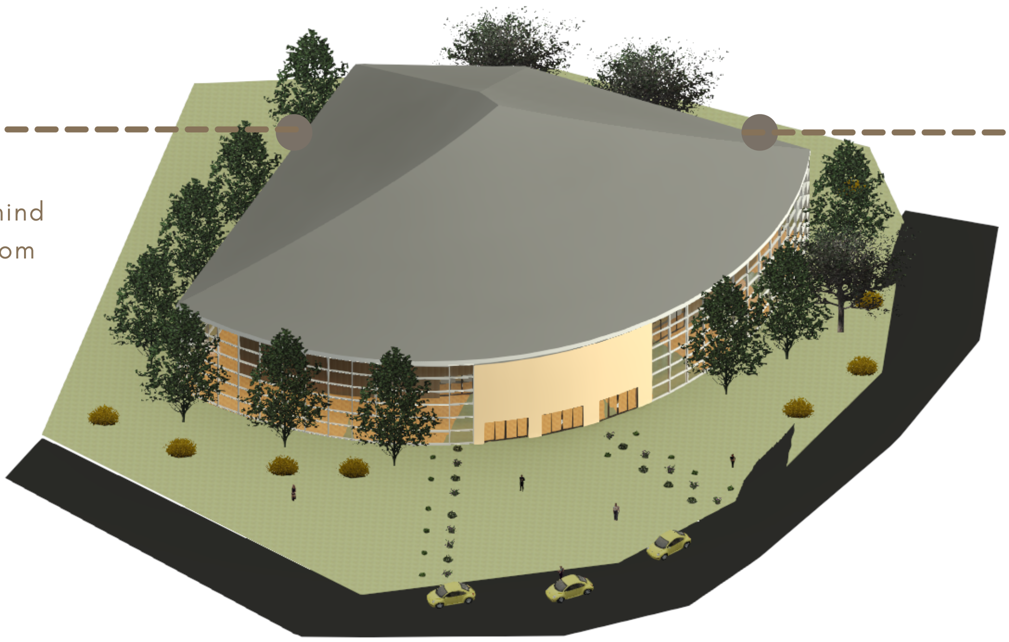


feeling of integration {mutual perception)



Contact relationship between the audience and the stage and with each other

Rows of spectators positioned in arcs, not only for better alignment toward the stage, but also to achieve a better perception of each other (security effect).



Stage at the behind prevent noise from the road

Curtain wall and have corridor in between to reduce noise from exterior act as a buffer.

FORM AND LAYOUT DESIGN

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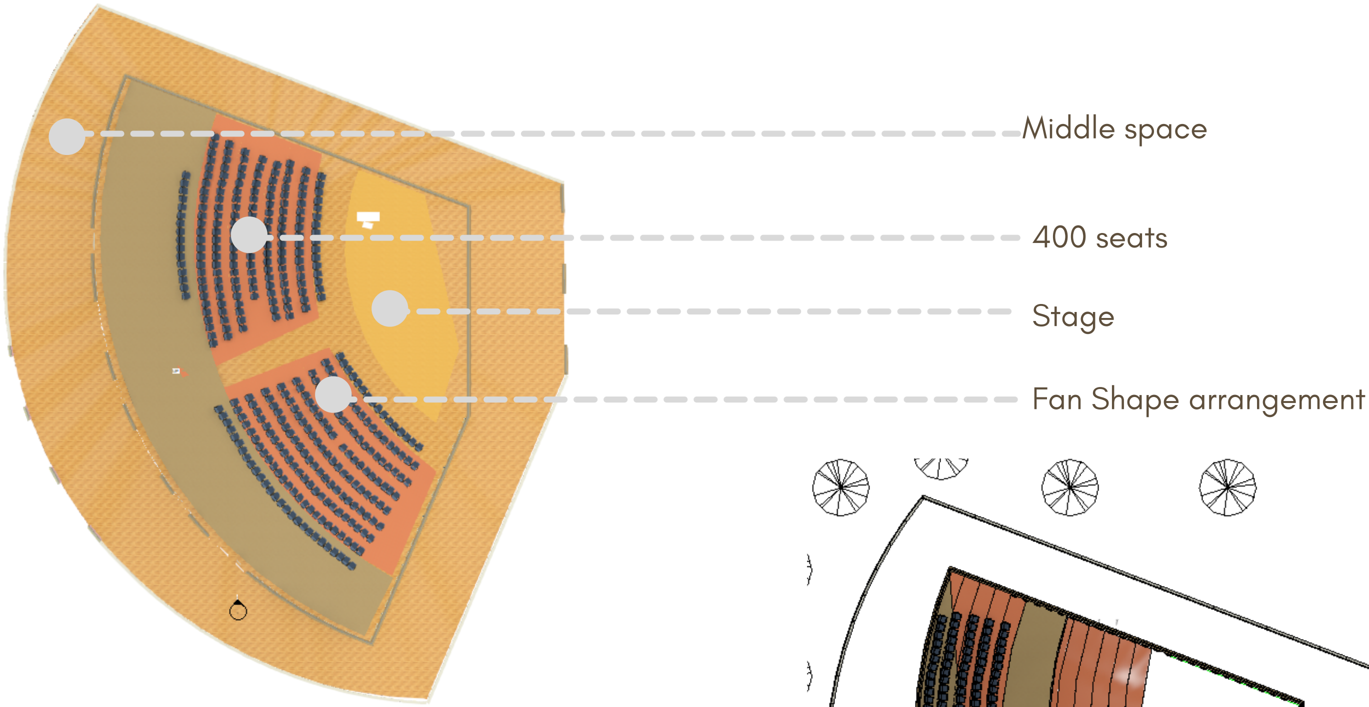
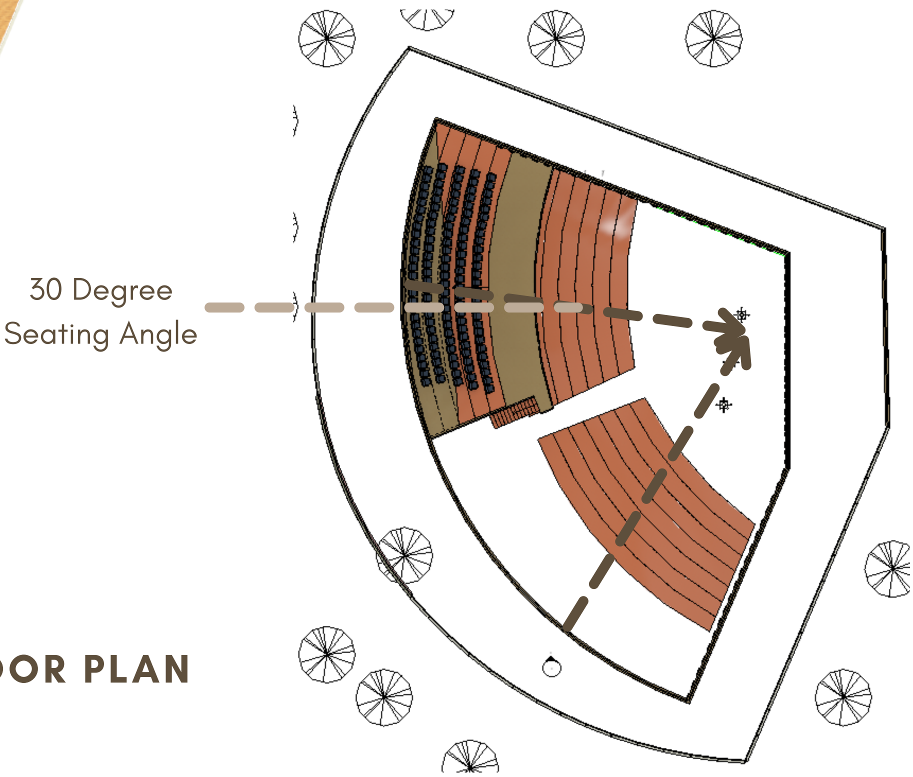
Fan Auditorium



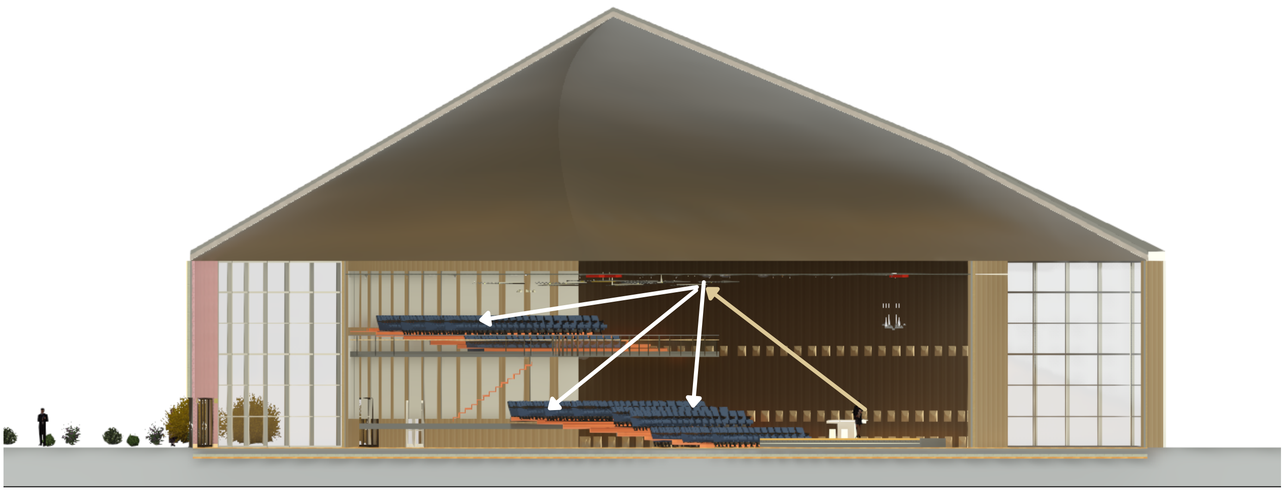
GROUND FLOOR PLAN

Scale 1:500



MEZZANINE FLOOR PLAN

Scale 1:500



LONG SECTION

Scale 1:500

FORM AND LAYOUT DESIGN

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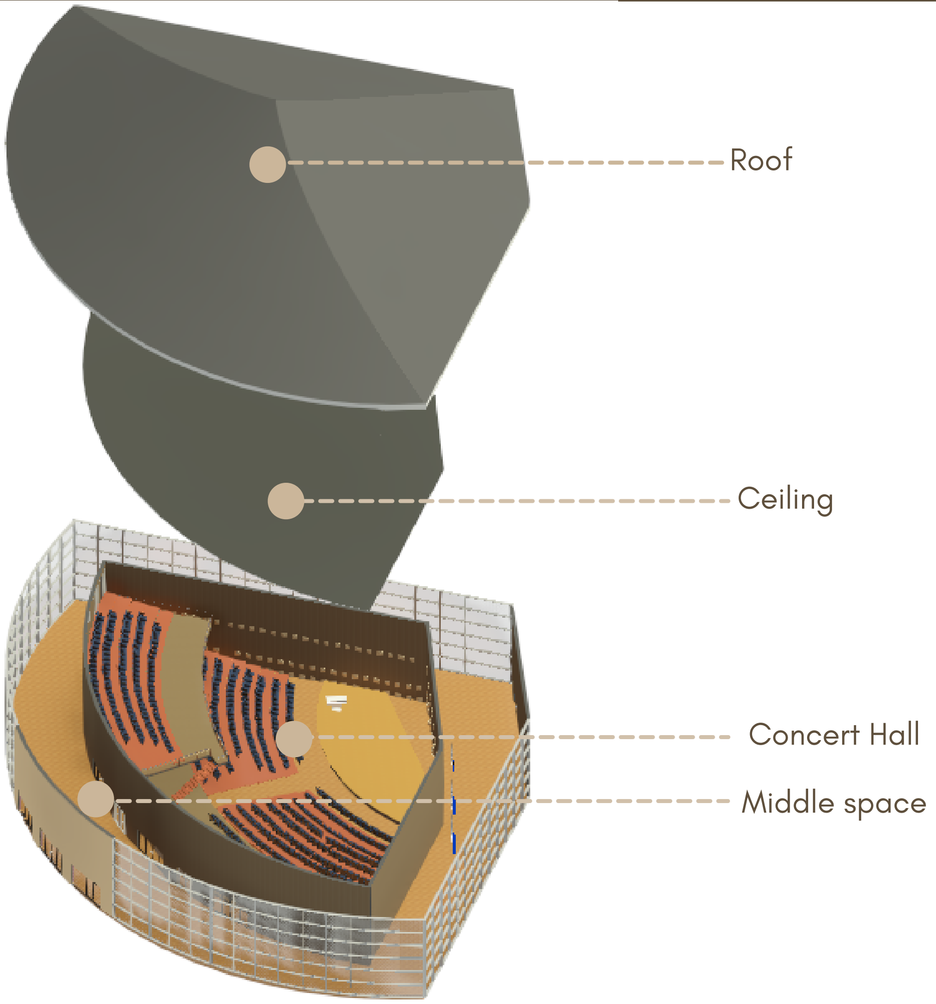
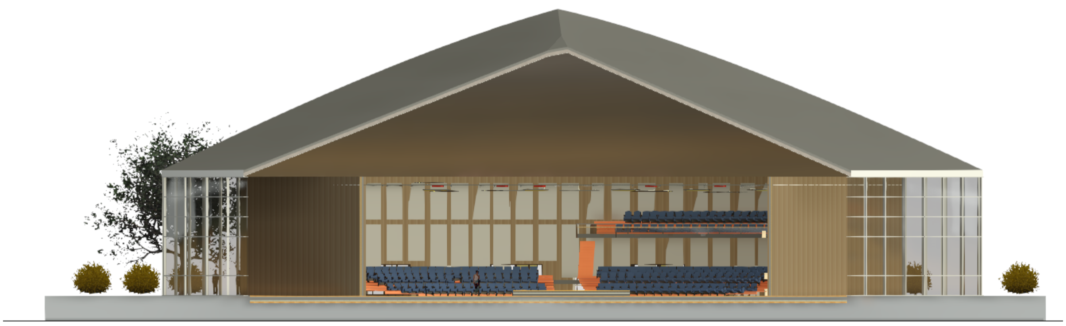
Fan Auditorium



EXPLODED AXONOMETRIC

Scale 1:Nts



SHORT SECTION

Scale 1:500

RATIONAL BEHIND MATERIAL SELECTION

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MATERIAL SELECTION

Ceiling

Suspended ceilings

Complex consisting of a core of high density rockwool sandwiched between 2 panels of PEFC certified wood wool (1 mm wide fiber). Combine low thickness (50 mm max) and high acoustic performance. Implementation suspended ceilings with exposed.

Wall

Wood Sheating , Chipboard

The major advantage of selecting particle board is that it is a cost-effective option against plywood or medium density fiberboards. Laminated particle boards and veneered particle boards provide decorative looks in low price as compared to plywood. Particle boards have thermo-acoustic insulation properties, so they are very much useful in speakers and in false ceiling of auditoriums, theaters.

Stage flooring   Stair flooring

8 mm plywood   Oak wood

Plywood and wood fibre acoustic products are used in theatres and auditoriums to provide low-frequency reverberation control. Timber acoustic paneling will often use holes or slots to increase the amount of sound absorption, essentially breaking up the energy of the soundwave. By breaking up the sound, the echoes are reduced.

Chair

Fabric

Fabric cushion chair uses high quality Owens Corning fiber glass acoustic cotton and sound absorbing fabric, it has environmental protection, fire retardant, wide range sound frequency absorption, good decoration, easy installation, no dust pollution.

CALCULATION OF REVERBERATION TIME

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Fan Auditorium

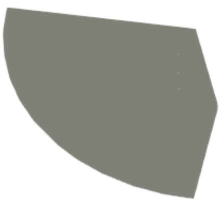
Formula:
RT = 0.16 V/A (METRIC UNITS)
Where
- RT= reverberation time in seconds
- V= volume in cubic meters
- A= total absorption in square meter

(sum of room surfaces times their sound absorption coefficients plus the sound absorption provided by furnishings or audience, etc)

Total Absorption(A)= Area x absorption coefficient

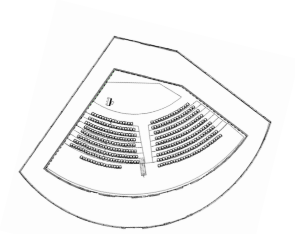
Material	Area (m2)	Absorption Coefficient (500 Hz)	Total Absorption
Timber	875	0.7	612.5
Wood Sheating	740	0.7	518
Acoustic Panel	246	0.7	172.2
Rookwool ceiling	875	0.6	525
8 mm plywood	104	0.1	10.4
People	400	0.44	176
Total Absorption			2014.1

acoustic panel area= 246

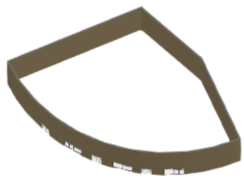


Rookwool ceiling = 875

8 mm plywood stage area=104



Timber floor area= 875



Wood Sheating wall area= 740

Using Sabines' Formula:
RT= 0.16V/ A
RT = 0.16 x (Volume of Exhibition Hall) / Total Absorption
RT = 0.16 x 7000/2014.1
RT = 0.556 sec

SOUND INTENSITY
SOUND LEVEL

Teh Yong Peng 1001954491

Concert Hall

Sound Intensity at main access

D1 = 10m, I1 = 9x10^-6 W/m^2

Assume that D2=20m where the entrance is 20m away from highway i2=?

d1=10m

i1=9x10^-6 W/m^2

d2=20m

$i2=d1^2xi1/d2^2$

$i2=10^2x9x10$^-6 $/20^2$

$=2.25x10$^-6 W/m^2

Sound Level

Assume the three sound sources in the interior space

$$SPL_{(total)} = 10\log_{10} \sum_{i=1}^{n} 10^{(SPL_i)/10}$$

Sound Source	Whisper	Piano	Orchestra
Sound Pressure Level (dB)	20	65	105
(SPLi)/10	2	6.5	10.5
10(SPLi)/10	100	3,162,278	3162277660
Σ10(SPLi)/10	100 + 3,162,278 + 3162277660 = 3165440038		
Log Σ10(SPLi)/10	Log Σ10 3,163,378 = 9.5		
10Log Σ10(SPLi)/10	95dB		

DESIGN STRATEGIES

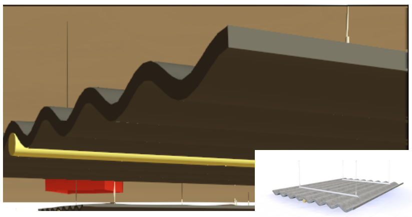
Teh Yong Peng 1001954491

Fan Auditorium

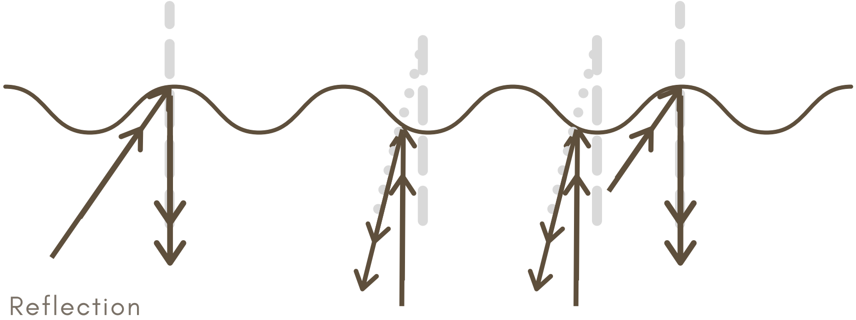
INTERIOR SOUND QUALITY OF CONCERT HALL

Interior

Scala ceiling



Polyester Fabric

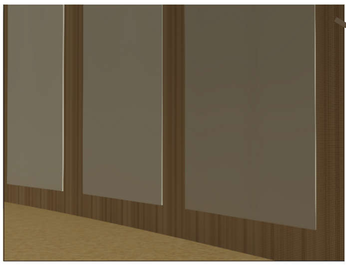


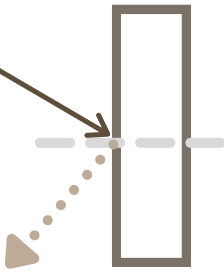
Reflection

The ceiling hung version of Scala prevents sound waves from continuing up in the room, contributing to a more pleasant acoustic landscape. This wavy shape produce a reflection of sound from the stage to all around the hall.

Acoustical Wall Panel

Echo Eliminator

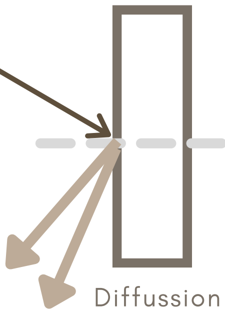




Absorption

This echo eliminator is a good acoustic panel to apply in concert hall. It can reduce the echo and absorb the excessive noise produce by the ochesrtra. The sound waves that hit on it get absorbed and they convert into low-intensity heat energy. The right amount of balance between absorption and reflection gives you a perfect sound setting in hall.

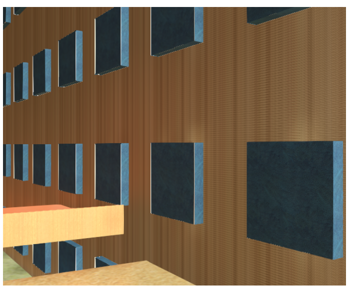
Acoustic Board

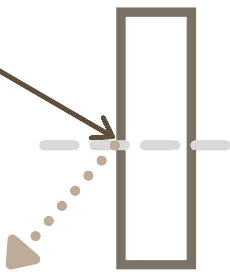


Diffusion

The walls of the concert hall are installed with diffusion panels to treat sound aberrations, such as echoes, in rooms. They are an excellent alternative or complement to sound absorption because they do not remove sound energy, but can be used to effectively reduce distinct echoes and reflections while still leaving a live sounding space. This also help to increase the richness of sound and help create a sense of spaciousness.

Acoustic Board





Absorption

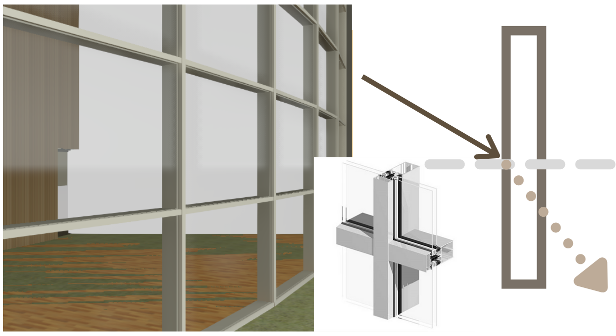
By installing absorbers in a space, the level of undesirable noise, in the form of echo and reverberation, is reduced improve sound quality. Noise is a relative term and can range from low levels of intrusive sound in a quiet environment to loud sounds in an already noisy environment. The risks posed to our health due to continuous exposure to loud sounds can be effectively eliminated with the help of these new age technologies.

NOISE PREVENTATION FROM OUTSIDE

Teh Yong Peng 1001954491

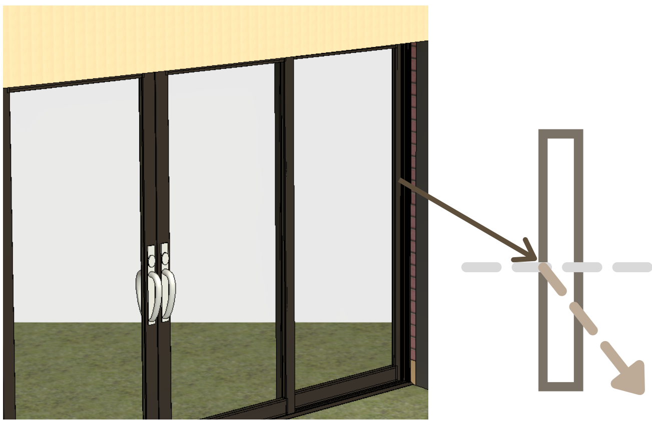
Fan Auditorium

Exterior



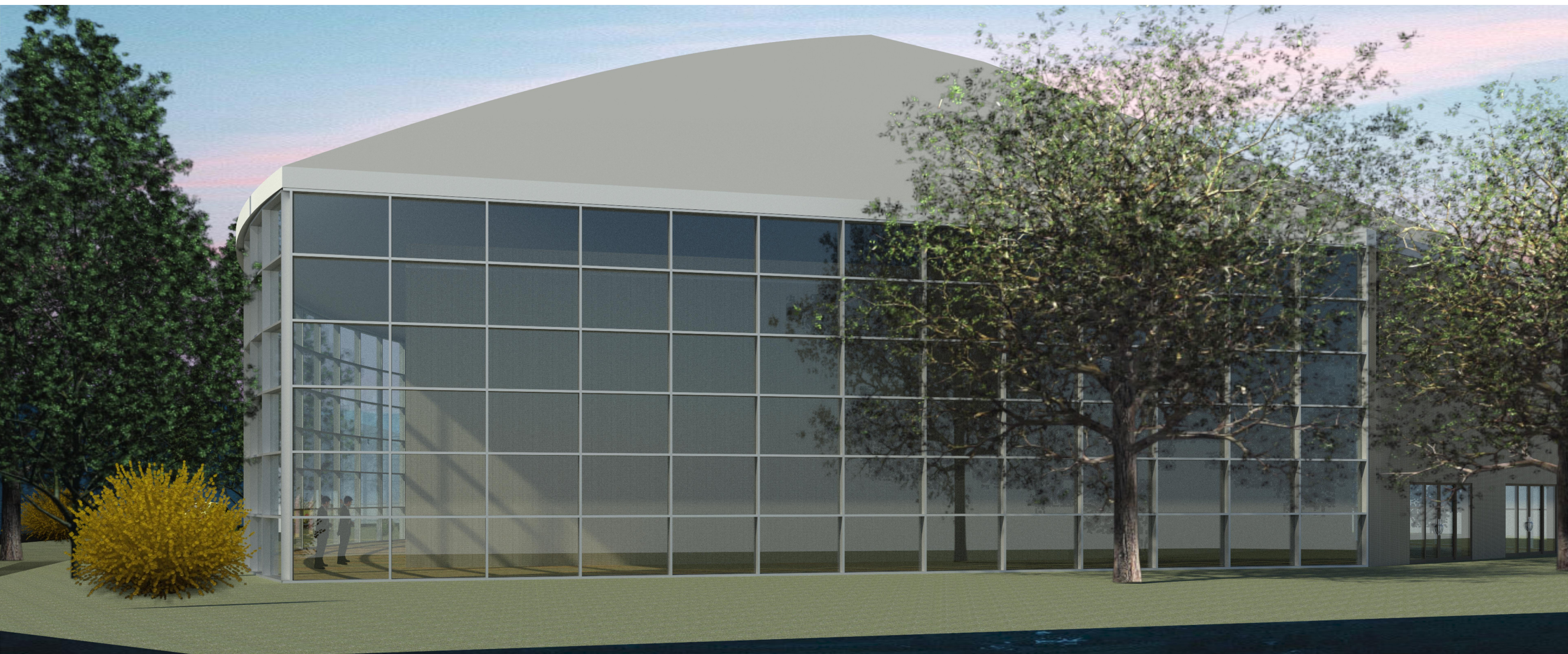
Technal_Curtain_Panel-Acoustic-Double_Glazed : 32mm Panel

Glass curtain walls for the outdoor of concert hall are increased in thickness and laminated with a tough transparent plastic which is both noise and shatter resistant. Glass reduces noise by the mass principle; that is, the thicker the glass, the more noise resistant it will be. They are sustainable, long-lasting and easily repurposed. They can incorporate illumination, acoustic optimization, and custom digital printing.
Quiet Natural Fiber Liner is used primarily as an acoustical liner designed for HVAC sheet metal ducts to absorb unwanted noise from multiple sources. Quiet Liner also reduces heat gain or loss. Quiet, the decrease of heat will reduced the loudness of sound.



Sliding Glass Doors -
Multi Track Sliding Glass Door

Solar's acoustical sliding glass door systems allow for a 1 3/8-inch insulated glazing unit and are a standout product in the industry because they combine enhanced acoustical performance. Acoustic doors are a great way to ensure that details can achieve anti-noise cancellation that totally block the sound from exterior. They also minimise the noise entering a room when quiet is essential. . In addition to reducing noise levels.



CONCLUSION REFERENCES

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Conclusion

In conclusion, I learned the knowledge about what is the standard requirement and the design strategic for a concert hall. The standard dimension of the corridor ,the distance between audience and the stage. Not only that the design strategies seating arrangement, angle of seating, volume of space , choice of materials will affect the experience in the concert hall. Using the suitable design strategies can reduce the echo and reverberation time in the hall, audiences will having a nice concert in this space.

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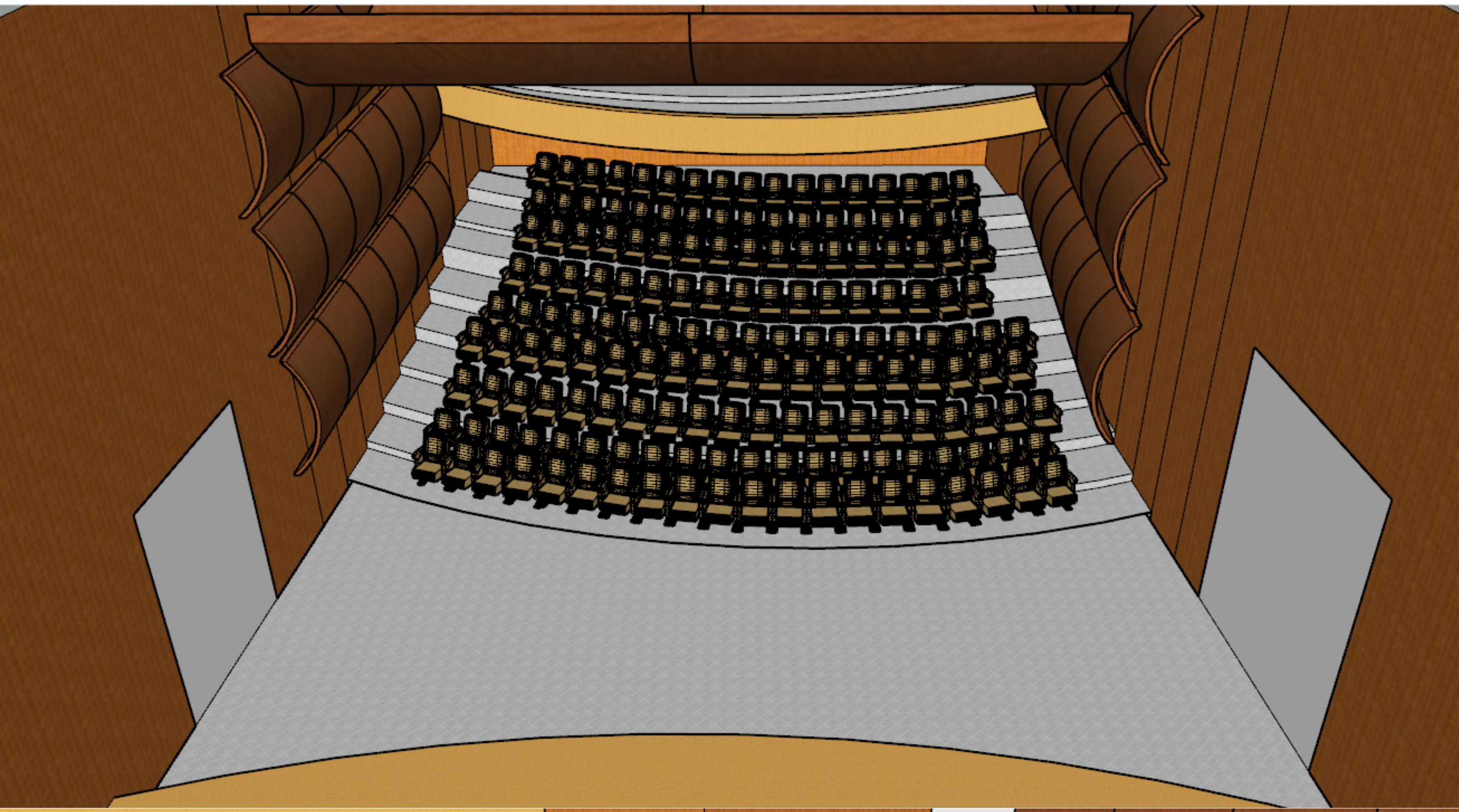
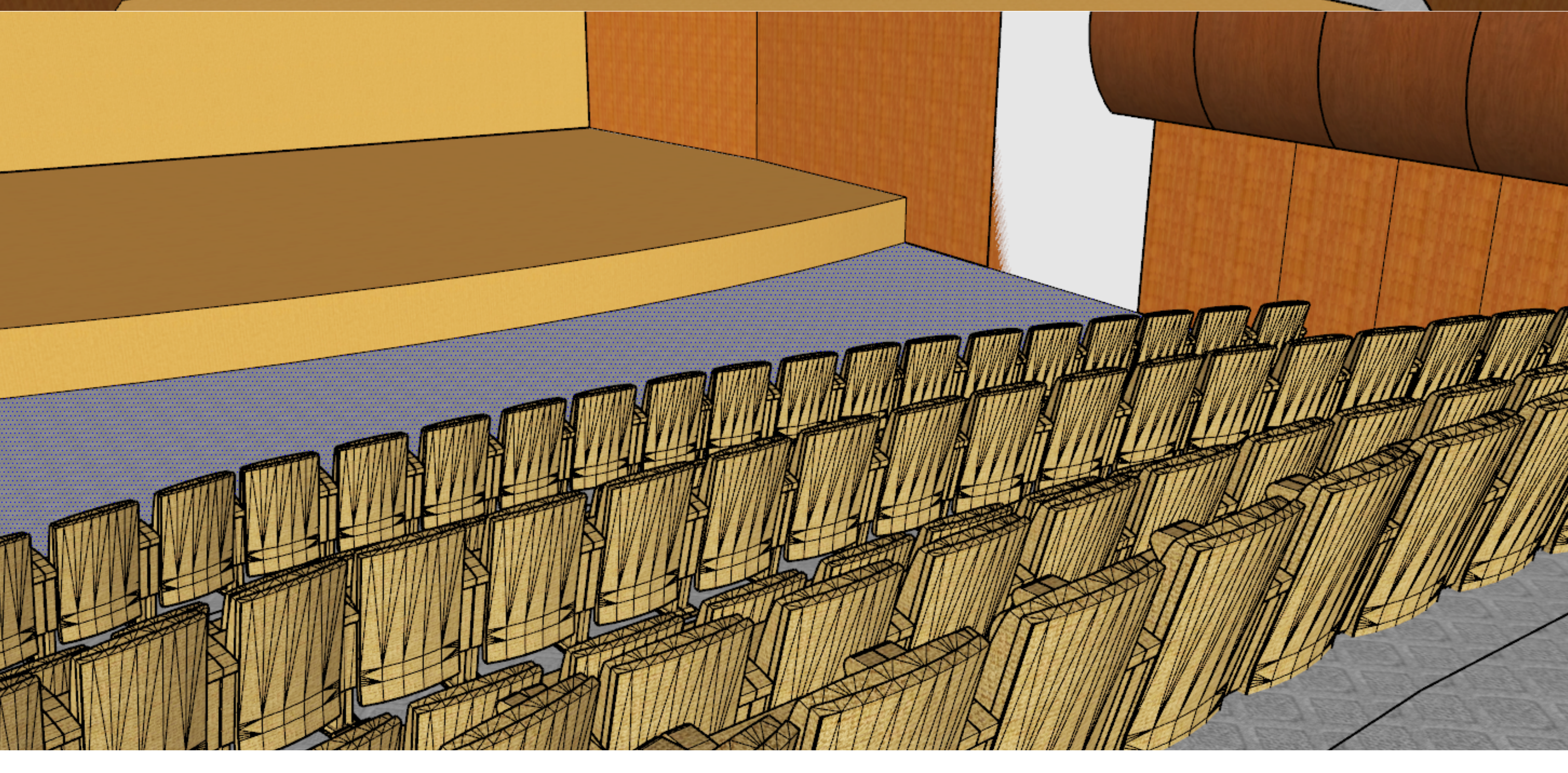
2

Individual Part

Concert Hall

Choo Pei Yan 1001955438





FORM AND LAYOUT DESIGN

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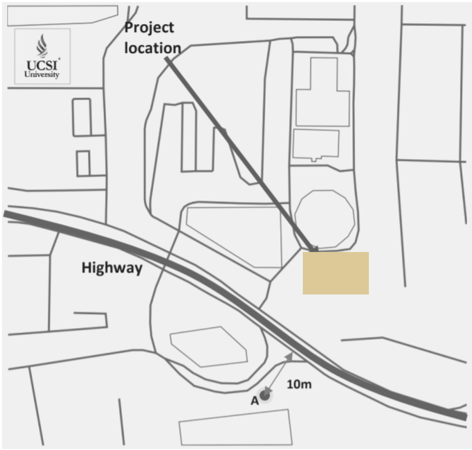
Concert Hall



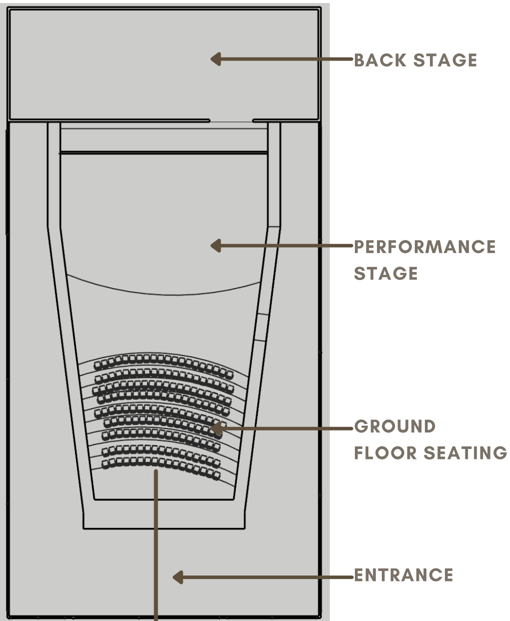
Given Site

The given site for this concert hall is located at UCSI University beside Block D. The neighboring context of this site include residential buildings and a highway which is under construction. Due to this factor, the design of the concert hall has to take full consideration of the acoustic parameters to achieve a good acoustic experience for the occupants.

Problems:

Noises from the busy traffic

Noises from the construction

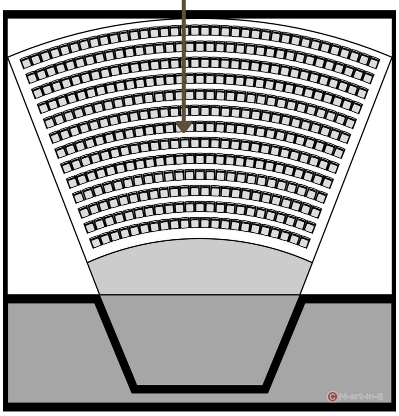


Form

The design proposal for this concert hall consists of ground level and mezzanine level. The ground level consists of 160 seats and the mezzanine level consist of 60 seats. A total of 220 occupants + 40 performers. (260ppl)

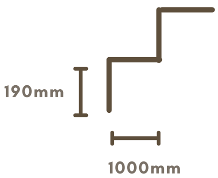
Fan-shaped layout

This layout can house a larger number of occupants while keeping a frontal view of the performers. The contact relationship between the audience and the stage and the with each other is clearer compared to a shoebox layout. On the other hand, the narrow end of the layout can benefit to the acoustic performance by reflecting back the sound to the occupants.

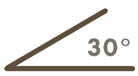


Arrangement and angle of seats

The seats are arranged in a curvilinear form with two aisles along the side. With the sloped seating, occupants are able to have a better view towards the stage, sightline unobstructed as the seats are placed in 30°. Another advantages of the sloped seat is that soundwaves can be distributed throughout the concert hall ensuring the occupant to have a great experience.



Rise of 190mm and run of 1000mm consist of 500mm width of seating

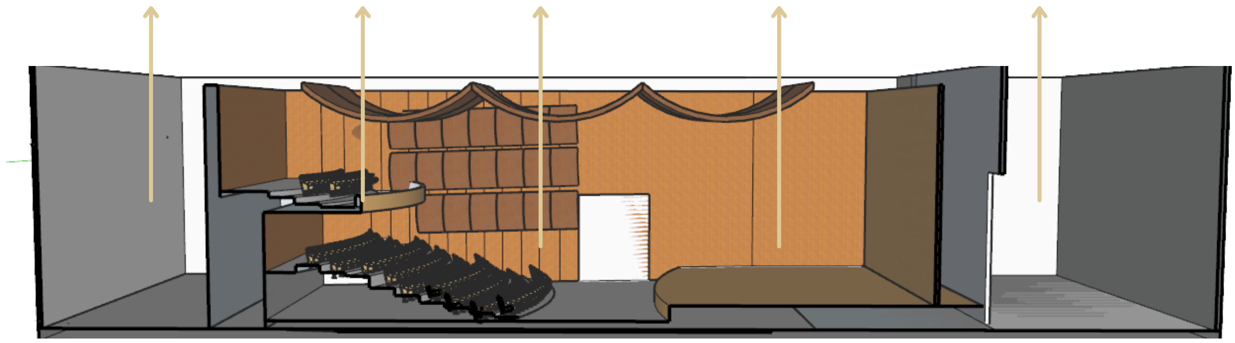


30° seating angle provide unobstructed view and required less movement but light eye movement

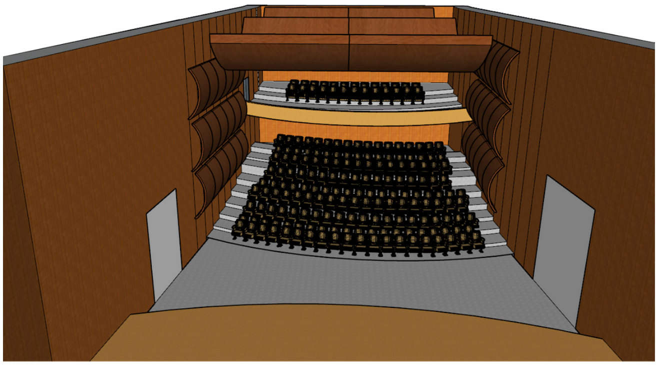
RATIONAL BEHIND MATERIAL SELECTION

Choo Pei Yan 1001955438

Concert Hall



Interior



Although the concert hall is in fan-shaped layout, sound will still garbled because there is echoes in the space hence occupant will be distracted. To provide equal and quality sound to the audience, it is important to soundproof the auditorium.

Wall

Groove Timber Wall

Acoustic Foam
(Open Cell Polyurethane Foam)

Timber wall + Acoustic Foam
The wall provides high performance, sound absorbing surfaces with extensive finishes. The groove panels have cut-outs to the rear or the center which meet with the slits in the front, creating perforations. Sound energy can be reduced due to the air the the cavity which acts like a spring and with the combination of the acoustic foam.

Floor

Tasmania Oak Timber Floor

Acoustic Carpet

Tasmania Oak Timber Floor + Acoustic Carpet
As a public building, durability of materials have to take in consideration. Tasmania oak wood is strong durable and provides high quality. It is a good sound insulator to reduce noise disruption and enhance sound quality. Carpet is great as it is a soft materials that provides comfortability and prevents any accident caused by excessive friction which is great for the concert hall. Most importantly because of its acoustic ability, it prevents sounds from reflecting echoes.

RATIONAL BEHIND MATERIAL SELECTION

Choo Pei Yan 1001955438

Concert Hall

Ceiling

Gypsum Plaster Board

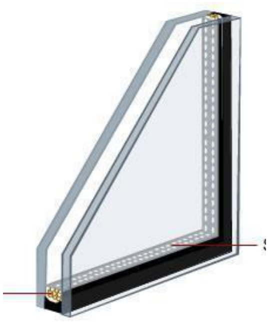
Gypsum Plaster Board
the largest, continuous surface in the space, ceiling are made with gypsum plaster board to reduce the ambient noise and to enhance occupant comfort and concentration in the concert hall. It is effective sound-dampeners and barriers against the transmission of noise.

Door

Acoustic Door

Acoustic Doors
They are used to reduced the escape of noise and vibration from one space to another. It can insulate the sound inside a space hence making it convenient and comfortable to use the space.

Exterior

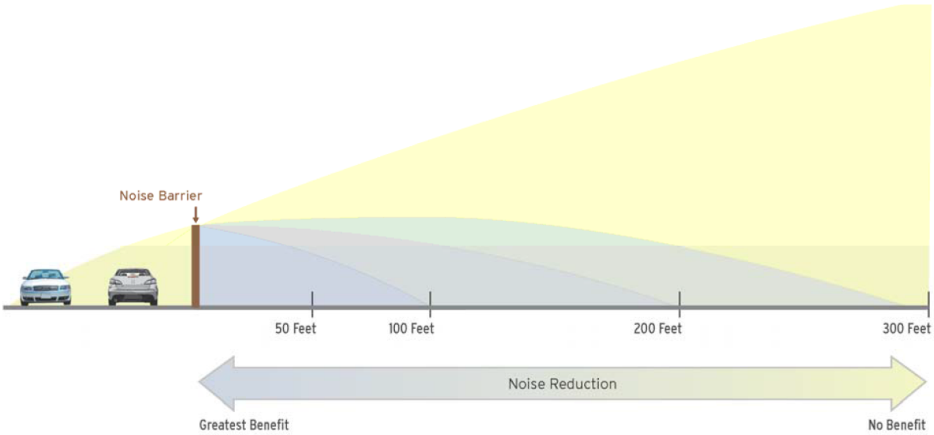


Precast Concrete

Curtain Wall with Insulated Glass

Precast Concrete + Curtain Wall
The facade of the concert hall is made up of precast concrete and curtain wall. They help to reduce noises from the surrounding. But these two materials cannot help in the extend of blocking noises from construction and highways. Therefore, sound barrier wall is needed to enhance the acoustic parameters.

Sound Barrier Wall

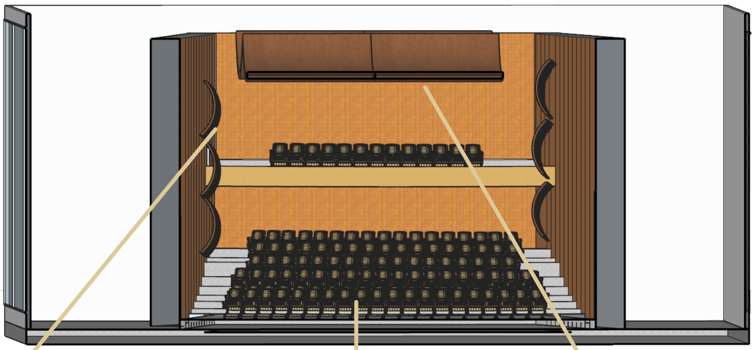


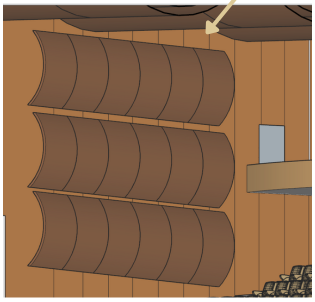
DESIGN STRATEGIES

Choo Pei Yan 1001955438

Concert Hall

Other strategies are used to enhance the acoustic performance in the concert hall.



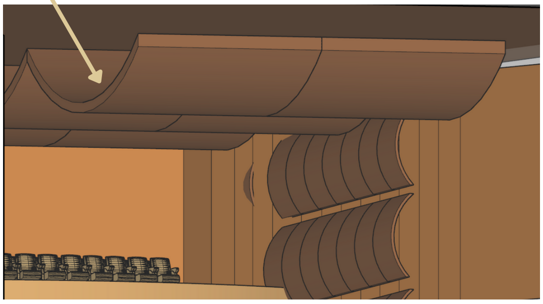


Wall Convex Reflector

Timber acoustic convex reflector will disburse sound waves by reflecting them in the opposite direction.

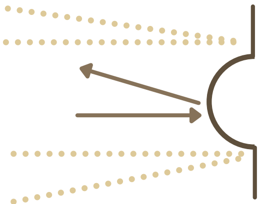
Cushion Seat

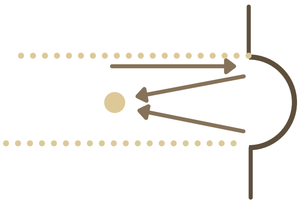
Cushion Seat can help is good in sound absorption and help to reduce reverberation time.

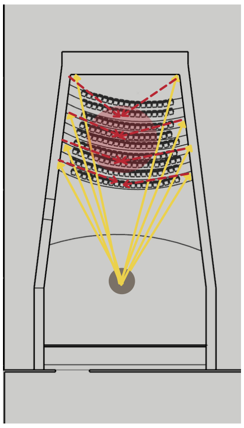


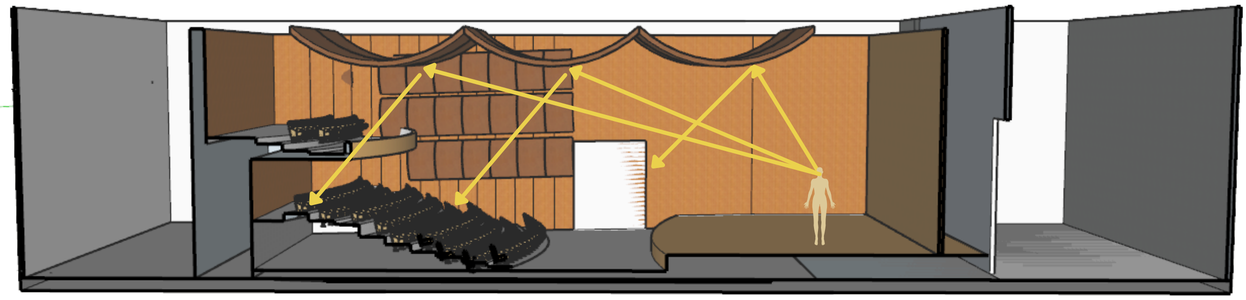
Ceiling Convex Reflector

Soundwaves can be concentrated and disbursed from the timber acoustic reflector.









CALCULATION OF REVERBERATION TIME

Choo Pei Yan 1001955438

Concert Hall

Formula:

RT = 0.16 V/A (METRIC UNITS)
Where

- RT= reverberation time in seconds
- V= volume in cubic meters
- A= total absorption in square meter

(sum of room surfaces times their sound absorption coefficients plus the sound absorption provided by furnishings or audience, etc)

Total Absorption(A)= Area x absorption coefficient

Material	Area (m2)	Absorption Coefficient (500 Hz)	Total Absorption
Wall			
Groove Timber Wall	225	0.38	85.5
Acoustic Foam	245	0.09	22.05
Acoustic Reflector	142	0.25	35.5
Floor			
Oak Wood Flooring	80	0.10	8
Carpet	235	0.6	141
Ceiling			
Gypsum Board	318	0.08	25.44
Acoustic Reflector	164	0.25	41
Other			
Cushioned Seat	120	0.48	57.6
People	260	0.44	114.4
Total Absorption			530.49

Using Sabines' Formula:
RT= 0.16V/ A
RT = 0.16 x (Volume of Exhibition Hall) / Total Absorption
RT = 0.16 x 1280.8/530.49
RT = 0.386 sec

SOUND INTENSITY
SOUND LEVEL

Choo Pei Yan 1001955438

Sound Intensity at Main Access

$$\frac{i1}{i2} = \frac{d2^2}{d1^2}$$

D1 = 10m, I1 = 9x10^-6 W/m^2
Assume that D2=22m,where the entrance is 20m away from highway , therefore i2=?

d1= 10m
i1= 9x10^-6/m^2
d2= 20m
i2= $d1^2$xi1/$d2^2$
i2= 10^2x 9x10^-6/20^2
= 2.25x10^-6 W/m^2

Sound Level

Assume the three sound sources in the interior space:

Sound Source	Whisper	Piano	Air Conditioner
Sound Pressure Level (dB)	20	65	30
(SPLi)/10	2	6.5	3
10(SPLi)/10	100	3,162,278	1000
Σ10(SPLi)/10	100 + 3,162,278 + 1000 = 3,163,378		
Log Σ10(SPLi)/10	Log Σ10 3,163,378 = 6.5		
10Log Σ10(SPLi)/10	65dB		

CONCLUSION
REFERENCES

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Conclusion

As a conclusion for this assignment, to build a functional concert hall, critical thinking like form of building, arrangement of seating and the choice of materials can make a big impact on the space. By researching materials online, I had realized the advancement of technology nowadays had really take acoustic parameters into consideration. For example how the width of groove on the timber panel has different absorption coefficient and how it will affect the acoustic performance. This assignment is a good practice for us as we will start to look at the properties of materials before decided using it in our design like the higher the absorption coefficient of a materials, the shorter the reverberation time.

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3

Individual Part

Chisic Concert Hall

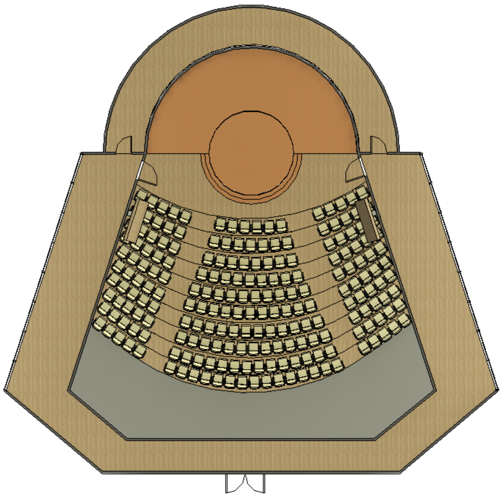
Helen Lim Xin Ying 1301849935

FORM AND LAYOUT DESIGN

Helen Lim Xin Ying 1301849935

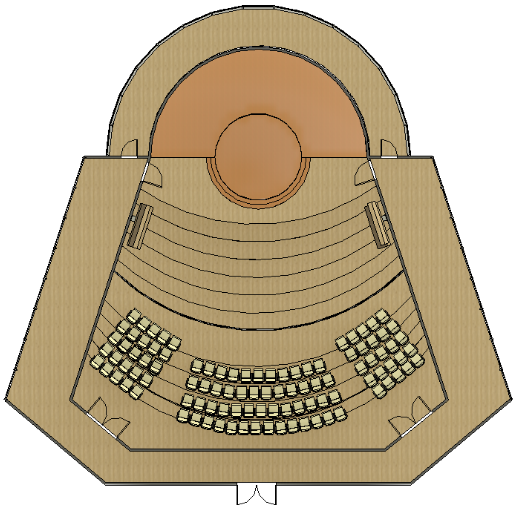
Chisic Concert Hall

Chisic concert hall means that it is China+Music



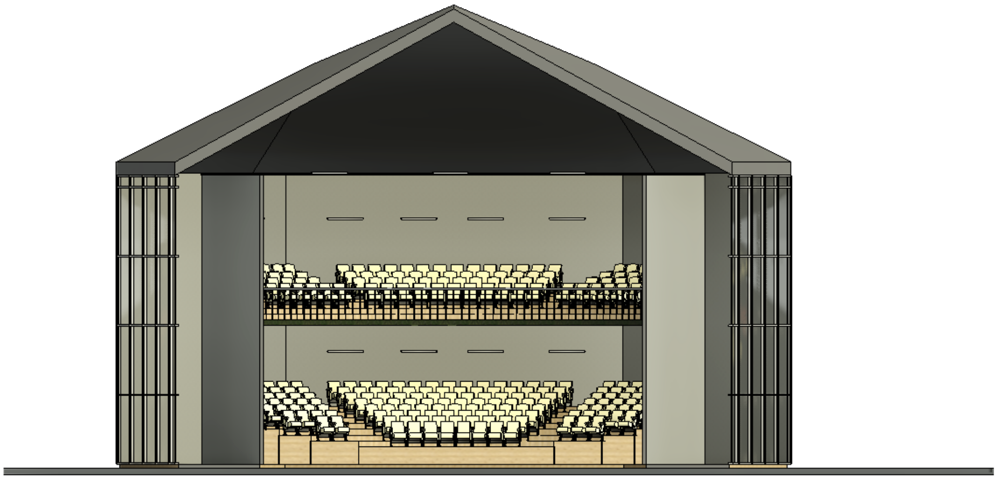
GROUND FLOOR PLAN

Scale 1:100



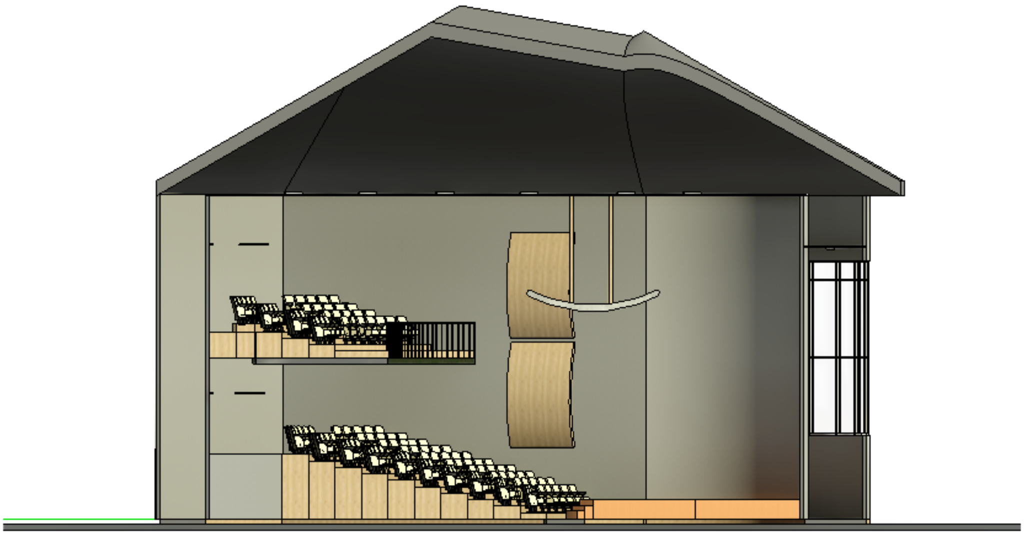
FIRST FLOOR PLAN

Scale 1:100



SHORT SECTION

Scale 1:100



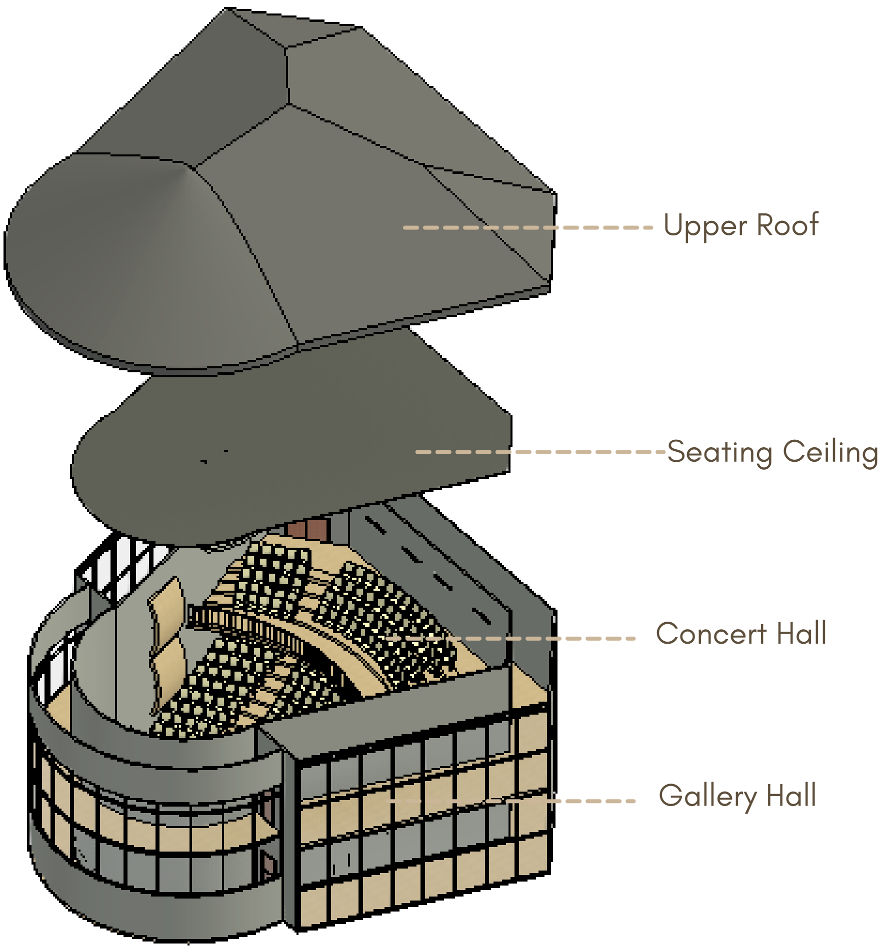
LONG SECTION

Scale 1:100

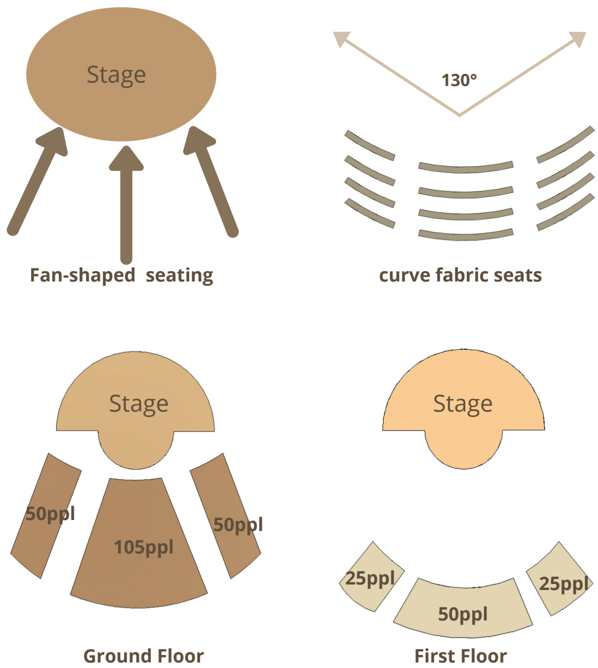
FORM AND LAYOUT DESIGN

Helen Lim Xin Ying 1301849935

Chisic Concert Hall



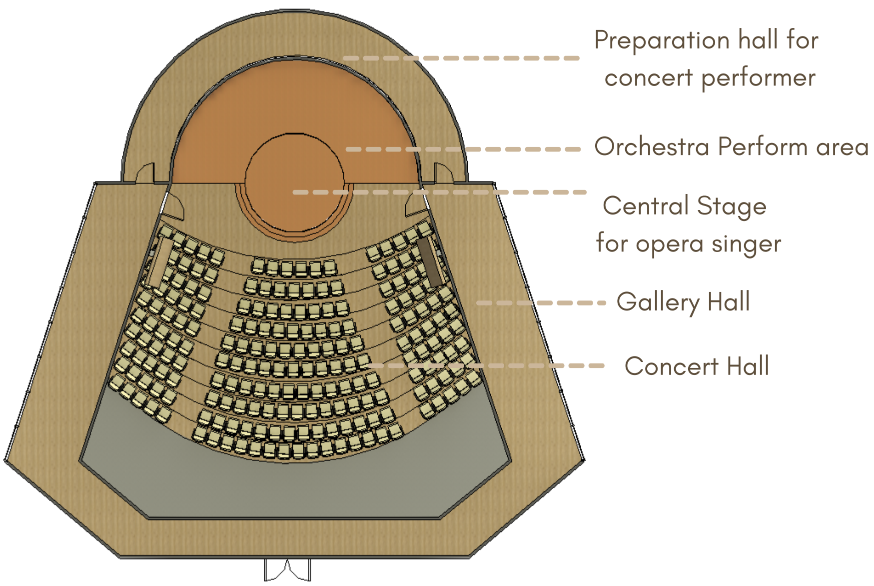
Layout and Seating Capacity



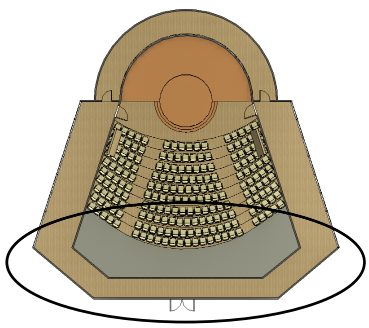
The concert hall is designed in fan shaped with a central stage so the audience can more focus on the perfomers and this hall accomodate 305 people in the same time.This fan-shaped helps to diffuse sound so it won't muddy the sound quality from the performers.The 130° angle is maximize the view and the audience can receive same sound quality.

EXPLODED AXONOMETRIC

Scale 1:Nts



Form



The form is inspired by the Chinese eight diagram.The seating arrangemet and the edge of the hall are following the edge of the eight diagram.The yinyang in the middle of the eight diagram also been applied in my design which is the stage.This means that it is the main focus of the concert hall.

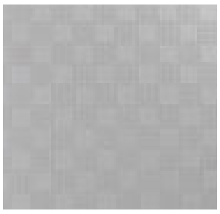
RATIONAL BEHIND MATERIAL SELECTION

Helen Lim Xin Ying 1301849935

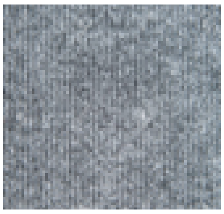
Chisic Concert Hall

MATERIAL SELECTION

Interior

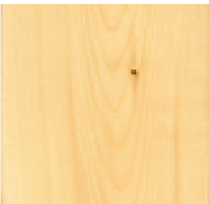


Glass fibre reinforced gypsum



Wool Carpet

Upholstery Fabric



Alaskan Yellow Cedar Flooring

Sarlon-Oak Flooring

Gypsum wall

Glass Fibre Reinforced Gypsum(ceiling)

This GFRG ceiling is being applied in the hall as it is lightweight but high strength.It Is also fire-proof which ensure the safety of the occupants.It can also prevent the unwanted sound from outside so the quality of interior sound will not be affected.

Sarlon-Oak Flooring

Oak consists of outstanding quality so it come with a high impact sound reduction and enhance the acoustic of the hall.

Wool Carpet

Woolen carpet helps to improve room's acoustic by reducing the airborne noise.It is absolutely a good absorder and dampen the noisy sound in the hall.

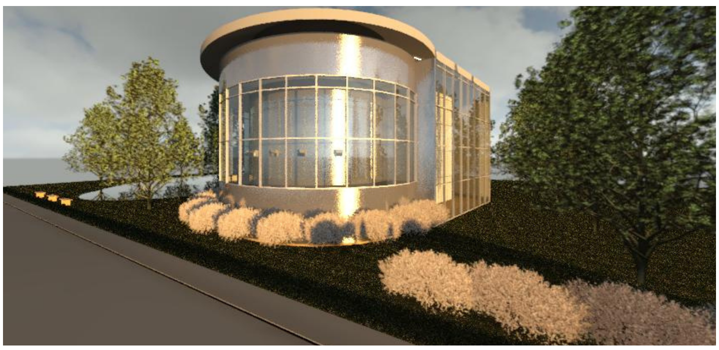
Gypsum Wall Panel

It helps to suppress sound energy and ameliorate the sound attenuation of the hall.

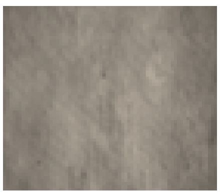
Upholstery fabric

The fabrics not easily to change their shape. As it consists of high abrasion resistance. This fabric play an important role that the same sound can be heard at all positions in the room. It can eliminate noise and which improves the comfort and experience of audiences during concert.

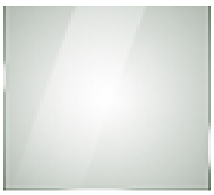
Exterior



Stainless steel panel



Concrete



Glass

Stainless steel panel

This panel is installed as the skin of the building as it can reduce vibration and avoid the unwanted sound from entering.

This concert hall is mainly constructed of concrete as the dense concrete wall improve the acoustic quality so it won't affect the experience of the user inside.Then,the glass panel at both side is to is to let the daylight to improve the productivity of the user at the same time reduce the use of artificial light.It also act as sound barrier by apply double glazing to prevent noise from entering.

DESIGN STRATEGIES

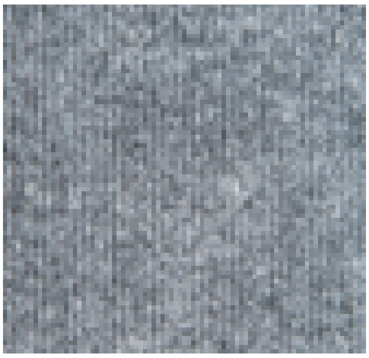
Helen Lim Xin Ying 1301849935

INTERIOR SOUND QUALITY OF CONCERT HALL

Seat material

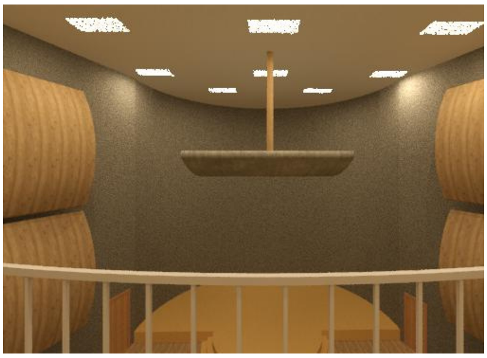
The material for the seat is ulphostery fabric as it softness makes the audiences relax and reduce the stress.This fabric provide acoustic effects as it absorb the noise to improve the sound quality from the central stage.

Wool Carpet



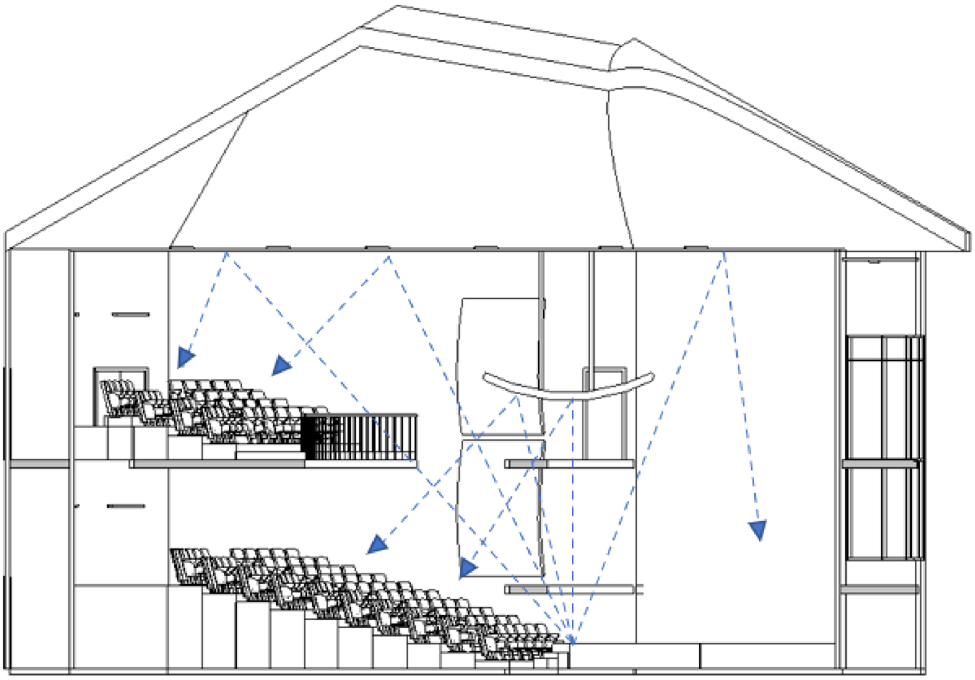
The carpet is applied at the back of the ground floor's .This is to absorb the sound waves and prevents echoing so it won't affect the sound quality of the concert.

Suspended Wood Reflector

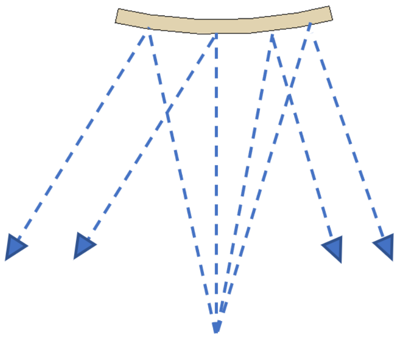


There are suspended wood reflector placed above the central stage and sails are placed at both side of the wall.This is to deliver the sound to different directions so the audience from different direction can receives best sound quality.

Sound Propagation



Convex Wood Reflector



The convex reflector made of wood above the stage helps to reflects the sound to the back so the audience can receive same sound quality.Then, the two sails at both wall allows the audience to hear the sound from more than 1 direction and receives best sound quality.

DESIGN STRATEGIES

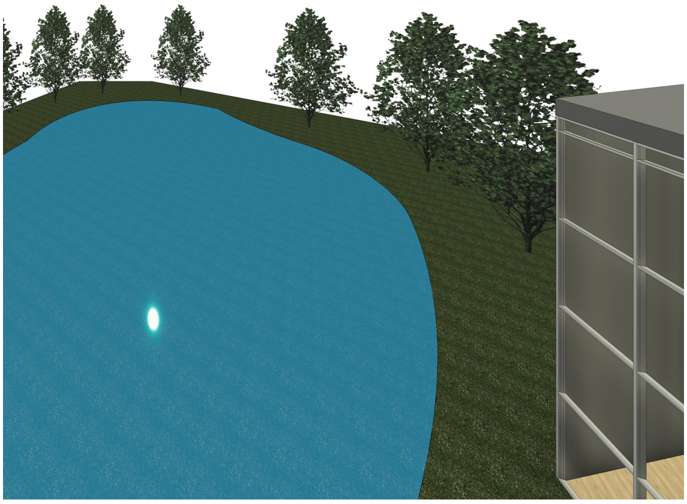
Helen Lim Xin Ying 1301849935

NOISE PREVENTATION FROM OUTSIDE

Trees

The surrounding of the building is planting with trees and scrubs to acts as sound barrier to lower and filter the unwanted sound from the road.It can deflect and absorb the sound so the sound won't leaking into the concert hall.The plants not only for sound barrier, it is also introduce biophilic design which connect people to nature, it filter the bad air quality so people can have fresh air.Then, it reduces the ambient temperature of the site so it can increase the comfort of the people when they walk around the building.

Waterbody

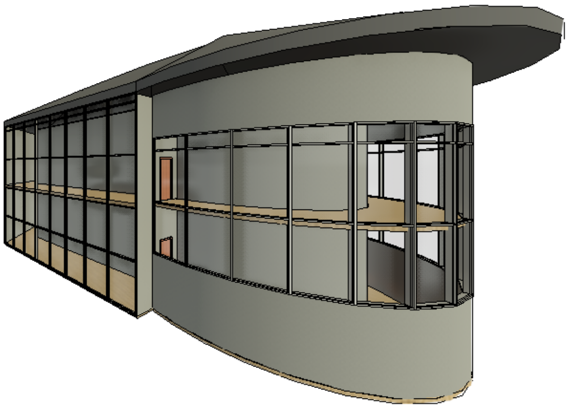


I propose a waterbody outside the building to act as the sound barrier too.The reason i placed it not only for sound barrier purposes, i want the people walk around the waterbody and relax themselves first then they can more enjoyable when listening to the concert.Then, The waterbody can also be a best view for people to view from interior to exterior.The waterbody helps to reduce the heat of the surrounding which improves the comfort of the people.

Stainless steel panel

The exterior skin is applying stainless steel panel to reduce the vibration and prevent the leaking of traffic sound from the road and the surrounding.

Double Glazing



The both side and the north side of the wall all apply double glazing for noise reduction which act as better sound barrier than normal glass.Then, the double glazing provide quiet environment away from noise outside at the same time the interior's sound will not leaks too so it won't disturb the people outside.

CALCULATION OF REVERBERATION TIME

Helen Lim Xin Ying 1301849935

Formula:

RT = 0.16 V/A (METRIC UNITS)
Where
- RT= reverberation time in seconds
- V= volume in cubic meters
- A= total absorption in square meter

(sum of room surfaces times their sound absorption coefficients plus the sound absorption provided by furnishings or audience, etc)

Total Absorption(A)= Area x absorption coefficient

Material	Area (m2)	Absorption Coefficient (500 Hz)	Total Absorption
Gypsum Ceiling	322	0.18	57.96
Timber Floor	269	0.10	26.9
Carpeted floor	52	0.50	26
Gypsum wall	223	0.30	66.9
People	305	0.44	134.2
Total Absorption			311.96

Using Sabines' Formula:
RT= 0.16V/ A
RT = 0.16 x (Volume of Exhibition Hall) / Total Absorption
RT = 0.16 x 882.8/311.96
RT = 0.453 sec

SOUND INTENSITY
SOUND LEVEL

Helen Lim Xin Ying 1301849935

Chisic Concert Hall

Sound Intensity At Main Access

$$\frac{i1}{i2} = \frac{d2^2}{d1^2}$$

D1 = 10m, I1 = 9x10^-6 W/m^2
Assume that D2=22m ,where the entrance is 22m away from highway,i2=?

d1=10m
i1=9x10^-6/m^2
d2=22m
i2=$d1^2$xi1/$d2^2$
i2=10^2x9x10^-6/22^2
=0.0000018595
=1.85x10^-6 W/m^2

Sound Level

Assume the three sound sources in the interior space




Sound Source	Orchestra	Opera Singer	Whisper
Sound Pressure Level (dB)	110	100	20
(SPLi)/10	11	10	2
10(SPLi)/10	100000000000	10000000000	100
Σ10(SPLi)/10	100000000000+10000000000+100=110000000100		
Log Σ10(SPLi)/10	Log Σ10 110000000100 = 11.04		
10Log Σ10(SPLi)/10	110.4dB		

CONCLUSION
REFERENCES

Helen Lim Xin Ying 1301849935

Chisic Concert Hall

Conclusion

To conclude, I think the layout is important to improve sound quality so I chose fan shape so that the audience can be more focused and each seat receive same acosutic quality. Second, the choice of materials will depend on the sound quality, such as the floor. I apply timber to reduce sound distruption and also reflector made of timber to reflect the sound back to the audience.Then, we also need to consider the exterior, I placed the tree and waterbody outside so that the noise from all directions can be greatly reduced and it can make people connected with nature and relax so they can more concentrate in listening to the concert.

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4 Individual Part

Ave Concert Hall

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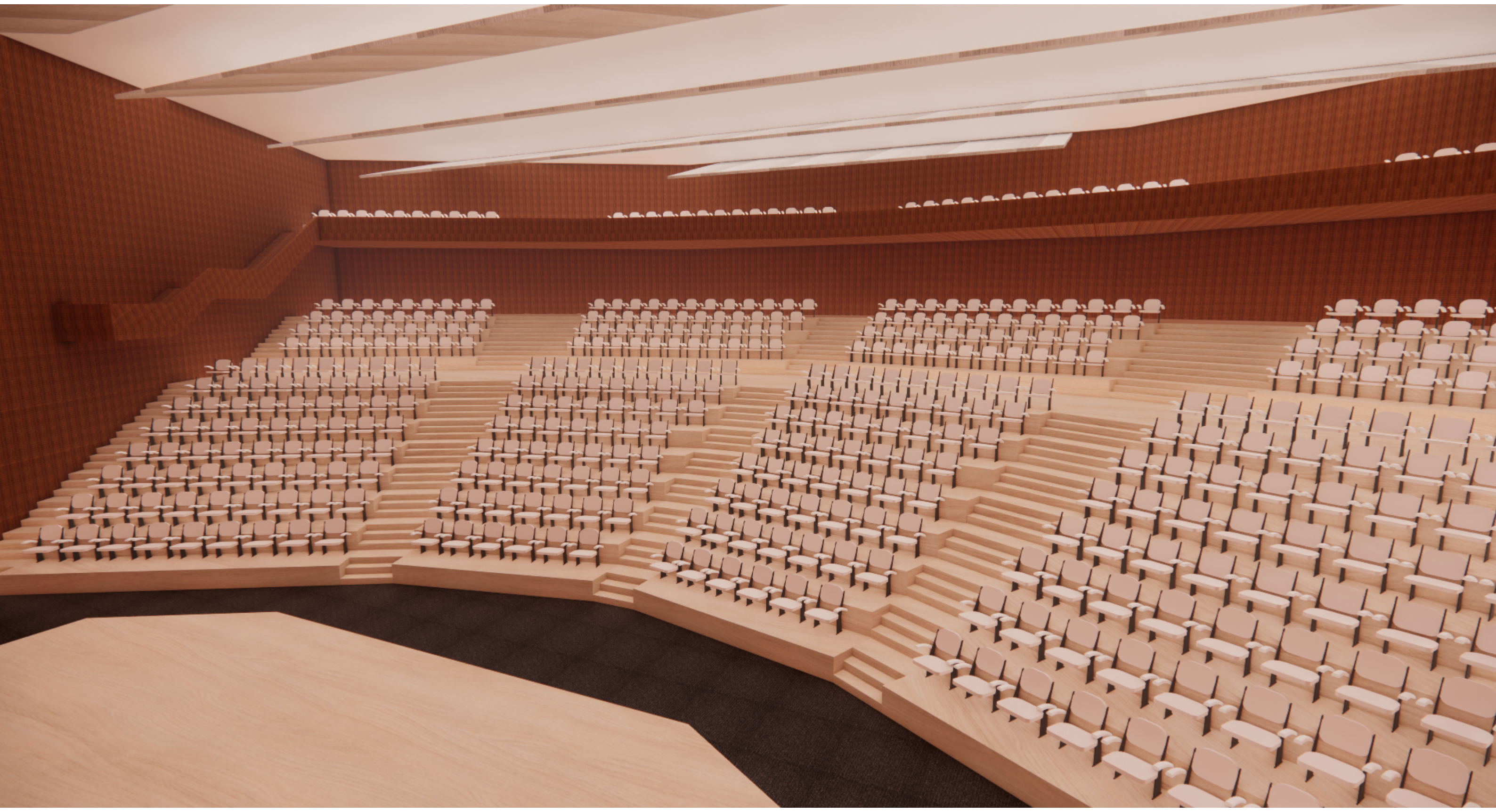

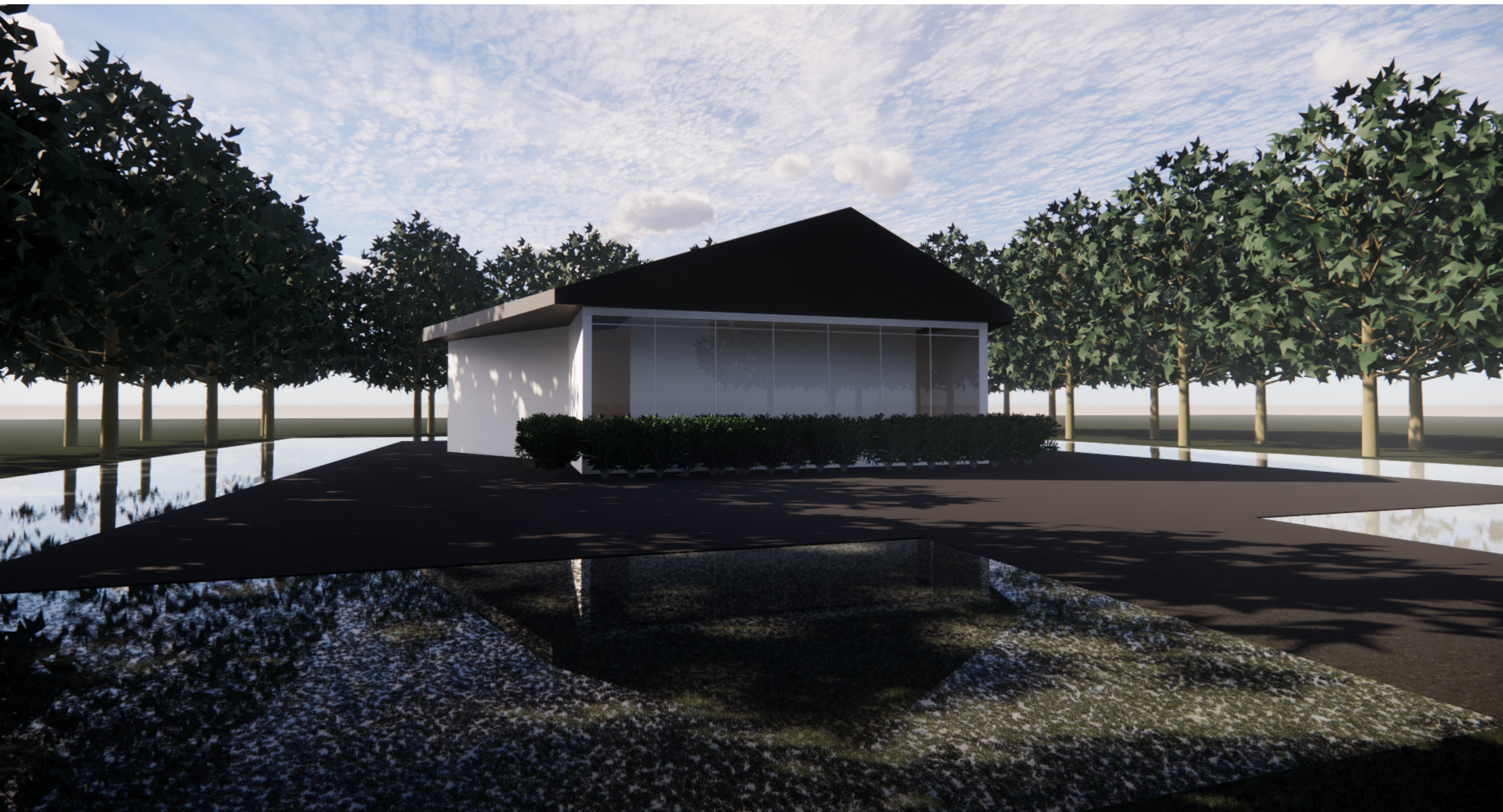

FORM AND LAYOUT DESIGN

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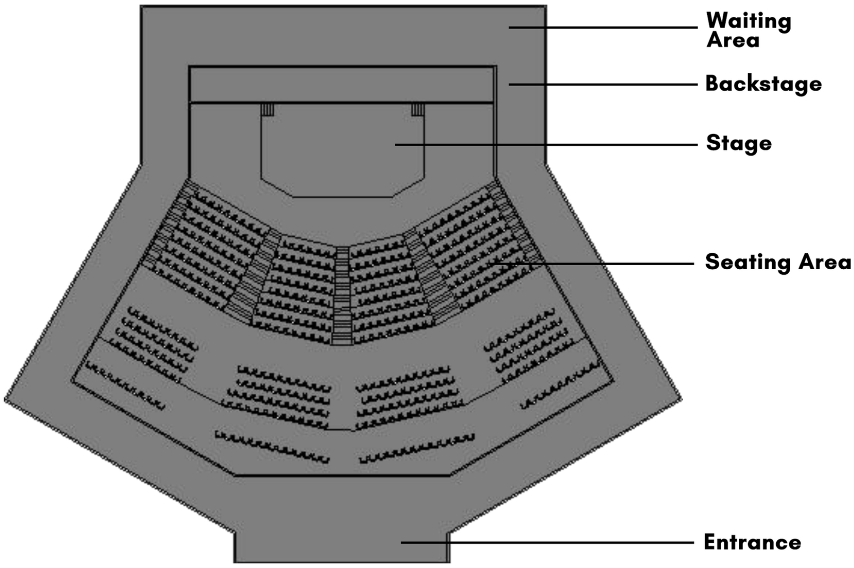
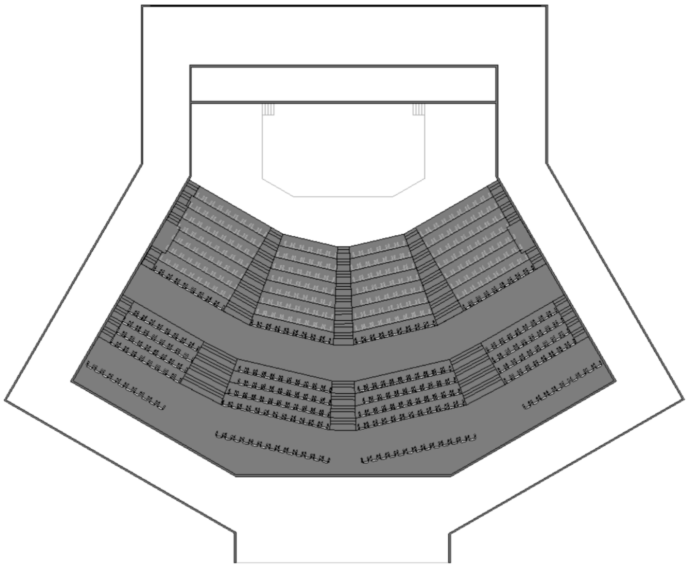
Ave Concert Hall



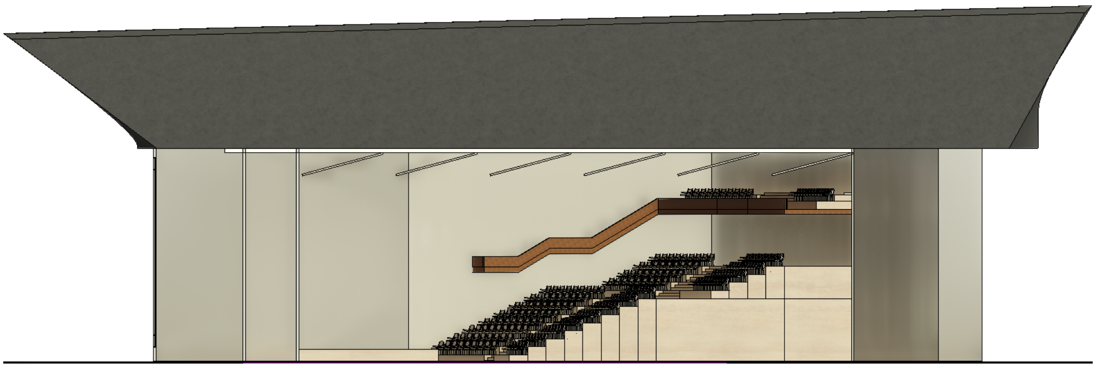
GROUND FLOOR PLAN

Scale 1:100



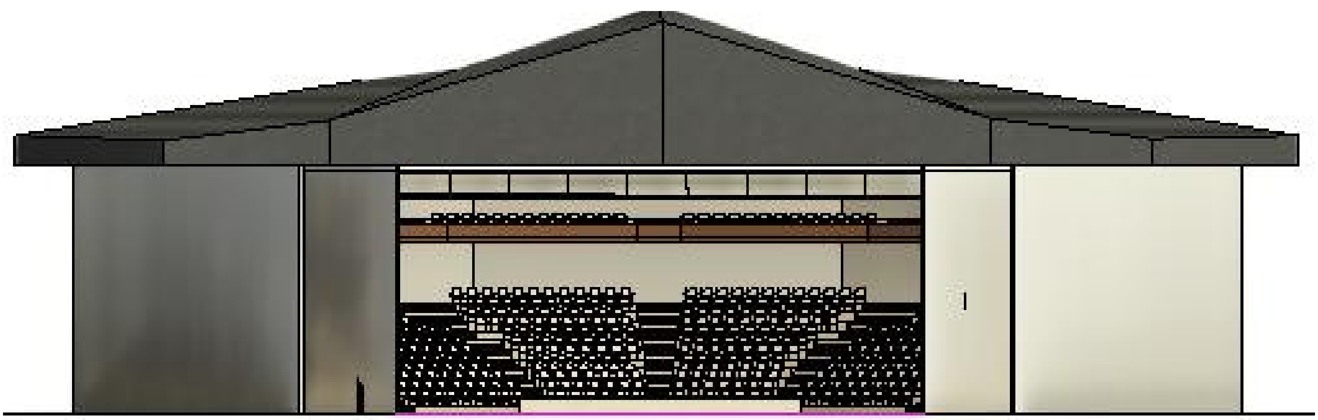
MEZZANINE FLOOR PLAN

Scale 1:100



LONG SECTION

Scale 1:100



SHORT SECTION

Scale 1:100

FORM AND LAYOUT DESIGN

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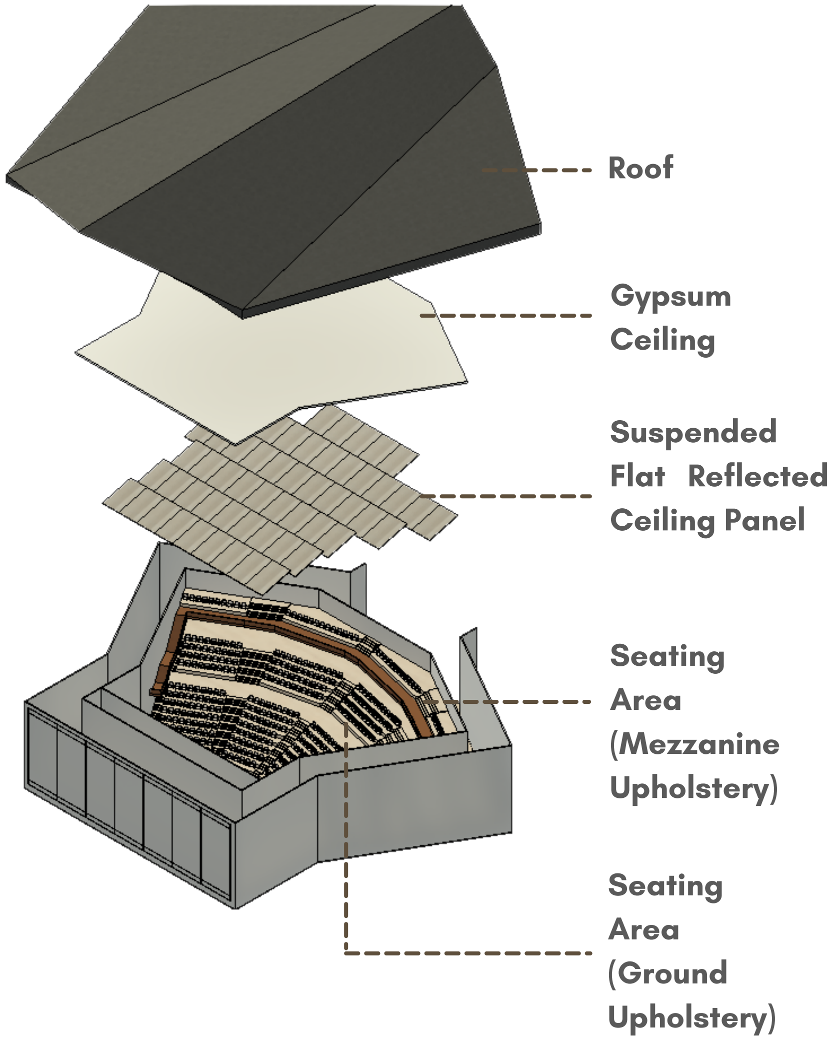
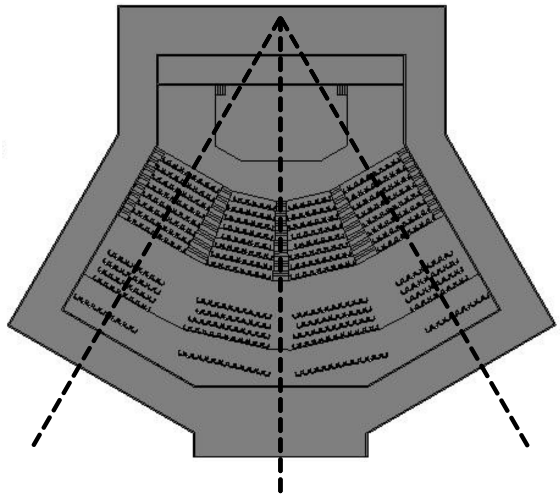
Ave Concert Hall

AXONOMETRIC | NTS

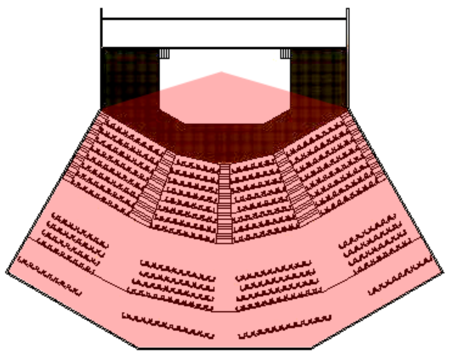


FORM

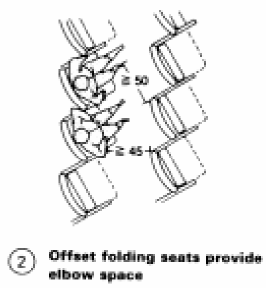


- The design of concert hall is inspired and adapted by the form of fan-shaped.
- By using 60° to create the shape of the seating area to give proper and great linear sightline for audience.
- It may cause slight head turning to the source if seated above 60° but still within the comfortable zone.
- 'Bounce-off' effect may occur.
- Able to accommodate a lot of audience in one event.

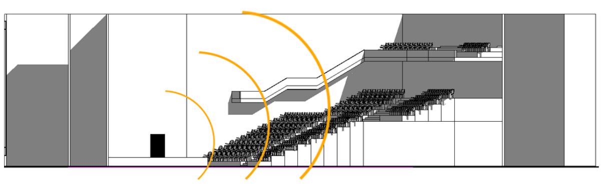
FEATURES



Seating Arrangement: The concert hall can accommodate about 474 people in one room.



International Standards: Hall designed based on Neufert Data



Seating Level: Racked seating are designed to allows direct sound travel in spherical wave until terrace level thus this decrease the chance of sound wave being obstructed and absorbed.

RATIONAL BEHIND MATERIAL SELECTION

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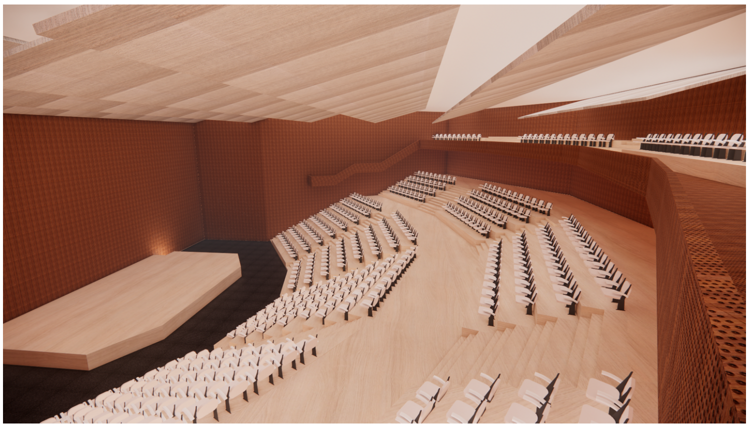
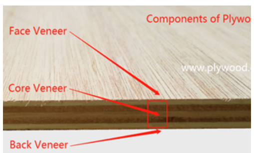
Interior

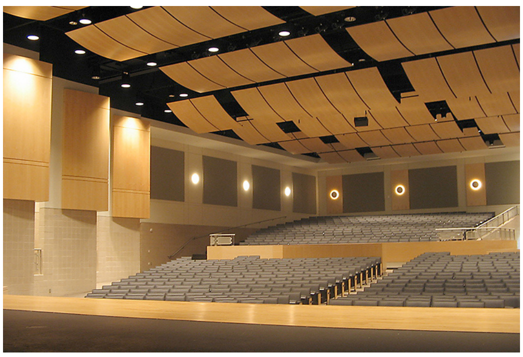


Ceiling |

Suspended Reflective Acoustic Ceiling Panel

The purpose of the material is to have minimal sound absorption but with high reflectivity. The size of panel are made in larger length about 3000mm to improve the low frequency of sound reflection. Then, it shaped into flat size to direct sound from the source to the audience better. The panel is made out of hardwood core veneer about 18.75mm thk. then coated with resin layer on surface and back of panel. The material have option to be upgraded to sustainable elements which is Class A fire rated core and laminated face to improve sound directivity, strength and timing of reflection from ceiling area. Another option to enhance the reflection panel is to add absorber or mass layer on other side of panel.





Ceiling |

Gypsum Panel

The purpose of using gypsum panel to act as end ceiling to allow cable and wire attached to the ceiling surface without any hidden intention. The material are made with calcium sulfate dihydrate with additives. This gypsum board are layered with laminated noise reducing to absorb high frequency sound.

Flooring |

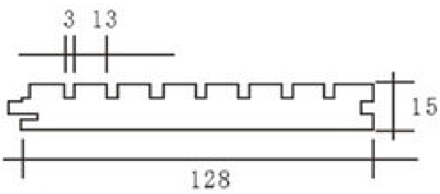
Timber Strips Solid Hardwood

The purpose of using these material is to reduce the loudest and echoes sound made from walking noise. By using solid hardwood with 12mm thk., it have acoustical properties where it absorbs most of the noise and non disturbance against musical performance.

Wall |

MDF Acoustic Wall Panel

The wall material use are eco-friendly MDF acoustic wall panel. The purpose of the material is to use as sound absorber and noise reduction towards the reverberation and echoes within the hall. The material are made of high density panels with groove on surface and perforated holes at back side. The panel give strong reflection of sound spectrum during particular performance which resonance on the middle and low frequency. The addition of having a cotton filled at the backside of the cavity is to take effect on medium to high frequency sound waves.



DESIGN STRATEGIES

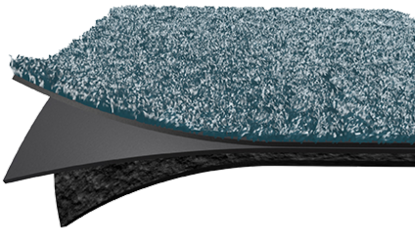
Choo Yee Lit Cassandra Vava 1001849555

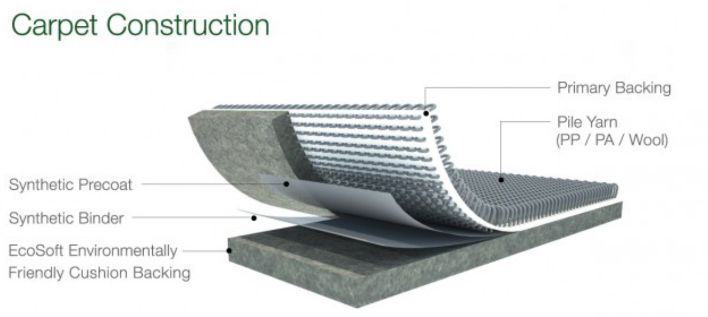
Interior

Flooring |

Carpet

The purpose of using carpet is to act as sound absorption, which means to make the room less reverberant and reduce transmission of footstep noise. Acoustical carpet is made of synthetic material such as polyutherane.

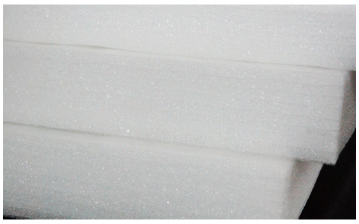




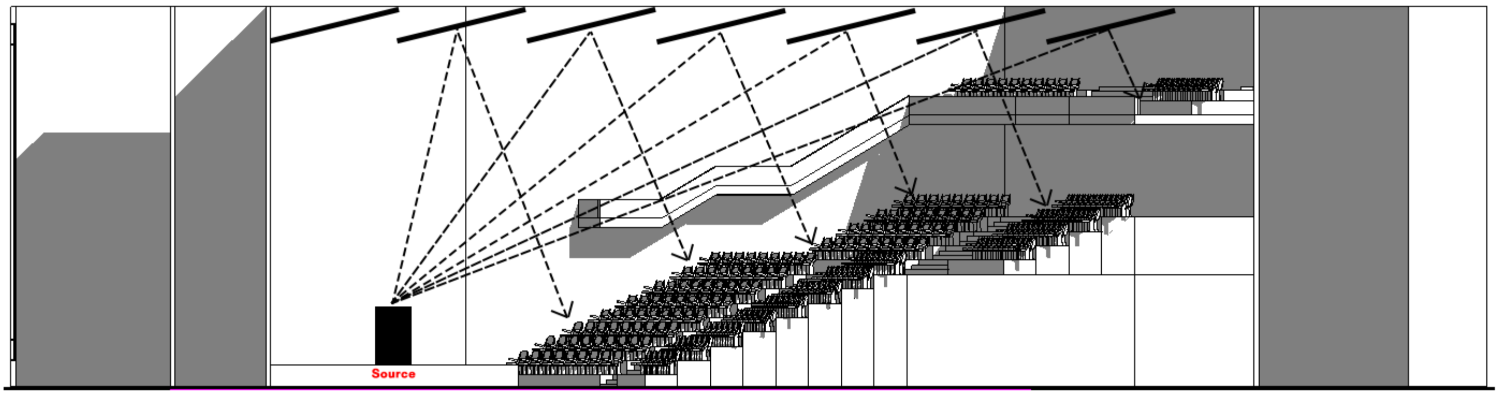
Furniture |

Upholstery Fabric Chair

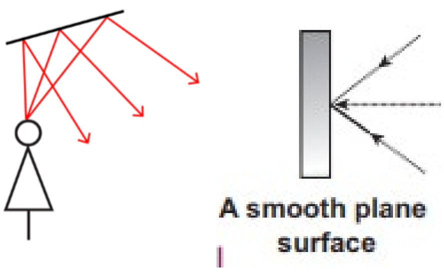
The material use for chair at auditorium is using solid fabric chair. The main structure for the chair is solid wood with 50mm polyurethane foam of polyester fabric upholstery at the bottom seat and backseat. The foam has high tensile strength to use as sound absorption, shock absorption and reduce noise. The materials are eco-friendly and does not contain any chemicals.



Sound Propagation



The ceiling flat reflector is place slanted towards the audience to reflect the direct sound waves up to the terrace seats. The propagation of sound travel does not obstructed as well. This panel allow to have evenly distribution and maintain the sound intensity with reverberation.



Flat Reflector

DESIGN STRATEGIES

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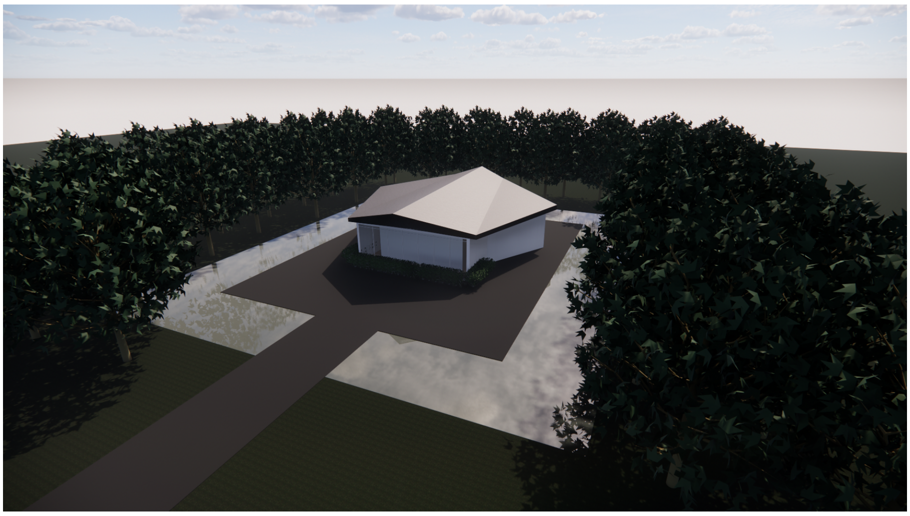
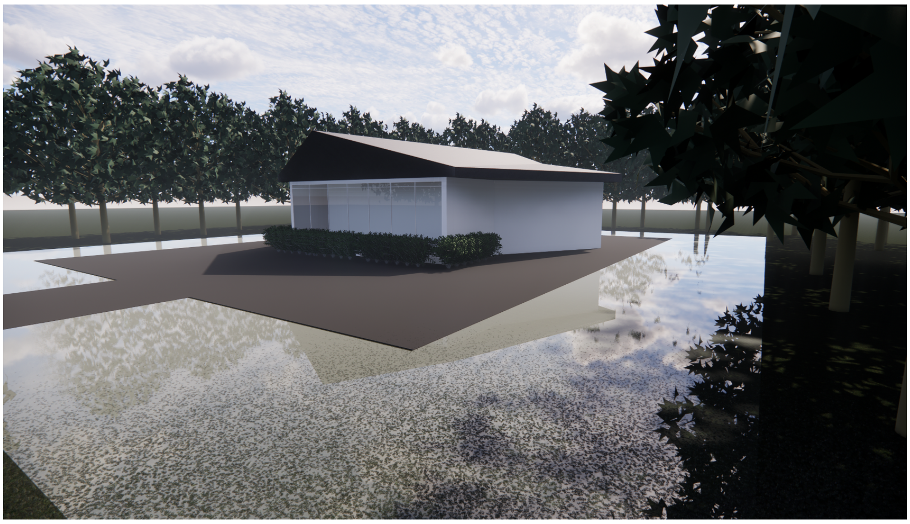
Ave Concert Hall



Plantations

Plantation are part of landscape where it must exist surrounding the building to reduce the sound travel and absorb the sound noise. Plant a single or dozen tree would not make any different. It needs at least a few acre to ensure the sound barriers are well solid and promising. Shrubs and other ground elements are necessary as well to provide more ground protection towards the building whether it is located indoor or outdoor.

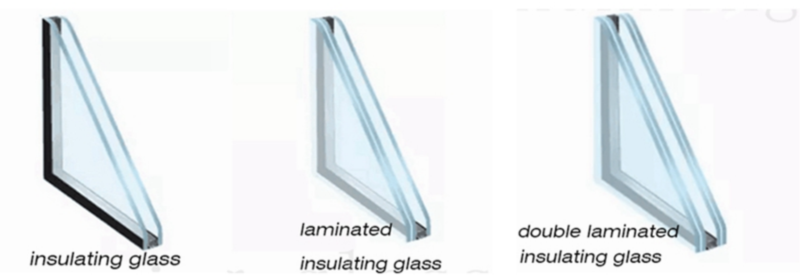


Water Feature

The water body or any other water features such as fountains or lake should also be part of acoustic barriers. The noise from water can disrupted the unstable frequency from road noises, loud people talking and other uninvited sound wave to ensure the musical exposure are at the greatest.

Window | Glass thickness

Introducing double glazing window, at standard size of 12mm thickness, it can reduce the transmission of medium frequency such as human voice. With an additional layer of protection such as addition thickness of glass pane or incorporating laminated glass can block out any low frequency sound wave such as traffic.



CALCULATION OF REVERBERATION TIME

Choo Yee Lit Cassandra Vava 1001849555

Ave Concert Hall

Formula:

RT = 0.16 V/A (METRIC UNITS)
Where

- RT= reverberation time in seconds
- V= volume in cubic meters
- A= total absorption in square meter

(The sum of room surfaces times their sound absorption coefficients plus the sound absorption provided by furnishings or audience, etc)

Total Absorption(A) = Area x absorption coefficient

Material	Area (m2)	Absorption Coefficient (500 Hz)	Total Absorption
Reflective Ceiling Panel	787	0.03	23.61
Gypsum Ceiling	953	0.07	66.71
MDF Wall Acoustic Panel	1170	0.82	959.4
Timber Strips Solid Hardwood Flooring	844	0.10	84.4
Carpet Flooring	145	0.3	43.5
People	474	0.44	208.56
Total Absorption			1386.18

Using Sabines' Formula:
RT = 0.16V / A
RT = 0.16 x (Volume of Exhibition Hall / Total Absorption)
RT = 0.16 x (9909 / 1386.18)
RT = 1.14 sec

SOUND INTENSITY
SOUND LEVEL

Choo Yee Lit Cassandra Vava 1001849555

Ave Concert Hall

Sound Intensity

At main access,

D1 = 10m, I1 = 9x10^-6 W/m^2

Assume that D2=22m where the entrance is 20m away from highway i2=?

D1 = 10m

I1 = 9x10^-6 W/m^2

D2 = 20m

I2 = $(I1 \times D1^2) / D2^2$

= $[(9\times10^{-6}\ W/m^2) \times 10^2] / 22^2$

= $2.25 \times 10^{-6}\ W/m^2$

Sound Level

Assume there are three sound sources within the hall space




Sound Source	**Whisper**	**Violin Solo**	**Orchestra**
Sound Pressure Level (dB)	30	85	110
(SPLi) / 10	3	8.5	11
10(SPLi) / 10	1000	316,227,766	100,000,000,000
Σ10(SPLi) / 10	1000 + 316,227,766 + 100,000,000,000 = 100,316,228,766		
Log Σ10(SPLi) / 10	Log Σ10 100,316,228,766 = 11		
10Log Σ10(SPLi) / 10	110 dB		

CONCLUSION
REFERENCES

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Conclusion

In conclusion, sound are tricky to manipulate in terms of reverberation, propagation, amplitude and etc. Through this research, I learn they are so many ways to overcome the sound flaw. The first implementation is to design a proper acoustical plan and form of the building shapes referencing based on international standard as it helps to control and navigate proper transmission of sound from one area to another. By applying material with acoustical properties is a better way to enhance one understand how acoustical effect makes big difference within a space. And lastly the calculation of materials are important to understand how does a material can triggered the sound bounce and reflected within a space.

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5

Individual Part

Concert Hall

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FORM AND LAYOUT DESIGN

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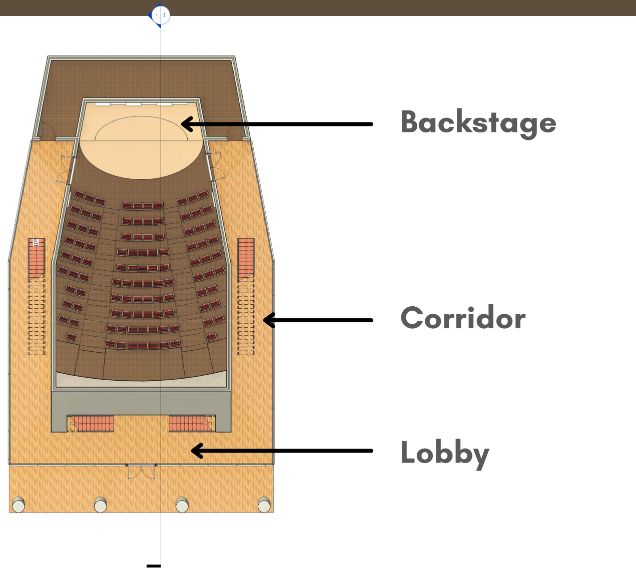
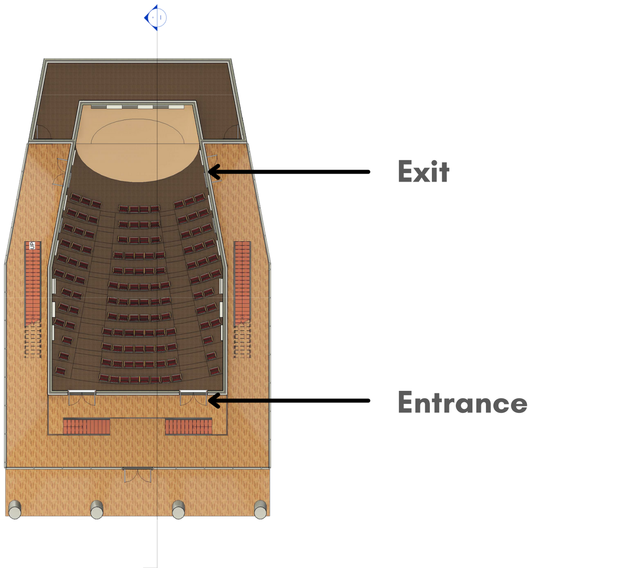
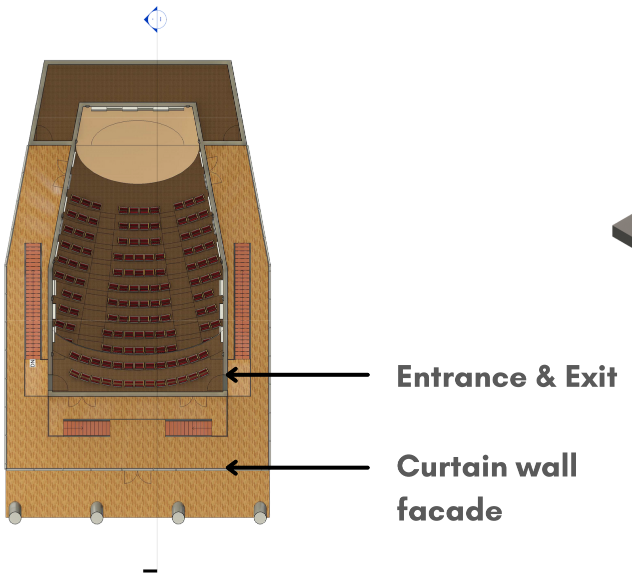


GROUND FLOOR PLAN



FIRST FLOOR PLAN



SECOND FLOOR PLAN

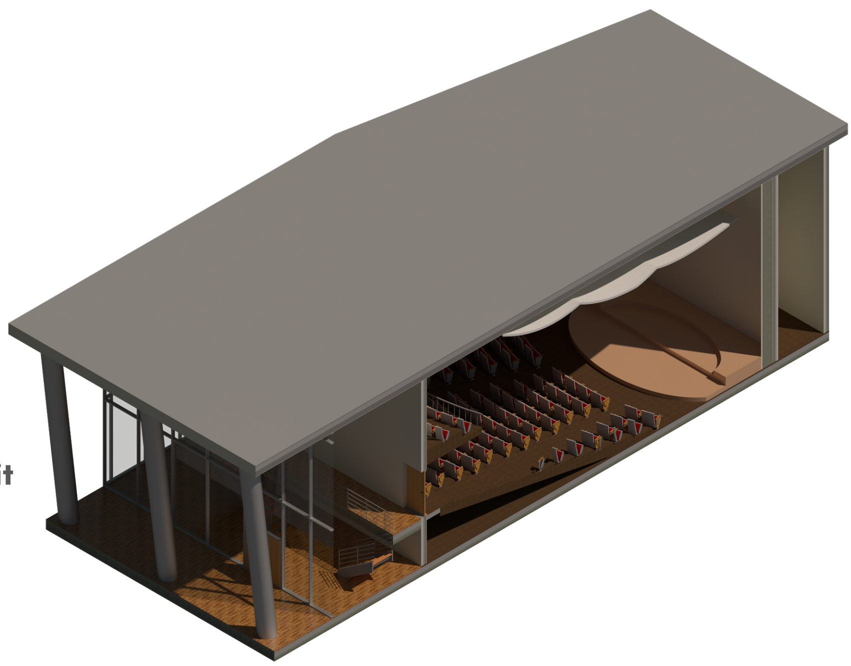
Form

The form of the concert hall is almost a cuboid for maximizing the usage of the space. The end of the form shrink for better sound propagation.

Layout

The concert hall plan is divide into four different space, lobby, corridor, backstage and the concert hall. The reason for a concert hall within space is to minimize the nice coming from surrounding the buildings for example the pedestrian noise and transportation noise around campus. The backstage corridor and lobby act as a barrier to blocking the noise.

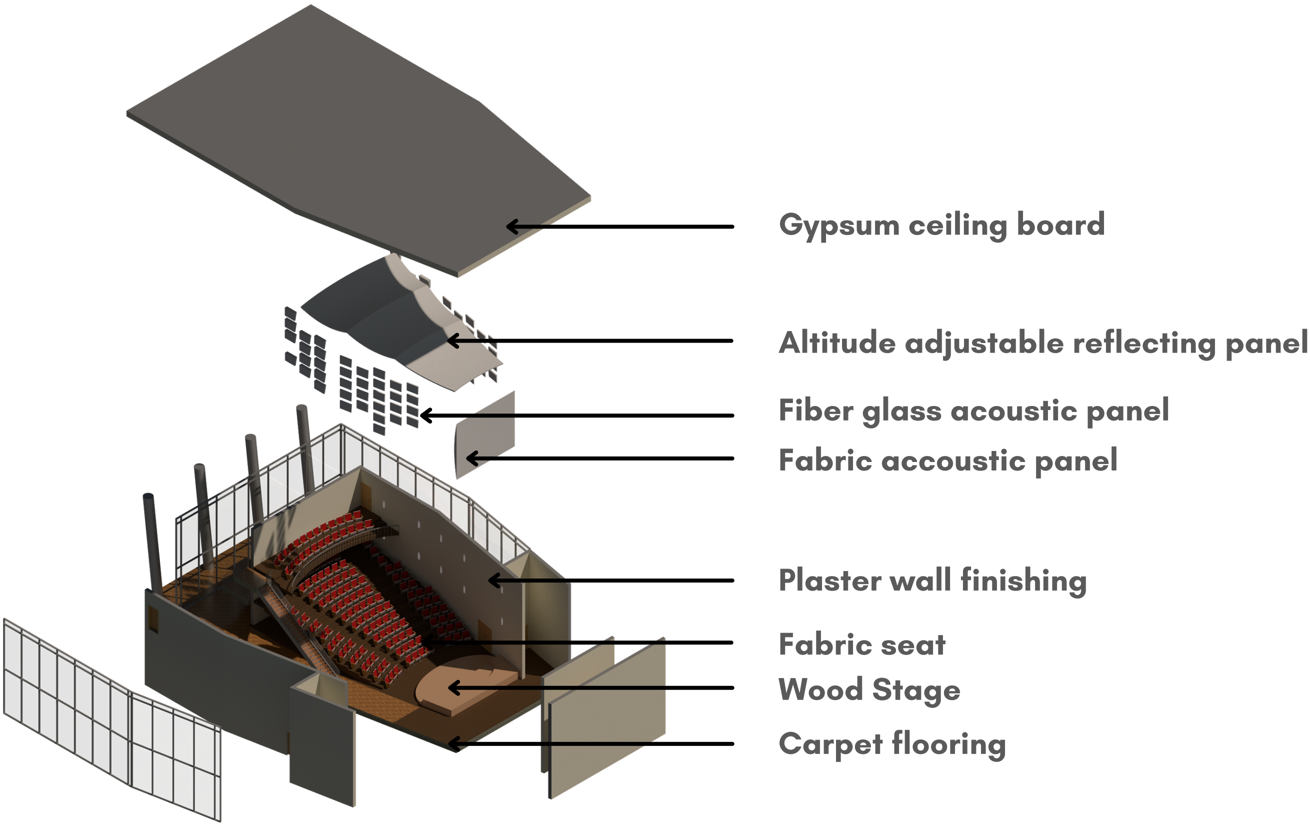
The concert hall consists of 149 seats for visitors and can accomodate a 30 people orchestra band. The layout of the concert hall is a circular concentric seating scheme with a vineyard pattern and a circular projecting stage. The reason for using this seating layout is because it maximizes the seating capacity while providing visitors a better view and acoustic.



SECTIONAL AXONOMETRIC

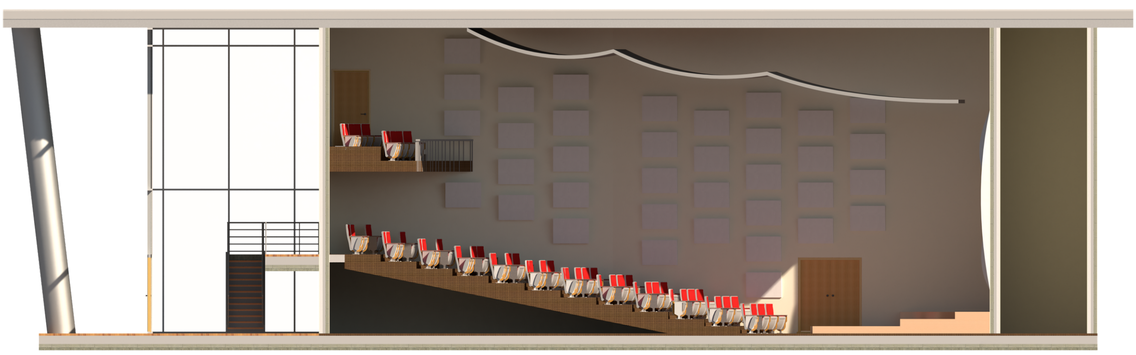
FORM AND LAYOUT DESIGN

Pang Jian Sheng 1001953249



EXPLODED AXONOMETRIC

SHORT SECTION



LONG SECTION

MATERIAL SELECTION

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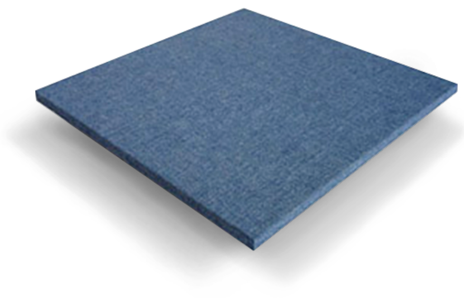
Acoustic Plywood

To improve its density and weight, acoustic plywood is often combined with other materials such as Amorim cork rubber to form soundproof plywood panels. Doing this improves the sound blocking capability of plywood, and the result is a panel that can block and absorb sound. Without other additives, acoustic plywood can still serve as a sound control material and is often used in home theatres and concert halls to reduce frequency acoustics and enhance sound clarity.



Fabric Panel and Fabric Seat

Fabric can absorb sound energy therefore having fabric panel behind the orchestra will rob them of some essential early reflections. The audience will play a major role in sound absorption. Therefore, the seats need to simulate the same amount of absorption as a real person sitting on it. This is really for a functional reason – concert hall acoustics should be consistent whether there are people in the concert hall, or if the hall was empty – so that reverberation time during rehearsal and the actual performance will not be too different.

Plaster

Plaster is one of the most commonly used materials to literally shape the architecture of concert hall acoustics. To do this, they have to be from 1.5 to 2 inches thick. This is to keep it stiff and prevent vibrations, as that will cause absorption of low frequencies. Bear in mind that having plaster to be thicker means a higher mass – which requires better structural support.

MATERIAL SELECTION

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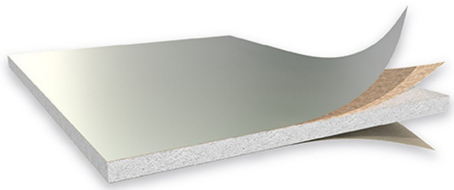
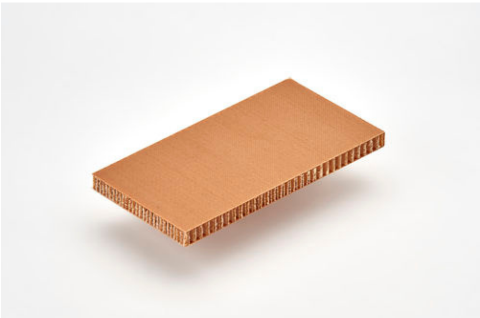


Gypsum Boar

A good drop ceiling or suspended ceiling will dampen ambient noise, and it will help the sound within the hall to seem fuller and richer. This can be great for spaces such as a theatre room, where you want to be able to experience every last bit of sound that is coming from the system. It also helps to dampen the sounds coming from other parts of the building.

Carpet

Since carpet improves acoustics, your favourite music will sound much better in a carpeted room. Concert halls and cinemas all over the world are fitted with carpet. The reason for this is because carpet halves the reverberation time of sound waves reflecting off the walls and furniture, offering better acoustics.



Fibreglass

Acoustic Glass Mineral Wool is lightweight and sound absorption. The shapeshifter of soundproofing materials, this fibreglass acoustic panelling is highly customizable and can be installed inside appliances, or as a ceiling panel, interior panel, office partition or chain-hung sound baffle. Audiophiles love acoustic glass mineral wool because it reduces reverb, ringing and unwanted reflections in recording studios and practice spaces. In close quarters, office workers love acoustic glass mineral wool because it reduce reverberation time.

REVERBERATION TIME

Pang Jian Sheng 1001953249

Type	Area m^2	Absorption coefficient (500 Hz)	Absorption surface
Gypsum Board	220	0.08	17.6
Fabric Seating	85	0.59	50.15
Fabric Panel	55	0.80	44
Timber Door	22	0.06	1.32
Timber Stage	43	0.42	18.06
Carpet Floor	250	0.30	75
Fiberglass Panel	90	0.42	37.8
Plaster	298	0.03	8.94
Occupants	149	0.44 / person	65.6
		Total Absorption =	278.63

Area of Wall = 146 x 2+ 100 + 73 = 465m^2
Area of Floor =220 + 73 = 293m^2
Area of Ceiling = 220m^2
Volume of Concert Hall = 1820m

Reverberation Time (RT)

= 0.16V / A

= (0.16 x 1820) / 318.47

=**0.9 second**

SOUND INTENSITY & LEVEL

Pang Jian Sheng 1001953249

Sound Intensity

D1 = 10m $I1 = 9 \times 10^{-6}\ W/m^2$

D2 = 12m (assumption)   I2 = ?

$I1/I2 = D2^2/D1^2$

$I2 = (D1^2 \times I1) / D2^2$

$I2 = (10^2 \times 9 \times 10^{-6}) / 12^2$

$I2 = (10^2 \times 9 \times 10^{-6}) / 12^2$

$I2 = 6.25 \times 10^{-6}\ W/m^2$

Sound Level

String orchestra sound level = 98dB

Woodwind orchestra sound level = 97dB

Brass orchestra sound level = 103dB

i	1	2	3
SPLi	98dB	97dB	103dB
(SPLi/10)	9.8	9.7	10.3
10^(SPLi/10)	6309573445	5011872336	19952623150
Σ10^(SPLi/10)	6309573445 + 5011872336 + 19952623150 = 31274068930		
log10 (Σ10^(SPLi/10))		10.50	
10log10 (Σ10^(SPLi/10))		**105dB**	

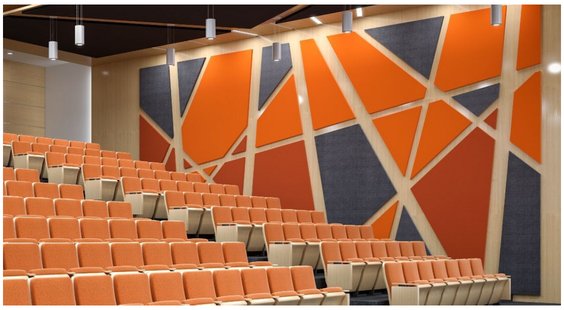
Sound Level at Hall = 105dB

INTERIOR DESIGN STRATEGIES

Pang Jian Sheng 1001953249

Fabric Seat

The use of fabric seat in the concert hall can greatly reduce the reverberation time in the concert hall since it mimics the human body to absorb sound. Therefore the concert hall reverberation time will not be too much different when it is occupied or not.



Acoustic fibreglass panel and fabric panel

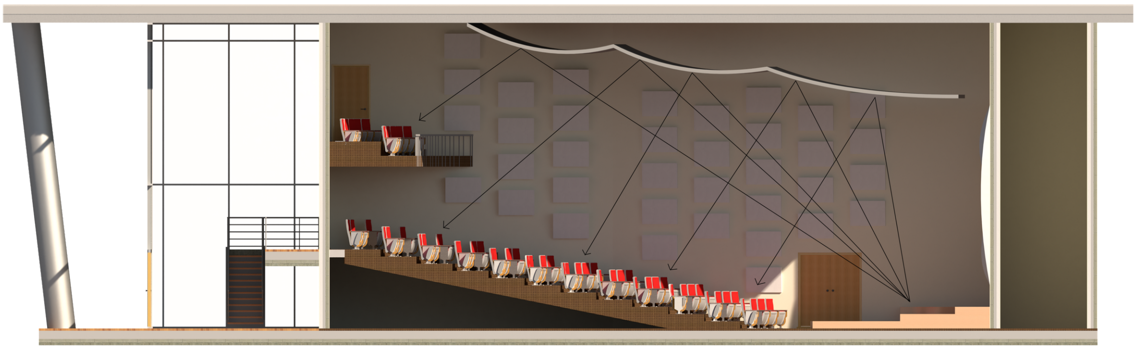
These two acoustic panels reduce the unwanted sound to prevent echo by absorbing it. Hence, control the reverberation time in the concert hall.

Carpet

The use of carpet is the almost the same function as the fabric, it reduces the unwanted sound reflection by absorbing it. hence greatly reduced the reverberation time and enhanced the acoustic within the concert hall.

Adjustable Ceiling Panel

The use of fabric seat in the concert hall can greatly reduce the reverberation time in the concert hall since it mimics the human body to absorb sound. Therefore the concert hall reverberation time will not be too much different when it is occupied or not.

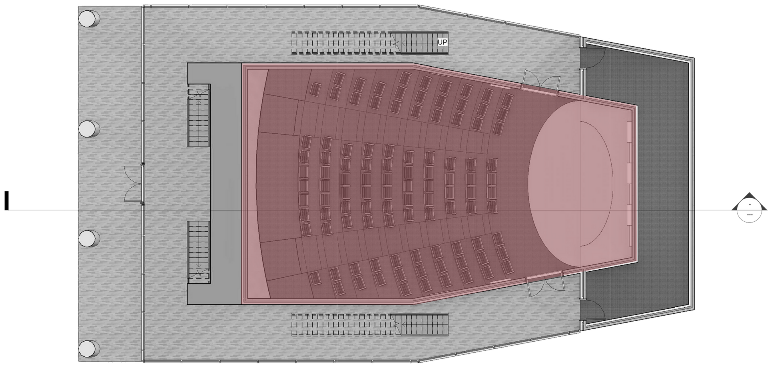


EXTERNAL DESIGN STRATEGIES

Pang Jian Sheng 1001953249

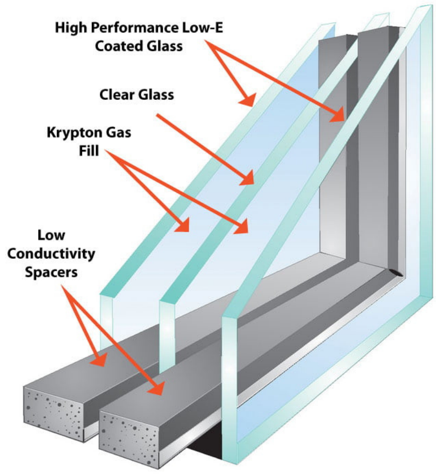
Concert Hall within Space

The concert hall is within the other spaces like corridor, lobby and backstage which act as a barrier to prevent sound pass through.



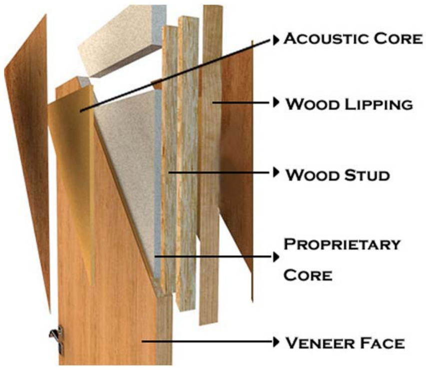
Triple-pane Glass on Curtain Wall

As you add panes of glass to a window's design, the amount of noise that is able to travel through is reduced. Single-pane windows have the least amount of materials to slow sound waves, so they allow the most noise into your home. Dual-pane windows, also called double-pane windows, help to reduce some noise. Triple-pane glass is the best option for reducing the most noise, it reduces 50% more noise than single-pane windows.



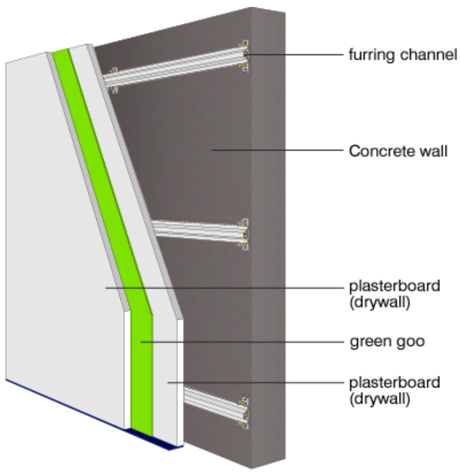
Acoustic Doors

Acoustic doors are a great way to ensure concert are not heard by people outside the hall. They also minimise the noise entering the hall which is very crucial during the performance.



Concrete Wall with Layer of Dry Wall

Drywall will shoot up the mass of the concrete and this means increased density and increased absorption. Therefore the noise from surrounding can be absorb into the drywall instead of pass through the concrete wall and enter the concert hall.



CONCLUSION AND REFERENCES

Pang Jian Sheng 1001953249

Conclusion

The suitable reverberation time of the concert hall is about 2 seconds, but the concert hall that I design is 0.9 seconds which is considered a good concert hall. However, the plaster wall that used because of cost-efficient is not aesthetic and has lower absorption coefficiency compare to other materials which can easily improve the reverberation time. The protruding acoustic board has provided a huge advantage since it increases the surface area and thus the total absorption. The shrink down of the space at the stage also provide a huge advantage since the volume of the space has decrease which further decrease the reverberation time.

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6

Individual Part

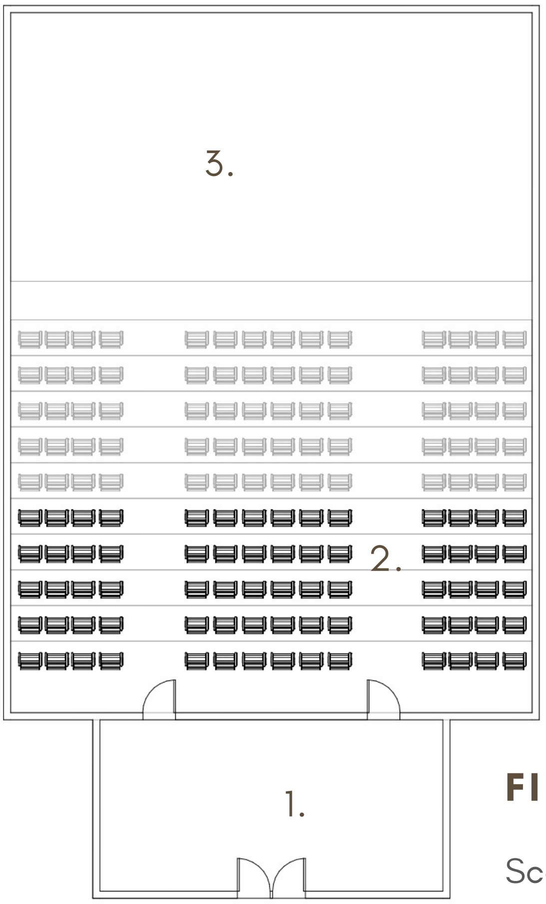
CONCERT HALL

Ng Xin Ru 1001850447

CONTENT PAGE

FORM AND LAYOUT DESIGN PROPOSAL

Ng Xin Ru 1001850447

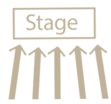


Shoebox shape is proposed for concert hall. It is a better form compared to fan shape as in a fan shape, there is sound directly from the performance but there are no side panels for the sound to be bounced off and this causes poor experience in sense of space from visitor's perspectives. However, in shoebox shape, the seating area has a narrower width as compared to performance stage and this allows sound to bounce off left and right the walls to maximise the sound coming from performance stage.

FIRST FLOOR PLAN

Scale 1:100

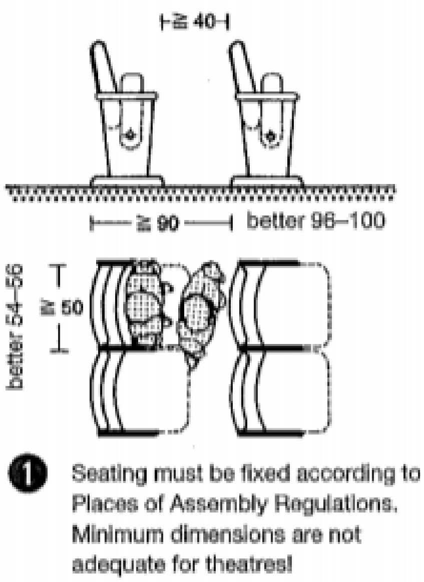
1. Reception hall
2. Seating area
3. Performance stage



Linear view towards rectangular stage

Linear seating rows in rectangular form

Seating dimension



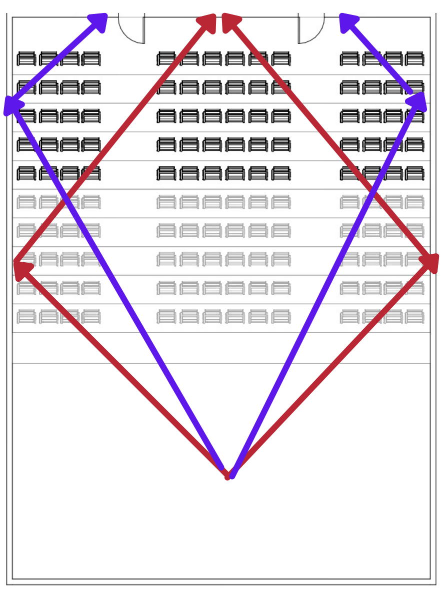


Diagram shows how sound is bounced off left and right the walls to magnify the sound coming from performance stage.

LAYOUT SEATING ARRANGEMENT

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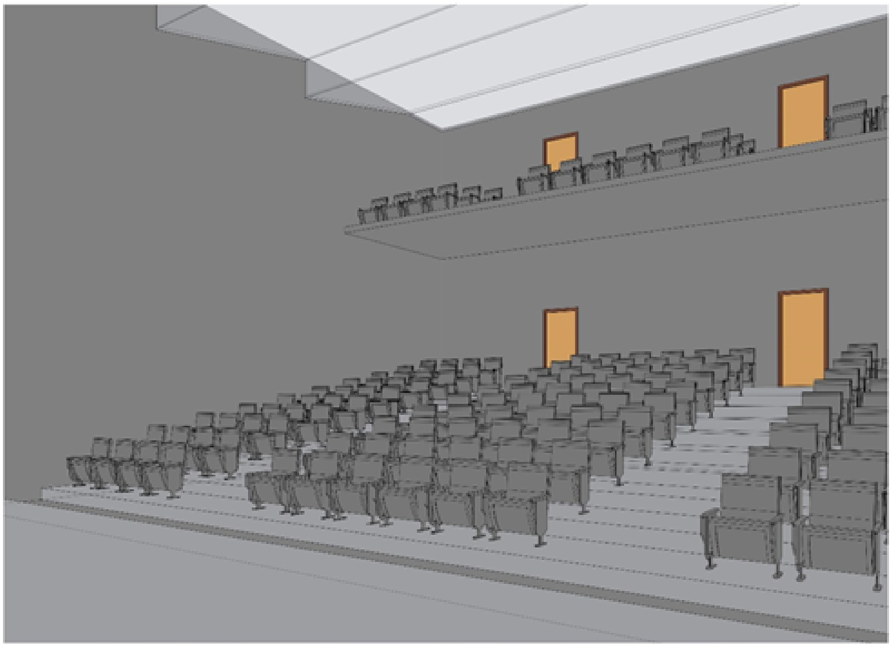
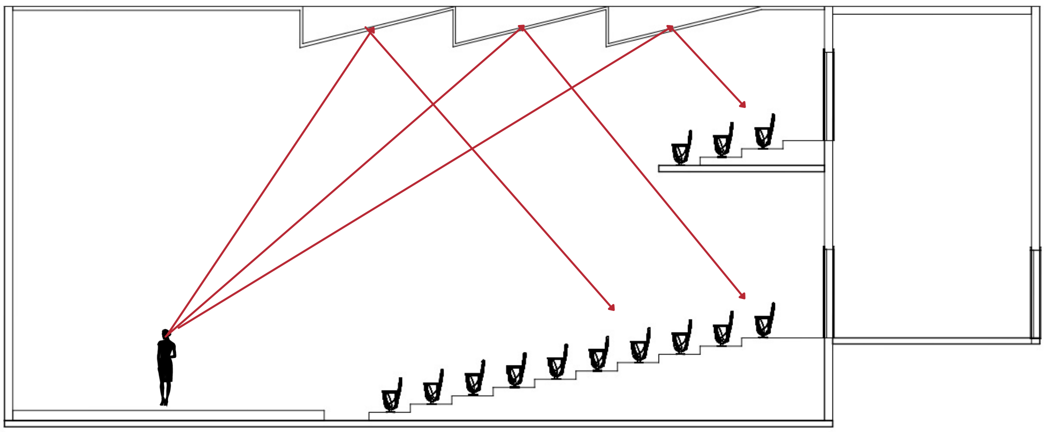


The seating is raised up in the manner of sloping terrace which allows sound to be travelled across the seat without being obstructed by any objects.

PERSPECTIVE VIEW

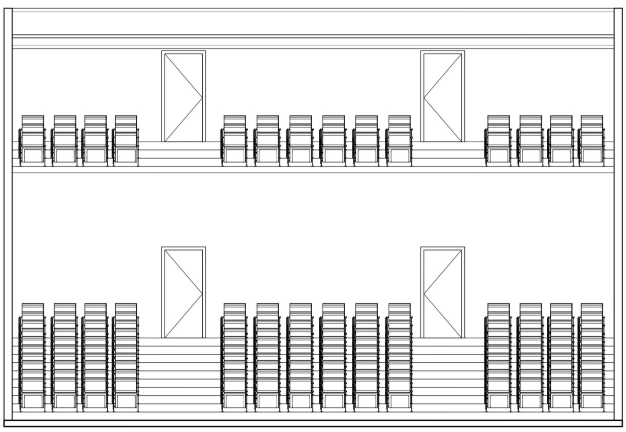
NOT TO SCALE

The hall consists a total of 182 upholstered seats where on the ground floor there are 140 seats while mezzanine floor there are 42 seats.



LONG SECTION

Scale 1:100



SHORT SECTION

Scale 1:100

RATIONAL BEHIND MATERIAL SELECTION

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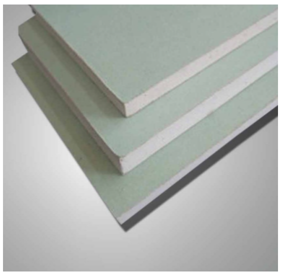
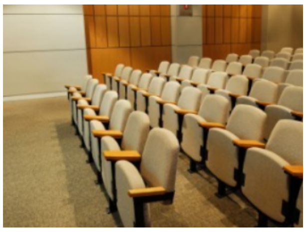


1.



2.

3.

4.

5.

6.

1.Gypsum ceiling board is used as it dampens sound transmission by using the inner polymer layer that reduces sound reflection

2.Upholstered seating with high resiliency polyurethane foam core covered with fabric cover helps to reduce sound reflection

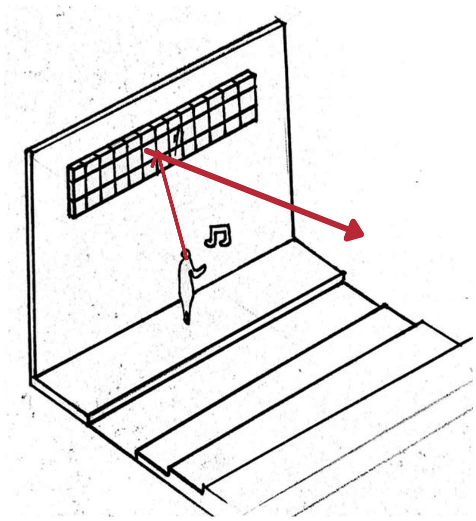
3.Acoustic wall panel that is covered with lightweight 100% polyester thin faux linen which is good in sound absorbing

4.Timber solid-core door with high density blocks sound transmission by eliminating the drum-like construction within a hollow-core door.

5.Timber floor with carpet laying on top is used as an effective sound absorber due to its fibres that have different resonant frequencies at which they absorb sounds

6.Glass block is used not only for allowing sunlight penetration but also shut out noise from outside due to its large mass-per-unit area. It also offers high level of sound insulation with its internal air gap between the glass.

Glass block at the back of stage



Its hard surface compared to acoustic fabric panel allows sound wave is reflected and bounced towards the direction of audience.

REVERBERATION TIME

Ng Xin Ru 1001850447

Formula:

RT= reverberation time in seconds
V= volume in cubic meters
AT= Total absorption of room surfaces

Components	Area (m2)	Absorption Coefficient (500 Hz)	Absorption of Surface
Gypsum Ceiling Board	310	0.08	24.80
Polyurethane Foam Seating	130	0.59	76.70
Fabric Wall	548	0.80	438.40
Timber Door	12	0.06	0.72
Timber Floor	360	0.42	151.20
Carpet Floor	360	0.30	108.00
Glass Block	15	0.03	0.45
Occupants	182	0.44/PERSON	80.08

Total Absorption = 880.35sq.m sabins
Volume of Concert Hall = 2400m^3

RT
=0.16 V/A
=0.16 (6400/ 880.35)
=1.16s

Sound Intensity at main access

D1 = 10m, I1 = 9x10^-6 W/m^2
Assume that D2=25m where the entrance is 25m away from highway
I2 = ?

$$\frac{I_1}{I_2} = \frac{D_2^2}{D_1^2}$$

$$I_2 = D_1^2 \text{ x } \frac{I_1}{D_1^2}$$

$$= 10^2 \text{ x } \frac{9 \, x \, 10^{-6}}{25^2}$$

$$= 1.44 \text{ x } 10^{-6} \text{ W}/m^2$$

SOUND LEVEL

Ng Xin Ru 1001850447

Sound Level

$L1 - L2 = 10 \log (I1 / I2)$

$= 10 \log (D_2^2 / D_1^2)$

$= 10 \log (25^2 / 10^2)$

$= 7.96dB$

Three sound sources are assumed.

Whisper

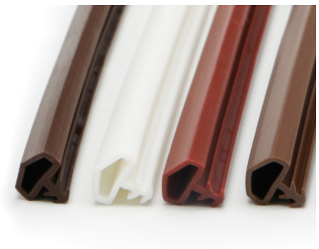
Ringing Telephone

Musical Instrument

i	Whisper	Ringing Telephone	Music Instrument
SPL_i	30dB	60dB	110dB
SPL_i / 10	3	6	11
$10^{SPL_i / 10}$	1000	1000000	$1x10^{11}$
$\Sigma 10^{SPL_i / 10}$		100001001000	
$log_{10}\ \Sigma 10^{SPL_i / 10}$		11	
$10\ log_{10}\ \Sigma 10^{SPL_i / 10}$		110dB	

DESIGN STRATEGIES

Ng Xin Ru 1001850447



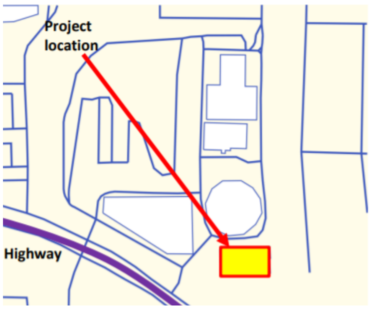
Design strategies relate to sound quality in interior

1.Sound generated by movement of doors and people at the reception or lobby

-Adding rubber gasket seal to reduce the amount of sound entering the concert hall. This helps to reduce the noise level to less than 25db for the seats nearby the entrance.

2.Footsteps from people entering and leaving the hall

-Carpeted floor is used to reduce the impulsive noise by efficiently absorbing the noise.

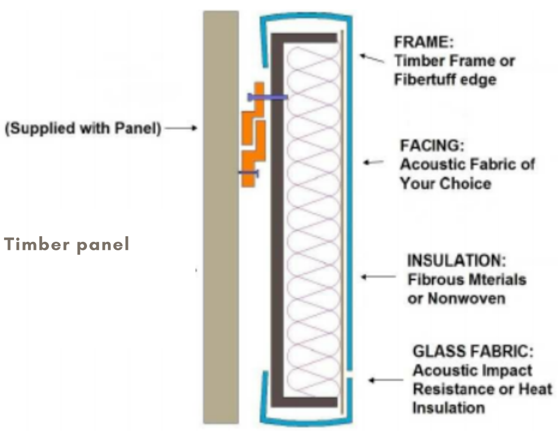


Design strategies relate to noise prevention from outside

1.Construction and traffic noise

-Due to the location next to a constructing highway and busy road, traffic sound can be heard clearly, and this distracts the performance happening within the building. Therefore, vegetations are planted around the building as it does not only visually aesthetic but also acts as buffer to reduce noise pollution. Trees are planted side by side and close to each other for maximum performance to shut down the noise.

-Thick Timber wall is used as base for the carpet to be installed on the surface of it which reduces the sound transmission into the concert hall.



Conclusion
References

Ng Xin Ru 1001850447

In conclusion, I found out that there are many thinking going on while designing a concert hall. The form of space, the layout or arrangement of seating, the choice of material and other factor that will affect the quality of experience during the performance. For a concert hall, it is best to have a reverberation time between 1.5s to 2.5s. If there is no reverberation time, the space gives pure inverse square law behavior which may cause difficult hearing in the back and it loses richness and fullness which is not a desirable condition for music. On the other hand, if higher than 2.5s, there will be severe loss of sound articulation where if people giving a speech, people could not understand clearly. Therefore, for my concert hall I have used carpet as one of the sound absorbing material to shorten the reverberation time while using reflective ceiling to lengthen the reverberation time.

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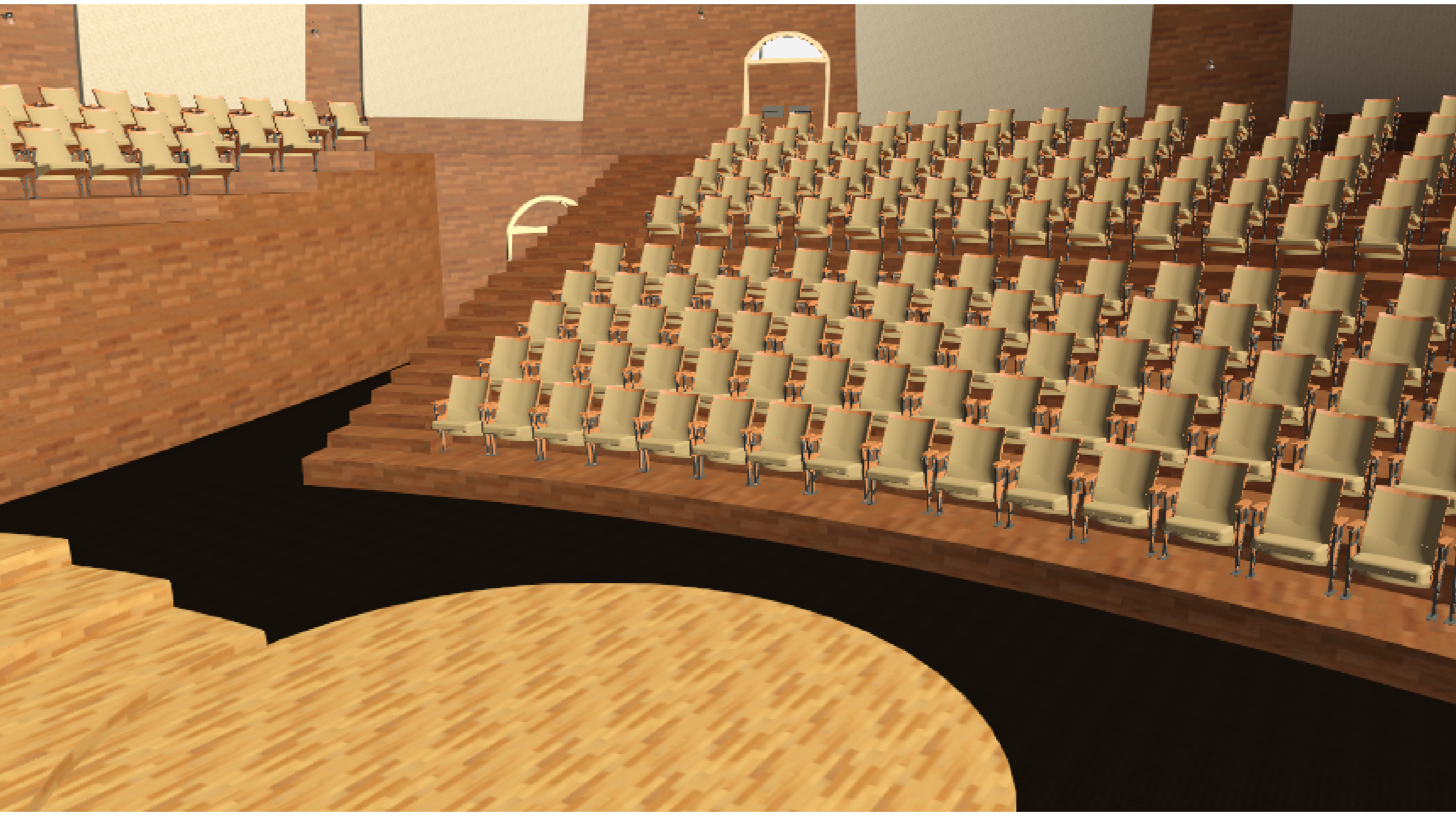
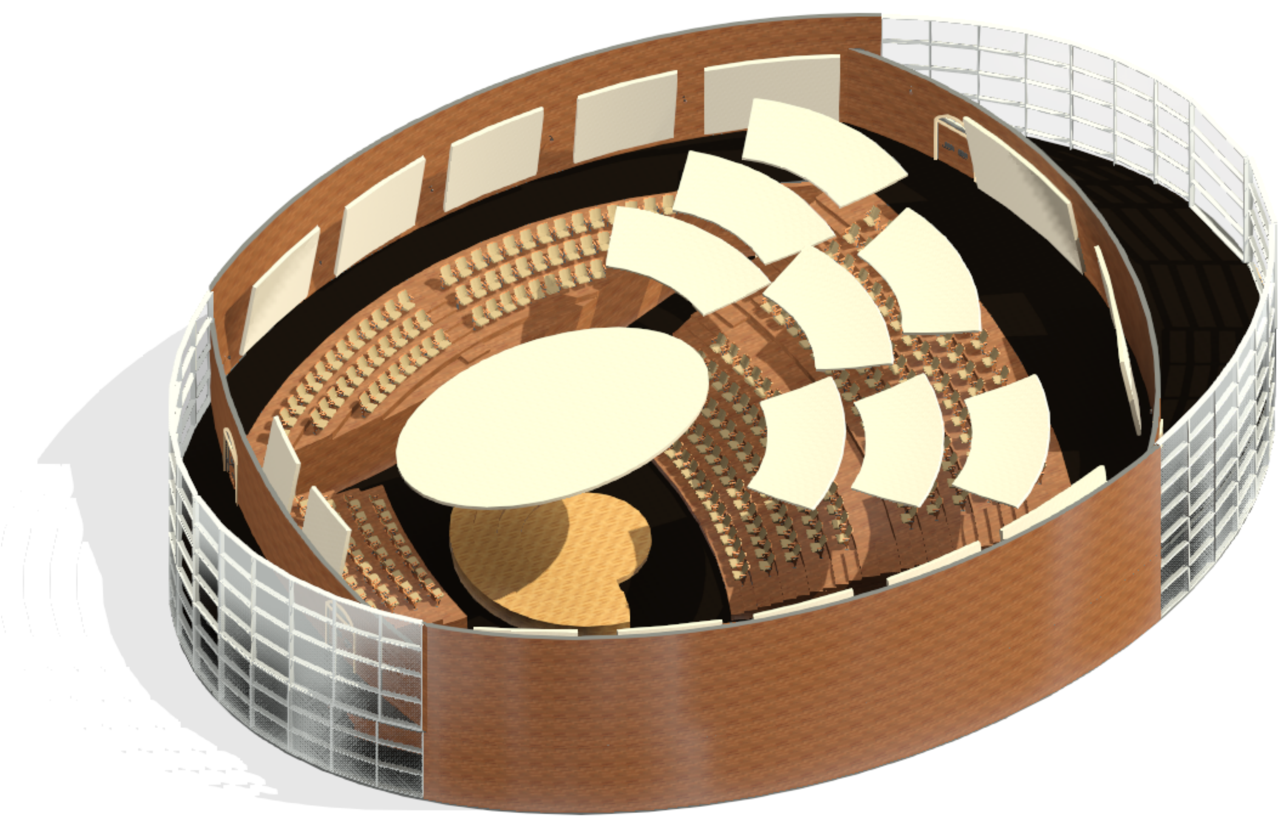
7 Individual Part

Concert Hall

Guma Sylvester Makajil 1001955608

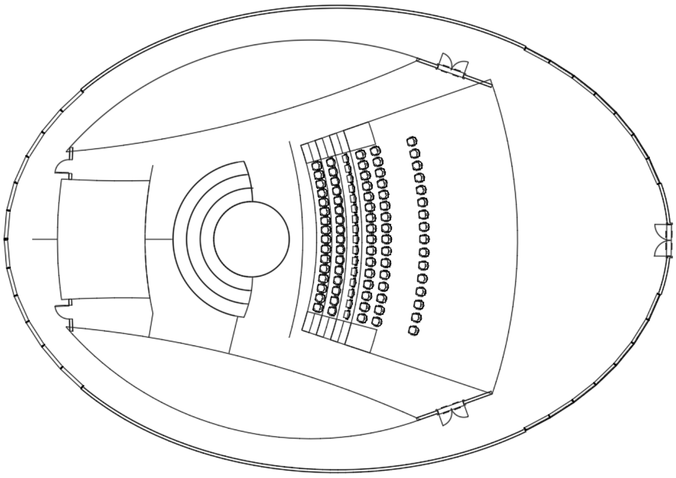




FORM AND LAYOUT DESIGN

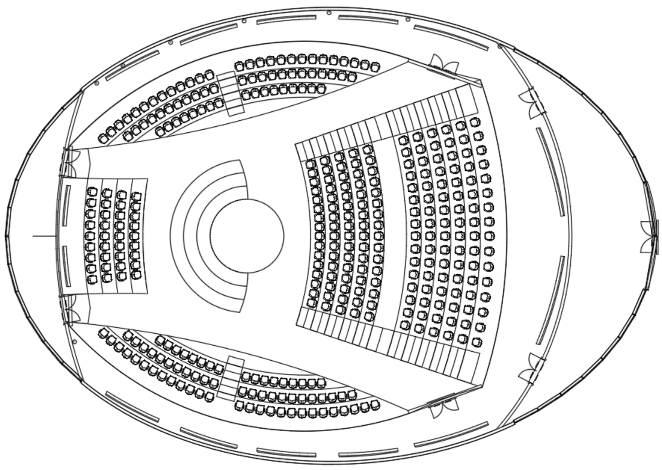
Guma Sylvester Makajil 1001955608

Ave Concert Hall



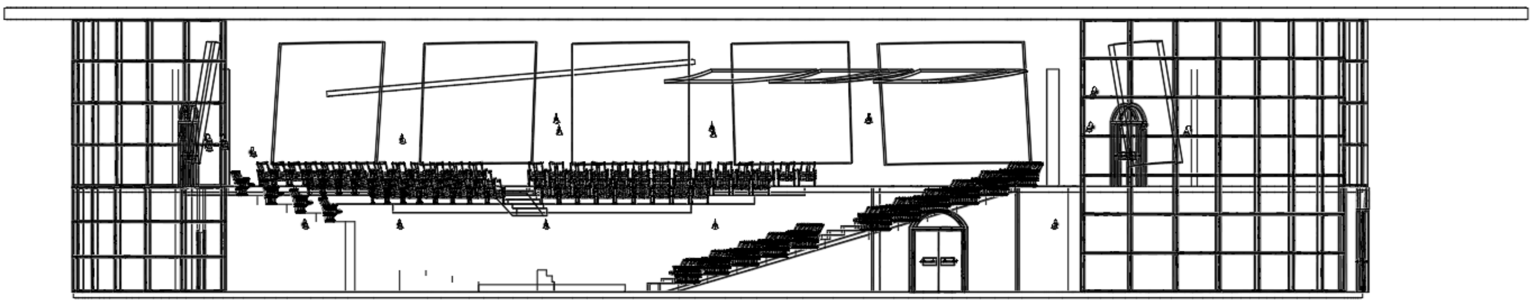
GROUND FLOOR PLAN

Scale 1:100



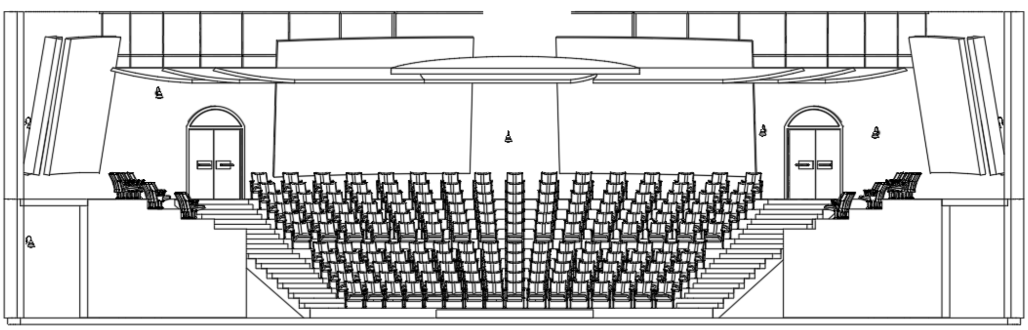
MEZZANINE FLOOR PLAN

Scale 1:100



LONG SECTION

Scale 1:100



SHORT SECTION

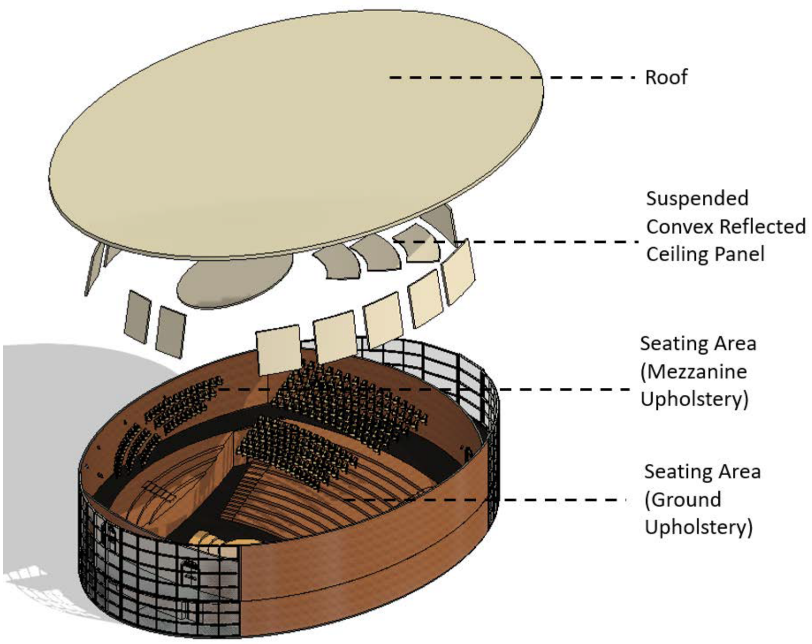
Scale 1:100

FORM AND LAYOUT DESIGN

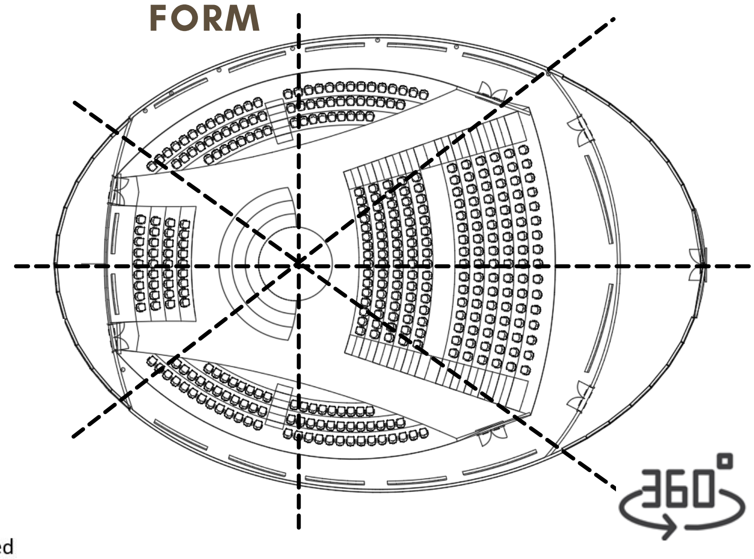
Guma Sylvester Makajil 1001955608

Ave Concert Hall

AXONOMETRIC | NTS



FORM



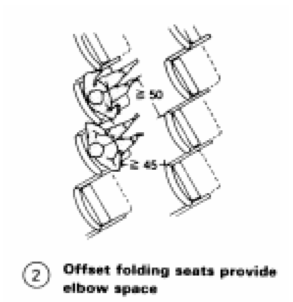
- The design of concert hall is inspired and adapted by the form of a vineyard layout.

- This provides a 360° layout create the shape of the seating area that allows for a more organic seating arrangement and provides concert experience of unparalleled intimacy, offering exquisite sightlines from all angles and a rare conjoining of artists and audience.

- The walls surrounding the stage on which the seats are banked help provide the early reflections of sound from the side that are generally considered favorable.
- Echoes occur when there is an audible gap between the direct sound and its reflection.[

FEATURES

Seating Arrangement: The concert hall can accommodate about 298 people in one room.



International Standards: Hall designed based on Neufert Data

RATIONAL BEHIND MATERIAL SELECTION

Guma Sylvester Makajil 1001955438

Chisic Concert Hall

MATERIAL SELECTION

Interior

1.CEILING

Glass Fibre Reinforced Gypsum

Consists of gypsum that provides good sound insulation performance paired with extremely resilient glass bers that give the material its strength and lightweight qualities

2.WALL

Solid Douglas Fir Panel

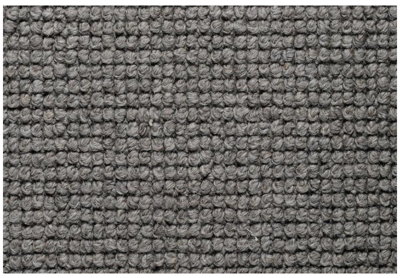
Solid Douglas Fir Panel consists of outstanding quality so it come with a high impact sound reduction and enhance the acoustic of the hall.

3.STAGE FLOORING

Oak flooring

Is used for the stage as the material is a hard surface but gives a coloring and mellowing to sound. Wood has some porosity and hardness so it gives you a richness that you wouldn't get from a tile floor or concrete floor.

4.GROUND FLOORING



Woollen Carpet Flooring

is an extremely effective sound absorber because the the millions of wool fibers in an area of carpet have a range of lengths, diameters, crimps and spirality, which enables them to absorb sounds over a wider range of frequencies.

4.SEATING

BURLAP FABRIC

is thick and porous. The waves enter into the fabric, and some become trapped in the bers and folds and convert from sound energy into heat. This can improve the quality of sound within a room, by decreasing reverberation and echo of the sound generated in the room.

DESIGN STRATEGIES

Helen Lim Xin Ying 1301849935

INTERIOR SOUND QUALITY OF CONCERT HALL

Suspended Wood Reflector

There are suspended wood reflector placed above the central stage and sails are placed at both side of the wall.This is to deliver the sound to different directions so the audience from different direction can receives best sound quality.

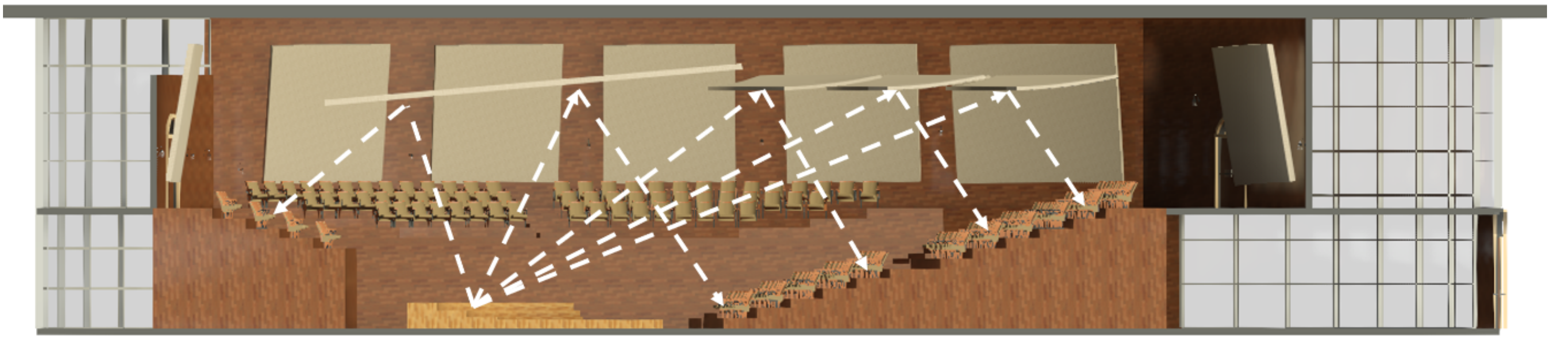
Seat material

The properties of the seat materials absorbs the sound coming from the stage thus reducing any unwanted noise

Wool Carpet

Hard surfaces will cause excessive sound reflection and lead to echo. Therefore, the floor is carpeted to absorb the sound of footsteps and from stage.

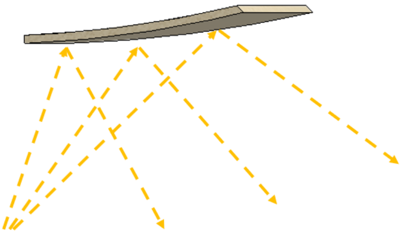
Sound Propagation



The sound from more than 1 direction and receives best sound quality. The convex structure plays an important role in reflecting surfaces that creates sound dispersion in an open space.

The walls of the concert hall are installed with acoustic diffusion panels to enhance the richness of sound and help create a sense of spaciousness. Diffusion spreads the reflected sound energy in a room, also reducing the harmful effects of strong echo and reverberation

Convex Wood Reflector



CALCULATION OF REVERBERATION TIME

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Concert Hall

Formula:

RT = 0.16 V/A (METRIC UNITS)
Where

- RT= reverberation time in seconds
- V= volume in cubic meters
- A= total absorption in square meter

(sum of room surfaces times their sound absorption coefficients plus the sound absorption provided by furnishings or audience, etc)

Total Absorption(A)= Area x absorption coefficient

Material	Area (m2)	Absorption Coefficient (500 Hz)	Total Absorption
Wall Solid Douglas Fir Panel	810	0.38	307.3
Acoustic Reflector	172	0.25	43
Floor Oak Wood Flooring	340	0.10	34
Wollen Carpet	235	0.6	141
Ceiling Gypsum Board	850	0.18	63
Acoustic Reflector	425	0.25	106.25
Other			
People	298	0.44	131.12
Total Absorption			825.67

Using Sabines' Formula:
RT= 0.16V/ A
RT = 0.16 x (Volume of Exhibition Hall) / Total Absorption
RT = 0.16 x 10643/825.67
RT = 2.06 sec

SOUND INTENSITY
SOUND LEVEL

Choo Pei Yan 1001955438

Concert Hall

Sound Intensity at Main Access

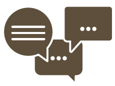
$$\frac{i1}{i2} = \frac{d2^2}{d1^2}$$

D1 = 10m, I1 = 9x10^-6 W/m^2
Assume that D2=22m,where the entrance is 20m away from highway , therefore i2=?

d1=10m
i1=9x10^-6/m^2
d2=22m
i2=$d1^2$xi1/$d2^2$
i2=10^2x9x10^-6/22^2
=0.0000018595
=1.85x10^-6 W/m^2

Sound Level

Assume the three sound sources in the interior space:



Sound Source	Whisper	Piano	Ochestra
Sound Pressure Level (dB)	20	65	110
(SPLi)/10	2	6.5	11
10(SPLi)/10	100	3,162,278	100000000000
Σ10(SPLi)/10	100 + 3,162,278 + 100000000000 = 100,003,162,378		
Log Σ10(SPLi)/10	Log Σ100,003,162,378 = 11.0		
10Log Σ10(SPLi)/10	110dB		