Room Acoustic Treatment for Multifunctional Hall Case Study: Yayasan Sinar Pelangi, Jatibening, Bekasi

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ABSTRACT
Designing a multifunction hall must pay attention to all aspects, one of the aspects is room acoustic. Acoustic in a performance hall must be perfectly designed so that the event can run well and a maximum performance also audience satisfaction can be achieved. Moreover, the hall on Yayasan Sinar Pelangi will be used for ballet performance. An optimal room acoustic design can avoid acoustic defects which include echo, prolonged reflection, reverberation, etc. To avoid those things, room acoustic treatment must be used on every interior element and the materials should absorb, reflect, and diffuse sound. The shape of the room is also very important to create acoustic comfort such as rectangular, hexagonal, horseshoe, and fan, each of the shape has its advantages and disadvantages. The method used in this journal is qualitative, while collecting data by using literature studies, interviews and observations. This journal determines to find the best room shape for multifunctional hall, acoustic materials and creating the interior elements in order to improve the acoustic quality of the room. By determining those things, the acoustic design of multifunctional hall will give comfort to the audiences.

Keywords: *Acoustic Defective, Acoustic Room Material, Multifunction Hall, Room Acoustic*

1. INTRODUCTION

The multipurpose hall building is a place that can be used for various activities, one of them is art including music, dance, and theater. Multifunctional hall in Yayasan Sinar Pelangi is intended for dance activities, ballet performances, and ballet practice. Related to those purposes, the design of the multifunctional building must consider several factors, one of them is room acoustics.

Acoustics is a science about controlling how sound behaves in a room or enclosed area. According to S, Handoko (2015), room acoustics also include all the effects that caused by a sound to the audiences. Room acoustics play an important role in interior design because with acoustics, sound can be evenly distributed to every part of the room, both near and far from the sound source.

The acoustic design of the room must be maximized so that when the event is held, the event can run well and optimal performance quality also audience satisfaction can be achieved. The multifunction hall in Yayasan Sinar Pelangi will be used for performing arts such as ballet and drama, so the feels, all the dramatic effects, and the purpose of the ballet or drama must be perceived and understood by the audiences. Therefore, audiences from every location should be able to hear and enjoy the art performance.

A poor acoustic treatment design will cause acoustic defects which include reverberation, formation of echoes, sound foci, dead spots, insufficient loudness, and external noises. According to a study conducted by A, Ramadhan (2017), acoustic defects occur because most of the floor, wall, and ceiling elements are using hard materials. Hard materials may increase the potential that cause acoustic defects such as echoes and resonance.

To avoid acoustic defects, it is necessary to use the right acoustic material according to the function of the room because a good acoustic material is one of the important requirements for improving the acoustic quality of the room. There are 3 characters of acoustic material, absorber, reflector, and diffuser. Those 3 are very important and must be carefully considered while designing a room acoustic.

This journal determines to find the proper shape of the room so that the sound energy distribution is evenly distributed in the space, to find out the alternative acoustic materials that are suitable for multifunctional hall, and developing interior elements starting from the floor, walls and ceiling) that can be applied in Yayasan Sinar Pelangi multifunction hall. When the acoustic is applied to the interior, it produces the optimum conditions for performance on the multifunction hall and prevent acoustic defectives.

2. METHOD

2.1. Research Method

The research method used in this journal is qualitative. Qualitative research method collects data to understand concepts, opinions, or experiences. This method produces descriptive data of the observed object, in this case,the acoustics of the multifunctional hall especially in area for audience and stage area. Qualitative research describes the reality correctly which is arranged in words as a result of data analysis.

2.2. Collecting Data Method

To obtain data, the methods used at the time of data collection are:

1. Literature
   Literature study was conducted by browsing the literature containing theories related to the topic of reports from journals and books. The data obtained from this literature study will be used as a comparison with the result data from the actual project to test whether the actual project is correct or incorrect.
2. Interview
   Interview is a process of communication or interaction to collect information between researchers and informants about the object related (Mudjia Rahardjo, 2011). In this method, researcher did an interview with the room acoustic team who handled the multifunctional hall acoustic to ask for advice on the right type of acoustic material that can be used in this project that matches the function and size of the room.
3. Observation
   The observation technique is a data collection that is carried out by observing the project directly. In this case, researchers did an observation on the shape and size of the room, the areas that will be given acoustic material, and the type of acoustic material that is suitable for the areas.

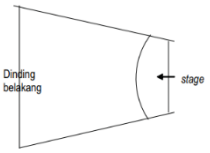
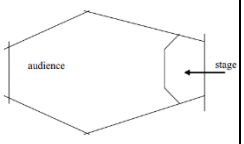
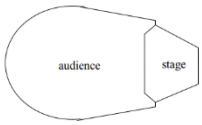
3. RESULT AND DISCUSSION

3.1. Literature Study Result

Based on the book by Leslie Doelle (1990), there are several main requirements in designing the acoustic of performance hall such as:

- Enough loudness
  Enough loudness is obtained by shortening the distance between the audience and the sound source using sound-reflecting materials and making a slope on the floor.
- The right room shapes
  Each shape of the room in the performance hall has its advantages and disadvantages according to Mills (1976) as follows:

Table 1 Performance Room Shape

Room shape	Advantage	Disadvantage
Rectangular  **Figure 1** Rectangular Shaped Room (**Source**: Doelle, 1990)	-High change of soundunifor mity -Good balance of early and late sound energy	-Distance between the audience and sound source is far
Fan  **Figure 2** Fan Shaped Room (**Source**: Doelle, 1990)	-Containing the maximum number of audience in a given angle for a specified maximum source receiver distance	- Soundabsorpt ion is too high on the back side or the wider side causing the acoustic material tendto be different on each side.
Hexagonal  **Figure 3** Hexagonal Shaped Room (**Source**: Doelle, 1990)	-The audience's position is closer to the sound source -There is acoustic uniformity	
Horse-shoe  **Figure 4** Horse-shoe Shaped Room (**Source**: Doelle, 1990)	-The shape of the wall makes the distance between the audience and the sound source closer	-Sound absorption is too high at the back (concave part)

(**Source**: Leslie Doelle, 1990)

- Sound distributed evenly
  Audiences from all sides should be able to hear the sound of the show clearly whether the position is near or far from the sound source. The selection of the right acoustic material affects distribution of the sound. The characteristics of the right acoustic materials for multifunctional hall are:

a. Absorber

Figure 5 Sound Waves on Absorptive Surfaces **(Source**: Mediastika, 2005)

A material which surface is made of a material that absorbs sound. Examples are glass wool, mineral wool, foam, fabric covers absorber, grid absorber, acoustic tile, etc.

b. Reflector

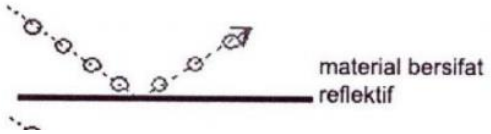


Figure 6. Sound Waves on Reflective Surfaces **(Source**: Mediastika, 2005)

A material which surface is made of a material that reflects sound. Examples are ceramics, metal, gypsum board, and concrete.

c. Diffuser

Figure 7 Sound Waves on Diffusive Surfaces **(Source**: Mediastika, 2005)

Material which has a surface that can spread sound, usually diffuser materials have an uneven surface. Examples of this material are QRD diffusers, BAD panels, diffsorbers, etc.

According to previous research, each element that makes up space has different characteristics.

Table 2 Material Characteristics for Interior Elements

Material Characteristics			
	Reflector	Absorber	Diffuser
Ceiling	√		
Front side wall	√		√
Side wall	√	√	
Back side wall		√	√
Flooring		√	

Source: Zuyinati, Ika (2015)

Each interior element (floor, wall, and ceiling) requires its own treatment. The area in the performance hall is divided into 2, the speaker area (stage as a sound source) which should be elevated by 60-120cm and the audience area which should be made with a minimum angle of 15º and a maximum of 30º (Everest and Pohlman, 2009). For wall, each side of the wall uses different materials characteristics (absorber, reflector, and diffuser). And for ceiling, the surface must be designed with false ceiling to control the reflections of the sound waves to have optimal acoustics in all places in the room and ceiling surface must be made uneven instead of flat.

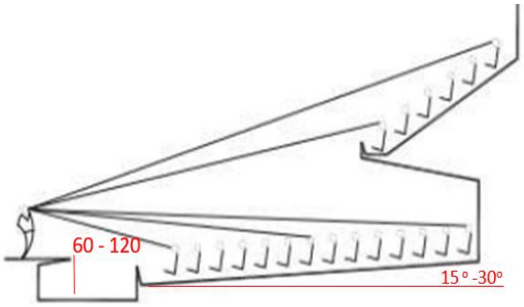


Figure 8 Elevation of Stage Area **(Source**: Long, 2006)

The shape of the ceiling also affects the acoustic quality. The best shape is concave because most of the sound wave spreads directly to the audience.

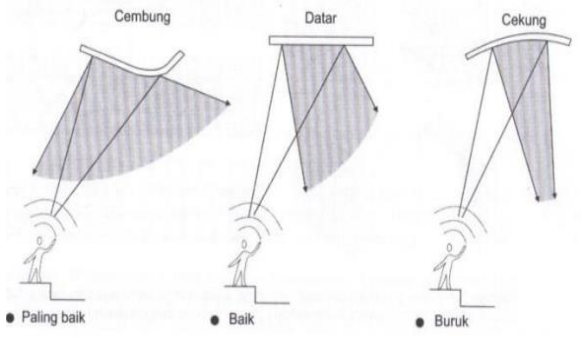


Figure 9. Sound Wave Reflection on Ceiling **(Source**: Mediastika, 2005)

• No acoustic defects

Poor acoustic design will cause acoustic defects. Room acoustic defects include:

1. Reverberation: a persistence of sound in the enclosed space, after the source of sound has stopped.
2. Echo: a sound reflected off a surface that arrives at the listener after the direct sound.
3. Sound foci: reflecting uneven ceiling surface cause concentration of reflected sound waves at certain spot, creating a sound of large intensity.
4. Dead spots: This defect is an outcome of the formation of sound foci. Because of high intensity of reflected sound at sound foci, there is deficiency of reflected sound at some other points.
5. Insufficient loudness: This defect is caused due to lack of sound reflecting flat surface near the sound source or excessive sound absorption treatment in the hall.

To avoid acoustic defects, the acoustic room design must use materials that have suitable characteristics on every interior element (floor, walls, ceiling).By proper designing

and by providing highly absorbent materials, this defect can be eliminated.

3.2. Interview Result

Interviews were conducted with an acoustic room and soundproofing specialist from PT. Tirtajaya Gemilang Abadi who handled the room acoustics treatment at Yayasan Sinar Pelangi Multifunction Hall. Here are some results from the interview:

- The audience area and the stage area of the multifunction room (each has the total area of 104m^2 and 15m^2) require soundproofing materials on the walls and ceiling such as rock wool insulation which has a nominal density of at least 60kg/m^3.
- In addition, the areas can also use acoustic panels that used to reduce the occurrence of echoes which are made of fabric.
- The door must also use an absorber material in the inner part of the door.

3.3. Observation Result

Yayasan Sinar Pelangi is located on Jl. Kemangsari II No. 39, Jatibening, Pondok Gede, Bekasi. This foundation is a social institution that helps children with physical disabilities medically and educatively.

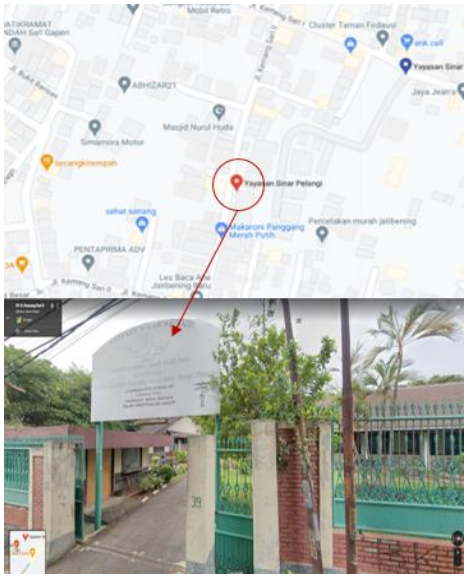


Figure 10 Yayasan Sinar Pelangi **(Source**: Google Maps, 2021)

There are several buildings in this foundation such as school, clinic, orphanage, and multifunction hall.

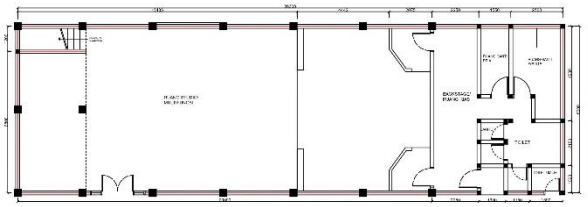


Figure 11 Yayasan Sinar Pelangi Existing Plan **(Source**: Author Document, 2021)

The shape of the multifunctional hall is rectangular, this shape gives some advantages by increasing the level of balance of the early and final sound and high change of sound uniformity. In the multifunction hall, there are several areas such as audience area, stage area, backstage area, generator room, and control room.

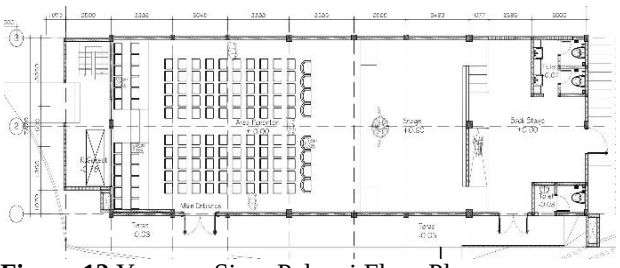


Figure 12 Yayasan Sinar Pelangi Floor Plan **(Source**: Damaska, 2021)

This research focuses mainly on the areas that will be applied with acoustic treatment which are audience area and stage area.

a. Audience Area

Figure 13 Audience Area **(Source**: Author Document, 2021)

Figure 14 Tribune Area **(Source**: Author Document, 2021)

Total area: 104.5 m^2
• The floor in the audience area uses vinyl.
• Walls use concrete with paint finish. Beside performance, this hall is also used for ballet practice, a mirror with a hollow frame is placed on the wall. When the hall is used for ballet performances, the mirror is closed with a blackout curtain.
• Ceiling uses gypsum with paint finish. Before installing gypsum, the ceiling was given rock wool with a nominal density of 40 kg/m^3.
• Door uses glass material with sandblast sticker finish.

b. Stage Area

Figure 15 Stage Area **(Source**: Author Document, 2021)

Total Area: 15 m2
• Stage area uses vinyl for flooring and is made with an elevation of 80cm.
• Walls on all sides use concrete with paint finish. There is a vide tron on the front side wall, so blackout curtains are installed on the front wall.
• Ceiling using rock wool material (density 40 kg/m3) and covered with gypsum finishing paint.

3.4 Analysis Result

Table 3 Room Shape and Interior Element Analysis

	Literature Data	Factual Data
Room Shape	A good performance room shapes are rectangle, hexagonal, horseshoe, and fan	The shape of the hall is rectangular
Interior Element Treatment	A good ceiling for performance hall is flat but the best one is concave with an uneven surface	This hall uses flat ceiling
	Back side wall should use absorber material to prevent echo	Back side wall uses bricks with paint finish (reflective)
	Side walls must use reflective material	Side walls use bricks with paint finish (characteristic of brick wall is reflective)
	Stage area is elevated between 60-120cm	Stage area is made with an elevation of 80m
	The minimum angle of the audience floor is 15° and a maximum of 30°	Audience area flooring is flat with no slope

(Source: Author Document, 2021)

The performance room shape, this is in accordance with the literature. This form gives high change of sound uniformity and a good balance of early and late sound energy. This building has a flat ceiling (in accordance with the literature). However, the acoustic design will be even better if using a convex ceiling with an uneven surface that makes most of the sound spreads directly to the audience.

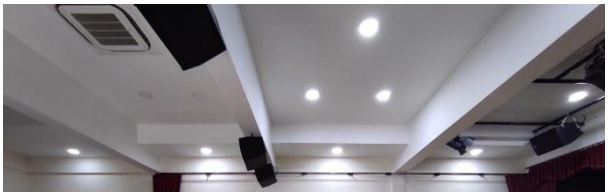


Figure 16 Ceiling **(Source**: Author Document, 2021)

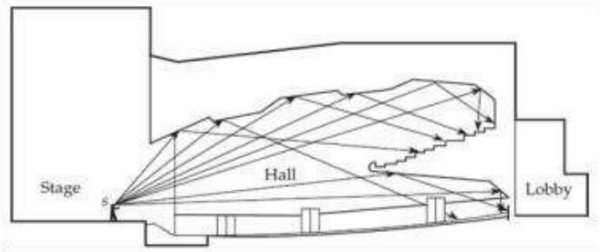


Figure 17 Recommended Ceiling Surface **(Source**: Zuyyinati,Ika, 2015)

The back side of the wall on stage area does not use any insulation so it is not in accordance with the literature. Instead, it can use some absorptive materials such as glass

wool, mineral wool, foam, fabric covered absorber, grid absorber, acoustic tile, etc.

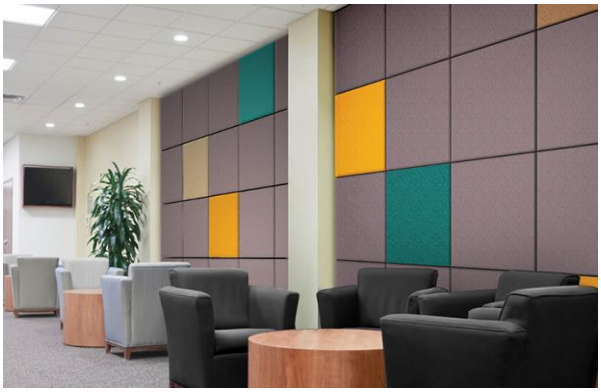


Figure 18 Fabric Covered Acoustic Panel **(Source**: dextroacoustics)

The side wall of the stage are in accordance with the literature because they use bricks with wall paint finishing so that they are reflectors.
The elevated floor on the stage area is 80cm so it is in accordance with the literature, but due to the limited height of the ceiling in the multifunction hall, there is no floor slope, so it is not in accordance with the literature. According to previous research, the floor must have a minimum slope of 15^{o} and a maximum of 30^{o} because sound travels faster when it travels through the slope.

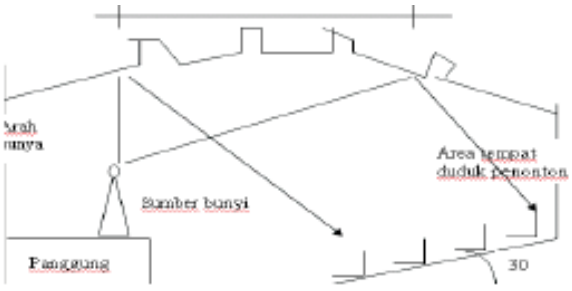


Figure 19 Recommended Floor Slope **(Source**: Doelle, 1990)

Table 4 Material Characteristics

Material Characteristic		
Audience Area		
Total area : 104,5m^2		
Material	**Literature**	**Factual**
Floor	Absorber	Vinyl (absorber)
Ceiling	Reflector	Rockwool (absorber)
		Gypsum paint finish (reflector)
Side Walls	Absorber & Reflector	Concrete paint finish (reflector)
		Mirror (reflector)
		Curtain blackout (absorber)
Back side wall	Absorber & Diffuser	Concrete paint finish (reflector)
Door	Absorber	Glass door sandblast finish (reflector)
Stage Area		
Total area : 15m^2		
Floor	Absorber	Vinyl (absorber)
Ceiling	Reflector	Rockwool (absorber)
		Gypsum paint finish (reflector)
Front side wall	Reflector & Diffuser	Concrete paint finish (reflector)
Side walls	Absorber & Reflector	Concrete paint finish (reflector)
		Curtain blackout (absorber)

(**Source**: Author Document, 2021)

There are several material characteristics that applied to every interior element of the performance hall. In all areas, the floor uses absorbent vinyl so that it is in accordance with the literature.
The ceiling in this building uses rock wool for the inner part of the ceiling and covered with gypsum with paint finish. Rockwool is a sound-absorbing material, so it will be more appropriate when it is used on the walls instead of the ceiling. Gypsum is a reflector material, so it is in accordance with the literature
The front side wall, as a sound source, uses concrete with paint finish so the sound can be spread throughout the room (already according to the literature). The left and right side of the wall also use concrete with paint finish and mirrors (when the multifunction hall is used for ballet practice). At the time of the show, the mirror is closed with a blackout curtain.

Figure 20 Mirrors on Side Wall **(Source**: Author Document, 2021)

Figure 21 Mirrors Covered with Curtain **(Source**: Author Document, 2021)

The mirror has reflector characteristic while the curtain has absorber characteristic so that it is in accordance with the literature. For the back side of the wall, the material used is a reflector so that does not match the literature. The right material to use is an absorber to absorb the sound produced by a sound source or a diffuser to spread sound.

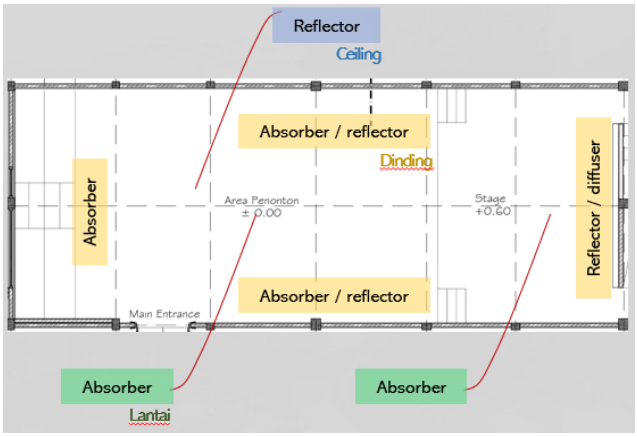


Figure 22 Recommended Material Characteristics **(Source**: Author Document, 2021)

The door in the multifunction hall uses a glass door, this is not in accordance with the literature because the door should use an absorber material. Absorber materials can be applied to the inner part of the door or the outside of the door to produce a soundproof door

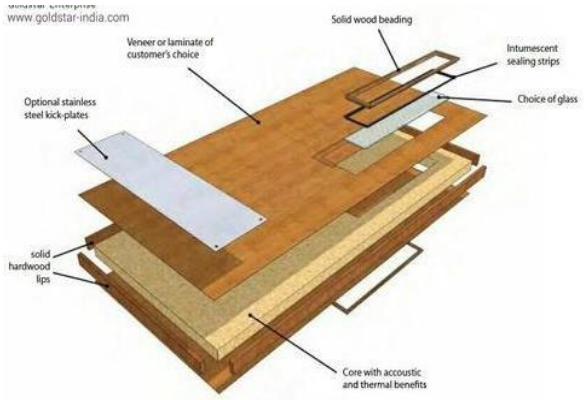


Figure 23 Soundproof Door

4. CONCLUSION

Good acoustic design can avoid the acoustic defects. It is necessary to choose the right material characteristic for every part of the room and give treatment to the interior elements that build up the room.

It can be concluded based on the acoustic design that the design of Yayasan Sinar Pelangi Multifunction Hall has not been maximized. Some interior elements that build up the space have not been optimally designed and the material characteristics used on the floor, wall and ceiling are not completely correct. The acoustic quality of Yayasan Sinar Pelangi will be improved by using an absorber/diffuser on the back side of the wall, reflector material on the ceiling so that sound can reflect to the audience, and absorber material for doors. In addition, this space can be maximized by making a slope on the floor and creating a false ceiling with uneven surface.

When the acoustic design is right, it will produce a room that can distribute sound evenly throughout the room without any echoes or any other acoustic defect so that the quality of the performance is optimal and the audience can enjoy the show.

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