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Acoustical Analysis of Auditorium in National Educational Museum, West Java

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Acoustical Analysis of Auditorium in National Educational Museum, West Java

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Abstract. Besides being the place for evidence of past history and future history, the National Educational Museum in West Java also has audio visual room, for the visitor to learn about the museum more. Visitor ability to understand what is being said in the auditorium depends on the acoustics quality of the room. This study primarily talks about acoustics auditorium and find out if the acoustics in Auditorium of National Educational Museum is optimal for its function. The objective of this analysis is to determine the acoustics quality of the room in Auditorium of National Educational Museum. The simulation results with acoustic standards was carried out after conducting field observations and simulations using Ecotect v.5.50 software. After the simulation conducted it is known that there is some factors that makes this auditorium reverberation time not optimal such as sound-reflecting materials, floor and ceiling shape and elevation, and the number of occupants in the room. Which resulted in the speaker's voice become less clear to the perceiver. Thus, to respond to the issue some materials can be change to sound-absorbing materials, and the ceiling shape can be made simpler to reduce the reverberation and echoes.

1. Introduction

The Auditorium of National Educational Museum is located in Universitas Pendidikan Indonesia area near the entrance. This create the necessity for the buildings in the area to be comfortable and suitable for learning and such, so that the students and the communities can learn comfortably.

Figure 1. Location of National Educational Museum. Source: (Google Maps, 2024)

The learning process in educational environments requires an effective acoustic design, considering the recent architectural surroundings. Unfortunately, many educational facilities have

inadequate acoustics due to various obstacles, particularly noise interference [1]. The room for speeches and other such activities must be ideal, so that communication between the speaker and the audience doesn't get lost along the way. This can happen when the room for speeches such as auditorium doesn't met optimal auditory condition. Therefore, research related to auditorium acoustics is vital to attain optimal auditory condition [2].

There are various factors that can impact the acoustics of a room, including loudspeakers, the room's shape and size, the design of the roof or ceiling, the materials used, and the number of individuals occupying the space [3,4,5]. In which, there are a several acoustical parameters as a benchmark to determine if the room is in accordance to the parameters. The quality of room acoustics can be deemed satisfactory when the reverberation time of speech or speaking attains the optimal value and the sound distribution is evenly spread [6]. Consequently, the reverberation time stands as a crucial determinant in assessing the excellence of room acoustics [7].

How well people can communicate or perform in an auditorium or such space is directly influenced by the effectiveness of its acoustic quality [8] In this study, the emphasis is on examining the acoustics of auditoriums to find out whether the auditorium suitable for people to be doing speeches, performing, or learning as this auditorium is placed in an educational area, facilitating clear communication between the perceiver and the speaker.

2. Material and Methods

2.1 Material

As mentioned earlier, building acoustics require some things to consider such as loudspeaker, the shape and size of the room, the design of the roof and materials used in the building. And some criteria to be met for an adequate acoustics performance [9]. Hence, creating an optimal acoustics building.

2.2 Methods

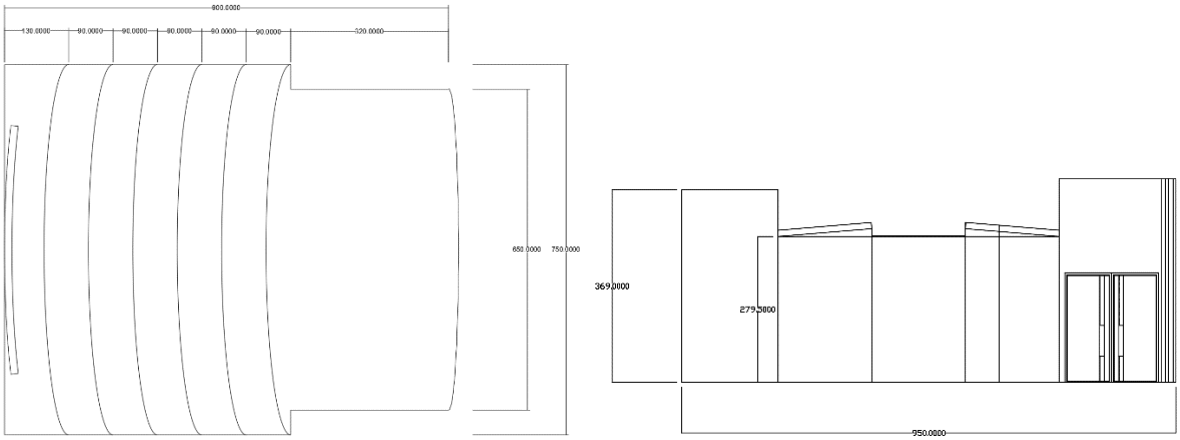
Through the utilization of auralization, This study analyzes the reverberation time and sound distribution using rays and particles [10]. After conductiong field observations, simulations using Ecotect v5.50 software, and extensive literature studies for the purpose of strengthen the research findings, the simulation results were compared to acoustic standards. Ecotect v.5.50 was utilized to identify key parameters such as reverberation time and rays and particles [11,12,13]

3. Result & Discussion

3.1 Room Design

Figure 2. Auditorium in National Educational Museum

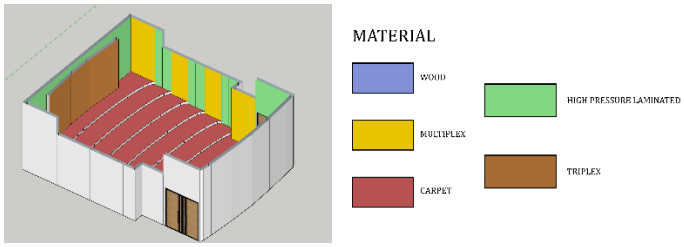
The auditorium in National Educational Museum are quite small as shown in Figure 2, measuring approximately 7,5 x 9 m. This auditorium can accommodate 53 people. The auditorium has different ceiling height as shown in Figure 3.



(**a**) (**b**)

Figure 3. (**a**) Floor plan of auditorium in National Educational Museum; (**b**) ceiling elevation of auditorium in National Educational Museum.

The auditorium in National Educational Museum utilizes six loudspeakers with identical specifications and five different types of materials. Figure 4 (a), (b) clearly demonstrate that carpeted floor, high pressure laminated (HPL), and multiplex are the primary materials employed in the construction of auditorium in National Educational Museum.



(**a**) (**b**)

Figure 4. (**a**) Interior material colors; (**b**) descriptions of colors.

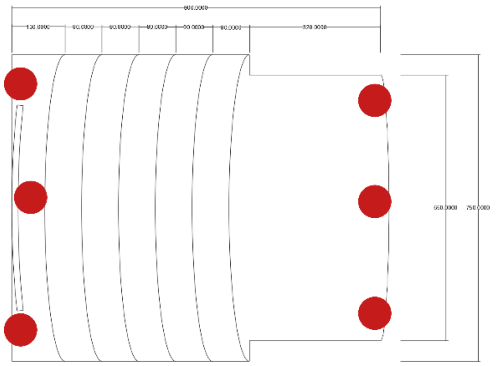


Figure 5. The placement of the 6 loudspeakers is marked by the red circle

Tabel 1 displays the absorption coefficient of the materials employed in Auditorium of National Educational Museum. The data clearly indicates that the Auditorium of National Educational Museum incorporates a few materials with low absorption coefficients. This selection is based on the fact that these materials have the ability to reflect sound. When sound waves into contact with solid, compact and firm surfaces such as PVC and HPL they tend to bounce off. This characteristic is likely to have an influence on the acoustic quality of the Auditorium in National Educational Museum. Other than that most of this auditorium has sound absorbing materials such as carpet, wood, tri-plex, and multiplex.

3.2 Reverberation Time

Table 1. Materials absorption coefficient.

Materials	Frequency (Hz)								
	63	125	250	500	1k	2k	4k	8k	16k
Carpet	0.08	0.08	0.08	0.30	0.60	0.75	0.80	0.80	0.70
Wood	0.18	0.18	0.12	0.10	0.09	0.08	0.07	0.07	0.06
Tri/Multiplex	0.42	0.21	0.10	0.08	0.04	0.07	0.09	0.09	0.08
PVC	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.01
HPL	0.10	0.07	0.03	0.02	0.02	0.02	0.03	0.02	0.03

The reverberation time was analyzed using Ecotect, takin into account the type of material and the number of speakers present in the room. The Auditorium of National Educational Museum uses a few of loudspeakers, 3 loudspeakers placed in front of the room, while the other 3 mounted on the walls at the back of the room. The positions of the speakers are depicted in Figure 5. All the speakers utilized possess identical characteristics, operating at a frequency of 500 Hz. They have a range width or azimuth angle of 180° and an axial rotation angle of 45°.

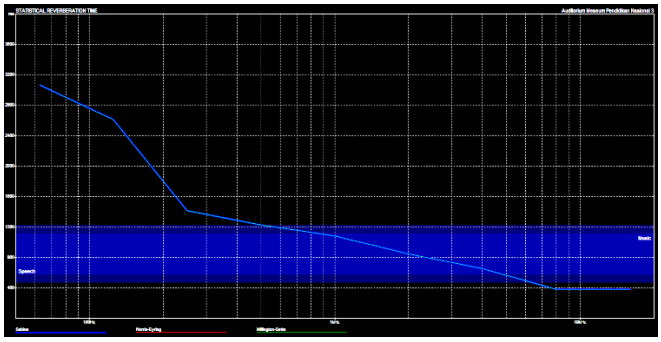


Figure 6. Reverberation time with 80% occupants

Reverberation time data obtained from Ecotect simulation is presented in Figure 6. The simulation was conducted at 80% of capacity, as the auditorium in general typically accommodates around 80% of its maximum participants.

According to Ecotect's recommendation, the reverberation time calculation employs sabine formula, which is emphasized on necessity of utilizing a more general formula [14]. The

ideal reverberation time for speech at frequency of 500 Hz is 0.58 s. While the ideal reverberation time for music at frequency of 500 Hz is 1.12 s.

Figure 6 illustrates that the reverberation time at ranging 63-900 Hz and 6k-16k Hz is far from the ideal reverberation time. This discrepancy can be attributed to various factors. This indicates that the acoustic quality of auditorium in National Educational Museum is subpar, resulting in less clear voice for the speaker.

3.3 Rays and Particles

A simulation that emulates the behaviour of rays and particles can be highly beneficial in visualizing the propagation and movement of sound generated by each individual speaker [10]. Through this simulation, one can also observe the impact of the shape of the space and the materials used on sound reflection. Furthermore, this simulation provides insights into the specific areas that are effective for sound generation, as well as the occurrence of echoes or reverberation. The ceiling in this Auditorium are constructed using triplex and HPL materials, which in can cause the occurrence of echoes or reverberation.

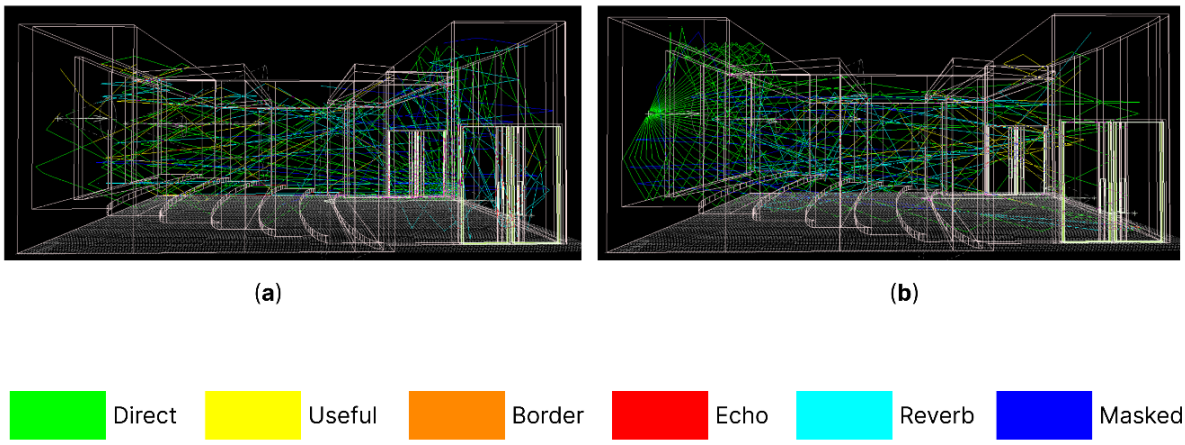


Figure 7. (a) Sound spread loudspeaker at front **(b)** sound spread loudspeaker at the back

Figure 7 (a) and (b) shows a quite large amount of green rays meaning the sound that travels from the loudspeaker to the receiver directly without disruption. It also apparent that the cyan colour appears quite a lot, which means the sound accumulate in the space before it reaches the receiver, this can make communication between the speaker and the receiver difficult because of too much ambient sound and it can make direct sound get lost or masked as depicted by the blue rays in Figure 7.

The simulation results indicate that the sound distribution generated by the loudspeaker at the front and the back of the room resulted in some amount of reverb in some area including the ceiling. The shape of the space plays a crucial role in influencing the direction of sound dispersion generated by loudspeaker. Both illustrations demonstrate that the different elevation of the floor and the ceiling facilitates a diffuse sound reflection, thus enhancing room acoustics. Nonetheless, the choice of materials, must also be taken into account to prevent the occurrence of echoing or reverberating sounds.

4. Conclusion

Based on the conducted analysis, the results reveal that the acoustic in Auditorium of National Educational Museum is influenced by various factors, including the number of participants, the ceiling's shape and elevation, and the materials used. A majority of the materials utilized in this audit such as wood, multiplex, triplex, and carpet had a high sound absorption coefficient. But there is also low sound absorption coefficient materials such as PVC and HPL in the material used in the ceiling, making them sound-reflective. This sound reflection material leads to diminishing sound clarity. Consequently, the participants face difficulties in hearing the speaker's voice clearly.

To address this issue, it is imperative to enhance the acoustic design of auditorium in National Educational Museum. One possible solution is to change the sound-reflecting materials (PVC and HPL) to sound absorbing materials into this audit. For instance, replacing HPL used in the ceiling to Gypsum to absorp sound better, which possesses a better absorption coefficient. Additionally, altering the ceiling shape to a simpler form can reduce the number of sound reflections.

Further research and simulations should be conducted to determine the most suitable acoustic modelling for Auditorium of National Educational Museum. This is crucial as acoustics significantly impact the comfort and quality of the speaker's voice as perceived by the listener.

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