Evaluation of stage acoustic parameters of Grha Sepuluh Nopember Room

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Abstract. The quality of the performance is determined by the stage acoustic condition. The parameter will determine the harmonization of performances as well as communication media between musicians. There are some acoustic parameters that determine the stage acoustics, which are ST early, ST late, reverberation time and clarity of music (C₈₀). The study evaluated the stage acoustic parameters in Grha Sepuluh Nopember. The evaluation has done by measuring the impulse response to obtain some acoustic parameters such as the direct sound energy, the first reflection energy and the final reflection energy of the sound heard by each position of the musician. Based on the measurement and analysis, the value of reverberation time is ranged from 0.8-2.9s, ST early has a range of -10dB - 6dB at each frequency, ST late has a range of -8dB - 3dB at each frequency and C₈₀ has a range of -2dB - 7dB at each frequency. So, the stage of Grha Sepuluh November cannot be said to be good as music (space) room or concert hall, but it is more suitable to be used as speech room. Therefore, it should have some improvement in order to make it functioned as performance room or concert hall.

1. Introduction
Grha Sepuluh Nopember is a multipurpose room belongs to Institut Teknologi Sepuluh Nopember Surabaya. A multipurpose room is a room that can be functioned for music or speech activities. In a multipurpose room, there is usually a stage area. Generally, in a concert hall, the acoustics quality of the room usually judged from audience preference[1]. While during a music performance, not only the audience who need a good acoustics preference but also the player on stage needs it too[2]. The role of stage acoustics that affects every player performing onstage is how they can hear their own instrument and each other instrument[3].

This paper discuss about the evaluation of stage acoustic parameters on Grha Sepuluh Nopember. As a multipurpose room, it could be possible if the room would be functioned as concert hall. Acoustic parameters that would be discuss here is Reverberation Time (RT), Clarity of music (C₈₀), STearly, and STlate[3]. From the impulse response can be obtained various parameters such as: Reverberation Time (RT) on the stage area serves to show the magnitude of the reflections that occur on the stage area of Grha Sepuluh Nopember. Then Clarity (C₈₀) can show the clarity of music on the stage Grha Sepuluh November. C₈₀ can be calculated by ten times the logarithm between the ratio of sound energy at an initial interval to 80 ms with sound energy after 80 ms. In addition, according to [4] ST early is the ratio between the energy of the initial reflections and the measured sound directly between source and receiver which is also mentioned in the ISO3382-1 standard[5].
2. Experimental Methods
This research was conducted on the stage of Grha Sepuluh Nopember building because as a multipurpose room it is possible that this building will be used as music concert hall, performances, and similar performances that require good stage quality as well. This building is a semi-open building because on the 2nd and 3rd floor there is an area directly connected to the outside area. Grha Sepuluh Nopember has a square-shaped stage with an area of 273 m$^2$ with the total volume of Grha Sepuluh Nopember is 45000 m$^3$. Because of the same size and shape in right and left side, it can be said that Grha Sepuluh Nopember has a form of symmetry.
The parameters obtained by each musician are the parameters dominated by the direct sound component. To obtain those values, this paper was done through the impulse response generated by blast of balloon which represents each position of the musician on the stage. From these measurements an impulse response is obtained at each microphone. Then the data retrieval is done again by placing the sound source at point 2. The data retrieval was done in the same way by putting the sound source at other points.

![Figure 1 Measurement point position](image1)

In this paper, data processing starts from obtaining an impulse response at each point. Then, process using matlab software to do FFT (Fast Fourier Transform) to convert the signal from time domain into frequency domain. Furthermore, after the FFT is done, then cut off by the upper and lower limit frequency values to get the sound frequency as needed.

![Figure 2 Measurement plan views from above](image2)

3. Result and Discussion
The reverberation time already obtained with such a configuration on the stage area has a relatively small value. Feelings felt on the stage can be said to be more echoed so that more adsorptive material is needed in order to get enough reverberation time.
Based on Fig.3, the reverberant which felt by position 1 (vocalist position) has a tendency in higher magnitude than the reference ones, especially in frequency of 1000Hz. This high magnitude could be caused by the background of the stage which made from concrete. So, it affects the amount of reflected sound arrived in position 1 (vocalist position). Aside from the reverberation time, there are others parameters that affect the clarity of sound heard by vocalist. This parameter is Support Time (ST); early support time (STearly), and late support time (STlate). According to the measurement results, the support time result shown in Fig.4 and Fig.5 below.

**Figure 3** Reverberation Time (RT) value in each frequency

**Figure 4** The ST early in each frequency

**Figure 5** The ST late in each frequency
According to high value of RT which means that reflected sound arrived in position 1 more than the direct sound, the STearly in low and high frequencies have a high value. But in mid-range frequency, the direct sound bigger than the reflected sound, which means in this range the vocalist could hear music clearly. Based on Fig.4, especially in frequency of 1000Hz, the best STearly is obtained by using source 2. This is because of the severity factor of the source itself is directional. At sources 2 has closest distance with the vocalist position, so it will get a great intensity from the direct sound. While the source 3 and 4 have a close distance with the background of the stage which gets a reflection that causes disturbance of direct sound energy.

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In general, the final reflected energy used to determine the ST late parameter has a value less than the direct sound energy. Due to the final reflection is the rest of the energy that is still in the room. At source 2 it is seen that the final reflected energy is high enough than the direct sound. The amount of energy of the final reflection is due to the factor of the reverberation time. A long reverberation time indicates that the room still has great energy. The energy includes the final reflected energy and it can be said that the energy can damage the direct sound energy. So the value of ST late that obtained when the reverberation time of the high room will be more positive.

**Figure 6** Clarity of music ($C_{80}$) in each frequency

Overall, the clarity of sound in music has a value greater than -5 dB. While the clarity of sound obtained more than 0 dB. Meaning the listener at point 1 (vocalist) will listen to the direct sound (energy before of 80 ms) which is bigger than the reflected sound (energy after from 80 ms). Can be said clarity of sound on stage Grha Sepuluh Nopember is more suitable for speech purpose.

4. **Conclusions**

Based on the evaluation, it is concluded that in Grha Sepuluh Nopember has a range of reverberation time of 0.8-2.9s, ST early has a range of -10dB - 6dB at each frequency, ST late has a range of -8dB - 3dB at each frequency and $C_{80}$ has a range of -2dB - 7dB at each frequency. So, the stage of Grha Sepuluh November cannot be said to be good as music (space) room or concert hall, but it is more suitable to be used as speech room. Therefore, it should have some improvement in order to make it functioned as performance room or concert hall.

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6. References

[1] M. Barron: Auditorium Acoustics and Architectural Design. London: Spon Press (1993).
[2] Wenmaekers, R. H. C. Stage acoustics and sound exposure in performance and rehearsal spaces for orchestras: methods for physical measurements. Eindhoven: Technische Universiteit Eindhoven (2017).
[3] Wenmaekers H.C., Hak C.C.J.M., and Van Luxemburg L.C.J. On Measurements of Stage Acoustic Parameters: Time Interval Limits and Various Source-Receiver Distances. Acta Acustica united with Acustica, 98, (2012).
[4] Gade, A.C. Investigation of Musicians Room Acoustic Conditions in Concert Hall II: Field Experiments and Synthesis of Results. Acustica, 69, (1989).
[5] ISO 3382-1-2009: Acoustics – Measurement of room acoustic parameters – Part 1: Performance spaces. International Organisation for Standardisation (ISO), (2009).