Analysis and simulation of acoustic parameter Cak Durasim Surabaya concert hall

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Abstract. In this study discussed the analysis of acoustic parameters of measurement and simulation of loudspeaker position at Cak Durasim Surabaya. Based on ISO-3382-1 acoustic parameters that need to be analyzed are SPL distribution, RT, C50, and C80. To get these parameters result, data retrieval using Impulse Response method was done. Measurements are made in a condition without audiences. Based on the measurement results, SPL distribution was less evenly with the maximum and minimum difference reached 14 dBA. In addition, the value of RT was 1.1 s which showed the impression of a sound was less "alive". From these measurements, it was necessary to add loudspeaker to improve the SPL distribution and the value of reverberation time. Based on the simulation, the result of the SPL distribution evenly with the maximum and minimum difference of 6 dBA, C50 of 4.5 dB, and C80 of 8.2 dB. For RT there were no significant change that were 0.68 s. It means the sound impression in the room was still less 'alive'. Problems in the simulation result can be solved by giving certain effects of the sound system so it doesn’t need to change the material composing of the room.

1. Introduction
In the performance building, the quality of acoustics is one of the success elements of the building design. As one of the performance spaces, Cak Durasim Art Building needs to have a good acoustic quality of space for players on stage and audience. But often at the time of the show there were some acoustic issues like the sound that sounded very loud at the certain places and the noise was too buzzing. Based on ISO-3382-1 there are several acoustic parameters that can be used to evaluate a space, especially auditorium space. These parameters include Background Noise (BN), Sound Pressure Level (SPL), Reverberation Time (RT), and Clarity (C80 and C50). The recommended RT value for a traditional gamelan art performance room is 1.2 - 1.4 s [1]. The recommended C80 value for a performance space is in the range of -5 dB - 5 dB while for C50 the value is between -4 dB - 4 dB [2]. In order for the acoustic parameter value of space from Cak Durasim Surabaya building can be optimally felt by the player and the audience, the effect of noise from environment or background noise should be as small as possible. The recommended noise levels for the performance space are with SPL range 30 - 40 dBA or with Noise Criteria (NC) NC 20 - NC 30 [3]. In a pre-existing study, research conducted by Dea Smita Pangesti, Jusuf Thojib, and Indyah Martineningrum, students of UB's Architecture Department in 2015, Cak Durasim's refurbishment is more focused on the redesign of the building and the measurement of the reverberation time. The research was conducted when the condition of Cak Durasim Building before the renovation. This paper analyzes the room acoustic parameters of Cak Durasim Building after renovation for existing condition and room acoustic simulation using EASE software to obtain acoustic parameter values according to player and audience preference.
2. Experimental Methods
To get the objective acoustic parameter value from Cak Durasi Building Surabaya, some measurement of acoustic parameters in the audience area is done. Figure 1 shows the position of the point of measurements in the study.

![Figure 1. Measurement tool scheme](image)

Based on Figure 1, the measurement of the acoustic parameters was done by using the Impulse Response method in a no-audience condition. Through the IR then could be known the distribution of acoustic parameters such as SPL, RT, C50 and C80. The sound source used a balloon eruption sound with SPL ± 125 dB which was placed in two variations of position that was in the center of the stage and in the gamelan space. Sounds from sources then were recorded by using Adobe Audition software and data processing was done by YMEC and Sound Analyzer software. Measurements were made at 15 measurement points. After measuring the existing condition, then the simulation of the audio system by adding loudspeaker using EASE software was done. The simulation was done with two variations loudspeaker location namely loudspeaker was placed on the floor and on the wall.

3. Results and Discussion
3.1 Measurement
As a performance hall Cak Durasi Surabaya building needs to have a noise criteria (NC) [4]. This criteria aims to find out how much influence of outdoor noise on indoor activities. From the measurement results is obtained background noise that occurs in the space ranged from 30-40 dBA with an average of 34 dBA. This range is in NC 20 - 30 so that the background noise that occurs in the space in accordance with the noise criteria for the performance hall. In addition to the background noise, the performance room also requires the distribution of sound pressure level (SPL) evenly throughout the room. From the measurement results, it is obtained the distribution of SPL shown by Figure 2.

From the data processing in Figure 2, it is obtained the SPL distribution by SPL difference between the nearest and the farthest point from the source is 12 dBA for the source in the center of the stage and 10 dBA for the source in the gamelan place. Based on Figure 2 it can be said that the SPL distribution in the room is not evenly distributed because the SPL difference between the nearest and the farthest point source for both of the location source more than the standard is 6 dBA. In addition to the uniform distribution of SPL, subjectively the performance room also needs to have a fairly lively sound and sound clarity in terms of both vocals and music. The values of the objective parameters of the impression are derived from the parameters of the reverberation time (RT), C50, and C80 shown by Figure 3.
From Figure 3 (a) the overall average of RT in the room is 0.93 s for the center stage source and 0.97 s for the source at the gamelan space. From these results can be seen that the RT that occurred in the room has not reached the specified target that is in the range 1.2 - 1.4 s. This means the sound impression that occurs in the room is less “alive” and not suitable for a room that is functioned as a show room. In Fig. 3 (b) the overall average of C50 in the room is 1.25 dB for the center stage source and 1.99 dB for the source at the gamelan space. These results explain that the C50 has met the target of C50 which is in the range of -4 - 4 dB. In Fig. 3 (c) overall, the average C80 in the room is 5.05 dB for the central source of the stage and 4.54 dB for the source at the gamelan site. These results explain that C80 has met the target of C80 which is in the range of -5 - 5 dB.
3.2 Simulation
To overcome the problem of uneven distribution of SPL and a too short reverberation time should be done in the form of additional loudspeaker in the room. The addition of loudspeaker is done through simulation using EASE software. The simulation is done with two layout variations of loudspeaker that is loudspeaker which is placed standing on the floor (simulation 1) and is placed on the wall (simulation 2). The SPL distribution of simulation results is shown by Figure 4.

![Figure 4](image)

**Figure 4.** Spl distribution of simulated results 1 (a) and simulation 2 (b)

Based on simulation 1 in Fig. 4 (a) the distribution of the resulting SPL has not been evenly distributed by the difference of maximum and the minimum is 16 dBA. The SPL which is generated at the points near the loudspeaker is too large than the other points so the sound is too loud and causes the uncomfortable for audience that sits in the area. While based on the simulation 2 in Figure 4 (b) the distribution of the resulting SPL is evenly distributed with the difference of SPL maximum and minimum 6 dBA. Due to its height factor, the loudspeaker is placed on the wall is more effective at distributing the sound than the loudspeaker is put on the floor using a tripod.

For the reverberation time we get the average of reverberation time for simulation 1 is 0.85 s and 0.68 s for simulation 2. From the simulation results it can be seen that the resulting of reverberation time is too short because it does not fall into the target range of the reverberation time specified ie 1.2 - 1.4 s [5]. A too short reverberation time causes the sound impression generated in the space to be less "alive". The addition of the loudspeaker causes the sound that the listener receives more direct sound than the reflected sound. This can be overcome by altering the spatial material with a more reflective material or by adjusting the sound system to produce sound with the appropriate hum if there is no need for a change in the construction of the building.

For C50 we get the average of C50 for simulation 1 is 3.01 dB and 4.53 for simulation 2. From the simulation result it is known that simulation result 1 and simulation 2 have reached the specified target that is in the range of -4 - 4 dB. However, if it is viewed from the distribution of maximal and minimal difference in simulation 1 reaches approximately 17 dB and 8 dB in simulation 2. From the difference it is known that the distribution results in simulation 2 explain that the clarity of excellent vocal sound occurs evenly at almost every point compared to simulation 1.

For C80, the average of C80 for simulation 1 is 6.37 dB and 8.23 for simulation 2. From the simulation results it is known that simulation results 1 and simulation 2 have reached the specified target that is -5 - 5 dB. If it is viewed from the distribution the maximum and minimum difference in simulation 1 reaches approximately 15 dB and 6 dB in the simulation 2. From the difference it is known that the distribution results in the simulation 2 explain that the clarity of the sound of very good music occurs evenly at almost every point compared to the simulation 1.

4. Conclusion
In conclusion Background noise that occur in space is 34 dBA so it is at NC 20 - 30. SPL distribution on existing condition is not evenly distributed by difference of nearest and farthest point from source of 10 dBA for both source location. The reverberation time in existing condition is too short ie 0.93 s for
source 1 and 0.97 s for source 2 so that it can be concluded that the reverberation time of space has not met the criteria as a traditional art performance space. The value of C50 in the existing condition is 1.62 dB. Overall, it still meets the C50 standard for vocal function. The C80 value at the existing condition is 4.8 dB. Overall, it still meets the C80 standard for music functions. Based on the simulation results, the best value is obtained from the second simulation with the result of the SPL distribution which is evenly distributed with the difference of maximum and minimum 6 dBA, C50 is 4.5 dB, and C80 is 8.2 dB. While for RT did not experience significant change that is 0.68 s.

5. Reference

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