
Acoustic parameter for Javanese Gamelan Performance in Pendopo Mangkunegaran Surakarta

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Abstract

Pendopo Mangkunegaran Surakarta is a building that has a volume of 3000 m³, a pyramid form of roof, and no walls. The objective of the research in this paper is to explore the condition of Listening Level (LL), a sub-sequence Reverberation Time (T_{sub}), Clarity (C80, D50) and Inter-Aural Cross Correlation (IACC) at Pendopo Mangkunegaran Surakarta. To quantify the acoustic parameters of the Pendopo, microphones were located in the area of the King, distinguished guests, dancers, and audience. The source of sound is located at the corner of where the Gamelan is played. The sound of Gamelan at the corner of the Pendopo produces a diverse distribution of sound and reverberation time in the room, especially in the center of the room. It is concluded that the acoustic quality of Pendopo building is appropriate for Javanese Gamelan performances with a well-developed spatial effect.

Keywords: Javanese Gamelan; acoustics parameters; semi-open concert hall; Pendopo Mangkunegaran

1. Introduction

Javanese Gamelan, as traditional music, has been developed for hundred years. The performance of Gamelan music takes place in the main hall of the Palace which is called as Pendopo. In addition to musical performance, Gamelan music is a symbolic communication media between the King and the people. Gamelan music is a medium

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for the King to send messages to the people and to hear people’s wishes. For this reason, the singing audience is part of the gamelan music performance. Gamelan music has a frequency of 40 Hz to 4000 Hz and sound envelope up to 10 s or greater (Suyatno, 2013). In a closed room, the Gamelan music performance can produce an excessive reverberation (Supanggah, 2002). This must be one of the reasons that Gamelan music is always performed in an open or semi-open hall. Gamelan music is played on a number of instruments which is placed on stage. The various instruments produce different sounds to the listener depending on the distance and its placement. It is important to notice that the sound level heard by a listener varies between the left and right ears (IACC / Inter Aural Cross Correlation). The value of IACC indicates the diffusivity of the space and the sound distribution that affected the stereo effect of the room (Ando, 1998).

According the Sabine formula (Schroeder, 2007), representative acoustics parameters of a room are reverberation time (RT). Reverberation time is the time by which a sound decay 60 dB after the source of sound is turned off. The value of RT represents the sound absorption occurs in the room which is determined by the volume and total absorption of the room (a). Theoretically, the value of RT is a single value that characterized by the room and not depended to the placement of instruments. However in real situation, the value of reverberation time differs to the position of instruments which is called as the sub-sequences reverberation time (Tsub). Tsub values are obtained based on impulse responses and depended on the position. There are other parameters for identifying the acoustic condition of a room:

- volume of the room
- background noise
- material properties in the room
- the shape and model of the room

In some Gamelan performances, the noise-like sounds from the audience around the Pendopo might be part of the show itself. However, clarity of the sound is a prerequisite for a proper performance, and it is required by any player (Supanggah, 2002). Clarity (C80) and Definition (D50) are parameters that are associated with the Reverberation Time (RT) (Campanini, 2009). Clarity is logarithmic value from ratio of the early energy at 0-80 ms to reverberant energy (80 ms - end). Definition is the ratio of the sound energy in the first 50 ms to the total energy (0 - end). The optimum value of the acoustic parameter for classical music performance in a concert hall are 1.30 s to 1.83 s for Reverberation Time, -2 dB to +4 dB for C80, and 45% to 65% for D50 (Ribeiro, 2003). On the other hand, based on simulation, acoustics parameter for Gamelan performance are 0.500 s to 0.650 s for Reverberation Time, 75 dB up to 77 dB for LL (Sarwono, 2001, 2002).

2. Pendopo Mangkunegaran Surakarta

Pendopo Mangkunegaran is one of the buildings at the residence complex of the Prince Mangkunegara and his family in Surakarta, Central Java. Pendopo is used for the King to meet his people, to deliver a message, to undertake social activities and to interact with the public. The message conveyed to the public very often in the form of art, music and dance performances accompanied by Gamelan music. The Pendopo becomes a culture centre, where many kinds of Javanese songs and music are being developed. It signifies the cultural artefact of Indonesian people. At present, the Pendopo Mangkunegaran functions as a centre of Javanese culture in which on certain days, a dance and wayang performance accompanied by Gamelan music is performed for the public.
Any areas in the Pendopo Mangkunegaran have a significance conjunction with audio-visual parameters, especially in the area of the King’s seat and Gamelan. To support the function of Pendopo as a place for interaction with the public and socialization activities, voices should be heard clearly from all directions of the building. For this reason, listening level and clarity of sound are the important parameter for evaluating the acoustic quality of the building.

For the analysis purposes, Pendopo Mangkunegaran is assumed as a concert hall in that acoustic parameter to be evaluated LL, Tsub, Clarity (C80, D50) and IACC at the audience area. Sound quality at some points in the audience area is measured and then calculation is made in two approaches. The approach of impulse response is applied for measuring the distribution of LL, Tsub, and Clarity while IACC parameter is applied for the quality during the live performance of gamelan music. The goal of this research is to evaluate whether acoustic quality of a semi-open hall is appropriate for music performances. The result of this research will recommend design parameter for gamelan music performance.

3. Measurement

As a semi-open hall, the ceiling and the floor are building elements that stand for sound reflection and diffusion. Under this condition, the sound response is not homogenous in the audience area. For this reason, each position in the Pendopo should have its own parameter. Parameter of distribution of the sound (LL), sub-sequent reverberation time (Tsub), clarity and IACC at each position should be different. To determine the distribution of sound, the measurements are undertaken at some positions in the area of dancers and audience. The approach of the impulse response and white noise are applied to obtain the values of LL, Tsub, C50 and D80. The source of sound is placed at one corner of the room, where gamelan instruments are positioned. Microphones are positioned at King’s seat, distinguished guest, dancer and public area. The height of microphones stand is varied: 1.2 m for the King’s seat,
and audience, and 1.5 m for the dancer. IACC values are particularly analysed during gamelan’s live performance of “Ketawang Puspowarno”. In this case, the microphones are put at the left and right position of the audience facing to the dancer area. Figure 2 shows the position of microphones at Pendopo Mangkunegaran. The signals are recorded at the sampling frequency of 44100 Hz. The recorded signal then were analysed by sound analyser with integral time of 1 s and ran step 0.01 s.

4. Result And Discussion

The physical layout of the Pendopo is surrounded by buildings that make the noise level in the main room of Pendopo 54 dBA, at the terrace 62 dBA and 70 dBA at the periphery. The buildings in the surrounding also serve as a sound reflector that makes reverberation around the Pendopo. The condition of a room without walls has caused sound energy decay in Pendopo quite fast. The shape of the ceiling and its slope has helped sound reflection and diffusion in that energy reverberation and distribution is adequate. The audience does not require amplifier or sound system to hear the music.
The illustration exhibits the sound propagation from the source to audience whereas the source is gamelan music at one corner of the pendopo (Figure 2). The sound heard by the audience is a combination of direct sound and reflection sound by the ceiling. During performances, the gamelan instruments on stage will produce a listening level of 98 dBA or more, depending on the music composition and types of performance (Suyatno, 2013). The listening level of 90 dBA at the source area will decline to 71 dBA at the area in 40 m distance from the source. The decreasing listening level is an impact of the ceiling’s shape. The audience are in various positions and, therefore, each audience will experience different listening level and sound direction. The parameter for defining direction of sound is IACC, which consider the direction based on differences of response (Listening Level) in left and right ear. The values of Tsub and IACC at the Pendopo are shown in Figure 4.

The Tsub at the Pendopo is between 1.3 to 2.2 s, which is acquired because of the shape and reflective material of the ceiling. The Tsub at the centre of the room, where the dance performance takes place, is equal to 2.2 s. This value is gained as a result of reflection from the horizontal ceiling, podium, and recessed ceiling in the middle of the room. Tsub at the entrance of Pendopo is equal to 1.3 s, which is the lowest in the building. This value is achieved because the place is adjacent to the open space in surrounding Pendopo where reflections have no impact. The seat of the king has Tsub of 1.6 s, and this value becomes the average value of the whole Pendopo.

The shape and reflective material of the ceiling make the energy of sound reflections in the room very strong. The strong energy in the room causes sound clarity (in speech and music) to be highly influenced by the sound distribution and reverberation. The value of clarity (C80) at Pendopo is +2 dB while the value of the definition (D50) is 54%. This means that reverberant energy is smaller than the early energy in that the signal (music) can be heard clearly (C80=+2 dB) and the vocal comes the next (D50=54%).

The value of IACC at the Pendopo is 0.22 s to 0.71 s. The highest IACC is in front of the stage where the gamelan instruments are situated. It means that the audience hear the direct component more dominant than the reflected component. The value of IACC at the king’s seat and VVIP guest area is 0.23. This means that the place has a good stereo effect. In the position of the dancer, the value of IACC is 0.64. This means that at this position the direct component is more dominantly heard. The condition is in line with the need of the dancer to perform harmoniously with the music.

5. Conclusion

The background noise in the Pendopo is 54 dBA, in the terrace is 62 dBA, and outside the building is 70 dBA.
Factors that have influenced the acoustic quality inside the Pendopo is the building’s shape and physical surrounding. The ceiling’s shape and floor’s material have contributed to the strong listening level in the audience area. The ceiling has worked well for reflecting sound, in that in a distance of 40 m listening level reached 71 dBA. The value is not much degraded from 90 dBA at the corner of the Pendopo where the instruments transmit sound. In general, the Pendopo has acoustic parameter of Tsub 1.2 to 2.2 s, clarity +2 dB, definition 54% and IACC 0.22 to 0.71. With this acoustic quality, the Pendopo Mangunegaran is appropriate to be used as a music hall.

This research should be continued with other research in order to add more considerations in the design of a concert hall. The next research should evaluate the physio- and psycho-acoustic judgments as acoustic parameter, in order to formulate the optimum acoustic parameter for gamelan music performances.

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References