Modeling and Simulation of Gamelan Bali Concert Hall Based on Objective Acoustic Parameters

Article *in* The Journal of the Acoustical Society of America · May 2013

DOI: 10.1121/1.4805926 · Source: PubMed

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Proceedings of Meetings on Acoustics

Volume 19, 2013 http://acousticalsociety.org/

ICA 2013 Montreal
Montreal, Canada
2 - 7 June 2013

Architectural Acoustics
Session 3aAAa: Virtual Concert Hall Acoustics I

3aAAa8. Modeling and Simulation of Gamelan Bali Concert Hall Based on Objective Acoustic Parameters

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Gamelan Bali music performances require special place to highlight the quality of the acoustic performances. A concert hall dedicated for Gamelan Bali was proposed to perform a better acoustic quality. Studies on Gamelan Bali has been done to achieved an optimum value of sound fields in Gamelan Bali concert hall. This paper shows a geometrical model designed to fulfill the suitable sound fields of Gamelan Bali Concert Hall. The model was modified from shoebox shaped with rear and side balconies. The acoustic performances of the model at 1 kHz summarized as follows: Tsub = 1.41 s, LL = 80.2 dBA, $\Delta t1$ = 39.43 ms, and IACC = 0.33. Those values meet the optimum values from the result of previous studies. Auralization of sound in the room also done for the purpose of subjective judgement.

Published by the Acoustical Society of America through the American Institute of Physics

Received 21 Jan 2013; published 2 Jun 2013

INTRODUCTION

Gamelan Bali is one of the traditional music instruments from Indonesia. It is a percussion music played by a group of player. There are many types of Gamelan Bali, Gong Kebyar is the most popular one among musician. “Kebyar” is Balinese term means ‘to open’, it is also the term for a fragment of song or composition in which all instruments played, stomping, at the same time [1]. Gamelan Gong Kebyar consist of gong, metallophones, drums, and flute as shown in **Figure 1**.

FIGURE 1. Gamelan Bali Gong Kebyar.

Gamelan Bali music performances naturally was played in open air area, since it radiates a high level of sound energy. Nowadays its performances can also be found in hotels, restaurants, or performance hall to accompany dance performances. Whenever gamelan played in open air stage performances with a lot of audience, the sound of gamelan will covered by noise from environment or noise generated by the audiences. On the other hand, there are many complains that the gamelan sounds too live and become not clear when it played indoor. Well designed concert hall that fulfill the optimum value is one of solution that can enhance the quality of Gamelan Bali music performances.

Based on Yoichi Ando theory [2], there are four objective parameters that define the sound field in a room, which listed as listening level, the delay time of early reflection after the direct sound (Δt_1), the subsequent reverberation time (T_{sub}), and inter aural cross correlation (IACC). Research about this optimum objective parameters value of Gamelan Bali has been conducted using psycho-acoustic and physio-acoustic [3,4,5], the result is mentioned as follow:

- Listening level : 75-85 dBA
- Δt_1 : as same as τ_e value of the Gamelan Bali music
- Subsequent reverberation time : 1.50 s
- IACC : 0.4-0.5

The present study was to design a concert hall dedicated to Gamelan Bali that can achieve the optimum value of objective parameters such as mentioned above.

EXPERIMENTAL PROCEDURE

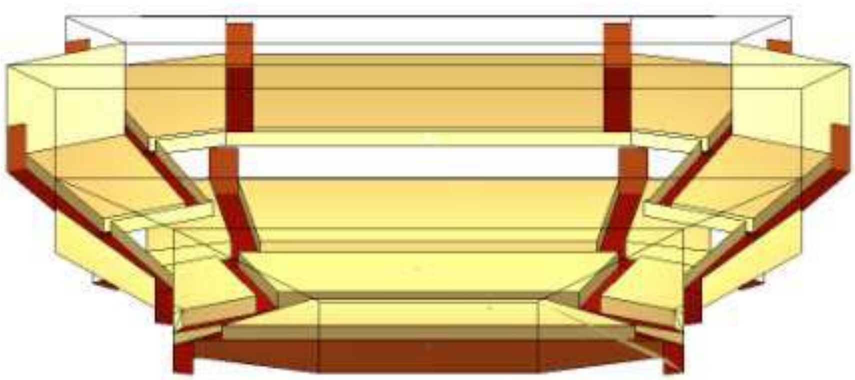
Design objectives of this concert hall was to achieve the optimum value of objective parameters and to accommodate for about 1,500 seats capacity. To determine the delay time of early reflection after the direct sound and frequency characteristic of gamelan music, required the τ_e value of gamelan music. Music sample used in this experiment is ‘Oleg Tambulilingan,’ one of popular gamelan music composition, with value of τ_e 38.93 ms. τ_e value is related to bandwidth frequency in the signal, lower value of τ_e represent wider bandwidth frequency [2].

A computer model of Gamelan Bali concert hall was developed and simulated using CATT Acoustic v.09. Results from the simulation then compared to the required optimum value. Repairs and alternative model was made when the results have not met the qualifications. This process continued until the final model achieved.

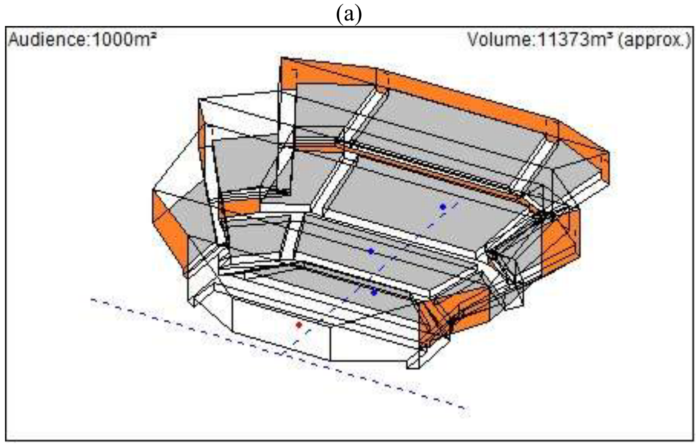
For the purpose of subjective judgement along with objective analysis, auralization was done in 14 points of audience area. Impulse response generated from the simulation then convoluted with ‘Oleg Tambulilingan’ gamelan music as the sound source. Dry recording is needed for the auralization, therefore recording was done in the open-air area using near field and Blumlein pair recording method. Recording results from auralization then distributed to some respondents to give their subjective judgement.

RESULTS AND DISCUSSION

The model of Gamelan Bali concert hall is shown in **Figure 2 (a)**. Room dimensions 34 m x 26 m x 15 m with a capacity of 1,666 seats. It is a shoebox-shapes hall, modified with side and rear balconies. Materials used in the room as follows, concrete for the ceiling, thin carpet cemented to concrete for the floor, wood for the wall and stage area, with addition of diffuser in some walls area as shown in **Figure 2 (b)**. Diffuser is used in the design to evenly distribute the sound energy in order to prevent echo. Most of the materials are hard and reflective, this is intended to maintain the sound energy in the room so that it can achieve optimum sound levels [6].



(a)



(b)

FIGURE 2. (a) The Concert Hall Model for Gamelan Bali, **(b)** Position of Diffuser in the Room, Indicated with Orange Color.

TABLE 1. The Value of Acoustic Parameters in the Room.

Acoustic Parameters	Frequency (Hz) 125	250	500	1k	2k	4k
SPL (dB)	72.6	75.2	77.7	80.2	83.2	85.6
Tsub (s)	2.06	1.76	1.57	1.41	1.66	1.21
IACC	0.98	0.90	0.51	0.33	0.50	0.17
D-50 (%)	45.0	47.1	49.7	51.1	50.8	55.9
C-80 (dB)	0.8	1.3	1.9	2.4	2.2	3.3
LF (%)	36	17	30	39	35	23

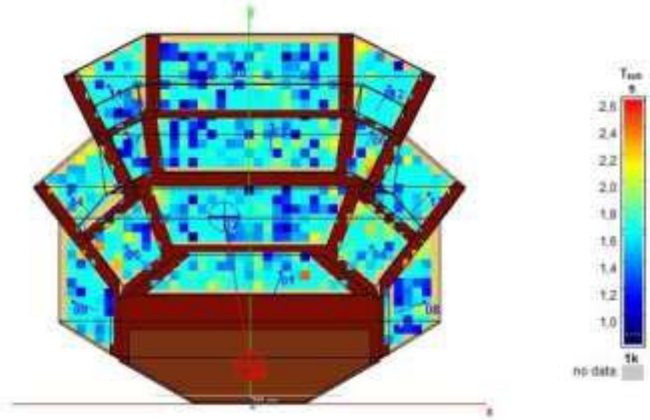


FIGURE 3. Color Mapping Diagram of Subsequent Reverberation Time

Subjective parameters of the acoustic performances in the room were analyzed using auralization recording. This analysis were compared with simulation results which is tabulated as shown in **Table 1**. Loudness on the 14 points audience area is uniform, the gamelan music sounds evenly loud from the front to the farthest area from the sound source. Therefore the use of sound reinforcement systems in the room is not needed.

The room also judge to have a warmth hearing condition, this are consistent with the results of simulations in which the reverberation time of 125 Hz and 250 Hz is higher than the 500 Hz and 1k Hz. Bass Ratio values obtained at the room is 1.27. Different audience position will results to different value of the subsequent reverberation time as shown in **Figure 3**, the average value is equal to 1.59 s.

By hearing the auralization recording of gamelan sounds, we can distinguished between each instrument in the gamelan. Thus it can be said that the room has a good clarity. Time delay of first reflection will contribute to the intimate situation in the room. Value of $\Delta t1$ in this room is worth about 39.43 ms. This first reflection coming from lateral side given by sidewall balconies. BQI value of the room is 0.55, it shows that the concert hall has a good spaciousness. In addition, the value of BQI also gives the sense that the voice signal received by the right and the left ear has a low degree of similarity.

CONCLUSION

The design of Gamelan Bali concert hall has been successfully created and meet the objective optimum parameters required. The acoustic performances of the room at 1 kHz are summarized as follows, LL : 80.2 dBA, Δt_1 : 39.43 ms, T_{sub} : 1.41 s, and IACC : 0.33. The rooms also generate warmth, clear, and intimate hearing conditions.

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