A Computer Modelling of Gagaku Chamber Music Hall

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Gagaku is a traditional Japanese court music form since the middle ages. *In an Autumn Garden* (for gagaku orchestra) was composed by Toru Takemitsu in 1973. In this project paper, a computer model of small chamber music hall was designed for this piece. Using this model, acoustical simulation was run in EASE. Room acoustic features such as reverberation time, EDT, T_{30}, C_{80}, etc. were calculated using Aura 3D modelling. Though small in size, the chamber concert hall is plausible with its basic acoustical quality for gagaku orchestra performance.

Keywords: Takemitsu, Gagaku, Chamber Music, Room Acoustics, EASE

I. INTRODUCTION

Gagaku has been performed for over 1200 years. It has been carefully preserved and handed down to present day as music of the Japanese Imperial Court. The story of *In an Autumn Garden* begins in 1970, with the decision by the National Theatre of Japan to commission a series of new works by contemporary composers for that most venerable of traditional Japanese musical institutions, the gagaku ensemble of the Imperial Household.[1] Takemitsu, at that time, also received a commission to provide a work for the series. And it became one of the classics for modern gagaku music in 20th century.

II. COMPUTER MODELLING METHODS

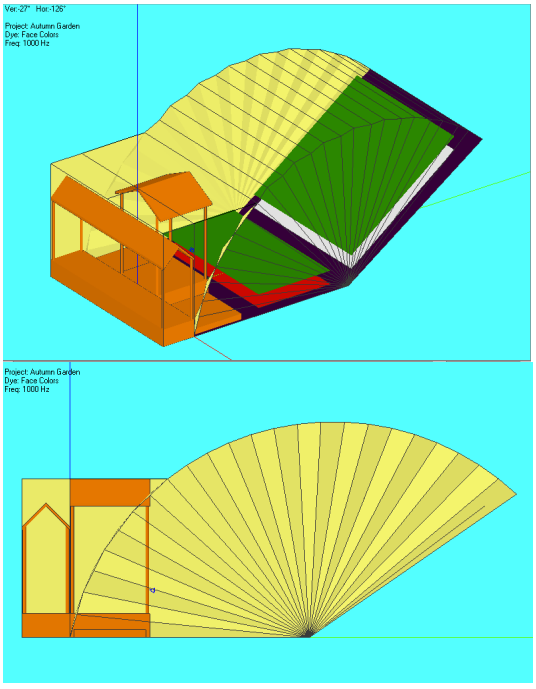

FIG. 1. EASE model of gagaku chamber music hall with over view and side view.

A simple model of Gagaku chamber music hall was created using EASE. The original EASE project design is as below (Fig. 1). The shape of hall is similar to *Kabuki*'s shoe during *Edo* era.

To make acoustical simulation, the project was run in EASE with aura 3D mapping. Each group of surfaces was defined with proper room materials selected from America Acoustic Database. The audience area was inserted in the centre box and the ascending area. One loudspeakers (SPX4-94) were inserted facing audience area which is 1m right above the main performing stage.

III. ROOM ACOUSTIC ANALYSIS

A. Room structure

The Gagaku chamber music hall is small, with seats designed to hold no more than 500 people. Seating area can be divided into two parts: one at the same height level of the stage and direct facing to it, the other one is the ascending area along with the radius of the fan-shaped side walls. The side walls are designed with foldings to imitate Japanese paper fan and increase diffuse reflections.

The whole building consists of an audience listening hall, a temple-like main stage (5m×5m) 1.5m above the floor with left and right side stages (4m×4m each) 1m above the floor, and a long corridor-like back stage (15m×5m) the same height as main stage. Side walls are fans with a radius of 15m and an arc of 150°. The spatial design of these performing stages are according to the composer's decisions of performing groups which will be further discussed in the latter part. The average height for the whole chamber music hall is 10m with a circular ceiling above audience area. In computer simulation, the room volume is calculated to be around 4300 m^3.

B. Room materials

The interior furnish of Japanese style traditional architecture is often largely consist of wood and paper. Although paper can be part of decoration materials, it is not proper to be wall materials with its diffusion properties and relatively great absorption effects.

In this model, plastic is selected as ceiling (PLAST/ LTHS) and wall (PLAST/TILE) materials. Stages (WOOD FLR), roofings and columns (WOOD GRIDO), seatings (MTSEAT WD) and floors (WOOD FLR) are all wooden surface but of different characteristics. These make an average absorption coefficient of room surfaces 0.19.

C. Acoustical features

Room Reverberation Time (Fig. 2) for the whole musical space is slightly different but keep concentrated between 1.20 to 1.32 sec through out the frequency band below 5000Hz. And RT still keeps over 1.0 sec when frequency band exceeds 8000 Hz.

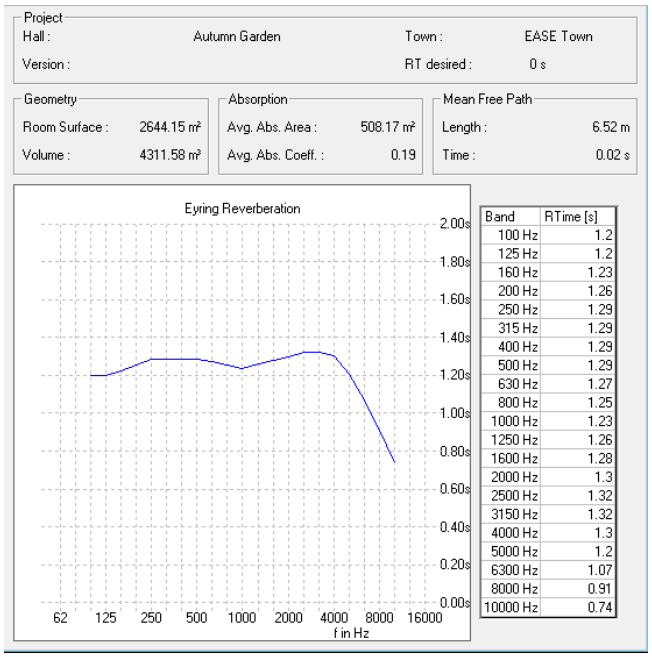

FIG. 2. Eyring reverberation time at different frequency of chamber music hall.

The Definition mapping is shown in Fig. 3, taking examples of 500Hz (for most of percussions), 1000Hz (for Koto and Biwa) and 2500Hz (for the wind part). The centre part of the A1 area enjoys a high percentage of definition. Most of the seating areas have a definition of 70%-80%. This makes the chamber room quite dry in hearing with little echo.

The clarity (Fig. 4) defined as C_{80} is from 3dB to 7dB between frequency band of 250Hz - 4000Hz in audience area near stage (A1). While C_{80} rise to over 10dB at high frequency in audience area far from stage (A2). This Clarity is much more higher than that of western music concert hall and nearly to the standard of a lecture room. However, it just fit well to the granule feature of eastern string music, most of which plucked note by note and hardly mix with each other. In fact, every note is supposed to be heard clearly so as to make a dry effect of gagaku music.

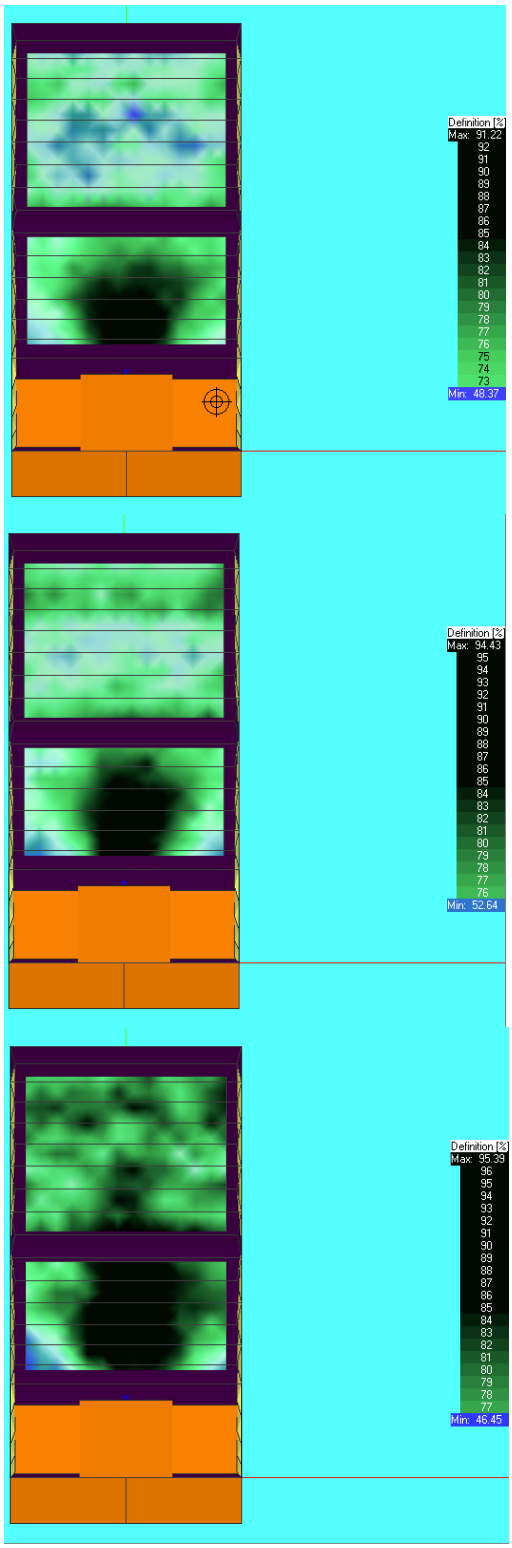

FIG. 3. Definition at Octave Band of 500Hz, 1000Hz and 2500Hz.

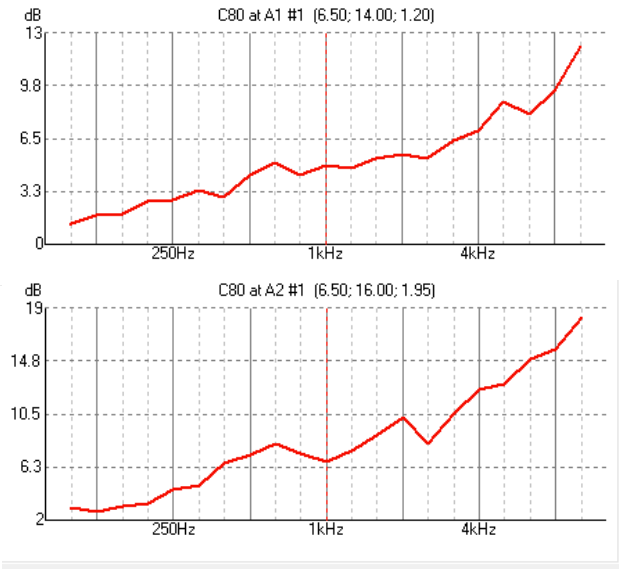

FIG. 4. C_{80} at different audience area (A1, A2).

Total SPL averages 78.94dB, with a maximum of 84dB and a minimum of 69dB at A1 area and with a maximum of 85dB and a minimum of 72dB at A2 area. Higher frequency has a smaller total SPL than lower frequency.

Early decay time mapping of mid-frequency (1000Hz, Fig. 5) shows that forehead area has a longer decay time than back area. As for the T10, T20 and T30, the result shows that there is no much difference between forehead and back seating area throughout the frequency band and most of the decay time is below 2.0 sec (Fig. 6).

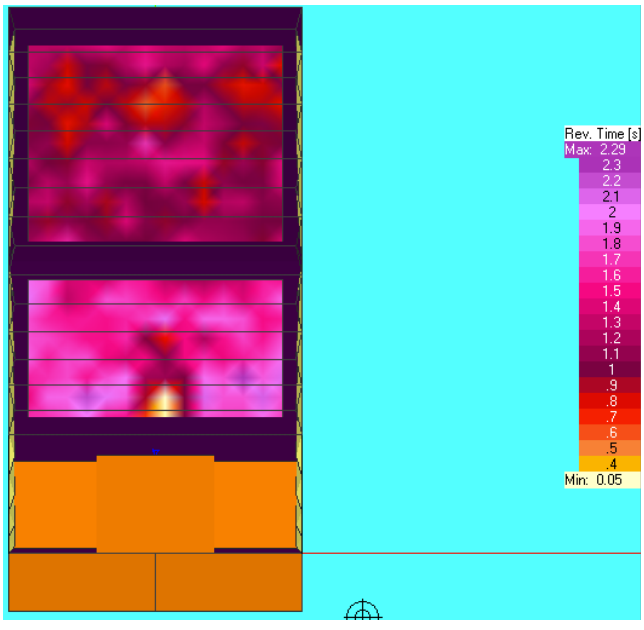

FIG. 5. Early Decay Time (EDT) mapping of 1000Hz.

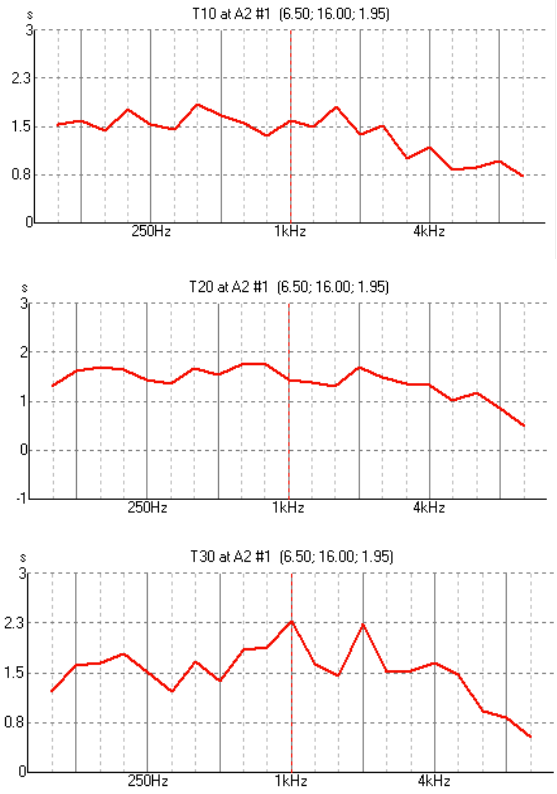

FIG. 6. T10, T20, T30 at different frequency (A2).

IV. DISCUSSION

For listeners educated in Western classical music, one of the most striking features of gagaku music is its emphasis on timbre. Unlike Western classical orchestral works, which primarily use functional harmony and instrumental sound fusion, gagaku music employs fixed harmony and non-fusion.

In this typical gagaku music piece, the ensemble consists of wind (Hichiriki, Ryuteki, Sho, Kagurabue, Shakuhachi), string (Gakubiwa, Koto) and percussion (Shoko, Daiko, Shakubyoshi). The string part is quite different from western orchestra for the instrument is played in a plucked manner instead of continuous sound. To distinct this feature, echo effects should be reduced in a large extent. Another reason for this echo-free tendency is that the piece contains many "blank" part which had better not to be "filled" with reverberations.

In this model, the room reverberation time as well as early decay time stay almost the same from low frequency to high frequency. This also reflect that the high-frequency sound also plays an equal part as mid-frequency sound in gagaku music. Different from western orchestra, the wind part in gagaku is the "highest" part of the chamber orchestra which plays notes at thousands of Hz. The melody of this high-frequency part should be treat with equal importance as mid-frequency part.

The design of stage is also compatible for the orchestra ensemble of this specific music piece and is flexible for different version of performance. In the 1973 version of the work, Takemitsu scored for a foreground ensemble of nine players (the 'Autumn Garden') and, upstage of them, an 'echo' ensemble of a further eight musicians (the 'Tree Spirits'). However, for the 1979 score Takemitsu added two more groups of 'Tree Spirits' to left and right at the rear of the auditorium, bringing the total number of players to twenty-nine. The size and distribution of stages is capable of holding each performance.

V. CONCLUSIONS

In Takemitsu's score, the spatial distribution of the instrumentalists plays a crucial role, contributing to an overall 'spatial and temporal discrepancy of sound' which the composer obviously considers close to the spirit of the original outdoor style of performance.[1] This chamber music hall is especially designed for his most famous piece and well respond to the timbre and pitch features of gagaku musical instruments ensemble.

REFERENCE

[1]P. Burt, *The music of Tōru Takemitsu,* First paperback ed. (Cambridge University Press, New York, 2006).