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콘서트홀 축소모형을 이용한 연주자 배치 시의 음향평가

Acoustical evaluation of the orchestra-occupied condition using scale model concert hall

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1. Introduction

Objective measurements in the concert halls are carried out under the unoccupied condition. From the previous study, the estimation of an audience-occupied condition are available based on the real measurements. However, the effects of players were not fully investigated on the effect of players on the concert hall acoustics. So, acoustical characteristics of concert halls need to be evaluated in a fully occupied condition with all players and audiences as a actual performance state.

Therefore, in this paper, acoustical characteristics of fully-occupied condition with orchestra players were evaluated in a scale model concert hall. A model player was reproduced based on the previous data from BBC in a reverberation chamber. In addition, a relevant simulation method was suggested via matching scale model and simulation results.

2. Scale model

2.1 Model orchestra player

A 1:10 player model was shaped based on human appearance. Absorption power per person was measured in the 1:10 reverberation chamber according to ISO 354. The model player was modified several times to fit to the real musician's absorption. Then, the player models were placed in the 1:10 model concert hall as shown in Fig. 1.

Reverberation time was measured on the number of orchestra players increase in the concert hall model of the audience occupied condition. (Five steps: 0, 40, 50, 70 and 90-persons) From the measured RT, the equivalent absorption power was calculated in a similar way to the Berenek's approach. It is calculated from the reverberation time of existing and non-existing players in the hall. Fig. 2 shows the measured absorption power of a player as a function of frequency and player-occupied area. The results showed that sparse formation of orchestra players yielded more absorption due to more exposed surfaces between players. In addition, absorption per a player in the reverberation chamber was lower than that in the scale model hall.

Fig 1 Orchestra player in a 1:10 scale model

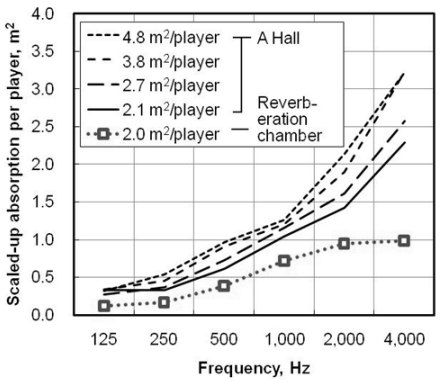

Fig 2 Evaluate the absorption/player in the reverberation chamber and the scale model hall.

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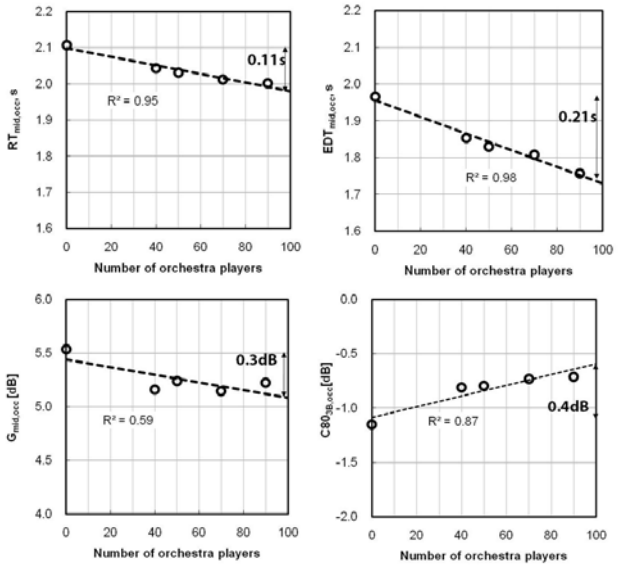

Fig 3 Effect of orchestra players on acoustical parameters

2.2 Effect of the number of orchestra player

Fig. 3 shows the measurement results of acoustical parameters according to number of orchestra players. After 90-players were placed on the model hall stage, RT and EDT were decreased by 1.1 s and 0.21 s, respectively, comparing to unoccupied stage condition. As the number of player was increased, RT and EDT were almost proportionally decreased. This indicates that orchestra players who located close to the source affect to disturb early reflections with increased sound absorption.

Sound strength (G) was also decreased by 0.3 dB, and C80 was increased by 0.4 dB. From the tendency by number of players, it was not much different between 40-players and 90-players occupied condition. This indicates that player-occupancy state itself is important to determine sound strength and clarity, whereas amount of players are not.

3. Simulation matching

A computer simulation model was reproduced based on the scale model results. Several player shapes with different absorption and scattering coefficients were appled in the computer simulation. RT and G results from each model were compared to those from scale model. As

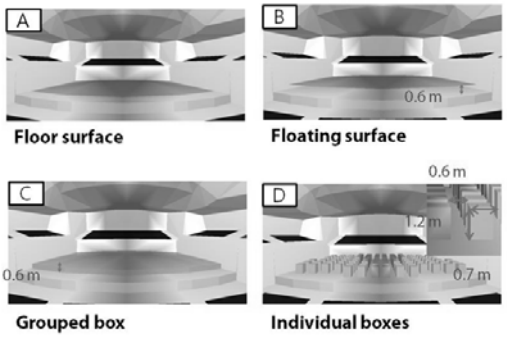

Fig 4 Computer simulation modeling of orchestra player

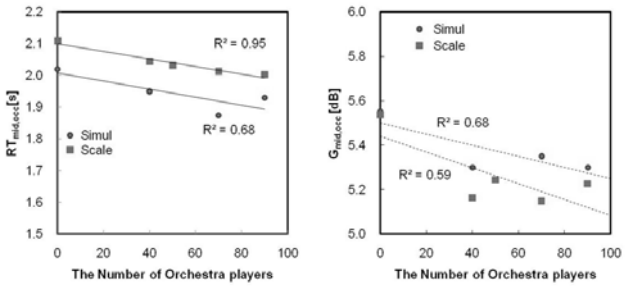

Fig 5 Comparison of RT and G between scale model and simulation as a function of number of orchestra player

results, the player model in a box-grouped shape showed the most matched results in terms of RT and G as shown in Fig. 5. RT and G decreased by around 0.1 s and 0.3 dB, respectively, as orchestra player occupied on the stage. Additionally, scattering coefficient of 0.6 and the absorption coefficient measured from the reverberation chamber yielded the best predicted results.

4. Concluding remarks

This study provided the acoustical changes by orchestra player placement using scale model and computer simulation. As a result, RT, EDT, G were decreased and C80 was increased by the orchestra players on the stage. Certainly, player-occupied state should be evaluated for concert hall acoustics. The proposed simulation method can be validated by different shaped hall models.