Abstract

The effect of diffusers and reflectors on Early Stage Support (ST1) in a concert hall was investigated at 8 positions in a 1:25 stage scale model. The scale model experiments showed that the ST1 values varied with diffuser coverage and that ST1 values were not affected by floor reflection. In addition, it was observed that the ST1 was affected by reflector height.

1. Introduction

Gade (1989) proposed a measure related to performing conditions which he called Stage Support (ST1). Stage Support assesses the support of the performer’s own sound and assumes that sound returning to the performer between 20 and 100ms is beneficial. Measured ST1 values have been found to correspond with musicians’ assessments of ease of playing (Barron, 1993).

In this paper, ST1 was used to investigate the Seoul Arts Center (SAC) stage. Measurements were made with a 1:25 scale model of the stage (Jeon et. al., 2004a).

2. The Concert Hall and its Scale Model

2.1. The hall and the scale model

With an area of 270m² and an average width of 22m, the Seoul Arts Center stage is large; however, no reflectors have been placed above the stage leaving a clear distance of 14-15m to the ceiling. The walls of the stage contain triangular diffusers.

A 1/25 scale model of the SAC Concert Hall stage was built of 9mm varnished timber. The model included correctly modeled seating in the choir region behind the stage. Because measurements only involved the early sound, no air drying or nitrogen atmosphere was needed for the model measurements.

2.2. Stage Support (ST1)

Gade’s proposed support measure ST1 (or ST early) is the ratio expressed in dB of the early energy (20-100ms) to the direct sound energy (0-10ms), as shown in Eq. (1).

\[ ST1 = 10 \log \left( \int_{20ms}^{100ms} p^2(t) \, dt \bigg/ \int_{0ms}^{20ms} p^2(t) \, dt \right) \, dB \] … (1)

Reflections that arrive between 10 and 20ms of the direct sound have no effect on ST1; however, surfaces in this region may screen sound that would otherwise reach surfaces further away from the source and receiver. Reflections that arrive between 20 and 100ms of the direct sound contribute to the support measure, and correspond to a region extending from about 3.4m to 17m from the source/receiver.

2.3. Source and receiver (Figure 1)

In the 1:25 scale model of the stage, a spark source with a 4mJ electrical discharge was used as the source in with a B&K 1/8inch microphone and nose cone as the receiver. Microphones were always placed 40mm from the spark source, which is equivalent to 1m at full-scale.

3. ST1 measurements

3.1. The effect of stage floor

To remove the floor reflection within 10 ms, the floor between the source and receiver was covered with highly absorptive fabric. From the ST1 measurement, it was found that the floor reflection does not affect the early sound reflection. This means that the direct sound energy is much higher than the floor reflection so that...
the ST1 is mainly determined by later energy between 20 ms and 100ms.

3.2. The effect of stage wall shapes

ST1 was measured with three types of wall shapes: with and without the present wall diffusers and with hemispheres (Jeon et al., 2004b). The ST1 values are shown in Figure 2. Although the average ST1 values of the three wall shapes were somewhat similar (-17.4dB, -17.9dB and -17.8dB), the standard deviation of the eight different positions for each wall shape were somewhat different (7.5dB, 5.5dB, and 4.8dB in order).

![Figure 2: Measured values of ST1 for different diffusers](image)

When plotting ST1 values by the distance from the stage walls from where the source is made, variation in the Stage Support over the stage was found.

3.3. The effect of reflector height

To determine the effect of the stage ceiling on Stage Support, a 1cm thick polycarbonate reflector with a slope of 1:13.5 was installed from the ceiling. The ST1 was measured at four different heights from 12m to 6m with a decrement of 2m. As shown in Figure 3, the highest values for ST1 occurred when the ceiling reflector was 6m above the stage. With the ceiling reflector at 6, 8 and 10m, the spread of ST1 values at the eight measurement positions for the 6, 8 and 10 m reflectors is relatively smaller than the spread for the 12 m reflector.

![Figure 3: The effect of reflector height above the stage on Support, ST1](image)

\[ y = -1.4289x - 9.9447 \]
\[ R^2 = 0.9413 \]

4. Conclusion

A study of the acoustic conditions in the Seoul Arts Center Concert Hall stage was made using a 1:25 scale model. The purpose of this study was to assess the acoustic conditions using Stage Support (ST1).

The Support measure ST1 involves measuring energy returning to a performer. In ST1 measurements, the floor reflection is negligible. From the ST1 values measured in this study it was found that the reflections from the ceiling seem to have a greater influence on sound reflection than the walls surrounding the stage.

The results from this study indicate that for larger stages, greater effort is required to ensure that sufficient reflections return to the musicians.

References


