Comparisons between Computer Simulations of Room Acoustical Parameters and those Measured in Concert Halls

Jens Holger Rindel*, Hiroyoshi Shiokawa**, Claus Lynge Christensen** and Anders Christian Gade**

*Norwegian Institute of Building Research, P.O. Box 123 Blindern, N-0314 Oslo, Norway
**Department of Acoustic Technology, Building 352, Technical University of Denmark, DK-2800 Lyngby, Denmark

Summary: A number of European concert halls were surveyed in 1989 [1]. In this paper comparisons are made between measured room acoustical parameters and those obtained from computer simulations using the ODEON program version 3.1 on two concert halls. One is Musikverein in Vienna and the other is Concertgebouw in Amsterdam. Comparisons are also made between the results obtained from computer simulations using models with high geometrical fidelity and those from models with simplifications to geometry on both concert halls.

Geometrical Data from Computer Simulations

Two models of each concert hall are used for computer simulation. One is made with high geometrical fidelity (C.H.) and the other one is made with simplifications to geometry, mainly in the platform area (C.S.). The latter is in better agreement with the laws of high frequency modeling.

Two models of Musikverein in Vienna are shown in Fig.1 and 2. Those of Concertgebouw in Amsterdam are shown in Fig.3 and 4.

Source and receiver positions in simulation models are defined according to survey in 1989. Sx (○1~3) are source positions. Px are measuring position of early decay time on the platform for each source position. All Sx and Px positions are one meter above the floor. Rx (●1~5 or 6) are receiver positions in audience area. All Rx positions are 1.2 meters above the floor.

1) Musikverein in Vienna (Actual Volume : 15000 m³)
   a) C.H. model: Number of surfaces in room is 110.
      The estimated volume is 15113 m³.
   b) C.S. model: Number of surfaces in room is 64.
      The estimated volume is 16048 m³.
2) Concertgebouw in Amsterdam (Actual Volume : 18700 m³)
   a) C.H. model: The number of surfaces in room is 84.
       The estimated volume is 19923 m³.
   b) C.S. model: The number of surfaces in room is 62.
       The estimated volume is 20072 m³.

Acoustical Parameters

Reverberation time (RT): Comparisons of measured (M) and calculated RT on the receiver position R2 in middle of audience area in the stalls and R4 in audience area of a balcony when the source position is S1 (typical soloist position) are shown in Fig.5, Fig.6 (Musikverein), Fig.7 and Fig.8 (Concertgebouw).

Three series of RT are displayed in each of the Fig.5-8; measured RT in 1989[1] and calculated RT by computer simulations using models of C.H. and C.S..

All three series of RT are similar except RT at 125Hz of Fig.5.
Early decay time (EDT) on the platform: Comparisons of three EDT on the receiver position P2 (middle of left side strings between first and second violins) when the source position is S2 (middle of right side strings between violas and cellos) are shown in Fig.9 and Fig.10. According to Fig.9, EDT of C.S. is in better agreement with that of M than that of C.H. in Musikverein. According to Fig.10, the difference between the two sets of calculated data is small and they are similar to the measured data except at 2kHz in Concertgebouw.

Level (L) and Clarity (C): Comparisons of L and C on the receiver position R2 and R4 in Musikverein when the source position is S1 are shown in Fig.11 and 12. Differences in Level between M and C.S. are less than about 2dB. Differences in Clarity between M and C.S. are large in R2 but small in R4 from 250Hz to 4kHz.
Accuracy rating of acoustical parameters: The average of all resulting relative errors for each acoustical parameter between M and C.H., C.S. at 500Hz are shown Fig.13 and 14 (Subjective limen: 5% for RT and EDT, 1dB for L, 0.5dB for C, 10ms for Ts, 0.05 for LF[2]). Relative Errors of EDT and C are large in both concert halls. Relative errors of C.H. are smaller than those of C.S. except RT in Musikverein but both of them in Concertgebouw are similar except RT.

Conclusion

- Measured and calculated reverberation times in single positions are in good agreement.
- Models with simplifications to the geometry are more useful than those with high geometrical fidelity for EDT on the platform.
- In both halls the average relative errors of Level and LEF are small (1-2 sub. limen) and those of Clarity are large (4-6 sub. limen).

References