

The Acoustic Situation at the St. Stephen's Cathedral in Vienna

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During history the acoustic itself as well as the music played at the St. Stephen's cathedral in Vienna has changed a lot. In the presented project extensive acoustic measurements were made and a model for room acoustic simulations was built. This is the basis for a better scientific understanding of the present acoustic situation and will help to develop a proposal for optimisation of the musician's situation.

1 History and present Situation

The St. Stephen's cathedral in Vienna (see figure 1) was built during the Romanesque and the Gothic period. At this time the music and its performance was completely different to now (see [1] and [2]). Additionally there were some architectural changes which had an impact on room acoustics, too.

Table 1 shows a list of typical positions for music performance. Figure 2 shows this positions within the ground plan of the cathedral.

The aim of the presented work was to get a better scientific understanding of the acoustic situation in this large room because there have no detailed measurements done before. On basis of these measurements and additional room acoustic simulations proposals for an optimization of the musician's situation should be made.

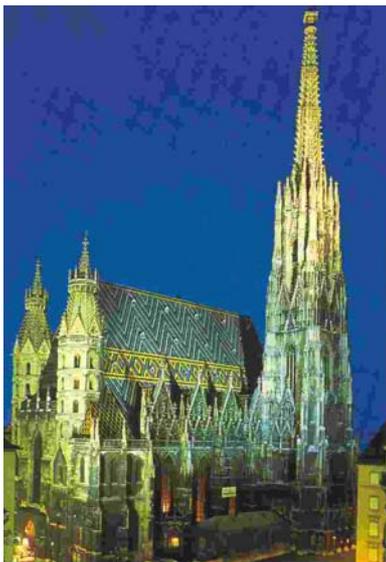


Figure 1: St. Stephen's cathedral in Vienna

Table 1: Typical positions for music performance at the St. Stephen's cathedral in Vienna

Position Number	Position Name
1	Füchselbaldachin
2	Orgelfuß
3	Neue Orgel
4	Friedrichsschiff
5	Altar Wr. Neustädter Schiff
6	Volksaltar

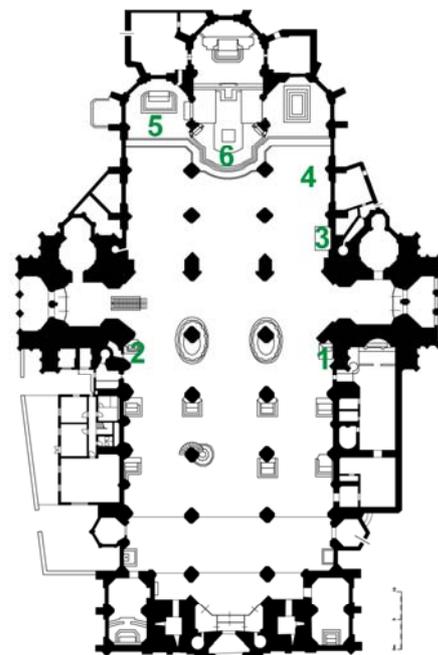


Figure 2: Ground plan of the St. Stephen's cathedral in Vienna with typical positions for music performance (1-6)

2 Measurements

The measurements were done with a Norsonic dodecaeder and AKG studio microphones, a PC, an 8-channel professional soundcard and the software WinMLS2000, which works with maximum length sequences.

Source positions of the dodecaeder were at position 3, 4, 5 and 6 (see fig. 2). There were in total 213 microphone positions all over the room. Figure 3 gives an impression of the measurements at the cathedral.



Figure 3: Measurements at the cathedral: the source was located at the Volksaltar and the microphones are in the Hauptschiff

For the analysis of this huge amount of measurement and simulation data a special tool for visualization was programmed. With the aid of this tool a 2-dimensional display of different user-defined parameters was possible (which is not possible within the software WinMLS).

Results of the measurements for the reverberation time T30 are shown in figure 4.

Concerning the height of the source position the measurements show a significant better acoustic

situation for a height of 3 meters in comparison with 1.5 meters (see figure 5).

A comparison of the measurements with the simulation show (see figure 6).

An analysis of the hall radius has shown that there are no musical relevant so-called coupled rooms at the cathedral.

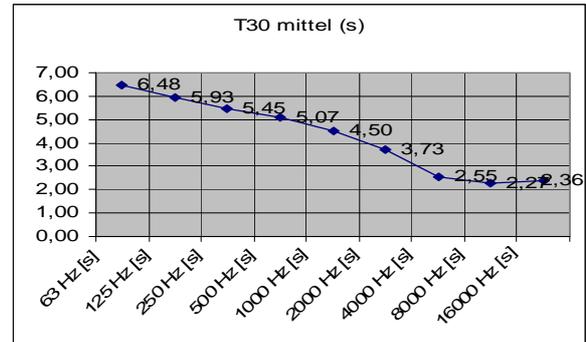


Figure 4: Results for the reverberation time T30 at source position 4 at a height of 3.0 m

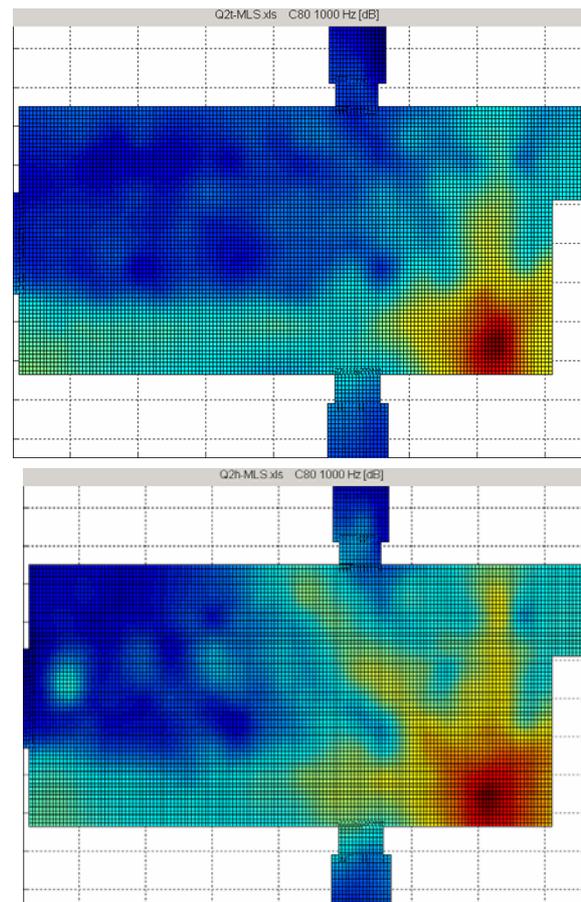


Figure 5: Measurement results for the clarity C80 at source position 4 at 1 kHz at a height of 1.5 m (above) and 3.0 m (below)

Figure 6: Simulation results for the clarity C80 at source position 4 at 1 kHz at a height of 1.5 m (above) and 3.0 m (below)

3 Simulations

The room acoustic simulations were done with the software CATT Acoustic. The model has about 4700 planes, which reaches the limits of the software. Figure 7 shows the model of the cathedral, figure 8 a view from the west balcony into the room.

The optimization of the model showed that the parameter for the air dissipation has an important effect on the calculation results.

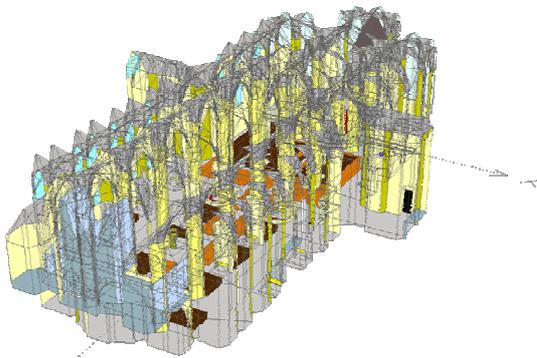


Figure 7: Room acoustic model of the cathedral



Figure 8: View from the west balcony into the room at the model (left) and in reality (right)

4 Possibilities for Optimization

Several variations and combinations of walls, reflectors and podiums were simulated for source position 4. These simulations showed that an optimization of the musician's and listener's situation could be achieved by a higher podium and special walls for the musicians as well as reflectors in the Friedrichsschiff and the Hauptschiff for a better sound distribution (see figures 9 and 10). The impact of the directivity of

musical instruments as analyzed in [3] was studied, too.

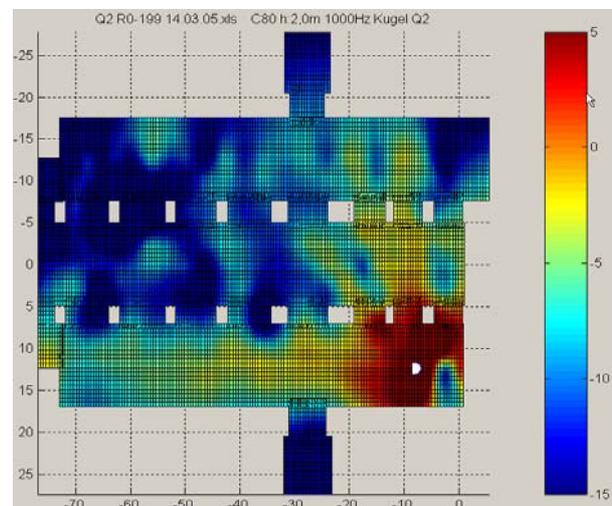


Figure 9: Example of a wall and reflectors for an optimization of the musician's and listener's situation



Figure 10: Example of an additional reflector in the Hauptschiff

Fig. 11 shows a comparison of the results of the simulation without any wall or reflectors (top) and with walls and reflectors as shown in fig. 9 (middle and bottom).



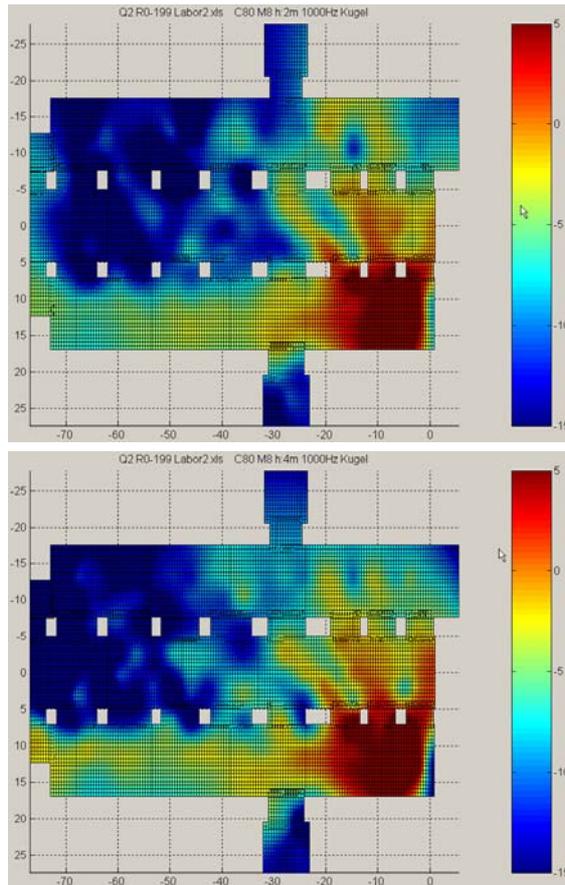


Figure 10: Comparison of the simulation results of clarity C80 without any optimization (top) and with walls and reflectors shown in figure 9 (middle and bottom) at the frequency of 1 kHz. The height of the source is 2.0 m (top and middle) respectively 4.0 m (bottom)

Figure 11 shows the simulation results of reflectors as shown in figure 10. The use of an additional reflector results in better values of C80 in the Hauptschiff.

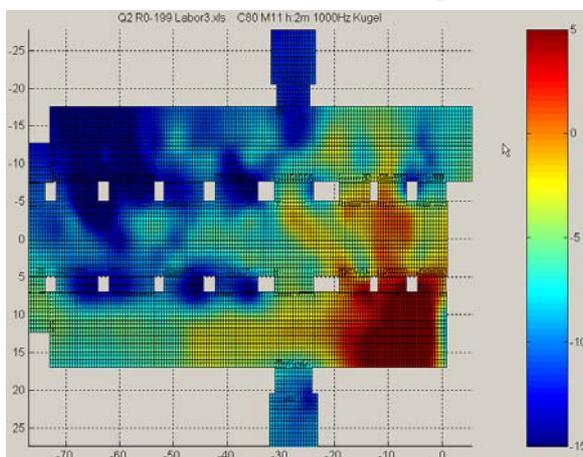


Figure 11: Simulation results of clarity C80 with wall and reflectors as shown in figure 10 at 1 kHz and 2.0 m

Limitations for realizing possible actions are liturgical aspects and the protection of monuments.

5 Conclusions

In this project the fine structure of the acoustic situation in a Gothic cathedral was investigated. Measurements as well as simulations have shown that there are no so-called coupled rooms at the St. Stephen's cathedral in Vienna. The position for music performance in the Friedrichsschiff (position 4) is the best one regarding the given liturgical and musical circumstances.

An optimization of the musician's and listeners's situation could be achieved by a higher podium and special walls for the musicians as well as reflectors in the Friedrichsschiff and the Hauptschiff for a better sound distribution. Limitations for realizing these actions are liturgical aspects and the protection of monuments.

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References

- [1] F. W. Riedel, 'Der Ort der Musik in der katholischen Kirche: funktionale, architektonische, akustische und musikalische Aspekte'. *Symposion, 1994*, Graz, ConBrio Verlagsgesellschaft Regensburg, 1996, pp. 9-40
- [2] P. Planyavsky, '1952 - Wohin mit der Dommusik?', *Pfarrblatt der Dompfarre St. Stephan*, 57 (3), March 2002, pp. 44-48
- [3] J. Meyer, 'Akustik und musikalische Aufführungspraxis', 5. Auflage, Verlag Erwin Bochinsky, Frankfurt am Main, ISBN-3-932275-95-0 (2004)
- [4] J. Meyer, 'Kirchenakustik', Verlag Erwin Bochinsky, Frankfurt am Main, ISBN 3-923639-41-4 (2003)