ACOUSTICAL DESIGN OF THE CONCERT HALL OF PÉCS CONFERENCE AND CONCERT CENTRE

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Abstract

The Pécs Conference and Concert Centre is a new building complex in southern Hungary built on the occasion of Pécs being one of the three Cultural Capitals of Europe in 2010. It consists of a large concert hall in its core surrounded by section halls, rehearsal rooms as well as ballet and other dance rooms. It hosts the Pécs Symphonic Orchestra, but will be used also for conferences and other social events, theatrical performances and pop/rock music concerts. The concert hall was designed in a cooperation of two consulting companies. This paper presents the design of this concert hall.

The hall is a modified shoebox-shaped hall with asymmetric layout, two level balconies. Most surfaces are covered with wooden panels, the walls are equipped with pyramid shape diffusers and there is a canopy above the stage consisting of 7 individually moveable parts. During the detailed design phase two different room acoustical modelling software were used in parallel for the evaluation of the acoustic design. Altogether six different hall configurations were examined (configuration for symphonic orchestra, opera, rock music, rehearsal, banquet and conference). These configurations differ in the setting of the stalls that can be raised (slanted) or lowered to be flat and horizontal, the setting of the orchestra pit that can be covered and also raised to give an extension to the stage, the curtains around the stage and the occupancy of the seats and of the stage. In all cases the spatial distribution of the main acoustical parameters (reverberation times, early decay time, clarity, strength, lateral efficiency and stage parameters were determined and optimized. In order to have reliable absorption value for the chairs, both empty and occupied, laboratory measurements were carried out. The results of these measurements together with the simulation results of both software are shown and evaluated.

1. Introduction

On the occasion of being one of the three cultural capitals of Europe in 2010, the leaders of Pécs, a city in southern Hungary, have decided to have a new concert hall and conference centre built. The complex, that is to be opened in December, 2010, is called the Pécs Conference and Concert Centre. It consists of a large concert hall in its core with section halls, rehearsal rooms as well as ballet and other dance rooms surrounding it.

In order to achieve excellent acoustics in the concert hall, the detailed design was carried out in a cooperation of two acoustic consultants, Mr. A. Chr. Gade (Gade & Mortensen Akustik A/S) –

who had already been involved in the tender design phase as well, and Mr. A. Kotschy (Kotschy and Partners Ltd.). The two consultants have access to different modelling software (Odeon and CATT), and although both software performed very well in earlier Round Robins (see [1] and [2]), this cooperation seemed to be a great opportunity to compare them in a real situation, by analysing the Pécs Concert Hall in different configurations. Altogether six different configurations were examined (configuration for symphonic orchestra, opera, rock music, rehearsal, banquet and conference). These configurations differ in (1) the setting of the stalls that can be raised (slanted) or lowered to be flat and horizontal, (2) the setting of the orchestra pit that can be covered and also raised to give an extension to the stage, (3) the curtains around the stage and the occupancy of the (4) seats and of the (5) stage. In all cases the spatial distribution of the main acoustical parameters (reverberation times (T30), early decay time (EDT), clarity (C80), strength (G), lateral efficiency (LFC, LF)) and stage parameters (STearly, EDTstage) were determined and optimized.

The results of these simulations were discussed in [3], the reverberation times are shown here as well. At the submission of that paper the type of seats were already chosen, but there was no data available on their absorption coefficients. Laboratory measurements were carried out in order to determine these data, both for empty and occupied chairs, and the authors also had the opportunity to perform basic room acoustical measurements in the empty hall before the installation of the chairs. In the following the results of these measurements are shown and evaluated.

2. The design of the concert hall

2.1 Basic layout of the concert hall

The concert hall is a modified shoe-box shaped hall with an asymmetric layout and two level balconies. The volume is app. 13000 m3, the maximum extents are about 42 × 22 ×18 m (length × width × height). The hall seats altogether 1000 people, the stage is designed to have enough place for large symphonic orchestra and choir. The walls and balcony fronts are covered with wooden panels, and the walls are equipped with pyramid shaped diffusers of different sizes. Above the stage there is a canopy consisting of 7 individually moveable parts. The architect's model of the concert hall from the final design phase is shown in Fig. 1, and a photo of the almost finished concert hall without the seats is shown in Fig. 2.

Figure 1. Architect's model of the concert hall of the final design phase

2.2 Acoustical studies

The basis for the simulations was a three dimensional architect’s drawing, that was adopted in different ways to suit each modelling software's needs. Two typical room acoustical model views are shown in Fig. 3. All configurations were analyzed with both software. Being the acoustically most demanding configuration, the symphonic orchestra setting was examined more thoroughly than the others: all combinations of 6 source and 61 receiver positions (6 of which on the stage) were verified.

The main attributes of the different settings are given in Table 1. Beside these, the curtains around the stage and the occupancy of stage were changed. As the most popular parameter for de-

scribing the acoustics of the hall, the spatial average of the predicted reverberation times of the different settings are shown in Fig. 4.

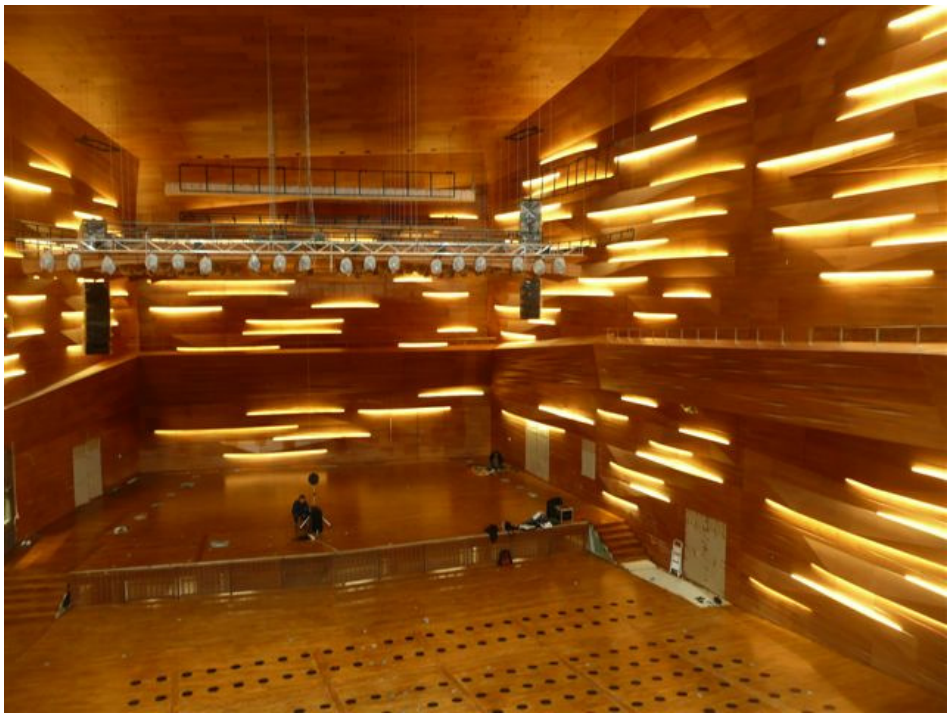

Figure 2. The concert hall without the chairs – October, 2010

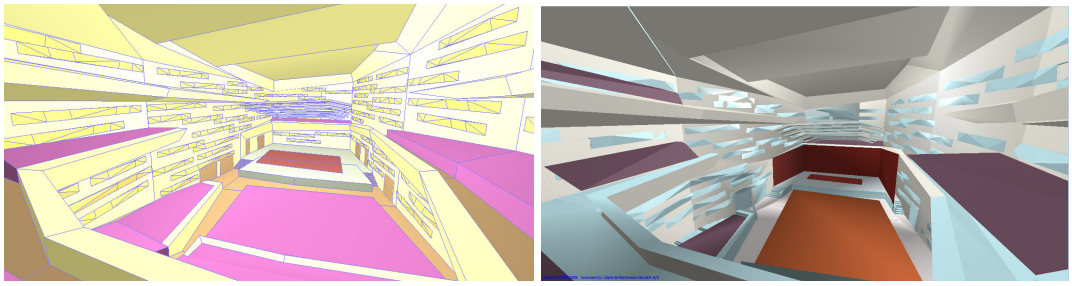

Figure 3. Model view of symphonic concert settings (left, CATT Acoustic, Kotschy and Partners Ltd.) and of banquet settings (right, Odeon, Gade & Mortensen Akustik A/S)

TABLE 1. Main properties of different settings for the room acoustical simulations

Setting	**Pit area**	**Stalls**	**Occupancy**
Symphony	Extended stage	Raised	All seats occupied
Opera	Orchestra pit	Raised	All seats occupied
Rock	Extended main floor	Raised	All seats occupied
Conference	Extended main floor	Flat	Main floor seats occupied, balconies full
Banquet	Extended main floor	Flat	Tables and chairs on main floor, balconies empty
Rehearsal	Extended stage	Raised	All seats empty

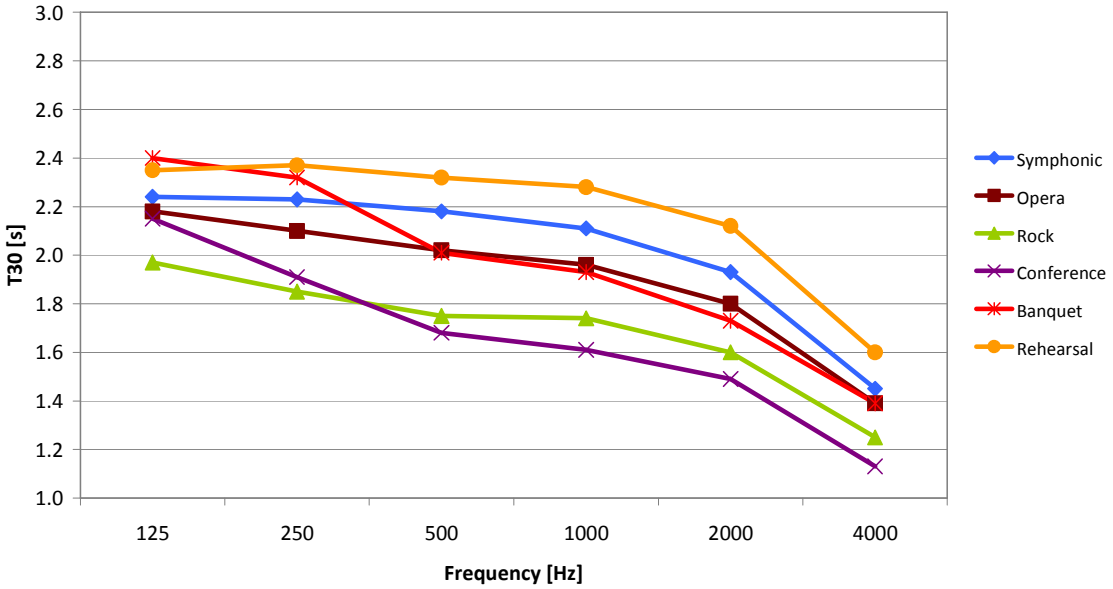

Figure 4. Spatially averaged predicted reverberation times of the different settings

3. Absorption of the chairs

Unfortunately, at the time of the design, there was no decision yet regarding the type of the chairs, therefore we had to use a typical absorption data recommended by Beranek [3] for occupied seats, and an average data for the unoccupied case (medium upholstered concert hall chairs).

In June, 2010 laboratory measurements of the seat absorptions were performed according to the MSZ EN ISO 354:2003 standard. The chairs of the hall and a picture taken during the measurement of occupied seats are shown in Fig. 5, the measurement results and the previously used data by Beranek are given in Table 2. It can be seen that despite the quite heavy upholstering, the chair absorption is much lower than expected, both occupied and unoccupied.

Figure 5. Seats (left) and measurement of chair absorption (right)

TABLE 2. Absorption coefficients (α) of seating with and without audience (in percents)

Frequency	**125**	**250**	**500**	**1000**	**2000**	**4000**
Beranek's data for occupied seats	62	72	80	83	84	85
Medium upholstered concert hall chairs	56	64	70	72	68	62
Measured audience absorption	40	45	40	60	75	60
Measured seat absorption	20	35	30	40	50	55

4. Measurements in the empty hall

In the beginning of October, 2010, basic room acoustical measurements were carried out in the hall before the installation of the chairs. An omnidirectional loudspeaker for mid and high frequencies was used together with a subwoofer to cover the whole frequency range from octaves of 63 Hz up to 4 kHz. Alltogether 8 source-receiver arrangements were measured. The measured reverberation times are shown in Fig. 6, and the averaged results are given in Table 3. Results of different measurement positions show good agreement.

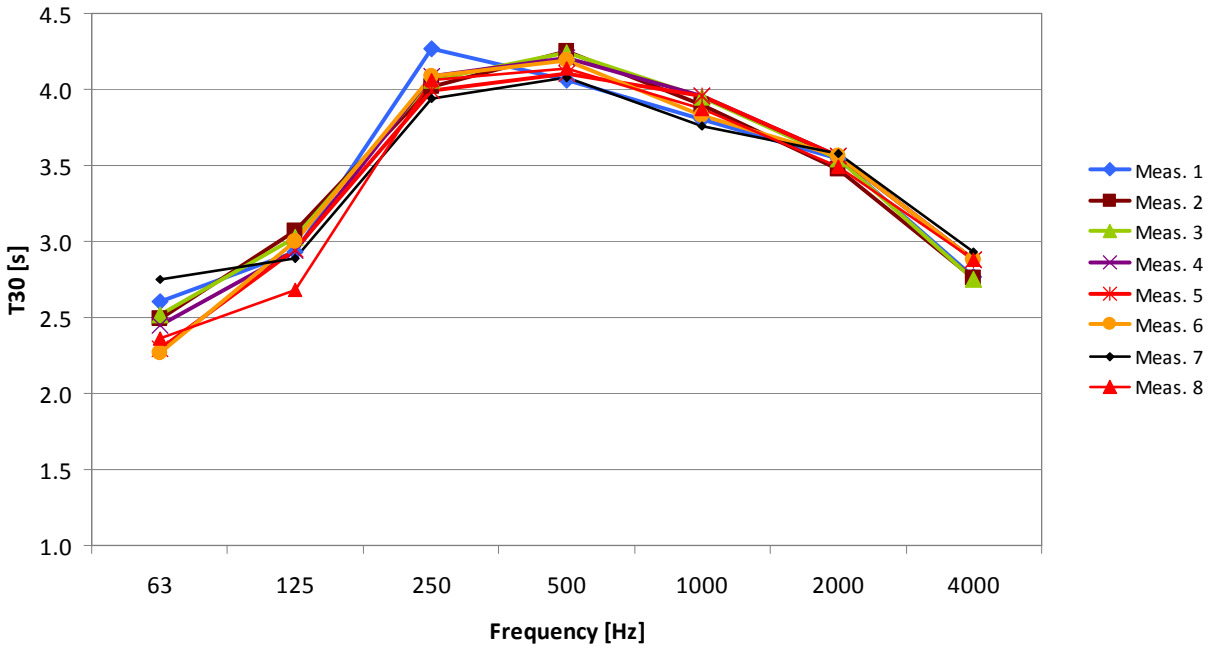

Figure 6. Measured reverberation times in the empty hall, without chairs

TABLE 3. Average of the measured reverberation times (empty hall, without chairs)

Frequency [Hz]	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Averaged T30 [s]	2.5	2.9	4.1	4.2	3.9	3.5	2.8

5. Expected reverberation times

The measurement results shown above are promising if we take into account the additional absorption that will be introduced with the chairs. However, in the lowest frequency bands the reverberation times are somewhat lower than expected, the reason for which is not yet clarified. There are two main assumptions: the resonator effect of the pyramid diffusers on the sidewalls and the resonator effect of the ventilation blow-in grids on the floor, with a large cavity behind it when the stalls are raised. As the pyramids were designed in a way that their filling can be modified and thus they can be hardened up, the reverberation time can be fine tuned later on.

By combining the reverberation times of the empty hall with the absorption data of the occupied seats, a rough estimate can be made on the expected acoustics of the hall. The estimated reverberation times for fully occupied and empty halls (without modification of the diffusers) are given in Table 4.

TABLE 4. Rough estimate on the reverberation times in the hall with all seats installed

Frequency [Hz]	**125**	**250**	**500**	**1000**	**2000**	**4000**
Empty hall	2.4	2.7	2.9	2.5	2.2	1.9
Fully occupied hall	2.1	2.5	2.6	2.2	1.9	1.8

6. Summary

During the detailed design phase of the concert hall of the Pécs Conference and Concert Centre we have used two different room acoustical modelling software to evaluate the acoustical design. At this phase there was no absorption data available on the chairs to be installed, therefore a typical recommended data were chosen and used.

During Summer of 2010 laboratory measurements were carried out on the selected seats and their absorption were determined for both empty and occupied case. Later on room acoustical measurements were also performed in the empty hall before the installation of the chairs.

The results of the simulations and the recently performed measurements are shown in this paper. The measurement results are promising, however, a fine tuning (increasing) of reverberation times in the lower frequency range might be necessary. The reason for the low reverberation time values is not yet clarified.

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