KODÁLY CENTRE – PÉCS, NEW CONCERT HALL OBJECTIVE AND SUBJECTIVE RESULTS

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1 INTRODUCTION

Pécs, a city in southern Hungary was one of the three cultural capitals of Europe in 2010. The cultural capital status served as a good occasion for designing and building a new concert hall and a conference centre for the city and for hosting the Pécs Symphonic Orchestra.
The Kodály Centre – Pécs was opened in December, 2010. The complex 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 design was carried out in a cooperation of two acoustic consultants during all phases of the design. The acoustical part of the permit and tender design was led by Mrs. Éva Arató (Arató Akusztika Ltd., Hungary) and Mr. A. Chr. Gade (Gade & Mortensen Akustik A/S, Denmark), whilst the detailed design was done by Mr. A. Kotschy (Kotschy and Partners Ltd.) and Mr. Gade. The designs were aided with different types of room acoustical modelling software by analysing the concert hall in many different configurations[1]. The models were also updated after the laboratory measurement of the absorption of the concert hall chairs.
During the construction of the building, several room acoustical measurements were carried out in the concert hall: measurements in the finished hall with all wall coverings fitted but without the chairs; later on with the chairs installed; and finally, during the technical opening concert, with audience in the seats (app. 75% occupied). The stage acoustics were also analyzed in the empty hall. Beside the objective measurements a subjective questionnaire has also been distributed among musicians and the audience – the distribution and evaluation of these questionnaires is still in process. In the following the results of the measurements are shown in details.

2 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. 13.000 m^3, the maximum extents are about $42 \times 22 \times 18$ m (length $\times$ width $\times$ height). The hall seats altogether 999 people, the stage is designed to have 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. Above the stage there is a canopy consisting of 7 individually moveable parts.

Figure 1. shows a general view of the concert hall, and two typical room acoustical model views are presented in Figure 2. The symphonic concert setting means fully occupied hall, orchestra pit raised up to extend the stage, and canopy is lowered, whilst in the banquet setting the floor is lowered, curtains are hung around the stage, the canopy is raised and there are no seats in the stalls but tables and people.

Altogether six different configurations of the concert hall were analysed 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.

Figure 1. A view of the empty concert hall

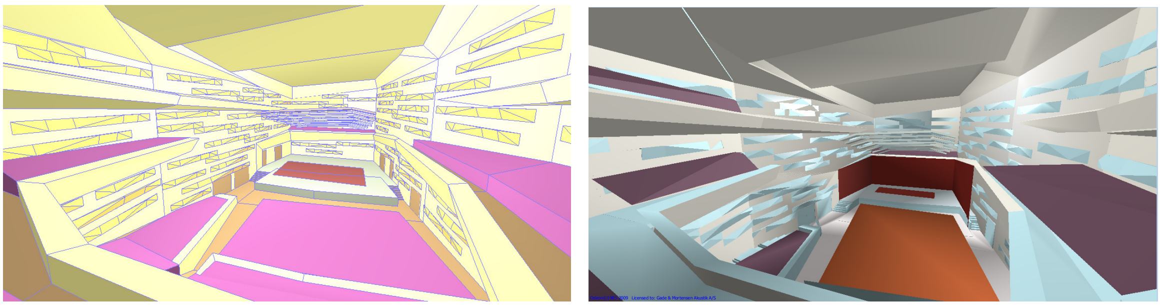

Figure 2. Model view of symphonic concert settings (left, CATT, Kotschy and Partners Ltd.) and of banquet setting (right, Odeon, Gade & Mortensen Akustik A/S)

3 MEASUREMENTS

3.1 Chair absorption measurements

The absorption of the concert hall chairs – both empty and occupied – were measured in a reverberant chamber according to the MSZ EN ISO 354:2003 standard. The absorption values are given in Table 1. The results are different from the typical literature values, which turned to be rather a measurement error, as the other measurements carried out in the concert hall gave 'typical' and more reasonable absorption coefficients (see below). The error might have been caused by having too many seats (20) in a relatively small reverberant chamber (236 m^3), however this assumption is not yet verified. The chairs are shown in Figure 3.

Table 1. Absorption coefficients of the concert hall chairs - laboratory measurement results

frequency [Hz]	125	250	500	1000	2000	4000
empty seats	0.20	0.35	0.30	0.40	0.50	0.55
occupied seats	0.40	0.45	0.40	0.60	0.75	0.60

Figure 3. The concert hall chairs

3.2 Measurements in the concert hall

Room acoustical measurements were carried out in the concert hall during its construction: in the finished hall with all wooden wall coverings and diffusers fitted but without the chairs (see Figure 4), and later on with the chairs installed. These measurements mainly focused on the reverberation times in the hall to see if any intervention was needed. This was very important, because only estimated absorption values of the special wooden diffuser elements on the walls, of the balcony fronts and that of the seats were available for the modell simulations, which meant a not neglectable level of uncertainty in the results. Fortunately, the measurement results justified the selection of the absorption values – except for the case of the chairs, where the laboratory measurements have turned out to be wrong. When the concert hall was ready, measurements in the empty and in the 75% occupied hall were also performed.

Figure 4: Measurements in the concert hall without the chairs

The reverberation times in the different states of the concert halls are shown in Figure 5. These results could be used to give an estimate of the absorption of the chairs. Figure 6 shows the absorption coefficients of the unoccupied and occupied chairs, measured in laboratory and calculated from the reverberation times. The figure also shows 4 other well known data: chair absorptions of the Wiener Musikvereinssaal and the Amsterdam Concertgebouw. It can be seen that the real (in situ measured) chair absorption values fall within the expectable range of coefficients, whilst the laboratory measurements are somewhat unusual.

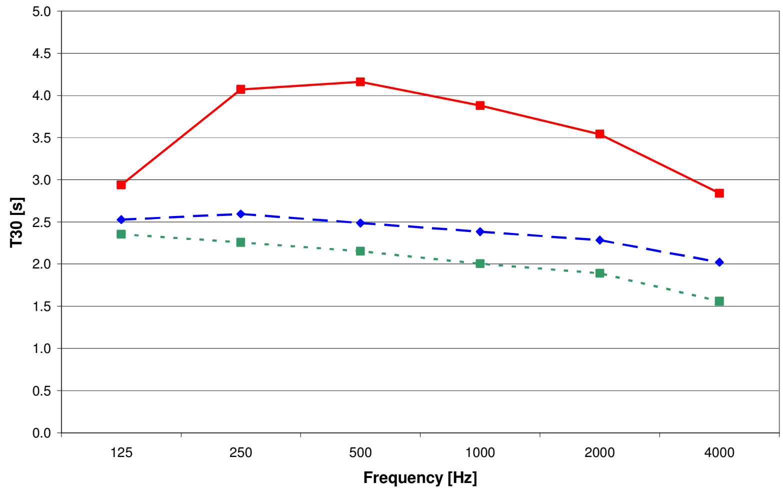

Figure 5. Average reverberation times in the hall without chairs (red, solid line), with unoccupied chairs (blue, dashed line), and in the 75% occupied hall (green, dotted line)

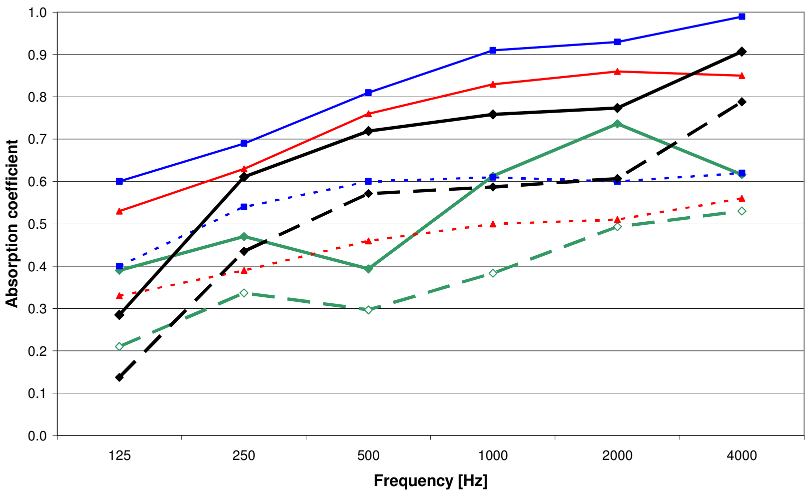

Figure 6. Absorption coefficients of unoccupied seats (dashed lines) and of occupied seats (audience, solid lines). Green: laboratory measurements of Pécs seats; Black: Pécs seats, calculated from reverberation times; Red: Musikvereinssaal; Blue: Concertgebouw

3.3 Designed and measured acoustical parameters

The measurement results below are averaged values of measurements with a source in the middle of the stage and with 8 receiver positions in empty hall and in 75% occupied hall. The optimal values are taken from several sources[2,3,4,5,6].

3.3.1 RaSTI

Although the hall is mainly intended to be used for classical music concerts, the speech intelligibility was also measured. The average RaSTI value is 67 percent, which can be further increased by the use of the electro-acoustic system.

3.3.2 Mean reverberation time and Bass Ratio

The mean reverberation time of the 500 Hz and 1000 Hz octave bands is 2.35 s in empty hall and 2.1 s in occupied hall. The optimal values are typically between 1.4 and 2.8 s for concert halls of different sizes. The design value was 2.2 s for fully occupied hall.

The bass ratio (warmness) of the hall is 1.05, which is very close to the design value of 0.98. Optimal values are in the range between 1.0 and 1.2.

3.3.3 Early decay time and Clarity

The average early decay time (EDT) in the audience is 2.2 s, which is in the preferable range of 1.8 -2.6 s. Figure 7 shows the early decay time values of both empty and occupied hall. The average clarity (C80) is -2.0 dB, which is a bit lower than the optimum. The design values were 2.0 s and 1.6 dB, both lower than the measured values, but these parameters can be slightly modified and fine tuned by adjusting the height and tilt of canopy elements.

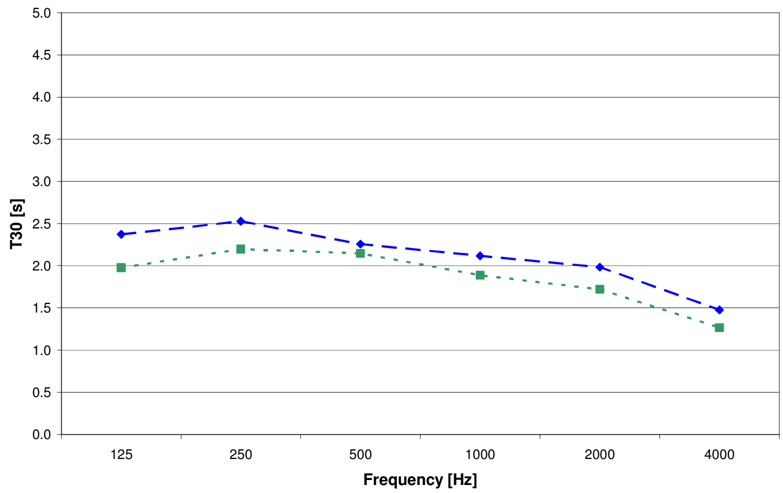

Figure 7 Early decay time values (measured). Blue dashed line: empty hall, Green dotted: occupied hall.

3.3.4 Inter Aural Cross Correlation

Unfortunately, we could measure IACC with only one dummy head in the occupied hall, thus we cannot form an overall judgement of this parameter. The $1\text{-}IACC_{E3}$ value of the one measurement position was 0.75, which is excellent, according to Beranek's – Hidaka's evaluation method. We hope to be able to perform several more IACC measurements in the near future.

3.3.5 Stage acoustics

The canopy above the stage is subdivided into six elements movable in height and angle, which make it possible to adjust the level and delay of reflections from above individually for different sections of the orchestra. By placing neighbour elements in different heights it is also possible to adjust the coupling between the acoustic volume on stage and that above the canopy. Additional reflections for the musicians arrive from the tilted balcony fronts around the stage.

Measurements on the stage with the setting used for the test rehearsals (without audience or musicians present) indicated favorable conditions[7,8] for ensemble with the position and frequency (250 – 2000 Hz) averaged value of STearly being -13 dB. This is in line with comments from the musicians indicating cross stage communication being fine (even with all strings sitting on the flat floor). The only complaint was about the tuba sounding too loud for the strings – a problem which can be solved by adjusting the canopy elements. Therefore, in spite of recent discussion[9] on the relevance of STearly this parameter has given meaningful results (also) in this case.

Both the STlate and EDT on stage are influenced by the rich reverberation in the hall with values being as high as -15 dB and 1.9 s respectively. Both values are slightly higher than what we would normally recommend for obtaining a sufficiently clear sound on stage; but the 1.9 s for EDT on stage matches well the value in the audience area: 2.2 s by being 15% lower than this value. If later, it should be decided to reduce RT in the hall – or to install and use further variable absorption – both STlate and EDT on stage will go down as well.

3.4 Subjective evaluation

We have created a subjective questionnaire to be distributed among musicians playing in the concert hall and among the audience listening to the concerts. We asked several questions regarding sound quality, stereo balance, clarity, brightness, overall experience, etc. Up until now, members of three Hungarian symphonic orchestras have been interviewed (the questionnaire is not obligatory). We have collected 28 answers from the Pannon Philharmonic Orchestra, 17 answers from the MÁV Symphonic Orchestra and 11 answers from the National Symphonic Orchestra. 33 musicians said the hall to be excellent and 23 judged it as good.

Maxim Vengerov called the hall ’a Stradivarius among the concert halls’.

The evaluation of the audience’ questionnaire is still on-going, but the subjective judgements are very good so far: 75 percent of the people have found the hall excellent and 25 percent found it good.

4 CONCLUSIONS

In this paper measurement results of a newly built Hungarian concert hall are presented. Several room acoustical measurements have been performed: already during the construction and after finishing the hall. The absorption coefficients of the chairs were determined by laboratory tests and also by calculating it from the reverberation time measurements. Although the laboratory measured absorption values of the chairs were somewhat unusual, the in-situ measurement values are rather typical for concert hall chairs. Preliminary results of a still on-going subjective survey is also briefly introduced.

According to the measurement results and the response of the public, the new concert hall has excellent acoustics, including the stage acoustics too, which the musicians extremely enjoy.

5 REFERENCES

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