CONVERTING MOVIE THEATRES INTO MULTI-PURPOSE CONCERT HALLS

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1 INTRODUCTION

In the recent years, many traditional movie theatres have been closed due to the increasing number of cinema complexes. Some of the buildings have remained unchanged and serve now as warehouse, a worship place for smaller congregations, some stand deserted. Fortunately, a few proprietors, typically local governments, try to find a new function for these fine buildings, conserving the architectural heritage by converting the theatres into concert halls or conference centres.

Within the history of room acoustics, the start of which dates back to ancient times, concert hall design has a tradition of 'only' 250 - 300 years. Still, these three centuries give many good and bad examples[1] so one can easily find a good starting point. The main design objectives are clear: typically rather high reverberation times, high clarity, proper early reflections, feeling of envelopment. For a multi-purpose hall one has to combine the objectives of a concert hall, with that of a lecture room, which is a challenging task, for the design objectives of the two types are quite contradictory. In case of converting an existing building, there are even more limitations and constraints.

In this paper we give an overview of recent acoustical designs of converting traditional movie theatres into concert and multi-purpose halls. Three halls of different shapes are discussed. Two of the halls were re-designed to be a concert hall, whilst the third was converted into a multi-purpose hall. In the latter a non in-line type electro-acoustic reverberation enhancement system has been installed in order to achieve variable acoustics for the different purposes. After introducing the main design criteria and the general problems of these conversions, the results of the room acoustical simulations and measurements are presented.

2 MOVIE THEATRES

In general, a movie theatre consists of an auditorium with a balcony in the back, a proscenium wall fitted with the screen canvas, and a small stage with space enough only for a few people. The ground plan of theatres is typically rectangular, the ceiling is varying. The walls are covered with absorbers to achieve low reverberation times and high speech intelligibility, and are patterned with rich ornamentation to avoid flutter echo.

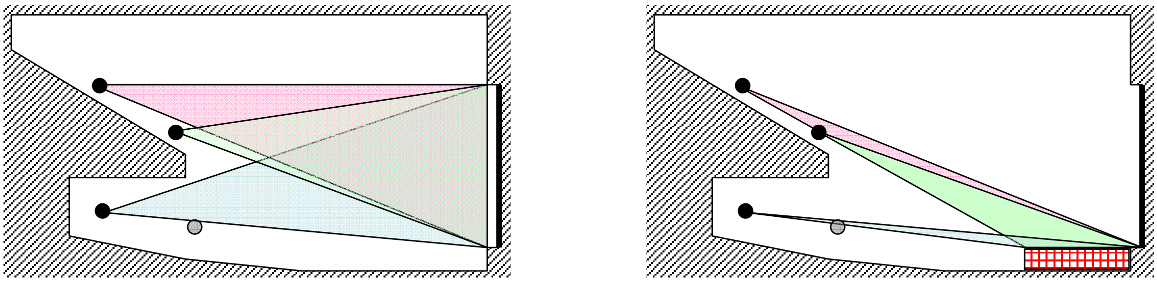
2.1 Drawbacks Of The Layout

Although the rectangular ground plan is quite common for concert halls and other types of auditoria[1], the layout of the movie theatres bears several drawbacks which encumber straightforward, direct adaptation of the hall for its new purpose.

The shape of the ceiling of movie theatres serves rather aesthetic than acoustic purposes: the audio tracks were played via loudspeakers placed along the walls and behind the screen, and the ceiling reflections were not exploited. Sound reflectors (canopy, stage shell and others) are needed to assure evenly distributed sound and sufficient sound energy throughout the hall.

The small or missing stage involves another problem of the conversion: for the new functions one has to build a stage large enough for the orchestra (chamber or symphonic, with or without a choir, as demanded). This means that either the auditorium has to be shortened to give space for the stage, or – if there is space in the building behind the proscenium wall – the hall has to be extended with the newly built stage.

Beside the decreased seating capacity in the first case, the placement of the stage may raise visibility problems at both options. The elevation of the stalls and the balcony in a movie theatre are set to give a free viewing angle covering the screen, with no heads obstructing the view. By building a stage in front or behind the proscenium wall, parts of the orchestra might become invisible (hidden) from the back rows of the balcony. Figure 1-a shows a typical movie theatre layout, with all audience having clear view on the screen. Figure 1-b shows the same layout with a stage created in the front rows of the stalls, the view from some positions is obstructed by other spectators.



(a) (b)

Figure 1. Typical movie theatre longitudinal section;
viewing angles for the screen (a) and viewing angles for the concert hall arrangements (b)

2.2 Acoustics Of Movie Theatres In Hungary

It is interesting to point out, that there existed guidelines on Movie Theatre Acoustics already in the seventies[2] (see Tables 1 and 2), however these guidelines regulated the reverberation times only. On the other hand, these guidelines were only recommendations, and architects usually never felt the need of an acoustic consultant when designing a movie theatre.

The presented movie theatres were built earlier than 1970, when there were no available guidelines at all. Now, when many of these theatres are being converted into concert halls, we can consider ourselves very lucky: the architects designed the movie theatres as if they had wanted to construct concert halls. This has resulted in large volumes that allow sufficient volume per seat ratio for concert purposes.

Table 1. Mid reverberation time values in the empty auditorium of movie theatres[2]

Volume [m^3]	$T_{mid\ (500\ -\ 1000\ Hz)}$ [s]
400 – 500	0.45 – 0.8
700 – 800	0.50 – 0.85
1000—1300	0.55 – 0.90
1500 – 1800	0.60 – 0.95
2500 – 3000	0.70 – 1.05
8000	0.90 – 1.30

Table 2. Acceptable range of reverberation time values in the 63 Hz – 8000 Hz frequency range[2]

Frequency [Hz]	63	125	250 - 4000	8000
Minimum and maximum of T/Tmid	0.75…1.45	0.85…1.30	0.85…1.15	0.7 … 1.15

Beside the large volume, we can note that fortunately – from an acoustic point of view –, there is usually no rigging-loft (catwalk) of considerable size above the stage to be built, which could act as a trap for the sound energy. The original ornamentation of the walls is useful in eliminating flutter echoes and making reflections soft.

3 THE THREE DESIGN CASES

In the following subsections the three converted movie theatre designs are presented. In all cases CATT-Acoustic software was used for finding the optimal arrangement of sound reflectors, and for verifying the designs.

3.1 Richter Concert Hall, Győr

The old "Rába" Movie Theatre converted to Richter Concert Hall houses the Philharmonic Orchestra of the City Győr. The views of the geometrical model are shown in Figure 2.

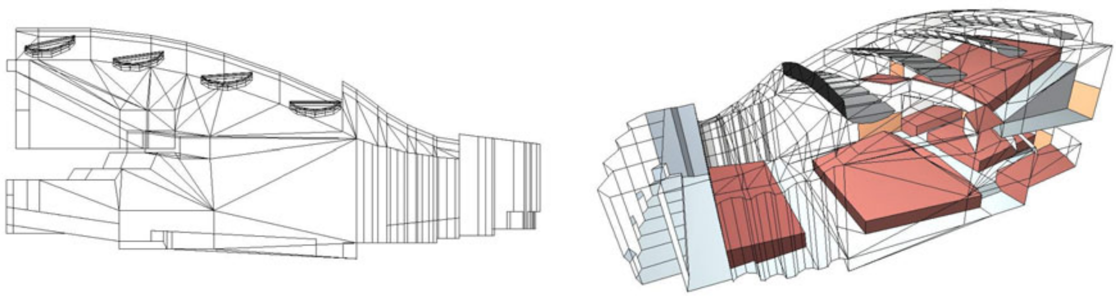


Figure 2. Longitudinal (left) and three dimensional (right) view of the geometrical model of the Richter Concert Hall

The overall volume of the hall is 3400 cubic metres, it seats 516 people (149 on the balcony), which gives 6.5 m^3 per person. The ground plan is almost rectangular, but the undulating ceiling makes the hall different from the conventional shoebox halls. The stage has been created by both shortening the stalls and extending the stage behind the proscenium wall (see Figure 3).

There are 32 rounded sound reflectors in four rows (eight in each row) suspended from the ceiling that are responsible for the smooth sound energy distribution. The reflectors and diffusers on the back and side walls of the stage resemble the preserved original wooden wall coverings of the auditorium, and give a pleasant playing environment for the musicians.

3.1.1 Measurement results

Room acoustic measurements using MLS and swept-sine signals were carried out in the empty Hall after its official opening. Two source and seven receiver positions were chosen, giving 14 impulse responses. Pictures in Figure 3 were taken in the empty hall during the room acoustic measurements. The main acoustic parameters are shown in Figure 4 and Table 3.

The measured $T_{mid(500\text{-}1000\ Hz)}$ is 1.3 s, which is optimal for a concert hall of 3400 cubic metres, C-80 values are varying around zero, and the distribution of sound pressure level is even, with small deviations.

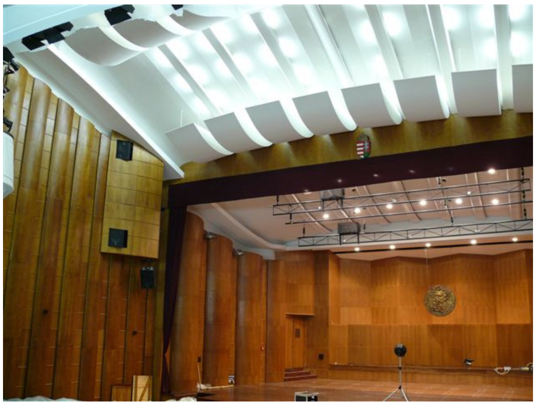


Figure 3. The stage and auditorium of the Richter Concert Hall, Győr (seats are covered with cloth)

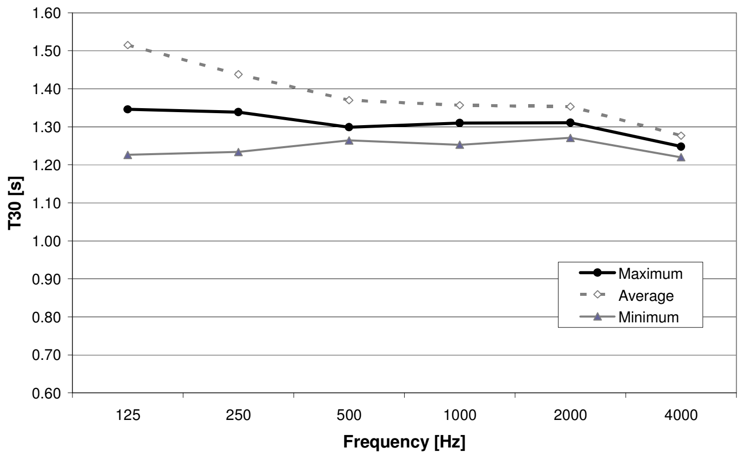


Figure 4. Measured reverberation times in the Richter Concert Hall, Győr
(values evaluated from 14 impulse responses)

Table 3. Room acoustical parameters measured in the Richter Concert Hall, Győr

Frequency [Hz]		**125**	**250**	**500**	**1000**	**2000**	**4000**
EDT [s]	**Average**	1.37	1.37	1.33	1.37	1.35	1.23
C-80 [dB]	**Average**	0.09	0.76	0.91	-0.26	0.15	0.77
SPL [dB]	**Maximum**	68.9	77.1	78.9	81.2	80.3	77.2
	Average	66.8	74.0	75.7	78.7	78.1	74.3
	Minimum	64.3	71.4	73.0	76.0	75.5	71.2

3.2 Kodály Musical Centre, Kecskemét

The Municipal Movie Theatre of Kecskemét is one of the buildings that still have an uncertain future. It has been closed in 1999 and in 2008 it still stands empty, although the design phase of converting it into Kodály Musical Centre was finished in 2006. The views of the geometrical model are shown in Figure 5.

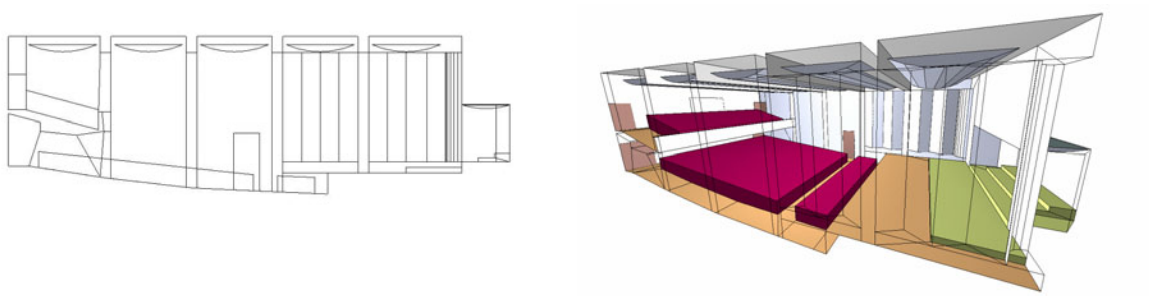


Figure 5. Longitudinal (left) and three dimensional (right) view of the geometrical model of the Kodály Musical Centre

The hall has an overall volume of 2300 cubic metres for 390 seats (82 on the balcony), giving an average 5.8 cubic metres per person. The hall is a typical shoebox hall, with a slightly sloping floor, flat ceiling and parallel walls. The stage is to be created mainly by sacrificing rows of audience, and it has a small extension behind the plane of the original canvas.

There are 5 rows of solid rounded sound reflectors suspended from the ceiling with adjustable angles. The stage walls are equipped with reflectors and diffusors.

The predicted reverberation times are given in Figure 6, LE and C-80 parameters are listed in Table 4.

Table 4. Predicted averaga values of Lateral Efficiency (LE) and Clarity (C-80) for the Kodály Musical Centre (with occupied seats)

Frequency [Hz]	**125**	**250**	**500**	**1000**	**2000**	**4000**
LE [%]	36.0	36.3	36.3	36.4	37.5	37.7
C-80 [dB]	2.50	2.36	2.89	2.62	2.66	3.39

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3.3 House of Arts, Multi-purpose Hall, Miskolc

The third design case covers the conversion of the old Béke Theatre of Miskolc. The theatre has been re-built into a Cultural Centre called the House of Arts. The old cinema room has been refurbished and operates now as a fine concert and conference hall, with variable acoustics. The views of the geometrical model are shown in Figure 7.

The volume of the multi-purpose hall is 3600 cubic metres, offering place for 580 peoples, of which 200 are on the balcony. The volume per seat is 6.2 m^3. The shape of the ground plan remained a simple rectangle, but the original flat ceiling of the shoebox shape has been opened up and the volume of the hall has been extended with the cavity of the attic. The stage was created by removing the proscenium walls and utilizing the space behind it.

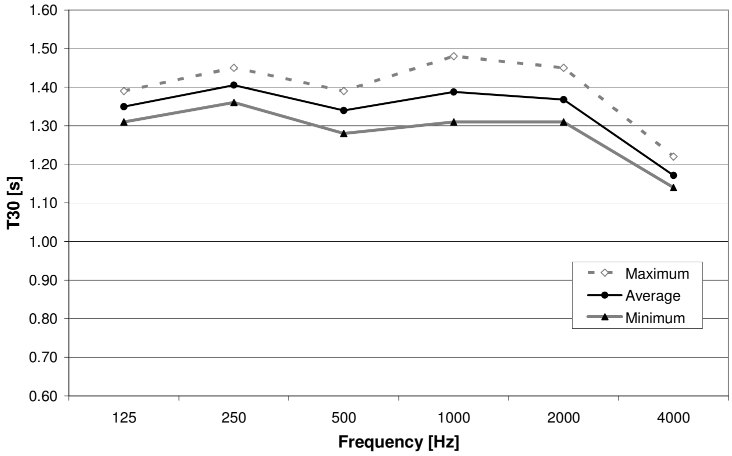

Figure 6. Predicted reverberation times in the Kodály Musical Centre (occupied seats)

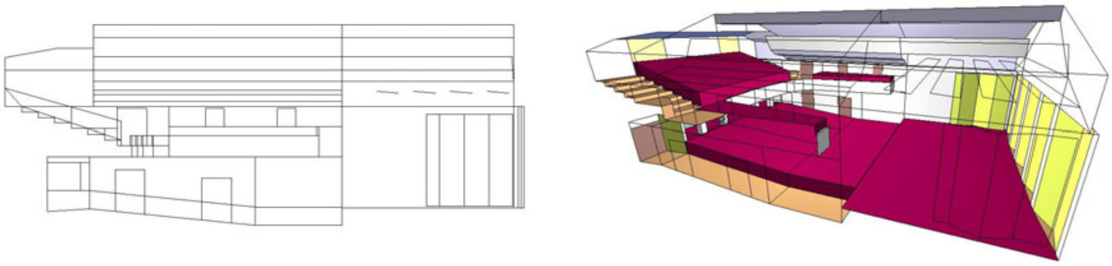

Figure 7. Longitudinal (left) and three dimensional (right) view of the geometrical model of the House of Arts' Multi-purpose Hall, Miskolc

There are five rows of moveable and tilteable flat sound reflectors above the stage, and a slant suspended ceiling along the sidewalls of the auditorium. The stage is surrounded by sound reflector prisms made of wood. Figure 8 shows the hall set for a concert.

Figure 8. Stage of the Multi-purpose Hall in House of Arts, Miskolc

3.3.1 Electro-acoustic reverberation enhancement system

The variable acoustics has been realized with a non-inline electro-acoustic reverberation enhancement system[2]. The system consists of 24 microphone and loudspeaker pairs (so-called cells) distributed through the hall. 8 pairs are attached to the lateral walls, 2 of which are at the side of the stage, 2 can be found below the balcony, 9 on the ceiling and 5 more in the ceiling of the stage. 10 different configurations can be chosen to comply with the different demands: from conference purposes which requires the lowest reverberation times so the system is switched off, through theatre performances, opera plays, chamber concerts and even symphonic or choir concerts, that require the longest reverberation. According to the designer of the system, the revereberation times can be set between the two limiting curves given in Figure 9.

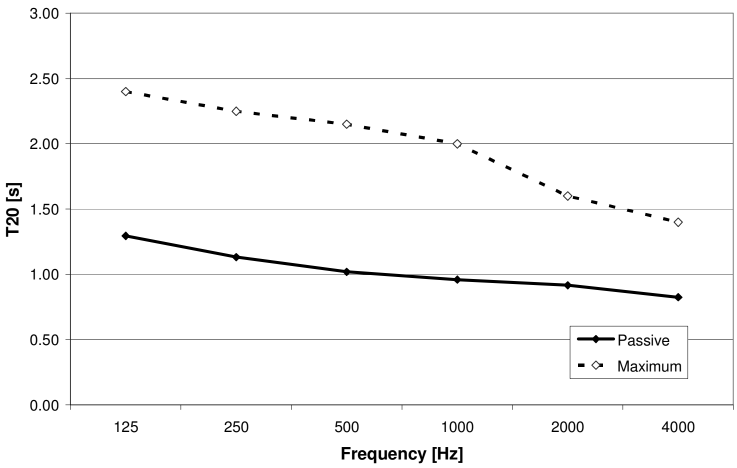

Figure 9. The limits of the installed electro-acoustic reverberation enhancement system[2]. Lower curve shows the reverberation times with switched off system, upper curve shows the achieveable maximum reverberation times

3.3.2 Measurement results

An extensive room acoustic measurement series were carried out in the multi-purpose hall of Miskolc. Both MLS and swept-sine signals were used, 2 source positions and 7 receiver positions were selected (just as in the case of the Richter Concert Hall in Győr).

Fortunately we had the rare opportunity to carry out measurements both in empty and occupied hall. The reverberation times and clarity values are shown in Figure 10 and Table 5.

Table 5. Measured Early Decay Time (EDT) and Clarity (C-80) values in the Multi-purpose Hall of House of Arts, Miskolc - Empty and occupied case

Frequency [Hz]		**125**	**250**	**500**	**1000**	**2000**	**4000**
EDT [s]	**Empty hall - stage**	1.3	1.2	1.0	1.0	1.0	1.0
	Empty hall - audience	1.2	1.2	1.2	1.2	1.1	1.0
	Occupied hall - audience	1.0	1.0	1.1	1.0	1.0	0.9
C-80 [dB]	**Empty hall**	2.49	1.89	1.03	0.92	2.34	3.06
	Occupied hall	1.47	3.44	1.23	1.81	3.20	3.71

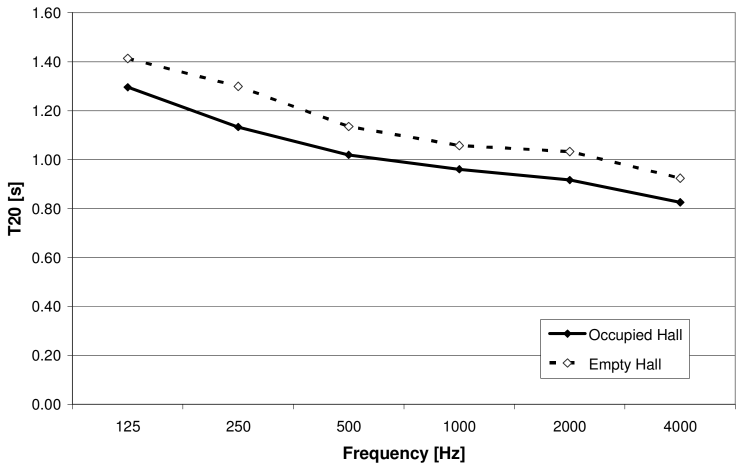

Figure 10. Measured reverberation times in the Multi-purpose Hall of House of Arts, Miskolc - Empty and occupied case

4 SUMMARY

In the recent years several traditional movie theatres have been re-designed and converted into concert halls. Three examples of such conversions are presented here. The basic parameters of the halls are introduced, and the results of extensive measurement series carried out in the concert halls are also given.

The design concept of old Hungarian movie theatres included large spaces which allow sufficient volume per seat ratio for converting them into concert halls. Beside this advantage, the lack of the stage and the shape of the ceiling are the two main drawbacks that have to be eliminated during the design. In case of converting a movie theatre into a multi-purpose hall, one needs variable acoustics. In the third case introduced above, an electro-acoustic reverberation enhancement system was employed to satisfy the contradictory acoustical requirements of a lecture hall and concert hall.

The subjective judgements of the public in Győr and in Miskolc is very good, both the audience and the musicians are completely satisified with the new concert halls. There had been no concert halls in these cities before.

5 REFERENCES

1. L. Beranek, Concert Halls and Opera Houses, 2nd ed Springer, 2004
2. Ministry of Education, Department of Filmy, 'Guidelines for design and objective evaluation of room acoustic properties of movie theatres', Hungary, 1971 (in Hungarian)
3. 'Carmen - Les salles équipées', http://www.cstb.fr/fileadmin/documents/telechargements/Camen_les-salles-equipees.pdf, September 2008