THE ACOUSTIC DESIGN OF A VINEYARD HALL AND A SHOEBOX THEATRE AT THE NEW KRAKOW CONGRESS CENTRE

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1 INTRODUCTION

Following the political changes in Eastern Europe in the 1990's, a number of cities in Poland proposed building performing arts centres as symbols of a modern face. Several of these have now come to fruition and the centre in Krakow is one of the latest.
Krakow is one of the most impressive of Polish cities, the former capital – its historic centre was not destroyed in WWII and it is an attraction today for many tourists.
The music scene in Krakow is vibrant and its international standing is enhanced by the eminent composer Krzysztof Penderecki, a Krakow resident, who was fully supportive of a new concert hall.

The new Centre in the foreground with historic Krakow in the background

2 THE COMPETITION

2.1 Background

In 2007, the City of Krakow decided to proceed with the building of a new centre but prescribed that as well as a venue for performing arts it should also provide facilities for congresses and conferences. A competition was announced and its requirements had a major influence on the building that was eventually realised.
The key factor in the competition conditions was the build cost which was limited to around 50 million euros. To illustrate how modest this sum is, a comparison is made in Figure 1 of the cost of other recent concert venues. Also, the working language was to be Polish. These conditions didn't attract widespread international interest which gave Polish architects a stronger chance of winning.
A leading Krakovian architectural practice, Ingarden and Ewy, had already explored concert hall designs on the site and invited Arup to provide acoustics, theatre design and MEP for the competition entry.

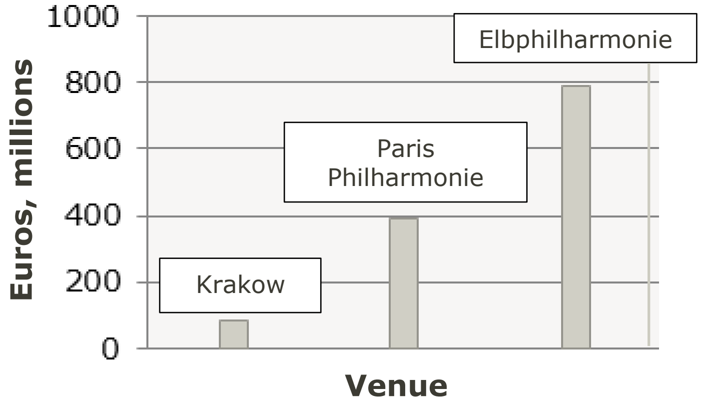

Figure 1: Comparison of costs for recent performing arts centres

2.2 The Brief

In essence, the brief required the construction of a main auditorium with around 1800 seats suitable for orchestral performances, amplified concerts and congresses. A second auditorium with around 600 seats was to be for a variety of events ranging from musical ensembles to conferences. The third hall, with 300 seats, is multipurpose and divisible into two halves. In additional there are a number of break-out spaces which can be adjusted in size using operable walls.
For the main auditorium, the brief suggested an amphitheatre layout rather than specifically referring to a vineyard terrace or shoebox arrangement. By contrast, the second hall specified a box layout. The stages of both halls were to be on the same level to facilitate access.

2.3 The Site

The site is on the south bank of the River Vistula with a spectacular vista of the historic centre in one direction and the picturesque church-on-the-rock in the other direction.
Busy roads run along two boundaries of the site along with a tramway along one of them.

2.4 The Competition Entry

For the main auditorium, the design was developed with the help of the experienced Japanese architect, Arata Isozaki, who was invited to join the team. The form selected was based on vineyard terrace concept with the stage at one end, a type of frontal/surround arrangement. This was refined to suit the brief and the site. Detailed acoustic computer modelling was carried out of the design and the competition entry included a comprehensive presentation of the acoustic design together with favourable values of predicted acoustic parameters.

3 DESIGN DEVELOPMENT

3.1 The main auditorium

Ingarden and Ewy Architects were successful in winning the competition and proceeded to develop the design. The fundamental geometry of the main auditorium envelope did not change significantly from the competition entry: the basic parameters are a volume per seat of 10m^3, a maximum room height above the stalls floor of 18m and a width at stalls level of 23m. The distance from the stage edge to the furthest seat for an orchestral concert configuration is 32m.

To enable a change from concert to congress mode, approximately 800m^2 of acoustic absorption in the form of drop down banners were incorporated, mainly along the side and rear walls. The banners can also be adjusted in banks to provide a range of reverberation times to suit various types of performance.

The design development comprised mainly of adjustments to the arrangements of the vineyard terraces and the inclinations of the terrace walls to provide an optimum sequence of early reflections incident on the seating. The acoustic performance was checked with an acoustic computer model and also a physical model at 1:50 scale. The scale model provided valuable confirmation that the specified reverberation times with and without variable absorption would be achieved. Also, it confirmed the value of having an orchestral reflector above the stage which was initially queried by the architect.

The acoustic proposal for the orchestral reflector was that it should comprise an array of panels approximately equivalent to half the area of the stage and that these should be variable in height but typically set at 8 to 10m above the stage. This was interpreted by the architect as a collection of organic shapes of similar size, distributed fairly uniformly above the stage area.

In terms of surface finishes, the walls of the auditorium are lined with timber which, as well as being aesthetically pleasing, is modelled to provide varying degrees of diffusion. At a lower level namely, the stage enclosure and lower balcony walls, the diffusion is based on battens of different depths, similar to a Schroeder diffuser without fins, but also set at different angles in the vertical plane. At a higher level, on the upper balcony walls, the diffusion is larger scale and consists of a mix of convex geometries together with battens.

The acoustic characteristics of the upstage wall can be varied by means of an arrangement of movable and rotatable panels. These are diffusing on one side and sound absorbing on the other, they can also be retracted to provide a plane reflective upstage wall.

The ceiling is made up of multiple layers of plasterboard to provide sufficient weight to minimize low frequency absorption. It has a gentle convex shape when viewed from the audience plane and provides moderate diffusion over the seating area. The orchestral reflectors are also made up of multiple layers of plasterboard. The floor is a heavy build-up of plywood and timber.

The seats are designed, as usual, to limit the room acoustic between the occupied and unoccupied condition. The specification for sound absorption was set accordingly. Surprisingly, the seats, when tested in a reverberation chamber, were not absorbent enough at mid/high frequencies despite being well upholstered. The best solution seemed to be adding light upholstery to the timber underside of the seat which, although resulting in a significant change in appearance, was acceptable to the architect. There was also a risk of a shortfall in reverberation time with this approach. The result of this modification was fortunately both a compliance with the specification and a successful outcome in auditorium reverberation times.

3.2 Second Hall

The second hall followed a more conventional rectilinear theatre geometry with a flytower. The seating is arranged on two main balconies with side balconies whilst the seating in the stalls is retractable so that a flat floor can be provided.

This hall also has variable absorption in the form of drop down banners on the side walls to change the acoustic from music performance to speech. For music performances, an orchestral shell comprising a number of heavy towers can be arranged on the stage to project sound into the auditorium and to block-off the flytower.

A gently curved overhead reflector in front of the proscenium directs early reflections onto the seating area. Other surfaces are generally diffusing. The auditorium walls consist of timber panels oriented at slightly different angles which provide recesses where feature lighting has been installed. The ceiling is made up of diffusing pyramids constructed of heavy plasterboard.

The flytower, which is fully equipped, is treated with acoustic absorption on its upper walls to reduce coupling between itself and the auditorium which can become problematic if the flytower is emptied of theatrical drapes.

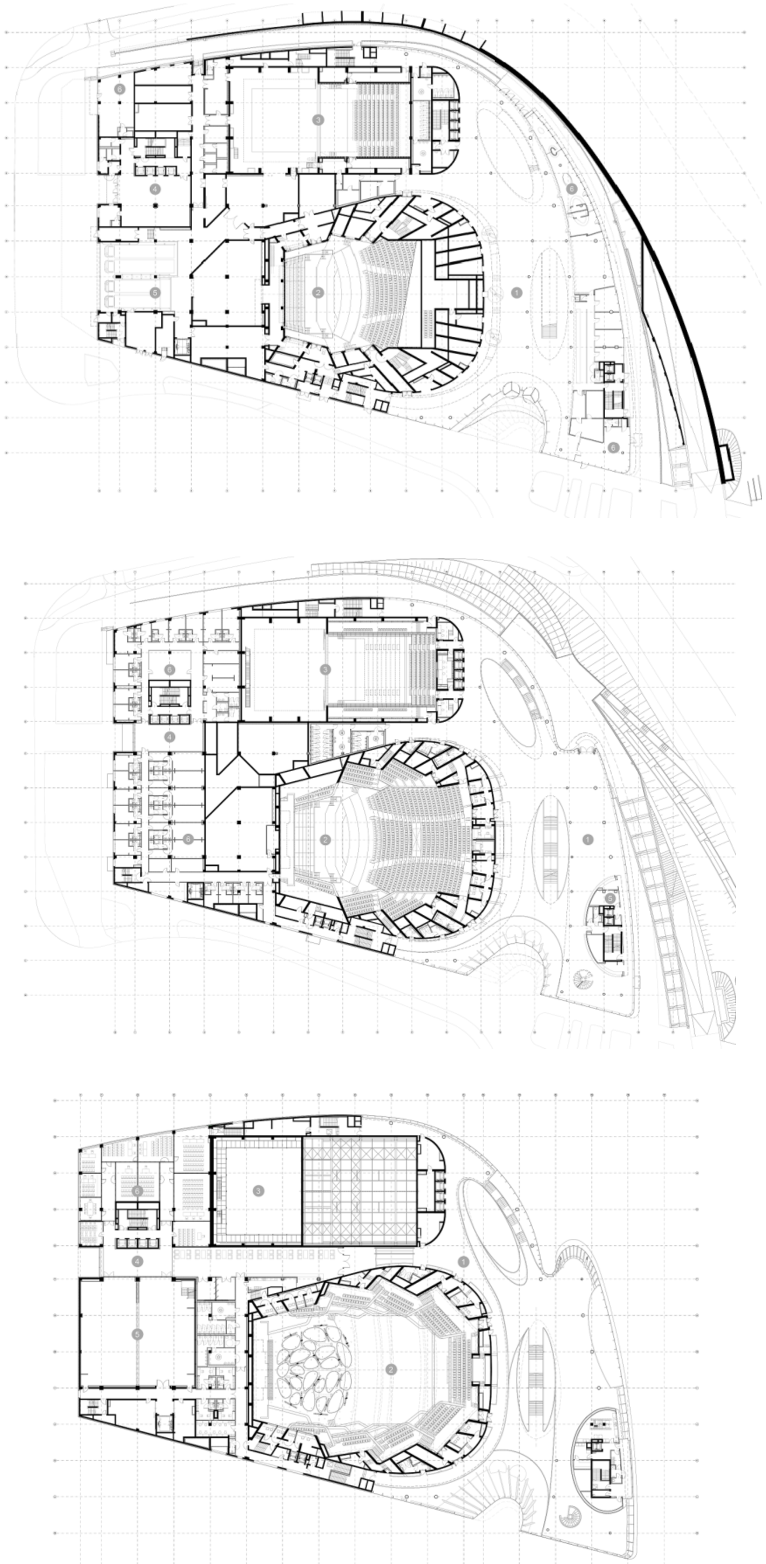

Figure 2: Ground floor, first floor and third floor plans

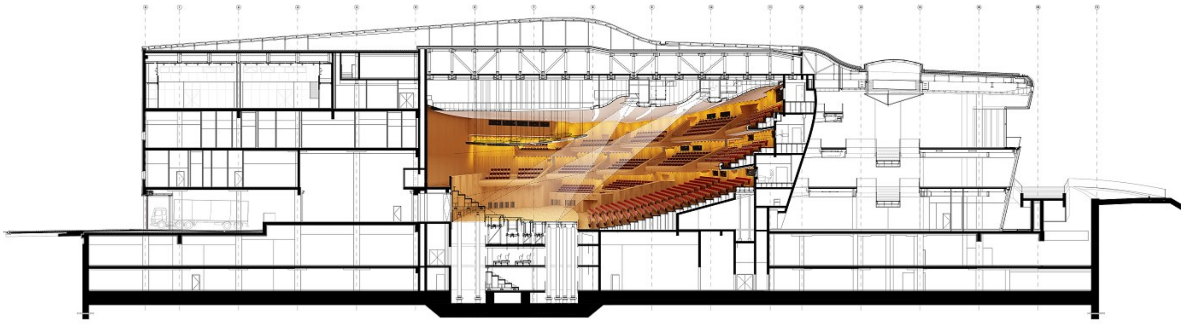

Figure 3: Longitudinal section of Auditorium Hall

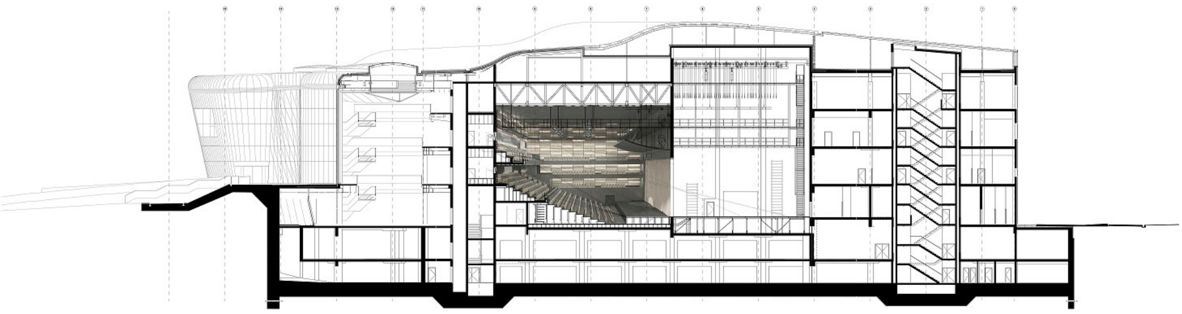

Figure 4: Longitudinal section of Theatre Hall

4 DESIGN IMPLEMENTATION

Following the completion of the acoustic scheme design and key aspects of the detailing, the implementation of the design was transferred to a Polish consultant, Robert Lebioda of Sound and Space. This was necessary as the fees for retaining the original acoustic team were unavailable. Inevitably, some of the finessing of acoustic detail was curtailed, particularly in the design of the second hall.

Fortunately, the appointed contractor, Budimex, faced with achieving a comprehensive list of acoustic parameters, sought out the original acoustician, now at Ramboll Acoustics, and invited him to join the team. This was very advantageous to the project as it enabled the construction process to be informed of the original design intent and advised on how to achieve it.

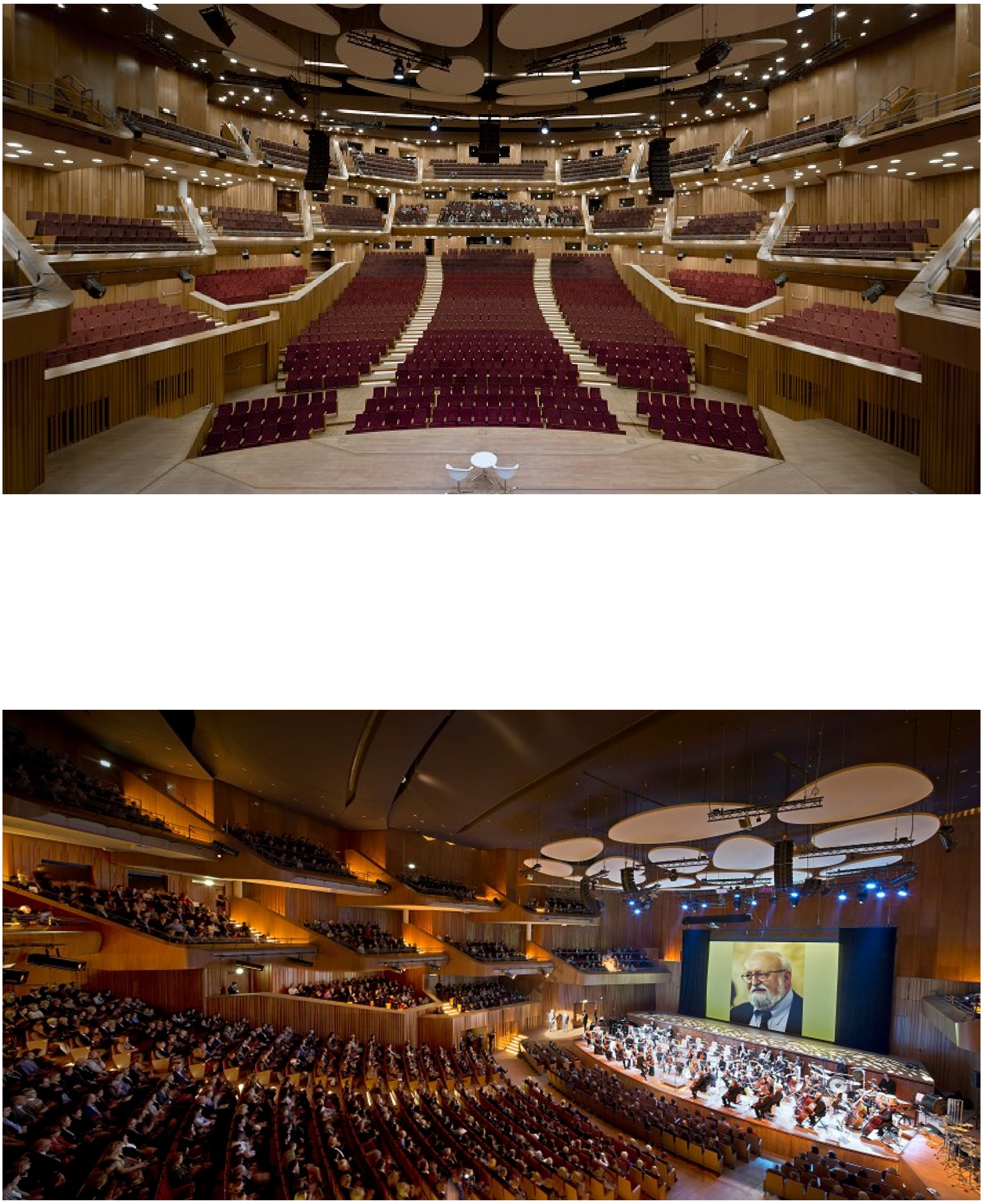

Figure 5: Views of the Auditorium Hall

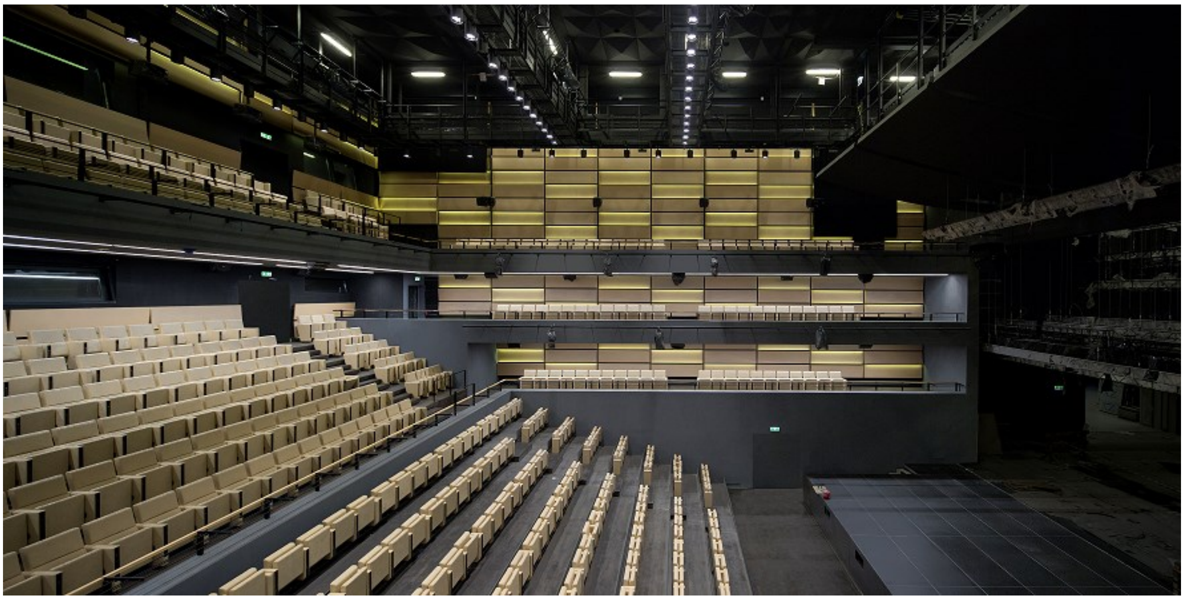

Figure 6: Views of the Theatre Hall

5 COMPLETION

On completion, an extensive series of acoustic measurements was taken in both halls. In the main hall these were carried out with and without an audience and orchestra present.

The key results are presented below:

	Main Hall	Second Hall
Parameter	Measured value	Measured value
Reverberation Time: $\mathbf{T_{30,mf}}$ unoccupied	2.15 s	1.4 s
Reverberation Time: $\mathbf{T_{30,mf}}$ occupied	2.0 s	-
Change in Reverberation Time with banners, (main hall, occupied – second hall, unoccupied)	0.5 s	0.32 s
Early Decay Time relative to Reverberation Time, unoccupied	100%	87%
Clarity Index: $\mathbf{C_{80}}$	-0.3 dB	+2.0 dB
Loudness: $\mathbf{G_{mf}}$	2.3 dB	4.0 dB
Speech Intelligibility Index using sound reinforcement system	0.64	0.64
Background noise level	NR19	NR20

6 CONCLUSION

The City of Krakow has built itself a very fine centre for performing arts and congresses at a very reasonable cost. Although limitations on the costs resulted in some restrictions of acoustic design services, the vision of the architect and the contractor in ensuring the acoustic design intent was fully implemented during construction has led to a successful outcome.

7 ACKNOWLEDGEMENTS

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