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SHOEBOX CONCERT HALLS FOR THE 21st CENTURY

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ABSTRACT

The success of the shoebox geometry as a concert hall form, which started in the 19th century, has continued more or less throughout the 20th century. In these early years of the 21st century the influence of the shoebox remains undiminished for the design of halls below 2000 seats although there have been some adjustments to accommodate amplified music, theatre lighting and variable staging.

Three examples will be presented of 21st century shoebox halls.

The first is the Alsion Concert hall in Sonderborg in Denmark, completed in 2007, which has 1000 seats and is the new home of the South Denmark Symphony orchestra. A unique feature of this hall is that the acoustics can be varied in an invisible way so that the audience always sees the same elegant architectural interior, whatever the performance.

The second auditorium is the Melbourne Recital Hall which also has 1000 seats and is currently under construction. A notable aspect of his hall is that is has no orchestral reflector; the all important reflections for the orchestra are provided by articulated surfaces around the stage.

The third auditorium is the Kristiansand Performing Arts Centre in Norway which is currently at the design stage.

1. INTRODUCTION

Three shoebox concert halls have been designed, or are being designed, by Arup Acoustics at the beginning of the 21st century namely, the Alsion Concert Hall in Sonderborg in Denmark, the Melbourne Recital Hall in Australia and the Kristiansand Performing Arts Centre in Norway.

The Alsion hall was completed in early 2007 and is now fully operational. Melbourne Recital hall is under construction and will be completed in 2008. The Kristiansand hall is currently at the design stage.

This paper will draw comparisons between the acoustic designs of the two completed shoebox schemes for the Alsion and Melbourne halls and will refer to the proposed design of the Kristiansand hall where possible.

2. THE ACOUSTIC BRIEF

The key requirement of the brief for all three halls was to provide a seating capacity of around 1000 to 1200 together with an acoustic quality that was to be uncompromised for the performance of classical music. The stage requirements for the halls were slightly different in that Alsion and Kristiansand had to provide for a full orchestra and chorus whereas Melbourne had only to provide for a chamber orchestra.

However, the halls would have to accommodate other uses such as concert format opera, ballet and jazz. Also a wide range of amplified events would be staged ranging from world music to conferences. The acoustics would be adjustable to suit these other uses.

3. THE SITES

The site of the Alsion University complex is on the Sonderborg harbour-front with scenic views over the Als Fjord. The site is long and narrow and this naturally led to a linear arrangement of buildings, ten in all, serving different functions of the scheme. The concert hall was inserted approximately at the centre of the linear array.

By contrast, the Melbourne site is approximately square and landlocked. However, what both sites have in common is a rail track within 30m of the halls, it carries a train in the case of Alsion and a tram in Melbourne. The site of the Kristiansand hall overlooks water in a similar way to Alsion.

4. AUDITORIUM GEOMETRY AND VOLUME

All the new buildings in the Alsion project have been designed with a rectangular plan form and so there was a good precedent for the plan form of the concert hall to also be rectangular. In the case of the Melbourne hall, the rectangular shape was favoured by the client because of its traditional acoustical success.

The width of the halls was chosen to be close to 20m in order to provide strong lateral sound to the audience. The length was set at around 40m which permits an audience of around 1000 to be accomodate on two levels, the stalls and the balcony.

The rake of the stalls at Alsion is angled steeply to give good sightlines and soundlines as well as to accommodate a change in level across the site. The stalls plane has two steps with accompanying horizontal balustrades which provide reflections back to the stage. The stalls at Melbourne are raked more gently and form one continuous plane.

The balcony at the rear of the halls wraps around the sidewalls of the hall providing additional seating as well as soffits for cue-ball reflections.

The volume per seat at Alsion was selected to be $10m^3$ in order to provide a reverberation time in the range 1.8 to 2.0 seconds. For Melbourne, the volume per seat is slightly lower at $9m^3$ as the required reverberation time range is a little shorter, 1.6 to 1.8 seconds. In both cases the ceiling height of the auditorium is around 16m.

5. SOUND INSULATION

The sites are not excessively noisy although careful account had to be taken of the railway and tram lines. In the case of Alsion, a passenger train arrives and departs from an adjacent terminus and is therefore moving very slowly. Groundborne noise was not considered to be problematic and no special isolation measures were implemented – this proved to be the correct decision.

At Melbourne, the tram is moving at speed past the auditorium and the risk of noise disturbance was thought to be significant. Auralisation of the transmission of train noise into the auditorium confirmed that the noise is audible and the auditorium was consequently isolated on resilient bearings.

Other sound insulation measures for the halls are relatively conventional and consist of a double concrete construction including a double concrete construction for the roofs. All entrance doors into the auditoria are lobbied and there are no windows. To prevent noise ingress from activities in adjacent spaces, the halls are surrounded, where possible, by buffer zones such as corridors and stores.

6. NOISE CONTROL FROM BUILDING SERVICES

Mechanical ventilation in the halls is provided by a displacement system with air brought in at low level under the seats and extracted at high level via the ceiling. This system was selected as it operates at very low air velocities and is therefore inherently quiet; it has been designed to meet an overall building services noise criterion of PNC 20 at Alsion and PNC15 in Melbourne. Other building services and technical equipment such as stage lighting are being carefully controlled and specified to meet this criterion.

7. SURFACE FINISHES

The surface finishes in the halls are predominantly hard and reflective to maintain reverberance at all frequencies.

At Alsion the walls of the inner envelope are clad at low level with solid timber panels fixed directly to the concrete. At higher levels and on the ceiling, the surface is bare concrete. The same general design approach has been taken at Kristiansand. However, what is unique at Alsion is that the upper walls are decorated with a screen of vertical timber battens which is also extended horizontally across the ceiling. The screen of timber battens forms a 300mm wide zone behind it which serves two acoustic functions. First, it contains an array of diffusing elements and secondly, it accommodates acoustic banners when they are required for varying the acoustic characteristics of the hall. The spacing between the individual timber battens in the screen is not regular and was carefully determined to avoid any absorption or sound coloration effects. Tests on sample panels of battens were carried out in a reverberation chamber to check and adjust absorption.

Further tests were carried out in an anechoic chamber to examine any sound coloration effects. The spacings finally selected were a balance between acoustic neutrality and visual screening.

By contrast, the surface finishes at Melbourne consist entirely of timber panelling which is faceted and modelled to provide reflective ledges and diffusion. The timber panelling is made up of several layers to permit surface decoration and also to provide sufficient mass to control low frequency absorption. Tests on the absorption of a sample panel were carried out in a reverberation chamber to check that excessive absorption was not occurring.

8. DIFFUSION

The strategy for diffusion was to provide limited high frequency diffusion on the walls at low level to maintain the strength of early and early lateral reflections. Higher up the walls the diffusion becomes more pronounced and yet more pronounced on the ceiling.

At Alsion, the diffusion on the lower side walls is provided by simply stepping the timber wall panels in and out in a random chequerboard arrangement. The degree of stepping is increased around the stage enclosure to provide a little more diffusion in this area. On the upper walls and ceiling, diffusion is provided by shallow pyramids of various sizes. The timber battens provide diffusion at high frequencies. At Kristiansand, the design is similar but without the timber battens.

At Melbourne, the entire walls and ceiling are covered in timber panels which are stepped in and out and also modulated to provide diffusion. In addition, the surface layer of the panels is grooved or cut away to form a random pattern and this also provides some diffusion at high frequencies. Around the stage area, the panels are smaller but also stepped, modulated and patterned to provide diffuse reflections back to the orchestra and some to the audience.

9. ORCHESTRAL REFLECTIONS

To provide the musicians on stage with sufficient early sound so that they can hear each other well and also hear themselves, an appropriate sequence of early reflections is required.

At Alsion and Kristiansand this is done by suspending an orchestral reflector at a height of around 10m above the stage. The reflector comprises individual rectangular reflector elements arranged in a rectangular array. At Alsion, each reflector element is made from solid timber and has dimensions 1m x 2.3m (at Kristiansand, the proposed elements are of similar size but squarer). The shape is slightly convex in long section when viewed from the stage to provide an even coverage of reflected sound. Gaps between reflectors provide space for movable lighting trusses and loudspeakers but are kept down to a minimum of 600mm, again to ensure uniform coverage. The whole reflector curves upwards slightly towards the front of the stage to reflect some sound into the stalls.

At Melbourne, the use of an orchestral reflector was vetoed by the client and early reflections for the orchestra had to be provided by articulating and shaping the surfaces around the stage. The strategy was to lower the ceiling above the stage in a series of steps which created ledges around the stage enclosure to provide early reflections. The target for providing sufficient early sound was a value for the support parameter ST1 of between -10 and -13dB. Computer modelling was carried out to ensure that the geometric design met the ST1 target.

10. ABSORPTION OF SEATING

For Alsion, the architect decided to design a new seat for the concert hall and therefore it was important to provide him with specific acoustic guidelines for the design. In essence, the seat follows a minimalist design with a hard timber back and a hard surface to the underside of the seat. Upholstery is restricted to those areas covered by a seated person and the thickness of the upholstery is around 50mm. Laboratory testing of prototype seats, which was considered essential, showed a typical seat absorption characteristic with mid-frequency absorption coefficients of 0.6 and 0.7 for unoccupied and occupied seats respectively. The measured performance met the required acoustic specification and this helps to ensure a minimal change in reverberation time between occupied and unoccupied conditions as well as maintaining the overall length of the reverberation time.

For Melbourne, the same specification and testing procedure is taking place although the seats are not being architect designed.

11. VARIABLE ABSORPTION

The fundamental requirement of all three concert hall briefs was to provide an acoustic suitable for classical orchestral, ensemble and choral music. No variable absorption elements are exposed when the halls are in this primary condition. However, to accommodate other uses of the halls such as amplified events, variable absorption systems can be brought into use.

At Alsion, the system consists of acoustic banners which can be lowered from the perimeter of the ceiling into the slot between the decorative timber wall battens and the concrete wall beyond. The banners can be deployed on the side walls and the stage wall and can cover the majority of these walls between the ceiling and the balcony. it is possible to lower the banners to intermediate positions so that a wide range of acoustic variability is possible.

An advantage of this scheme for variable absorption is that the appearance of the hall does not change substantially with the deployment of banners.

For Melbourne, the architect took a different approach where the banners are visible when they are deployed.

12. ACOUSTIC MODELLING

Acoustic modelling of all the designs was carried out predominantly using a computer model (Odeon). This proved valuable for checking and optimising geometrical features such as side balconies and also for monitoring the values of key acoustic parameters. Additional confidence in the predicted characteristics was gained by testing physical scale models.

13. TESTING AND COMMISSIONING

Testing and commissioning has only been completed for the Alsion hall although the process will start at Melbourne next year.

At Alsion, a comprehensive series of objective measurements and subjective tests were carried out at the beginning of 2007. Objective measurements involved measuring six key acoustic parameters which were compared with the original design criteria – all values met their targets – a good result. Subjective assessments were carried out during public performances of a symphony concert and an operatta. The results indicated excellent acoustics. The orchestral sound has high clarity which is balanced by long reverberance and ample loudness. The tonal quality was judged to be 'beautiful' and listeners were highly 'enveloped' in sound.

14. CONCLUSIONS

The design of a 1000 seat shoebox concert hall at Alsion has resulted in excellent acoustics for symphonic and other classical music as well as providing a high quality venue for amplified events such as rock and world music. The halls in Melbourne, Australia and Kristiansand, Norway which are also shoebox designs are promising to be equally successful. Therefore, for seating capacities below 2000, the potential for the continuing success of shoebox halls in the 21st century is strong.