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The acoustic design of the Elisabeth Murdoch Hall, Melbourne, Australia

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The Elisabeth Murdoch hall is a 1000 seat recital space which will be completed in the latter half of 2008. The overall geometry is based on a classical shoe-box shape to provide acoustic excellence although the internal appearance is wholly contemporary. The walls and ceiling of the hall are clad in timber paneling which is stepped in and out and also modulated to provide diffusion at mid and low frequencies. In addition, the surface layer of the panels is grooved or cut away to form an abstract pattern which is both decorative and diffusing at high frequencies.

A notable aspect of the hall is that it has no orchestral reflector. The important early reflections for good orchestral ensemble are provided by articulating and shaping the surfaces around the stage.

Although the hall is primarily for recitals of classical music, provision is made for amplified music by introducing variable absorption.

1 Introduction

This paper describes the acoustic design of the recital hall at the Melbourne Recital Centre in Melbourne, Australia. Arup is responsible for providing acoustics, theatre planning and theatre technical systems advice.

The firm responsible for the architectural design is Ashton, Raggatt McDougall (ARM) which is based in Melbourne.

The recital hall is part of a new arts building which also includes a 500 seat theatre for the Melbourne Theatre Company.

The new building is located in the arts precinct of Melbourne, on the south bank of the Yarra River, and the new hall will provide a much needed recital space that will complement the main concert hall at the Victorian Arts Centre.

The hall has been named after Murdoch family matriarch Dame Elisabeth Murdoch AC DBE, in recognition of her tremendous support for the arts in Victoria. Dame Elisabeth will celebrate her 100th birthday at the official opening of the hall in 2009.

The Melbourne Recital Centre will also include recording and broadcasting facilities, dressing and practice rooms, and a contemporary, flexible performance space which can seat up to 150 people.

2 The acoustic brief

The key requirement of the brief is to provide a recital hall with a seating capacity of 1000 and a stage that will accommodate a chamber orchestra of up to 45 musicians. An orchestra pit and stage extension are also to be provided.

The acoustic quality of the recital hall is to be uncompromised for the performance of recitals, chamber and choral music.

The recital hall will be able to accommodate other uses such as chamber opera, early music, jazz and contemporary music. Small cross genre performances such as dance and music are also envisaged.

3 The site

The site for the overall building, which houses both the recital hall and theatre, has a square footprint. It is surrounded on three sides by roads, two of which are main roads, and the other a side street. A key feature is that a tramline runs along two sides of the site and turns the corner where the recital hall is positioned. At its closest, the tramline is a distance of 16m from the recital hall envelope, and this has had a major impact on the structural design.

4 Auditorium geometry and volume

The brief states that the preferred shape for the recital hall is the classic shoe-box shape although slight variations are permissible as long as they do not compromise the acoustic.

Arup concurred that the shoe-box shape was appropriate for this hall and adopted it as a fundamental basis for the design. The long section and plan of the recital hall are shown in Figures 1 and 2.

The width of the hall was chosen to be 20m in order to provide strong lateral sound to the audience. The length was set at 37m which permits an audience of 1000 to be accommodated on two levels: the stalls and the balcony. The balcony at the rear wraps around the sidewalls of the hall providing additional seating. The soffits of these side balconies, in combination with the sidewalls, provide early reflections to the stalls. The rake of the stalls is gently angled to give good sightlines and soundlines. The whole geometry of the space aims at providing a highly intimate experience both aurally and visually.

The volume per seat target was selected to be 9m³ in order to provide a reverberation time in the range 1.6 to 1.8 seconds. This set the ceiling height of the auditorium at approximately 17m above the lowest stalls level.

5 Sound insulation

The site is in an urban area and noise on the site is characterised by road traffic and trams along the total length of two sides of the site boundary. This led to the structural design of the recital hall as a box-in-box arrangement with the inner 250mm thick concrete box floated on a series of 38 spring assemblies. This followed

extensive vibration measurements and analysis of the predicted structureborne noise in the auditorium.

The spring assemblies comprise a total of 496 steels springs. Each spring was tested individually prior to installation, and this allowed for very accurate monitoring of construction progression.

6 Noise control from building services

Mechanical ventilation in the recital hall 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 therefore is inherently quiet; it has been designed to meet an overall building services noise criterion of PNC15. This building services noise level also plays an important role in conjunction with the structural isolation system in that, although very low, it still provides masking of potential tram noise intrusion, ie if it is too quiet then there is a risk that an occasional tram pass-by will be heard.

The terminal units within the auditorium are integrated with architectural finishes, such as timber fins on stage to visually disguise the grilles, or furniture, such as the seating pedestals. Therefore, all terminal units have been acoustically tested in their final configuration to ensure that overall compliance with the noise criterion will be achieved.

Other building services and technical equipment such as the chandeliers and stage lighting have been carefully specified, measured and controlled to meet this criterion, as well as audibility criteria.

7 Surface finishes

The surface finishes in the recital hall are predominantly hard and reflective to maintain reverberance at all frequencies. All the walls and the ceiling are clad in timber paneling which is faceted and modeled to provide reflective ledges and diffusion. A particular challenge was that no two panels in the recital hall are the same. The timber paneling is made up of several layers of Australian hoop pine plywood, up to 75mm thick, to provide sufficient mass to control low frequency absorption.

Prototype panels were constructed in order to trial constructability and installation methods, and to test the acoustic absorption coefficients in a reverberation chamber to check that excessive absorption was not occurring. Fabrication of the timber panels was assisted by computer generated modeling and computer numerically controlled machinery, and meticulous attention to detail has ensured precise installation.

The main auditorium floor is 32mm thick timber built over a shallow structure which forms the underseat air supply plenum. The stage floor is 42mm thick timber fixed to the concrete structure. The flooring is a composite timber structure comprising a plywood substrate with a finish of 15mm thick carbonized bamboo (a readily renewable resource).

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 a little more pronounced and is yet more prominent on the ceiling.

The timber panels forming the walls and ceiling are stepped in and out to provide medium scale diffusion. Whole sections of walls and ceiling are modulated to provide large scale 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.

The use of an orchestral reflector was not favoured by the Client and so early reflections for the orchestra are 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 'cue-ball' reflections. The target for providing sufficient early sound was a value for the support parameter ST1 of between -10 and -13dB. Computer modeling was used to develop the geometric design and confirm that it met the ST1 target.

10 Absorption of seating

Stringent criteria for the sound absorption of seating were specified which are based on computer and scale model predictions of the reverberation time and room acoustics.

The final seating design was developed from a prototype with input from the architect, acoustician, client, builder and seating manufacturer Quinette Gallay. Swatches of various fabric options were tested by Arup Acoustics using an impedance tube.

Compliance with the sound absorption criteria of the final seat design was demonstrated by the manufacturer by careful testing of an array of 12 seats in a reverberation chamber at *Centre Scientifique et Technique du Batiment (CSTB) laboratory, Champs-sur-Marne*, with the seats both occupied and unoccupied.

11 Variable absorption

The fundamental requirement of the brief for the recital hall was to provide an acoustic suitable for classical chamber music concerts, choral music and the like. No variable acoustic absorption elements are exposed when

the hall is in this primary condition. However, to accommodate other uses of the recital hall such as amplified events, a variable absorption system can be brought into use. This comprises individual banners which are deployed along the sidewalls and rear wall.

The banner is a double layer air-cell design that folds into itself as the banner is retracted. The banners include a timber plug at the base which seals against the ceiling when the banners are retracted out of the auditorium.

12 Acoustic modeling

Acoustic modeling of the design was carried out predominantly using a computer model (Odeon). This was used to explore and develop the geometry by evaluating room acoustic parameters and checking how they varied throughout the seating area. Evaluation of the acoustic characteristics on stage was equally important.

A scale model was also constructed at 1:25 scale which provided added confidence in the design, especially as it was able to model the intricate diffusion with considerable accuracy.

13 SoundLab

Output from the Odeon model also enabled auralisations to be carried out in the Arup SoundLab for the benefit of the Client, users and designers.

These included presentations of string quartets, chamber orchestras and solo instruments. Considerable confidence was gained by the design team and Client that the fundamental design was appropriate and developing well.

14 Construction

The building has been constructed by Bovis Lend Lease. Site works commenced in August 2006 and practical completion has just been achieved.

Much time and effort was spent at strategic phases of construction to educate the builder about the acoustically critical aspects of the design and how these must be integrated into the construction. "Acoustic inductions" were run by Arup to trades people and contractors, and as a result the builder embraced the concept of crafting a finely tuned instrument rather than assembling a standard building.

15 Testing and commissioning

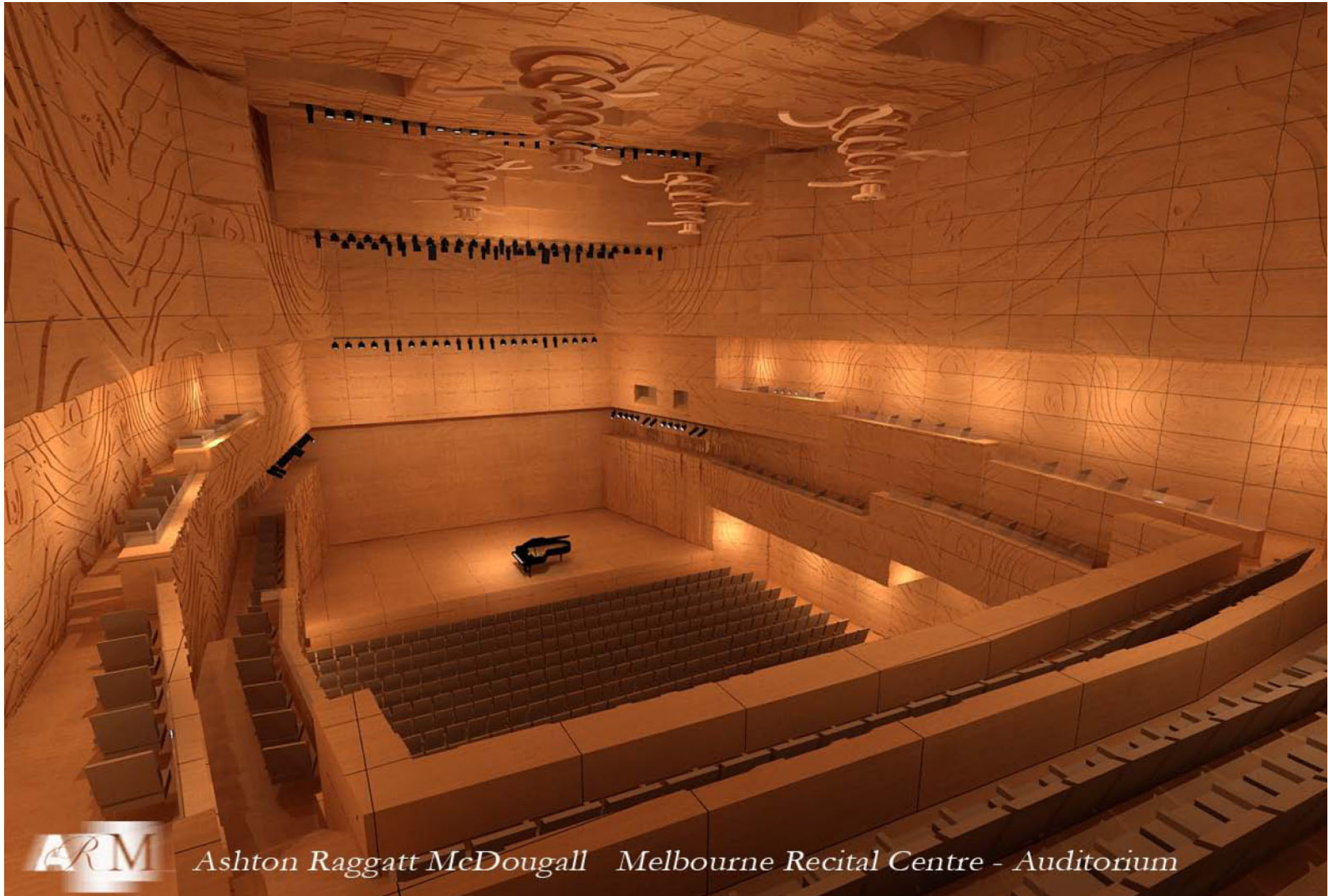
Testing and commissioning have just started in the recital hall. The programme will comprise a comprehensive series of objective measurements and subjective tests. Objective measurements will involve measuring the six key acoustic parameters and background noise levels. Subjective assessments will be carried out during rehearsals and public performances of various musical ensembles.

Peter Sculthorpe will compose the first piece of music to be played in the recital hall in a new work commissioned for the opening in 2009.

16 Conclusions

A recital hall has been designed and built which retains the classical geometry of a shoe-box but which has an internal appearance composed of an entirely contemporary and unique design which is fundamentally driven by the acoustic requirements of reflection and diffusion.

The attention by the design and construction team to acoustic form, detail and installation will provide an acoustic which is intimate and well matched to the performance of recitals and chamber music.



ARM

Ashton Raggatt McDougall Melbourne Recital Centre - Auditorium

Figure 3: Render of auditorium (image courtesy of ARM)