THE ACOUSTIC DESIGN OF THE CONVENTION CENTRE DUBLIN

R Muir Sandy Brown Associates, London, UK

1 INTRODUCTION

The Auditorium Acoustics Conference at the Convention Centre Dublin (CCD) presents an opportunity for Sandy Brown Associates to describe the building, its development, the acoustic design and some of the acoustic challenges encountered in delivering the building. The building officially opened in August 2010 when the completed building was handed to the State. The same day the keys were handed back to the CCD under licence to run the building and carry the risk for 25 years with the capital cost paid back over this time. The Dublin Office of Public Works (OPW) awarded the contract to a consortium consisting of Treasury Holdings the developer, ICC the operator and John Sisk the main contractor who formed a new company CMP to manage the project. The project was a Public Private Partnership arrangement to finance, design, manage and operate the building. The design team consisted of New York based but Dublin born architect Kevin Roche of Kevin Roche John Dinkeloo, Dublin based Structural Engineers O'Connor Sutton Cronin, Dublin based Mechanical and Electrical Engineers McArdle McSweeney Associates with Theatre Projects Consultants and Sandy Brown Associates providing theatre and acoustic consultancy respectively. The Building is a vertically stacked layout around a 2000 seat conference auditorium with two large exhibition and banqueting spaces on the lower levels. The project was challenging due to a relatively short design and build construction period of 40 months.

2 BACKGROUND TO THE SCHEME

The Convention Centre Dublin has had a slow evolution. The developer's team has bid for the project 3 times and won 3 times over the past 13 years. The earlier bids did not proceed because the developer did not secure planning permission for the surrounding developments.

Sandy Brown Associates have been involved in the Convention Centre Dublin since 1999 where a larger scheme was developed around a similar auditorium. This scheme was shelved in late 2000 and there was a 5 year hiatus until the Dublin Office of Public Works (OPW) produced a new brief in the form of an Invitation to Tender (ITT) for the Design, Build, Finance and Operation of the building.

The 1999 scheme was resubmitted in response to the tender on the basis that the tight programme demands could be met by using the already developed design. This was followed by a three month Invitation to Negotiate period where the original design was scaled down to comply with the OPW's revised brief requirements. In practical terms, this meant that the original building had to be lower into the ground to meet specified room heights and the building footprint had to be reduced to a maximum of 24,000 m^2 which in turn drove the price that was acceptable to OPW. This, in essence, meant that OPW would not accept the building that won the previous competition.

3 BRIEF

The brief defined the facility as a conference centre competing for its share of the international conference market. The scope of activities catered for includes international conferences, lectures, concerts, specialist theatre, award and other national and international events. Whilst it was to be used periodically for other events, public meetings, stage shows, major and minor trade and cultural exhibitions etc, the principal end user is the international, national and corporate meeting market. The OPW User Requirements[1] provided the acoustic brief which was defined in the paragraph:

"The 'hub' of the complex will be the Main Conference auditorium, providing as a minimum a total of 2,000 usable seats for plenary sessions. This auditorium shall be designed primarily for amplified sound performance rather than to a natural acoustic standard required by, for example, an orchestral concert. "

The brief also defined the principal components as follows:-

- a main Conference Auditorium with a minimum capacity of 2,000 delegates in plenary session.
- Multiple break-out meeting rooms.
- Public Foyer and circulation spaces.
- Banqueting Hall and supporting kitchens to cater for a minimum of 2,000 persons.
- Exhibition Hall of a minimum of 2,000m² with the ability to provide an additional adjacent 3,000m² of exhibition space through flexible use of the Banqueting Hall.

The brief also provided comprehensive minimum performance requirements for all rooms and defined reverberation times, background noise levels and sound insulation performances of separating structures for all areas of the building. For the auditorium, the brief defined a "maximum" reverberation time as in the range 1.0 - 1.2s (250 Hz – 2000 Hz) and a background noise level of NR20 with separating structures having a minimum sound insulation of R_w 60 dB.

As is the nature of design and build projects, many of the key strategic decisions were made at bid stage some of which were to have significant impacts on the acoustic design. The reduction in footprint was achieved by a reduction in internal plant room areas. This meant that the majority of the air handling plant was relocated from internal spaces to external locations on the roof either at auditorium level adjacent to the flytower or directly above the auditorium which presented more of a risk in terms of noise break in and also environmental noise to neighbours. The building height restrictions meant that vertically interstitial zones became very restricted and the relocation of the air handling plant meant that service routes had not been clearly established.

4 AUDITORIUM DESIGN

Conference usage was the design priority of the auditorium. Corporate conferences can often be theatrical so that a theatrical stage complete with side stages and flying facilities was required. There is a forestage elevator with 135 removable seats to give a stage extension, or extra audience area, or an orchestra pit.
Above the stage there is a full fly tower with a counterweight flying system. Beyond side stage right, protected by an acoustic door, there is a truck lift large enough to take the trailer of an articulated lorry. The maximum distance in the auditorium is 40 m from the front of the stage to the rear of the balcony and this is at the limit of visual distance; beyond the limit for natural speech. The sightline requirements for 2,000 seats dictated an auditorium with two tiers with every seat having access to the stage. Therefore, tiers had to be accessed from within the auditorium.
The auditorium was not designed to provide a natural acoustic but is suitable for amplified sound. The walls are profiled and modulated to provide diffusion. Broad band sound absorption is provided by perforated timber wall panels with sound absorbent backings on the side and rear walls and also at rear of the ceiling. Additional sound absorbent panels were considered for the flytower but not adopted after discussion with the operator because there would always be wool serge curtains hanging in the flytower. The auditorium was modelled in ODEON and this modelling formed part of the submissions to the OPW and confirmed that the reverberation time requirements were likely to be achieved.

The measured unoccupied reverberation times were as follows:

Octave Band Centre Frequency	250	500	1k	2k	Hz
Reverberation Time	1.0	0.95	1.0	1.1	Seconds

The specified brief reverberation time criteria were therefore met.

The sound reinforcement system consists of left, right and centre stage vertical arrays. The left and right arrays consist of 2 loudspeakers at high level and 1 at low level. The centre cluster consists of two loudspeakers at high level above the stage. This is supplemented by infill speakers deployed to cover the rear stalls, and balcony. The system has been configured to allow control from two points; the main control room and the sound cockpit console situated in the stalls.

Seven permanent Simultaneous Interpretation (SI) booths designed to ISO 2603, have been provided at the rear of the auditorium at stalls level. The operator stated that the booth areas should be kept but not fitted out and were of the view that SI Booths were likely to be rarely used. However the 7 SI Booths was a specific requirement of the OPW brief.

5 SOUND INSULATION

Early in the project there were protracted discussions about fully floating each of the major spaces to provide full acoustic isolation for all types of events operating simultaneously. There was also a potential risk of environmental vibration from the proposed extension to the LUAS (Dublin Light Rail System) tram line and from heavy vehicles traversing the canal bridge. However, vibration assessment of the potential impact of trams and the measured ground borne vibration levels on the site indicated that structural isolation was not essential to control vibration and reradiated noise levels were likely to be much lower than the mechanical services noise limits. Nevertheless, to maximise the sound insulation, a scheme was worked up with the structural engineers to structurally isolate every room in the building. This was defined as a cost option and at the time the cost was identified as 1.7 million Euros.
In response to the revised performance requirements of the brief the structural isolation did not form part of the cost plan and guaranteed maximum price. Nevertheless, a high degree of sound insulation was still required between the Liffey Suite then known as Hall B and the main Auditorium, and also between the auditorium and the external plant areas.

A double concrete slab with a 1500 mm void was provided at roof level to form an acoustic buffer zone between the rooftop mechanical plant and the auditorium. This void also served as a duct route for services to the meeting rooms and foyer. A major concern was the proximity of the smoke vents to the external chillers. An attenuated fan enclosure and duct smoke louvre was detailed to control noise via this path.

To control external noise, mainly from relocated mechanical equipment, a high sound insulation for the auditorium external walls was necessary. The auditorium wall was an 870mm thick lightweight wall consisting of an inner wall of 3 layers of dense plasterboard and an outer wall of external weather cladding lined with Blueclad (Calcium Silicate) board. The actual construction was laboratory tested and provided R_w ($C:C_{tr}$) 76 (-2,-8) dB. The wall construction was also tested on site and the performance was greater than D_w 64dB (the full potential could not be practicably be measured on site).

The flytower construction was similar to the auditorium wall construction, but to provide a robust finish in the flytower 140mm thick precast concrete panels were used internally instead of the three layers of plasterboard. At the roof of the flytower and side stages, the detail was inverted: a plasterboard sound insulating ceiling beneath a concrete slab installed internally above the flytower grid.

The need for low duct velocities to meet the low noise requirements which led to the inevitable conflict of squeezing large ducts into small zones which led to some complex and substantial duct penetrations through the external wall.

The key adjacency for the auditorium in terms of sound insulation was The Liffey Room (known as Hall B) and this is shown in Figure 1.

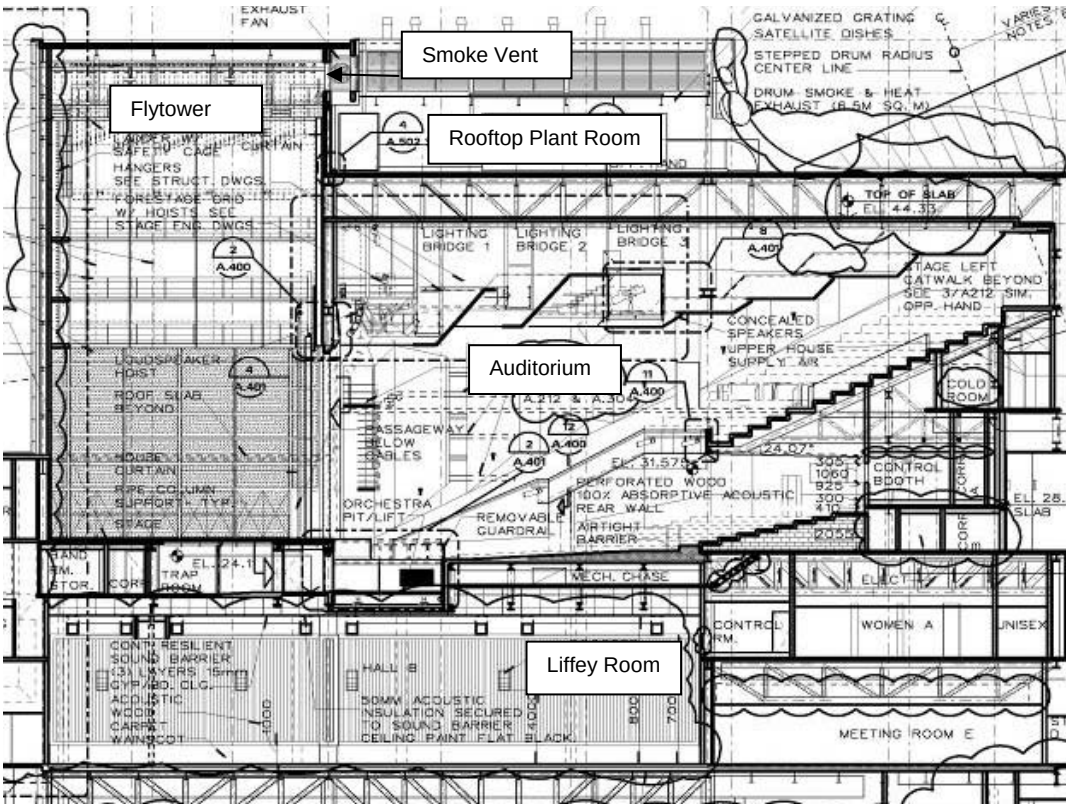

Figure 1 Auditorium to Liffey Room Section [2]

The separation between the Auditorium and The Liffey Room includes a double structure with a sound insulating ceiling resiliently suspended beneath the Auditorium. At the bid stage the mechanical servicing routes were not defined other than that the auditorium would be a displacement system and the air needed to be supplied beneath the seats. The orchestra pit had a

dedicated air system supply grilles at the side of the pit whereas the main auditorium has an air supply plenum beneath the seating rake.

The integration of this resilient suspended sound insulating ceiling with the mechanical services ducts, rigging points and structural trusses - proved to be a major challenge. Within this zone was ductwork that serves the main auditorium installed above ductwork that serves the Liffey Room. A secondary grid was created beneath the acoustic ceiling which allowed suspension of the services serving the Liffey Room.
The Liffey Room (Hall B) can be subdivided by two *Skyfold* partitions: vertical moveable walls that are also stowed in the ceiling zone. These partitions performed reasonably well with on site performance of D_w 45 dB.
Between the auditorium and the Liffey Room the measured weighted level difference was D_w ($C:C_{tr}$) 69dB (-1,-5) with a similar performance in both directions.

6 MECHANICAL SERVICES

The mechanical services presented a number of acoustic challenges. The air handling units for the main auditorium were located immediately outside the auditorium with typical duct sizes of 2000 mm x 2000 mm to maintain low airflow velocities. This presented a considerable risk of noise break-in to the ductwork and no room for secondary attenuation in some instances. The potential risk of noise transfer was compounded by a proposal by the contractor to use ALP ductwork (pre insulated foam board duct) in lieu of conventional galvanised ductwork. This was not adopted because of the risk of low frequency noise break in to the ducts.
There was also a request to reduce duct sizes when the coordination of services began in earnest. A particular concern was the auditorium supply routed through the sound insulation zone - the mechanical engineers original scheme had this ductwork exposed to the Liffey Room (Hall B). The duct was located in a plasterboard bulkhead above the sound insulating ceiling and this was a major concern of noise break-in because there was no room for secondary attenuation prior to the duct entering the floor plenum.

7 CONSTRUCTION AND COMPLETION

As is common with a design and build project, much of the detailed design took place during the construction period with little scope for revision. Most of the architectural design and principles had been established early on although there was a lag in the mechanical design over the course of the construction period.
The acoustic design required regular review sessions with the OPW's acoustic consultant Niels Jordan of Jordan Akustik, who provided valuable suggestions as the design progressed. A programme of progressive acoustic testing was adopted – although, in practice, this proved to be difficult because the contractor was eager to test and sign off elements before works were complete. The benefit was, however, that the contractor gained a clearer understanding of the importance of acoustic detailing and was able to rectify potential problems prior to the final testing.
There were quite a number of snagging issues in relation to mechanical services noise levels in the auditorium. The dimmer room located above the lighting gallery had cable openings into the auditorium and a poorly sealed access hatch. Consequently the dimmers were clearly audible. There was significant airflow noise from the orchestra pit supply system which had been installed without a secondary attenuator and with a balancing damper directly behind the grille. This was addressed by relocating the damper and installation of an attenuator. Following rectification of these issues the residual noise on the stage was still NR28 with a strong tonal component. Every piece of plant was turned off and the noise was traced to the transformers located behind the stage which had been installed without any anti- vibration mounts. This required a total building shutdown to install the mounts. With anti vibration mounts successfully installed under the transformers and the residual noise level was NR22 with the contribution of the dimmers. With the final sealing of the dimmer room hatch completed the auditorium noise level met the required NR20.

The design team and contractors worked well together to resolve these issues during the three month soft handover period and to ensure compliance with project brief. The final acoustic sign off was achieved on the 1st September 2010 one week prior to the official opening. The CCD opened for business in September 2010 and the future pipeline of business is understood to be the strongest of any convention centre with bookings into 2017.

8 REFERENCES

1. Office of Public Works National Conference Centre Construction Requirements Dec 2004
2. Kevin Roche John Dinkeloo CCD Drawing A102 Architectural Section 2010