THE ACOUSTIC DESIGN OF THE O2, DUBLIN

D Prasad Marshall Day Acoustics, London, United Kingdom

1 INTRODUCTION

The O_2, formally called The Point (Theatre), went under major redevelopment in 2007. The original building was constructed in 1878 as a train depot to serve the nearby port. In 1988 it was converted into a venue predominately for music concerts, but had also been used as an ice rink, a boxing arena, a conference hall, an exhibition centre, a wrestling ring, a theatre, an opera house and a three-ring circus. It has also hosted the Eurovision Song Contest on three separate occasions in the 1990s and the 1999 MTV European Music Awards.

Although being successful as a venue, the stage area was too small to handle large-scale production. It also suffered from poor sightlines and inadequate bar and toilet facilities. The building maintained the original appearance of a train station and as such did not reflect Dublin's changing expectations for a high quality music venue. A decision was made redevelop the venue and increase its capacity from 8,500 to 14,500 people. Furthermore much of the original historic structure was to be maintained posing an additional challenge to the design.

The venue reopened in December 2008 to great reviews. It now includes 14 new bar areas, dedicated VIP sections, a high security area to serve alcohol (to avoid under age drinking) and two substantial loading bays to allow for rapid access for production. The furthest seat is now 20 metres closer than the original venue.

This paper discusses the acoustic aspects to the design. Capita Symonds was the appointed acoustic consultant with this author being the lead designer. Permission to publish this paper has been kindly provided by the Client.

2 DESIGN BRIEF

The design brief was simple – to provide a world-class venue capable of handling worldwide production. In most cases the production would be amplified however the space would need to be flexible to host a wide range of performances. This flexibility would be important, as there is no dedicated house sound system. Productions arrive with touring rigs that are quite often installed on the day of the performance; giving little time to ensure even sound coverage throughout.

The venue has a maximum capacity of 14,500 people or 9,500 fully seated. There was also the requirement to have smaller, more intimate, plays or opera in a 2,000 – 3,000 seat configuration. Whilst this capability exists, its requirement has been superseded by the newly built Grand Canal Theatre, which is operated by the same client.

There was also tight planning restrictions with respect to noise emissions. At the time of the design there was planned to be a residential tower some 20 metres to the north of the venue. As such it was critical that venue achieved this planning requirement otherwise a license would not have been granted to operate.

3 ACOUSTIC DESIGN

3.1 Room Acoustics

A fan type seating plan was selected to provide an 'amphitheatre' arrangement. This was of significant benefit as there are virtually no primary reflections from wall surfaces to the audience. It is well understood that acoustics do not scale with the size of the auditorium. Here we have an auditorium with dimensions in the order of 100 by 65 metres. As such any unwanted reflections can affect clarity therefore great care has been taken to minimise reflections and create a diffuse space.

The auditorium has a volume of 70,000 m^3 therefore it was always appreciated that there would be a higher than ideal reverberation time. As the primary design was for amplified music it was necessary to get this as low as possible.

The primary, and by far the largest area of acoustic absorption, is that of a perforated ceiling liner that encompasses the whole ceiling and the upper portions of the walls. Acoustic panels have been applied to walls above trafficked areas. Owing to cost constraints no specific acoustic treatment was applied to the seats.

Our experience of variable absorption concert halls is that, when deployed, the absorption is very good at absorbing the mid and high frequencies but not the low frequencies. This makes amplified music sound 'boomy' and creates a very unnatural spectrum shape. In many cases operators of these venues chose not to deploy the variable absorption and to accept a higher, but more natural, reverberation time.

This same principal was adopted here, with there being a great deal of attention to introduce as much low frequency absorption as possible. In some areas blockwork was substituted for drywall constructions. The roof, being lightweight, offered a reasonable amount of low frequency absorption.

The wall panels had to be relatively thin as not to take up to much space in the auditorium but also because of cost concerns. It must be remembered that the surface areas within the auditorium are large and even small changes can have sizeable cost implications.

By far the biggest contribution to the low frequency absorption is the ventilation ductwork. This was used as a novel approach to introduce 'bass traps' within the auditorium. The original specification was for circular steel ductwork. This has the benefit of having a diffuse surface and to minimise specular reflections. A decision was made to substitute this with double skinned aluminium rectangular ductwork which had fibreglass insulation sandwiched between the skins. This not only provided the contractor ease of installation but also reduced the loading on the roof structure. This aluminium/fibreglass sandwich also provided a significant amount of low frequency absorption. The benefit of this was believed to greatly outweigh the specular reflections from the rectangular ductwork.

Diffusion has been proved for by the angled wall geometry and exposed services and steelwork in the ceiling.

The result of this is a flat unoccupied reverberation time of 2.0 seconds from 200 Hz to 4000 Hz. Below 200 Hz there is a gradual base rise and above 4000 Hz the reverberation time starts to drop slightly.

3.2 Sound Insulation

There were a number of challenges to the external sound insulation of the venue. Firstly the proposed residential tower some 20 metres to the north that would overlook the venue. Secondly the relatively lightweight construction and thirdly the complex internal arrangement that allowed for circulation between various spaces.

3.2.1 Neighbouring Residential

The proposed residential tower presented the biggest risk to the sound insulation design of the auditorium. A daytime (0700 to 2300 hours) criterion of 56 dB $L_{Aeq,5\ mins}$ had been negotiated with the Local Authority at the façade of this building. This Tower was adjacent to the nearby port, which operates 24 hours a day. As such the planning conditions for the Tower required mechanical ventilation and an enhanced façade construction. This allowed for a higher external noise limit than would have been otherwise granted.

This Tower also overlooked the roof of the auditorium. With an internal design level of 105 dB, flat across the frequency range, this was going to be demanding on the lightweight roof construction.

3.2.2 Layers

Whilst it would have been desirable to construct the auditorium shell out of concrete this simply was not possible due to the large span of the roof. There were strict weight limits imposed by the supporting structure. As such the roof had to be constructed of multiple layers to provide the sound absorption and both the thermal and sound insulation.

Overall the roof build-up was in excess of 600 mm, this included:

- a perforated metal ceiling liner;
- acoustic absorption (fibreglass);
- a structural liner tray
- two layers of fibre cement board;
- thermal insulation (mineral wool);
- another layer of fibre cement board and;
- the external standing seam roof.

There were several instances were sound insulating partitions abutted this roof construction. Originally it was envisaged that these would penetrate the sound absorbing zone otherwise there would have been an open void above the head of the partition. Trail cuts to the perforated liner tray onsite resulted in a substandard finish so an alterative detail was required. An innovative approach was taken to externally seal the perforated liner tray to create a long thin attenuated air path over the partition head. This also created a flat surface to fix the partition head channel.

The layer theme also continued elsewhere within the building. As you moved down, from roof level, varying elements provided the external sound insulation. At high level the roof cladding wrapped around to form the upper part of the walls. On the upper levels plasterboard partitions and the external polycarbonate cladding maintain the sound insulation. Further down the building the majority of the sound insulation is provided by the auditorium bowl. At the lower levels all of the circulation spaces are coupled. Here the sound insulation is provided by the existing stone façade and lobbied doors.

3.2.3 Loading Bays

The venue has also been designed so that productions can be installed and disassembled during night-time hours. There are two loading bays, one to the north that can take for articulated Heavy Goods Vehicles (HGVs) and one to the west, which can accommodate another two HGVs.

Both are lobbied with large acoustic doors that operate in the same manner as an ‘airlock’. With the inner doors closed works can still go on inside the auditorium allowing the outer doors to be opened to allow vehicles to enter or leave.

3.3 Ventilation

The ventilation design was probably the most challenging aspect of the whole project. Given the site constraints there was very little space within the plantrooms to accommodate all of the necessary attenuation. Supply was by means swirl diffusers mounted at high level. The air volumes are large and with some of the diffusers being mounted 24 metres above the audience, high velocities are required to push the air down. Careful design and selection was required to ensure there was not a regenerated noise problem.

The system is also designed to operate in a reduced capacity mode for a much smaller 2000 – 3000 seat capacity. In this more ‘intimate’ mode the auditorium is divided by use of a retractable acoustic drape and the ventilation flow is reduced and redirected. In this mode the ventilation noise is reduced to NR30 down from the maximum capacity criterion of NR40.