THE ACOUSTIC REQUIREMENTS OF THE IRISH CHAMBER ORCHESTRA

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1 INTRODUCTION

The Irish Chamber Orchestra (ICO) is considered by many to be the premier ensemble in Ireland and one of the finest Chamber Orchestras in the world. This reputation has kept the orchestra in high demand, both nationally and internationally, and has helped the orchestra to attract world class musicians. The experience these musicians have of performing in some of the world's best concert halls has given the members of the ICO a fine appreciation of the importance of a good acoustic environment to the enjoyment of their performances.

Based in the University of Limerick since 1995, when it joined the World Academy of Music and Dance at the invitation of Mícheál Ó Súilleabháin, the ICO has performed in many venues throughout Ireland and the world over the last 30 years. The orchestra first became a client of AWN Consulting in 2005 when developing its bespoke rehearsal space on the University of Limerick campus. Since then AWN has worked closely with the ICO, providing acoustic design advice on a variety of projects, developing in the process a clear understanding of the acoustic requirements of the orchestra.

This paper presents case studies of the two highest profile projects that AWN and the ICO have collaborated on together, demonstrating the key acoustic requirements that the orchestra has and how these requirements have been met through comprehensive acoustic design.

2 THE ACOUSTIC REQUIREMENTS OF THE ICO

2.1 The Musician's Perspective

The members of the ICO ensemble are experienced musicians who understand the importance of a good acoustic environment, both in respect of their own performance and the enjoyment of the audience. They know instantly by ear if the space in which they are playing has an appropriate acoustic environment for their music. Subjectively their acoustic requirements are clear; their music must be heard as it is intended, musicians must have feedback and the audience must be enveloped. They have identified that the Wigmore Hall in London is an ideal acoustic environment for them and as a result like to compare other venues to this space.

2.2 The Acoustician's Perspective

Although the requirements of the ICO are clear, they are lacking the objectivity required of acoustic design goals. It was therefore important to translate the subjective description of the ideal acoustic space into objective design goals that could be used to ensure that any potential venues had an acoustic environment that met the required standard. Design goals were established in terms of reverberation time (T_{mf}), intimacy, clarity (C_{80}), loudness (G_{mid}), early lateral energy fraction (LF_{80}) and support factor (ST1).

3 CASE STUDY 1 – THE VILLAGE HALL

In 2005 work commenced on the architectural design of the ICO's new home on the University of Limerick (UL) campus. This development is known as the Village Hall, due to its location within one of the student residential villages at UL. The development would become home to all aspects of the ICO, including office space, ticket sales and rehearsal rooms, however, central to the development was a large studio that would be the main rehearsal space and occasional performance space for the orchestra. The acoustic design brief for the studio was to provide a space that would be suitable for both rehearsal and performance whilst catering for multiple orchestra configurations.

The brief for the acoustic design of the studio was to provide the orchestra with an un-weighted space with an acoustic environment comparable to world class venues such as Wigmore Hall. The finish within the space needed to be to a high specification that would match the strong architectural style of the rest of the development. The studio is rectangular in plan with a volume of 2,100m^3. The basic schedule of finishes in the space comprised polished timber floor boards, plasterboard walls and ceiling with solid core timber doors and double glazed windows.

3.1.1 Design Goals

Based on the acoustic requirements of the ICO and the dimensions of the Studio, objective design goals were adopted following reference to several published guidance documents[1,2,3,4,5,6]. Table 1 lists the design goals chosen in this instance.

Acoustic Parameter	Design Goal
Mid Frequency Reverberation Time, T_{mf}	1.2s ± 0.1s
Intimacy	<20ms
Clarity, C_{80}	0 to -4dB
Loudness, G_{mid}	5dB ± 1dB
Lateral Energy Fraction, LF_{80}	0.25
Support Factor, ST1	-11 to -13dB

Table 1 Adopted Design Goals for the Village Hall Studio

3.1.2 Room Acoustics Model

A computer based model of the Rehearsal Space was prepared using the *Odeon* software package. This package provides a mechanism for assessing in detail the behaviour of sound in a room and allows the user to assess multiple scenarios involving alternative uses and layouts.

Figure 1 shows a 3D wireframe view and rendered view of the basic model prepared using the information supplied by the project architects.

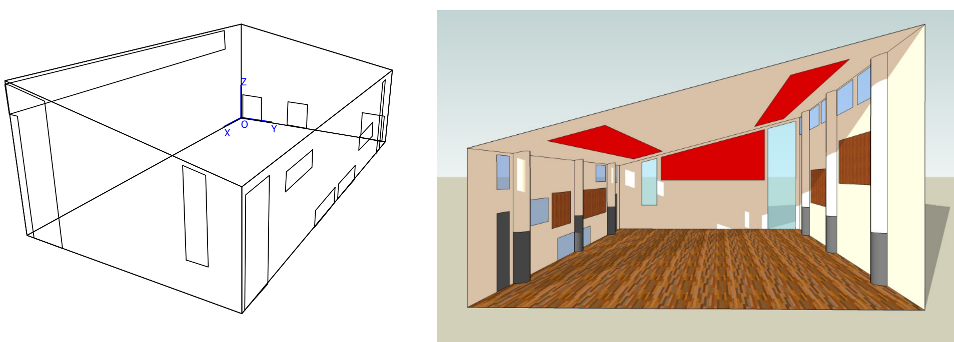


Figure 1 3D view of the Village Hall Studio as modelled

Based on the proposed basic schedule of finishes, the acoustic parameters for which design goals had been specified were calculated and analysed. In all instances the predicted acoustic parameters failed to meet the adopted design goals by a significant margin. In particular the T_{mf} of 4.2s represented a very long reverberation time for the volume of the space and would not have been suitable for orchestral music. Acoustic absorption was required to reduce the reverberation time in line with the design goal.

3.1.3 Recommended Acoustic Measures

As part of the ongoing design of the facility, consideration was given to a variety of products, both proprietary and non-proprietary. The two treatments selected for use were as follows:

- *Topline TLS6/2* – a veneered timber panel with a pattern of slots and holes, available in varying system heights;
- 50mm thick mineral wool slabs behind open-weave fabric.

In summary, acoustically absorptive materials were required as follows:

- 123m^2 of fabric-faced mineral wool, in four elements (walls and ceiling);
- 24m^2 of Topline TLS6/2, 67mm system height, in two elements (wall only);
- 14m^2 of Topline TLS6/2, 200mm system height, in two elements (wall only).

The locations of the acoustic absorption in the finished room are highlighted in Figure 2.

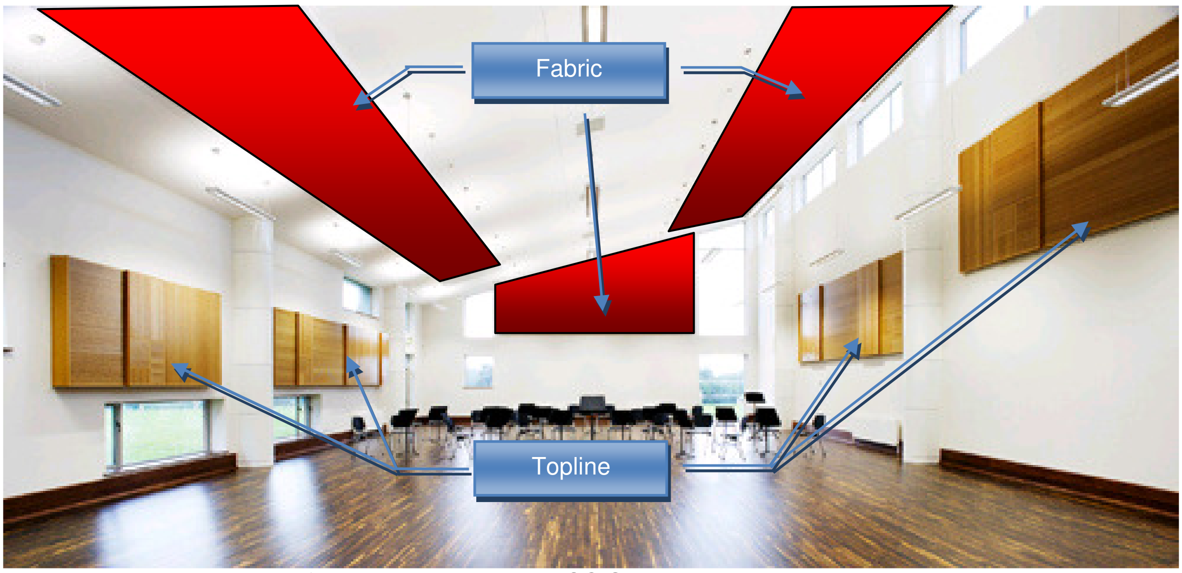
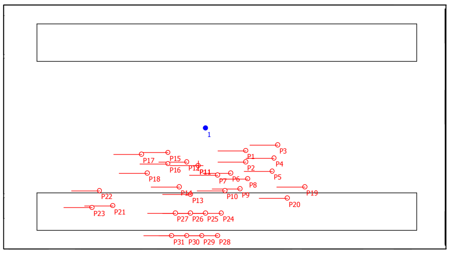


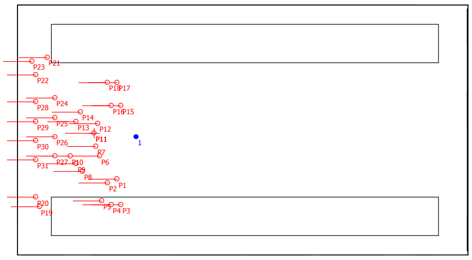
Figure 2 Location of acoustic absorption in ICO Studio

The Odeon room acoustic model was updated to include these measures and the acoustic parameters of interest were recalculated. With these measures in place the objective room acoustic design goals were achieved. The T_{mf} was predicted to be 1.2s which achieved the design goal exactly. Furthermore the space was found to have excellent clarity and intimacy with a high degree of beneficial reflections to both the audience and orchestra members.

The ICO also requested that the studio would be versatile enough to accommodate several different orchestra sizes and orientations within the space. In order to ensure that the space was un-weighted and suitable for these different scenarios further iterations of the model were developed to investigate these scenarios. Figure 3 illustrates the different orchestra positions that were considered. The images in Figure 3 are a plan view of the studio showing individual point sources for each orchestra member.



Full Orchestra, Rehearsal 1



Full Orchestra, Rehearsal 2

Small Ensemble, Performance

Figure 3 Different orchestra layouts

The design goals were achieved for all of the scenarios under consideration, thereby ensuring that the ICO was being provided with a space suitable for both rehearsal and performance with a variety of orchestra layouts.

Compliance with the design goals was subsequently confirmed by commissioning measurement.

4 CASE STUDY 2 – THE RDS CONCERT HALL

In 2008 the ICO was approached by the Royal Dublin Society (RDS) to hold a series of performances in the Concert Hall venue at its premises in Dublin. The ICO had been looking for a suitable base in Dublin for some time and was very enthusiastic about this. The Concert Hall at the RDS was the perfect venue size with approximately 800 seats and also the perfect location in Dublin's Ballsbridge. Unfortunately, however, the ICO was of the opinion that the acoustic environment within the Concert Hall was not up to its exacting standards. AWN was appointed with a brief to improve the acoustic environment to comply with the requirements of the ICO.

4.1.1 Description of the Concert Hall and the Existing Acoustic Environment

The Concert Hall is rectangular in plan with seating located both on the flat and tiered, bleacher style, to the rear. The main ceiling is vaulted with large coffers and there are two gallery spaces running the length of the space on either side. The side walls of these galleries are almost completely covered in exposed bookshelves full of antique books. The Concert Hall has a volume of approximately 5,850m^3.

Figure 4 RDS Concert Hall

The basic schedule of finishes within the concert hall comprised timber floorboards, carpet tile to the bleacher seating area, painted plaster walls where exposed and book shelves elsewhere. The ceiling is also painted plaster and the seats are fabric covered. The reverberation time within the space was found to be relatively low considering its volume, with a T_{mf} of 1.3s. In addition to the measured values of reverberation time a subjective survey of the acoustic environment was also conducted. It was noted that the while the space had excellent direct sight lines to the stage from all areas of the audience there was a noticeable lack of beneficial, in particular lateral, reflections. Furthermore, the ambience of the room was not commensurate with its size.

4.1.2 Design Goals

Based on the acoustic requirements of the ICO and the dimensions of the Concert Hall we adopted various design goals, again making reference to published works[1,2,3,4,5,6]; the values chosen are listed in Table 2.

Acoustic Parameter	Design Goal
Mid Frequency Reverberation Time, T_{mf}	1.6s ± 0.1s
Intimacy	<20ms
Clarity, C_{80}	0 to -4dB
Loudness, G_{mid}	5dB ± 1dB
Lateral Energy Fraction, LF_{80}	0.23
Support Factor, ST1	-11 to -13dB

Table 2 Adopted Design Goals for the RDS Concert Hall

4.1.3 Room Acoustics Model

A 3D computer model of the concert hall was prepared using Google's *Sketchup Pro* software package; this was then exported into *Odeon* for acoustic analysis. Figure 5 shows the model created in Sketchup and a 3D wireframe view of the basic model prepared using the information summarised above.

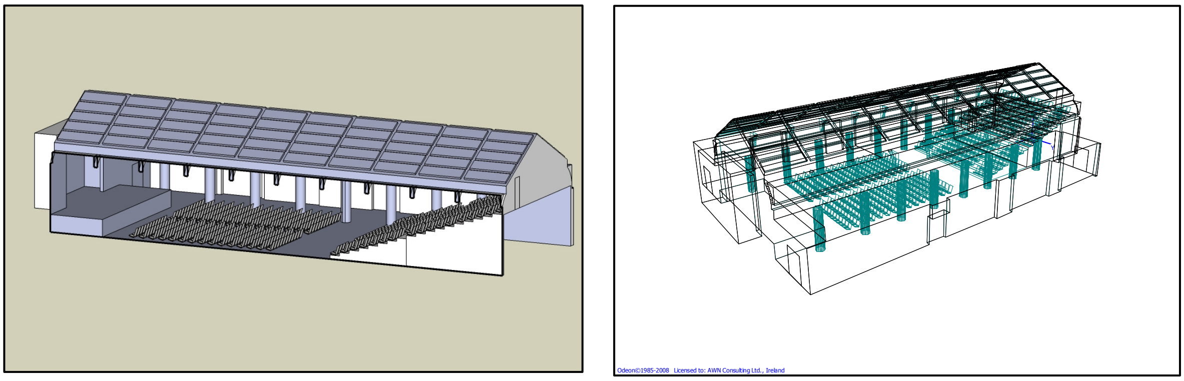


Figure 5 3D model of Concert Hall within *Sketchup* and *Odeon*

In order to have confidence in the results of the modelling process the room acoustic model was calibrated against the reverberation time measurements taken during the room acoustic survey detailed in Section 4.1.1. The calibration process involved tweaking the absorption coefficients applied to the bookshelves in order to match the measured and modelled reverberation times. The other finishes within the Concert Hall were considered to be accurately represented by materials present in the *Odeon* materials database. The differences between the predicted and measured reverberation times across the hall were found to be well within acceptable tolerances. The model was therefore, considered to provide an accurate representation of the room acoustic environment within the hall.

4.1.4 Model of Full Orchestra and Full Capacity Audience

This model was a representation of the existing concert hall with a capacity audience of 811. The room finishes for this scenario were the same as the basic schedule of finishes within the concert hall with the bookshelves exposed. The acoustic parameters for which design goals have been specified were calculated for this scenario and the results compared to the design goals.

The predicted T_{mf} for this scenario was 1.2s, well below the design goal. In addition, C_{80} values in the range of 3 to 4dB indicated that the space was too acoustically "dead". The two measures of beneficial reflections, LF_{80} and ST1, did not meet the design goal, indicating that there was not enough acoustic energy being reflected back to the musicians themselves or into the audience.

4.1.5 Recommended Acoustic Measures

The total exposed area of the book spines is relatively small compared to the total area of the exposed room surfaces. If, however, one were to undertake a simple appraisal of Reverberation Time (RT) in the room, it is likely that the projected impact of the removal of the books would be understated, the primary reasons for this being as follows:

- RT formulae, such as the one put forward by Sabine, tend to assume that the sound field in the room under consideration is diffuse, and;
- these formulae typically return values for mean RT throughout the room.

In this instance, it is important to note that the geometry of the RDS Concert Hall is such that the sound field is not diffuse. Furthermore, we were not concerned with the mean RT within the room, instead focusing on the acoustic conditions in the main working parts of the space, i.e. the stage area and the audience areas. It was therefore appropriate to conduct the detailed 3D modelling described here which took account of the non-diffuse nature of the space and allowed us to consider key locations within the room.

On foot of this modelling it was recommended that the bookshelves on either side of the hall be covered with polished timber panels that can be moved into position as required.

Given that the ceiling rises to a central ridge, the only strong primary reflections to the audience areas are those provided by the side walls at low level. Once the books are removed and replaced with an acoustically reflective and non-diffusive surface, the strength and resultant beneficial effects of these reflections increase substantially.

In addition to covering/replacing the bookshelves, polished timber reflectors were recommended to either side of the proscenium arch to the rear of the stage and in the form of suspended reflectors above the stage. Figure 6 illustrates schematically the size and placement of these reflectors.

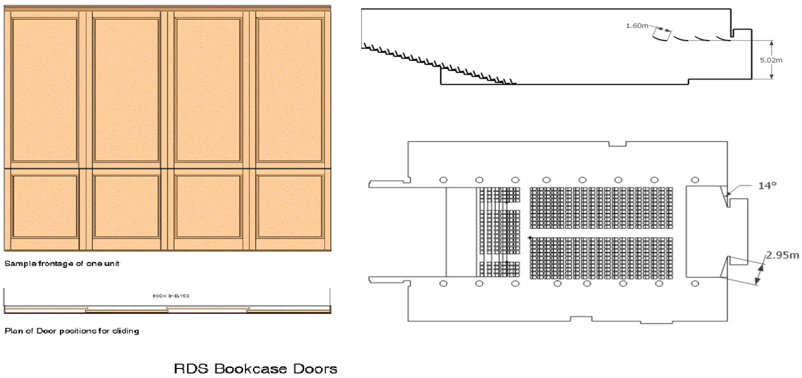


Figure 6 Schematic of acoustic reflectors

The Odeon room acoustic model was updated to include these measures and the acoustic parameters of interest were calculated for the full orchestra and full audience occupancy scenario.

For this scenario the predicted T_{mf} met the adopted design goal of 1.6s. In addition, the measure of beneficial reflections to the audience, LF_{80}, was predicted to be of the order of 0.21 – a significant improvement over the base scenario. Also, the predicted value of ST1 was of the order of -12dB, indicating that there would be sufficient reflections returning to the musicians to provide the necessary feedback. It should be noted that the loudness parameter G_{mid} was predicted to be slightly above the adopted design goal, however, this was not expected to have a significant impact on the room acoustic environment within the concert hall.

Figure 7 compares the predicted reverberation times for the before and after scenarios.

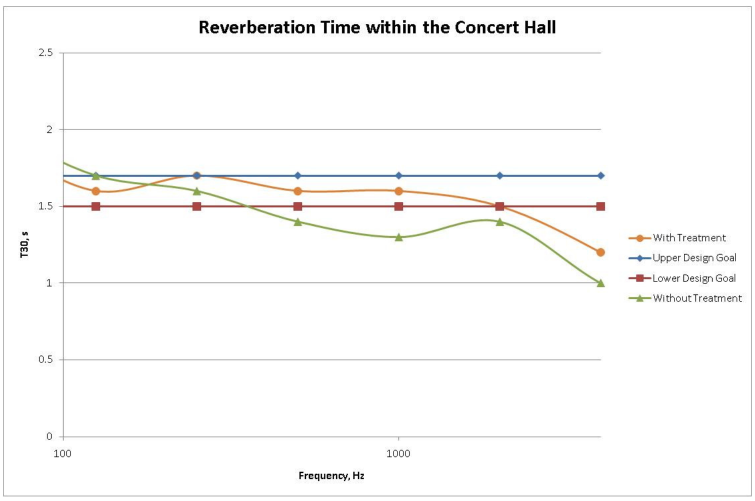


Figure 7 Reverberation time of the before and after scenarios

4.1.6 Commissioning Room Acoustic Survey

Following the physical implementation of the mitigation measures discussed in Section 4.1.5 a commissioning survey was conducted to confirm the acoustic environment had improved to meet the adopted design goals.

The average mid frequency reverberation time (T_{mf}) measured within the empty space was of the order of 1.9s. There was an increase in the reverberation time within the space across the frequency range above 63Hz. The change was most noticeable at the mid frequencies where the difference between the absorption coefficient of the books and the new timber panels covering them is most pronounced.

The measured value of T_{mf} is above the design goal, however, it should be noted that in this instance the design goal of 1.6±0.1s is based on the room with approximately 800 seats fully occupied. When the measured reverberation time values are corrected to account for this seating capacity the T_{mf} within the Concert Hall is calculated to be of the order of 1.6s, complying with the design goal. Furthermore, the distribution of sound within the concert hall was noted to be much improved with a greater feeling of envelopment due to the greater lateral energy fraction.

Feedback from both the ICO and other critics since the acoustic refurbishment has been very positive.

> "The acoustic of the RDS venue has definitely been improved in recent years."
> *Michael Dervan, The Irish Times*
>
> "The audience at the RDS cheered it as if they were absolutely certain they'd heard something very special indeed."
> *Michael Dervan, The Irish Times*
>
> "We were treated to a display of bright, brilliant playing with crisp, tightly controlled rhythms and lovely dynamic contrasts."
> *Declan Townsend, The Examiner*

5 REFERENCES

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