THE ACOUSTIC DESIGN OF THE BBC HODDINOTT HALL

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1 ABSTRACT

In January 2009, the BBC National Orchestra of Wales moved to its new home, BBC Hoddinott Hall at Cardiff's Wales Millennium Centre. Since 1967 the Orchestra was based in Studio 1 at Llandaff, Cardiff but has long outgrown its old home. Now a new purpose-built Concert Studio has been added to the Wales Millennium Centre (WMC) in Cardiff Bay. BBC Hoddinott Hall (named after the Welsh Composer Alun Hoddinott) will not only be the orchestra's base, from where all of its rehearsals and studio recordings, and broadcasts will be made, but also a new state of the art concert hall seating 350 people. The building also includes a smaller performance and rehearsal space, the Grace Williams Studio, and control room and editing facilities. Hoddinott Hall is one of the largest Concert Studio facilities in the world.

2 INTRODUCTION

The BBC National Orchestra of Wales has performed and recorded in a facility in Llandaff, Cardiff since 1967. This facility is a studio with a fairly short reverberation time (1.05s 250Hz – 4kHz) in which good ensemble and well supported orchestral sound for performance was not easy. The development of the Wales Millennium Centre in Cardiff provided an opportunity for a new purpose built home to be built for the orchestra.

The site for the new building was identified as an area of car park within the existing WMC boundary.

The facility includes two performance spaces, the main orchestral broadcast studio for the BBC National Orchestra of Wales symphony orchestra to rehearse, record and broadcast from, and a smaller sectional rehearsal room (the Grace Williams Studio), and music practice rooms. This paper focuses on the acoustic design of the orchestral broadcast studio.

3 ACOUSTIC CRITERIA

The design brief for the main studio was unusual insofar as requiring a range of room reverberance that could be maintained regardless of audience occupancy. When dealing with large volumes with a small fixed quantity of absorption (the orchestra and the fixed seats) the amount of variable absorption needed becomes substantial. To ensure that the tonal quality of the room remains consistent, the variable acoustic system needed to provide broadband absorption. Consequently, the use of drapes alone (with their limited low frequency performance) was not considered appropriate.

The criteria were a) to have a mid-frequency reverberation time longer than 1.8 seconds with a full orchestra, choir and audience, and b) to achieve a reverberation time shorter than 1.6 seconds with just the orchestra present.

The background noise design target was a maximum of NR12 for noise from building services and a total of NR15 including intrusive noise from environmental sources. With an audience present, the total noise level was permitted to increase to NR20. The environment around the hall is not particularly acoustically hostile, but helicopters do cross the site and there is a car park located underneath the Hall.

The volume of the studio was optimized on the site. For rehearsal and performance conditions, the larger the volume the better – it has been Arup Acoustics' experience that orchestral studios with limited height and volume present conditions that result in a significant amount of post processing required to add reverberance to the recording or broadcast. In studios with a low ceiling and smaller than desirable volume, high sound levels also result. It was a desire to not only provide the best room acoustic possible on the site, but to also provide conditions in which musicians could play for extended periods without undue concerns over noise exposures.

The volume of the concert studio is $9000m^3$ which means that this is one of the largest dedicated orchestral studio facilities in the world. As a reference, Maida Vale Studio 1 is $6200m^3$, and Abbey Road Studio 1 is $4500m^3$. The old studio used by the orchestra was $3800m^3$.

4 SOUND INSULATION

The stringent background noise level is necessary for recording and live broadcast. Noise sources around the site include helicopters flying over the site and a car park located under the studio. The site is also adjacent to a potentially busy road once developments around the site have been completed.

The requirement for low intrusive noise levels and maximum protection against intrusive environmental sources led to the decision to build the studio as a masonry box-in-box construction supported on elastomeric bearings.

To reduce the construction time, a decision was made to construct the studio from precast concrete panels bolted onto a steel frame (see Figure 1). The steel columns supporting the concrete walls and lid to the studio take the load onto bearings through a spreader plate. The floor is a jack-up concrete floor on bearings which was installed towards the end of the construction programme, after the main scaffolding had been removed.

Multiple layer, deep cavity windows provide natural light into the rear of the hall whilst not compromising the sound insulation of the studio.

Figure 1: Precast concrete panels being bolted to the inner steel portal frame.

5 VENTILATION DESIGN

The very tight site meant that there was no sensible location for an air handling plantroom within the building. Due to the very onerous internal noise criterion, it was recommended that the plant be located away from the roof system. The resultant design saw 6 AHUs cantilevered over the roof from the external structure only, each providing air through an attenuated dropper to the mid level services distribution shelf within the studio.

Ventilation distribution was incorporated into the acoustic design of the room. To provide a ‘cue-ball’ reflection to the audience areas from the orchestra, a shelf was recommended at a 4m height from the platform floor level. In a concert hall, this shelf would be the underside of a side balcony. However, side balconies were not required for the limited seat capacity. This shelf supports the supply ventilation header duct along the sides of the room. Jet nozzles fixed to this duct project air up from the sides of the room, which mixes at mid level in the room then drops to the audience and orchestra. This method of air delivery is more efficient and works with lower velocities than blowing it from high level through the production lighting to the audience plane.

6 ROOM ACOUSTIC DESIGN

The acoustic design concept for the room was to approach it more like a studio rather than a concert hall, even though it needs to operate as both. Consequently, the room is a concrete box with specific, quantified absorbent surfaces introduced. Modular boxes following the long established BBC design were used together with new boxes designed by Arup. Acoustic tests on our own designs, together with the BBC designs were undertaken – including the effect of spacing the boxes apart on the resultant absorption coefficient. This information allowed us to develop an optimization process, with the outcome being a design with the fewest number of boxes to provide the design RT.

The test results yielded some very interesting results – whereby enormous ranges in low frequency absorption efficiency can be brought about by spacing the boxes apart. See figure 2 below for indicative test results on BBC D2 type boxes:

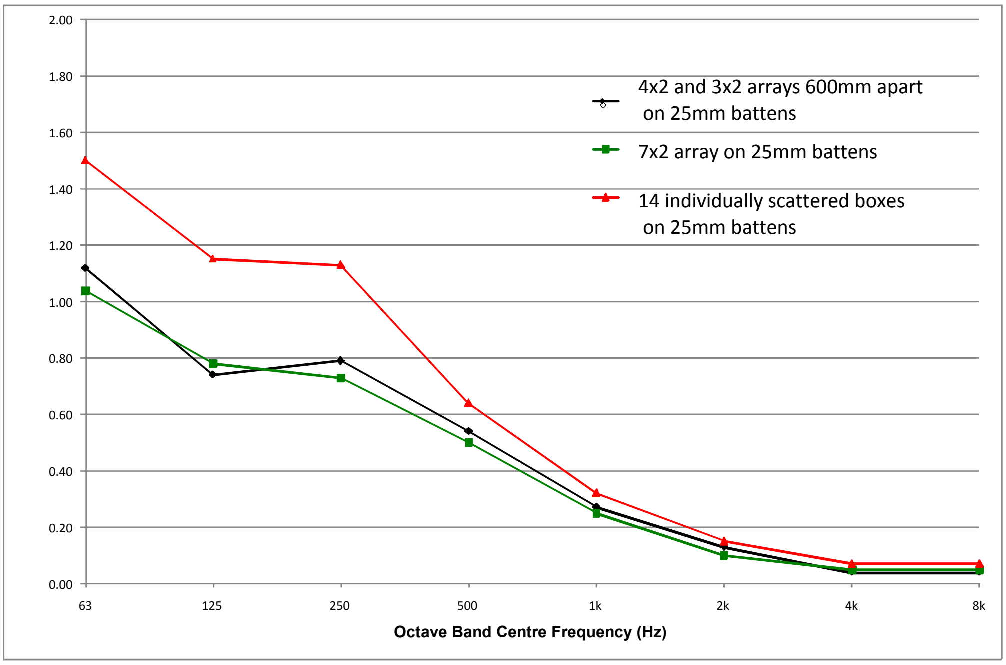

Figure 2: Absorption coefficients of D2 boxes with different spacing arrangements

Acknowledging the need for the studio to provide typical concert platform conditions, timber finishes were proposed for the lower part of the room, with exposed concrete at higher levels.

The wall finish from floor level floor level to the underside of the 4m high shelf has a progressive diffusing finsh to aid string tone, to control harsh reflections and to diffuse sound throughout the studio. The finish is more densely diffusing around the orchestra and on the rear wall, and is more sparse around the audience areas. The absorption provided by this finish was also established by laboratory test.

The platform walls are parallel to optimize the platform size. To control the risk of flutters across the platform, diffusion is applied in a saw-tooth profile, the 7^{o} angle of which is similar to a conventional concert platform flared shape.

7 VARIABLE ACOUSTIC SYSTEM

To achieve the substantial transformation of room acoustic needed to compensate for the audience being present or absent resulted in the investigation and design of a unique horizontally moving unity absorber that is stored in four timber garages located above shelf level. These have been described as the acoustic 'duvets'.

The tracks for the absorption acoustic duvets are remotely controlled in pairs so that the front pair by the orchestra, or the rear pair to the back of the room can be individually deployed. They can be extended as much as needed. In addition to the acoustic 'duvets' there is also a drape that can be deployed across the rear wall.

Diffusion in the form of timber pyramids was applied to the bare concrete at high level to control harsh reflections when the variable absorption is retracted.

Figure 3: Variable absorbing panels tracking above 'shelf' level

8 ORCHESTRAL REFLECTOR ARRAY

The performer conditions on the platform are critically important in a studio environment. In a studio every effort should be taken to ensure that the orchestra's needs are taken care of, as the musical output, rather than the audience conditions are paramount.

With the ceiling in the hall being at 15m, it is too far away to form a useful surface for across-orchestra reflections (ensemble reflections). So a series of low level reflectors were designed to assist in orchestral ensemble. The open area of the array is 50%, which ensures that the volume above the array is well coupled into the main room volume and also helps to control loudness. The solid areas of panels, the gaps between them and the overall size of the array were initially determined by published guidance by Rindel and Gade[1]. The reflector coverage was then investigated and optimized by Arup using the visualization software Rhino.

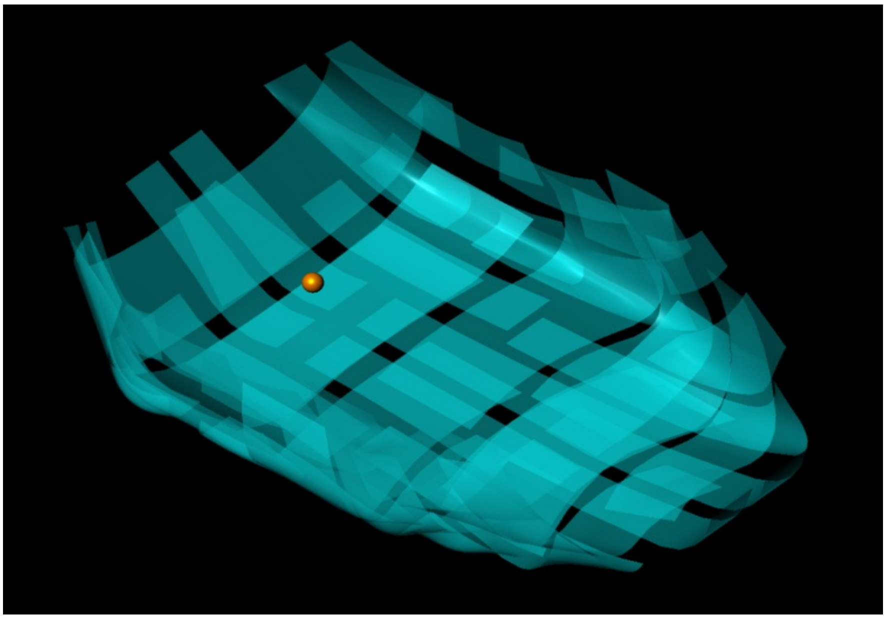

Figure 4: Single source reflection pattern from suspended array

To rationalize the design, a panel arrangement was developed that used the same module for each reflector but alternate panels curved in orthogonal directions. A further development was to include the performance lighting into the array. The reflectors are located on 5 motorized trusses which can be individually raised or lowered.

Test performance sessions with the orchestra identified the optimum height for the array for maximum orchestral benefit – and this was found to be at an average of 8m from the platform with the array rising at the front and rear.

Figure 5: Reflector array in orchestral position

9 FINAL RESULTS

The acoustic achieved in the room met all of the BBC's requirements, and from a subjective perspective resulted in a warm reverberant sound within the space.

Figure 6 demonstrates the extent of the acoustic variability that can be achieved in the studio, with significant change available at low frequencies. In the day to day operation for rehearsal and recording, the orchestra prefers to work with some of the variable absorption deployed to achieve the desired balance between clarity and reverberance.

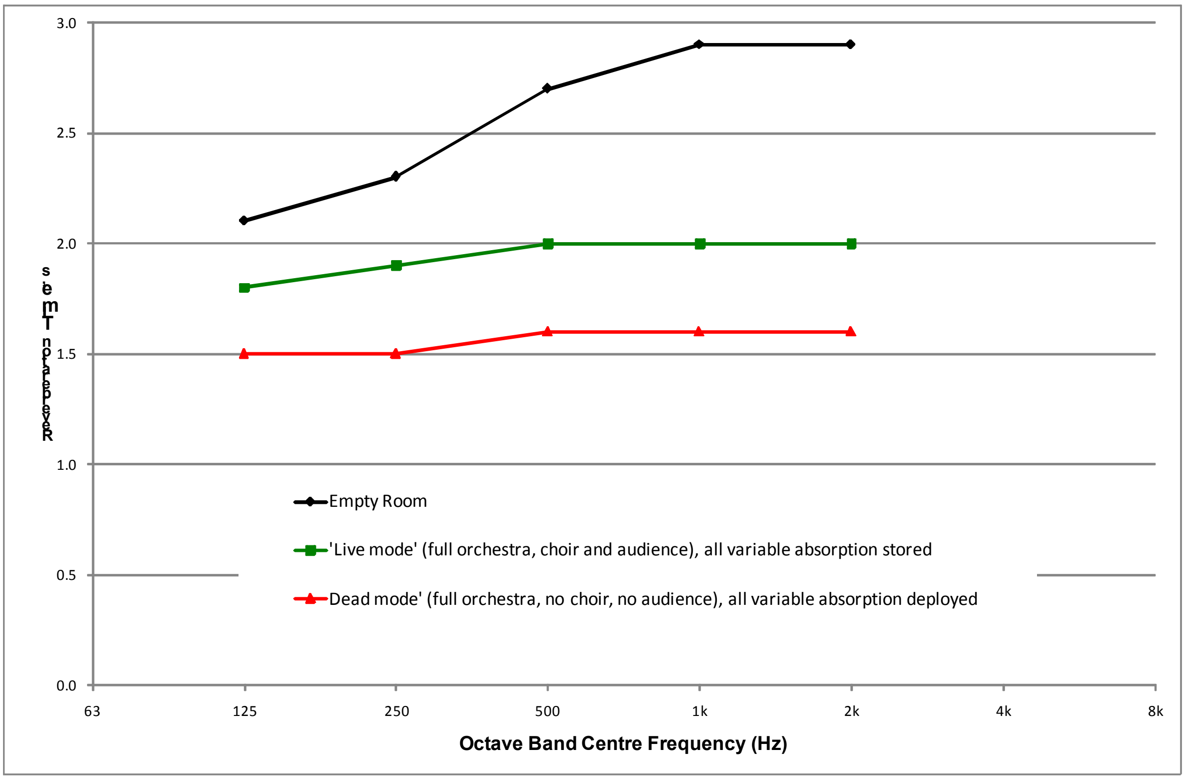

Figure 6: Extent of variability of reverberance[1]

Background noise levels in the studio are very low, being up to 10dB below NR15 at most frequencies. Intrusive noise is not audible with a sound insulation of at least D_w72 between the car park and the studio and at least D_w74 between the control room and the studio.

Critical listening and rehearsal tests were carried out with the BBC National Orchestra of Wales as well as the choir using a broad spectrum of repertoire including Debussy *Nocturnes*, Copland *Fanfare for the Common Man,* Williams *Star Wars* and Verdi *Requiem.*

Recorded and live broadcasts and recordings for TV programmes regularly occur with the BBC National Orchestra of Wales now in residence. The final stages of the BBC Young Musician of the Year were broadcast from Hoddinott Hall in February 2010.

David Murray, Director of the BBC National Orchestra of Wales commented that

"Arup Acoustics have fulfilled admirably the exacting acoustical brief drawn up for BBC Hoddinott Hall, meeting all targets and exceeding many. The hall is extremely well balanced with warmth, clarity and a remarkable bass response. The variable aspects of the acoustics work convincingly and the low noise floor is huge advantage for recording.

It's a marvelous place to work and will transform the life of the BBC National Orchestra and Chorus of Wales".

The Royal seal of approval was given at the official opening when HRH Prince Charles described the room as “an acoustical triumph’ at its opening in January 2009.

[1] Empty room measurements corrected for acoustic effect of audience, orchestra and choir

10 REFERENCES AND ACKNOWLEDGEMENTS

[1] Rindel, J. H., Design of new ceiling reflectors for improved ensemble in a concert hall. Appl. Acoust. **34** [1991] 7-17

[2] Gade, A.C., Investigations of musicians' room acoustic conditions in concert halls. I: Methods and laboratory experiments. Acustica **69 [**1989] 193

[3] Gade, A.C., Investigations of musicians' room acoustic conditions in concert halls. II: Field experiments and synthesis of results Acustica **69 [**1989] 249

[4] Gade, A.C., Gustafsson, J., Comments on Arup Acoustic' Stage D acoustic report [2006]

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