Proceedings of The Institute of Acoustics

EDEN COURT THEATRE, INVERNESS

F.J. Fahy

John Wyckham Associates and ISVR, University of Southampton

Eden Court is a theatre and arts centre designed for the Royal Borough of Inverness by the Architects Messrs. Law and Dunbar-Nasmith. John Wyckham Associates were the theatre consultants to the Architects and to the Royal Borough of Inverness.

1. The Brief

The brief called for a main auditorium holding about 800 seats, and which would be suitable for performance of live theatre drama, opera, ballet and orchestral music, together with provision of facilities for conferences, popular music concerts and social events of various kinds. Such a wide range of requirements is particularly challenging in respect of the acoustical design of the auditorium and associated services. The following additional conditions were implicit in the brief. (i) The auditorium should have a good actor/audience relationship in a warm, friendly, intimate and comfortable atmosphere, however many or few of the seats are occupied; (ii) there was likely to be an approximately 40/60% division between dramatic productions, based primarily upon unaided speech, and performances in which music plays a major rôle; (iii) the acoustic 'dryness' of some of the recently built smaller theatres should be avoided.

2. The Auditorium Configuration

In order primarily to satisfy requirement (i) stated above, a tiered horseshoe configuration was chosen, having about 60% of the audience on fairly steeply raked stalls (Figure 1). Thus the walls of the main floor are 'papered with people', ensuring good audience rapport. The most remote seat is only 22 m from the front of the stage.

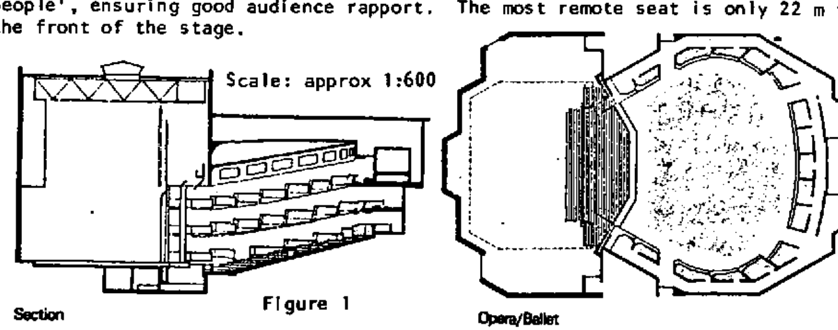

Figure 1

3. Acoustic Considerations

The major goals were three fold: (i) high quality sound communication from performers to listeners; (ii) minimisation of interference with the communication by noise from other sources, either internal or external to the building; (iii) good communication between members of performing groups, to aid balance and ensemble.

EDEN COURT THEATRE, INVERNESS

3.1 Speech Intelligibility

In view of the proposed extensive use of the theatre as a concert hall, and the requirement to avoid dryness, it was decided to aim at a mid-frequency reverberation time of 1.3-1.35 seconds, which it was considered would allow acceptable speech intelligibility, provided that good sightlines were achieved, and that long delayed, discrete reflections were avoided. Also there is likely to be little difference between stage house and auditorium R.T.'s. The chosen R.T., plus the layout of the audience, dictated the auditorium volume. The total area of seating plus aisles was about 485 m^2 which, for an R.T. of 1.3 seconds, required a free volume of about 4500 m^3, excluding the stage volume, or a ratio of volume/seating area of about 9 m. This is considerably higher than the maximum of about 4 recommended by some experts. This volume dictated the ceiling height, which is about 12 m on average. No special purpose acoustic absorption was installed in the auditorium, although the choice of carpet was based partly upon absorption tests. The bottom panels of the fully upholstered seats were specially perforated to improve their absorption when tipped up.

It was felt that the broken, splayed surfaces of the sides of the horse-shoe would not provide the early, discrete reflections which are knwon to enhance speech intelligibility, although the facetted balcony fronts and lower surfaces were expected to provide useful diffused lateral reflections for orchestral performances. Consequently the main (upper) ceiling was chosen to be unbroken by lighting bridge slots, which tend to leave little useable area for the direction of reflections into the mid/rear stalls. (This can be a major area of conflict between lighting and acoustic designers). The orientation of the high ceiling ensures that no first ceiling reflection arrives in the stalls more than about 50 milliseconds after the direct sound, but the discontinuity at the junction with the procenium arch was not acceptable to the architects on visual grounds. Hence a lower false ceiling, penetrated centrally by a large hexagon, which is the main motif of the building design, was installed as shown in Figure 1. Lighting stations were provided in vertical slots at the sides of the auditorium and in the windows seen above the upper gallery. It would have been preferable acoustically to direct balcony front reflections down into the audience but for architectural reasons this was not possible, and so to avoid redirecting reflections from the ceiling into the front/mid stalls, the fronts were given a backward tilt which increased progressively towards the rear of the auditorium. Hence rear balcony front reflections can be considered to contribute to the reverberant, and not the early, sound. Although not ideal, this does at least avoid any perceptible focussing effects from the curved surfaces.

3.2 Orchestral Performances

With the R.T. and basic configuration decided, acoustic provision for orchestral performances on the stage and in the pit was made primarily with the playing conditions in view. Pit acoustic criteria are not well established, and are heavily outweighed by considerations of lifts, head and floor room, orchestra -conductor-stage relationships, and heating, among others. Even the question of degree of stage overhang is largely settled by the revenue factor associated with loss or gain of front stall seating. However, a fully open pit does introduce a distracting 'barrier' between the audience and the stage, which is not beneficial to operatic performances, and it would seem that suitable arrangement of the pit orchestra, especially of the woodwind instruments which seem to suffer most from partial 'burial', can do much to overcome problems of balance created by large overhangs. Hence in Eden Court, the pit was provided with a number of free standing absorber boxes, having a broad band perforated absorber on one side, and a low frequency panel absorber on the other. These can be used to control the excessive loudness problem which frequently arises in untreated, overhung pits. It is not known how effective these have been, although the pit sound is good, especially in the galleries. To quote Francis Reid in 'Tabs': '...as the seats become higher and cheaper, the pit orchestral sound becomes richer although remaining in balance with the stage. Was this calculated or even predicted ?' Good question !

As for the stage, it was clearly necessary to provide some sort of orchestral shell in order to separate the orchestra visually and acoustically from the enormous volume of the stage house, and to provide some early 'feedback' and 'cross talk' for the benefit of the musicians. The main design requirement was ease of erection, demounting and storage, preferably by a two-man crew. Fortunately there seemed to be no good physical reason for constructing the shell from heavy materials, especially since special purpose bass absorbers are often installed in heavy shells, and a combination of ¼" and ½" plywood panels stiffened by framing was used. The side and rear walls are constructed of folding panels mounted upon wheeled 'dollies' which can be moved by one man. Three ceiling panels, which are spaced apart to accept lighting bars, are folded up and flown from the grid. Various configurations can be arranged to suit the size of the performing group. The vertical surfaces take the form of irregularly spaced triangular projections of about 0.5 m depth which are uniform in a vertical direction; the splay of the sides approximately follows that of the side balcony fronts thereby giving an impression that the shell is integral with the auditorium. Quoting again from 'Tabs': 'The acoustic shell for orchestral concerts, however, is a model of how to arrange things with a minimum of manual effort'.

3.3 Noise

The design ambient noise level in the auditorium was NC.20. The site is well removed from main traffic routes and external noise was no problem. In designing the heating and ventilation plant at Eden Court great care was taken to reduce system noise entering the auditorium by the following means:

(a) The plant room was sited at the rear of the auditorium volume, at roof-space level, from which it was separated by a heavy concrete wall containing only one 'acoustic' door. All builder's work, cracks and apertures were heavily sealed.

(b) The air moving plant and associated ducts within the plant room were lagged with sound insulating material, so that the noise level in the plant room was minimised (70 dB(A)). Individual extract fans situated around the auditorium were in separated, isolated rooms with well-fitting doors.

(c) All rotating machinery was mounted on vibration isolators, thereby minimising structure-borne sound.

(d) The main supply ducts were run forward from the plant room above the continuous heavy plaster ceiling of the auditorium. Lighting ports in the upstand between the upper circle soffits and the ceiling were either glazed or fitted with individual enclosures and doors.

(e) The vertical branches of the extract and supply ducts were housed within builder's work ducts and only penetrated the auditorium at the level of each distribution branch.

(f) Splitter silencers were incorporated in each main supply and extract duct at the fan positions. Individual silencers were installed at the penetrations of the smaller extract fan rooms located around the auditorium.
(g) Airspeeds in the ducts were kept very low by attention to the distribution and maximisation of the size of duct branches, particularly in the vicinity of the terminal air control devices. Particular attention was paid to those grilles located close to the heads of the audience.
(h) All dampers were located as far as possible from terminal grilles, while the potentially noisy ones were identified and some small downstream attenuators incorporated in the duct work. The system was carefully balanced.
(i) All major metal air ducts were suspended on flexible hangers, while the main forward running supply ducts in the roof space were lagged - mainly for reasons of thermal insulation. All installation work was closely supervised.

4. Acoustic Tests

4.1 Acoustic Model

A 1:10 scale acoustic model was commissioned from Mr Brian Day of Bristol University whose contribution to the success of the design is gratefully acknowledged. The main conclusions from these tests were as follows: (a) a mid-frequency reverberation time in the range 1.3-1.4 seconds; (b) satisfactory reflection sequences (echograms) at all nine measurement positions, with all major discrete reflections being received within 55 milliseconds of the arrival of direct sound; (c) a significant difference between the R.T.'s for irregular and smooth walled concert shells; the latter produced low frequency reverberation times for a stage source which were about 15% greater than the smooth shell. The reason was never discovered, but an irregular shell was chosen as probably being of greater benefit to the performers by directing some reflections back into the orchestra.

4.2 Commissioning Tests

Reverberation times in the half full house were measured at ten positions within the auditorium using pistol shots on the stage. The average 500/1000 Hz value was 1.45 seconds; values at 125 Hz and 4000 Hz were 1.6 and 1.1 seconds respectively. The shape of the curve corresponded well with the model results for full audience, but the higher frequency values were 5-10% greater as might be expected with less than full audience.

Simple P.B. word list intelligibility tests were performed with a live speaker facing the audience on the stage. The results demonstrated that loudness of the spoken word was adequate in most areas, with the poorest results in the extreme side mid-stalls seats. Noise levels with all the ventilation and heating systems in operation satisfied NC.20 at all seating positions measured.

5. Conclusion

Since its opening in the spring of 1976, Eden Court has accommodated a wide range of activities, as envisaged in the brief. Audience and performer response has been generally favourable, especially for operatic performances. Solo piano performances also sound very well. Pop music performances using 'brought in' sound amplification systems tend to be too loud because of the fairly live natural acoustics, but this is to be expected. There are some side stalls seats in which unaided speech is less intelligible than is desirable, as the tests suggested, but these are very few in number.