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THE ACOUSTIC DESIGN OF THE EDINBURGH FESTIVAL THEATRE

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1. INTRODUCTION

The Edinburgh Festival Theatre opened in June 1994, and seats an audience of approximately 1900.

The site, in Nicolson Street, Edinburgh, is that of the former Empire Theatre. The auditorium of the Empire, dating from 1928, has been retained, refurbished and upgraded. To this has been added a new stage, flytower, orchestra pit, backstage accommodation, foyers, bars and hospitality spaces. The brief was to provide a fully equipped lyric theatre for the staging of opera, dance, and musicals, as well as drama, to achieve a standard of "affordable excellence".

2. BRIEF HISTORY

The site has been in use as an entertainment venue since about 1830. The first Empire Theatre, designed by Matcham, opened on the site in 1892. By 1927, it was decided that the theatre should be rebuilt to cope with bigger shows, and the second Empire Theatre designed by W & T R Milburn was opened in 1928. From 1928 to 1963 the Empire was used as a variety, musical and opera house, and was one of the main venues used for the Edinburgh Festival (from its establishment just after the War). In 1963, the building was converted to use as a Bingo Hall, and apart from a few exceptions was no longer used for performances.

As the Edinburgh Festival grew in international stature, so did the campaign to provide the city with a venue capable of presenting operatic and other large scale productions. A number of options and potential sites were considered over the years, but did not come to fruition.

It was realised that the Empire Theatre was capable of fulfilling the brief, but it was not until 1990 that the opportunity arose to buy the Theatre. Following an economic assessment and technical feasibility study it was purchased by a partnership of public and private sector interests.

The design team for the refurbishment and redevelopment comprised the architects Law & Dunbar-Nasmith (who had identified the potential of the site in a 1975 study for the Scottish Arts Council), theatre consultants Theatre Projects Consultants, acoustic consultants Sandy Brown Associates, engineering consultants Blyth & Blyth Associates, and quantity surveyors Doig and Smith. TEAM Management (Scotland) Ltd were subsequently appointed project managers.

3. APPRAISAL OF THE EXISTING EMPIRE THEATRE, PRIOR TO THE REDEVELOPMENT

A plan (stalls level) and longitudinal section of the existing Empire Theatre prior to the redevelopment are shown in Figure 1.

The 1928 Empire Theatre auditorium had a number of technical deficiencies, including an inadequate orchestra pit, insufficient lighting positions, no lighting or sound control rooms, poor ventilation, and awkward audience access to the Second Circle. The raked stage was not suitable for ballet. The sound insulation of the auditorium was also deficient on occasion, with external noise intrusion, and conversely, noise from loud performances affecting nearby residential properties. The stage, foyer, dressing rooms, and offices were not adequate for modern requirements.

The auditorium was however remembered for its good acoustic quality. This reputation was supported by studies of the geometry of the existing space, and the results of acoustic measurements. The mid-frequency reverberation time (T_{60}) in the unoccupied auditorium prior to the redevelopment was 1.3 seconds, with a gentle rise in RT below 250 Hz, indicating a warm acoustic, and capable of achieving a good compromise between operatic, music and theatrical uses. Speech intelligibility and sightlines were judged to be good.

Although the auditorium is comparatively wide, the shape is good, and reflections from the side walls were expected to give adequate early reflections. There was little variation in sound level between the majority of seats, the exception being seats under the deep balcony overhangs, and in the rear of the Upper Circle, which are screened from overhead reflections, and where the sound is noticeably attenuated. The furthest seat is approximately 29m from the stage.

4. DESIGN OF THE EDINBURGH FESTIVAL THEATRE

It was proposed to retain the Empire Theatre auditorium as the basis for the new Edinburgh Festival Theatre, preserving the good acoustic and other qualities, and enhancing them where possible, bearing in mind the "listed" interior of the space. The remainder of the old Empire Theatre was demolished, to make way for new stage, back of house and front of house facilities.

Plans of the new theatre are shown in Figure 2, and a longitudinal section shown in Figure 3. The main features of the design are noted below:

4.1 Auditorium

The volume of the auditorium (excluding the volume of the flytower) is approximately 8850m^3, giving a volume per seat of approximately 4.7m^3.

Because of the listed interior, major changes to the auditorium in relation to shape, appearance or additional reflecting surfaces were not feasible. A small increase in volume was effected by openings in the ceiling to provide new lighting positions (at the expense of ceiling reflecting surfaces), and by the new orchestra pit. All new finishes were assessed to ensure that they were no more absorbent than those they were replacing.

The stalls were re-raked to provide optimum sightlines to the new flat stage. Seating areas are uncarpeted, with the exception of aisles. Existing seats at Dress and Upper Circle levels were refurbished and re-upholstered. New seats in the same style were manufactured for the Stalls.

The sound insulation of the auditorium was improved by upgrading the roof structure, bricking up windows into the auditorium (but retaining "false" backlit windows), and by forming sound lobbies to auditorium entrances.

4.2 **New Orchestra Pit**

Detailed discussions were held with the future users and others in the design development of the Orchestra Pit. Three elevators are provided to facilitate various pit arrangements:

- No Pit
- Small Pit - for musicals etc. (10 - 50 players). Floor area 82m².
- Standard Pit - for the general opera and dance repertoire (60 - 84 players). Floor area 115m².
- Super Pit - for large operatic requirements, (up to 112 players), or for smaller orchestras playing "in the open". Floor area 150m².

The width of the pit is defined by the splayed walls at each side of the proscenium opening. The stage overhang is 3.5m deep, and the floor to ceiling height beneath the overhang is approximately 2.9m at the front. Wall finishes in the pit are of timber panelling.

4.3 **New Control Rooms**

New lighting, projection, and sound control rooms were introduced along the back wall of the Dress Circle. These are flanked by two boxes which can be converted to simultaneous interpretation booths or commentary boxes, by adding glazed panels to the window openings.

4.4 **New Stage and Flytower**

A new flytower of dense double skin blockwork was constructed, with a flat stage approximately 18m x 25m. The existing proscenium opening (13.4m wide) was retained. A wing stage is provided at stage left which gives a total stage and wing stage width of between 34m and 37m. A large vertically sliding acoustic door (11.2m x 9.5m clear opening) divides the stage from the scene dock behind. The latter can also be used as a rear stage when the occasion demands, by raising the acoustic door.

Seals were added to the massive steel safety curtain, to provide a degree of acoustic separation between stage and auditorium, to allow the auditorium to be used independently, while the stage is being set. Sound insulating smoke vents were specified for the flytower roof.

The combined volume of the flytower and wing stage (approximately 14650m³), constructed of fair faced blockwork, is largely devoid of acoustically absorbent finishes, apart from scenery and stage drapes. At the design stage, consideration was given to additional acoustic treatment so that the flytower would not be excessively reverberant if there was minimal scenery present. The general manager of the theatre was able to reassure us that this situation was unlikely to exist, and had commissioned a series of back cloths which would be permanently installed, in addition to the normal stage drapes. On this basis, and on cost grounds, the additional treatment was omitted, a decision that has proved acceptable.

4.5 **Ancillary Areas**
Ancillary areas provide a buffer zone around the auditorium. New dressing rooms, support areas, administration offices and hospitality spaces were formed to the south of the auditorium. The new foyers, incorporating bars, cafe, and box office, have a fully glazed frontage. The glazing was selected to achieve the best compromise between sound insulation, cost, and thermal performance.

4.6 **Building Services**
The main air handling plant rooms are located to the north of the auditorium above the Wing Stage, and to the south of the auditorium above dressing rooms and office accommodation. Air-cooled condensers are located above the Scene Dock, and boilers and chillers in the energy centre, below the Scene Dock.

The design aim for building services noise in the auditorium was NR 20, and this has been achieved. Supply air to the auditorium is provided via drum-jet diffusers on the side walls, and via linear diffusers in the balcony soffits. Extract is via the large ceiling dome. Where feasible, ductwork was threaded into existing void spaces, but the main duct runs and distribution to the auditorium had to be on the exterior of the building. To achieve acceptable standards of noise break-in, and to preserve the integrity of the sound insulation of the auditorium, vertical duct runs were enclosed. Roof mounted ductwork was also enclosed or acoustically lagged.

5. ACOUSTIC CHARACTERISTICS OF THE AUDITORIUM

5.1 **Reverberation Time**
The mid frequency reverberation time (T_{60}) is in the range 1.30 - 1.45 seconds, depending on the absorption of scenery on the stage. Typical results are shown in Figure 4. The Early Decay Time is typically in the region of 88 - 91% of the RT in the unoccupied auditorium.

5.2 **Early-to-Late Sound Ratio**
The following values of early-to-late sound ratio or clarity (C_{80}), were determined from impulse response measurements in the unoccupied auditorium (sparse stage set, safety curtain open).

Octave Band Centre Freq. (Hz)	500	1k	2k
Seat	**Early-to-Late Sound Ratio (dB)**		
Stalls L31	2.0	3.6	1.9
Stalls TO17	4.0	3.1	5.4
Dress Circle E25	3.2	2.3	1.9
Dress Circle H16	3.9	3.0	3.3
Upper Circle D27	1.8	2.9	2.4
Upper Circle H9	2.3	3.5	4.7

Seat T17 is under a balcony overhang, which may account for the high values of C_{80} in terms of lack of late reflections. Seat H9 at the rear of the Upper Circle is similar in that it is screened from overhead reflections.

5.3 Strength

Strength (or total sound level) with respect to the direct sound level at 10m was determined from impulse response measurements. Typical values (125 - 8000Hz) were as follows for the unoccupied auditorium:

Seat	Strength (dB)	Distance from Source
Stalls L 31	3.8	14m
Stalls T17	3.4	22m
Dress Circle E25	2.9	18m
Dress Circle H16	1.4	21m
Upper Circle D27	2.2	22m
Upper Circle H9	0.4	26m

Results fall within acceptable limits, although the value at the uppermost seat in the Upper Circle is near the limit - this seat is screened from overhead reflections, (and the direct sound is almost at grazing incidence over the Upper Circle seats for a sound source well forward of the proscenium). A similar situation would be expected at the rear of the stalls.

5.4 Speech Intelligibility

Measurements of the Speech Transmission Index (STI) indicate good speech intelligibility, and this is confirmed subjectively.

5.5 Subjective Impressions

The Edinburgh Festival Theatre is used for a wide range of events, ranging not only from those envisaged by the brief, but also for staged concert performances, chamber music, variety, light entertainment, and pop music performances. Subjectively, for opera and ballet, and for staged performances such as chamber and choral music, the acoustics are very favourable, with a warm, well blended sound. The best seats are in the Dress Circle, and the front part of the Upper Circle. Comments by users, audiences, and by press critics have been very favourable.

6. REFERENCES

Further information on the design of the Edinburgh Festival Theatre is given in the following publications:

- The Architects Journal; 22.06.94, pages 29 - 39
- RIBA Journal; May 1994, pages 25 - 29

7. ACKNOWLEDGEMENT

The author would like to thank Law and Dunbar-Nasmith for the plans and sections Figures 1 - 3.

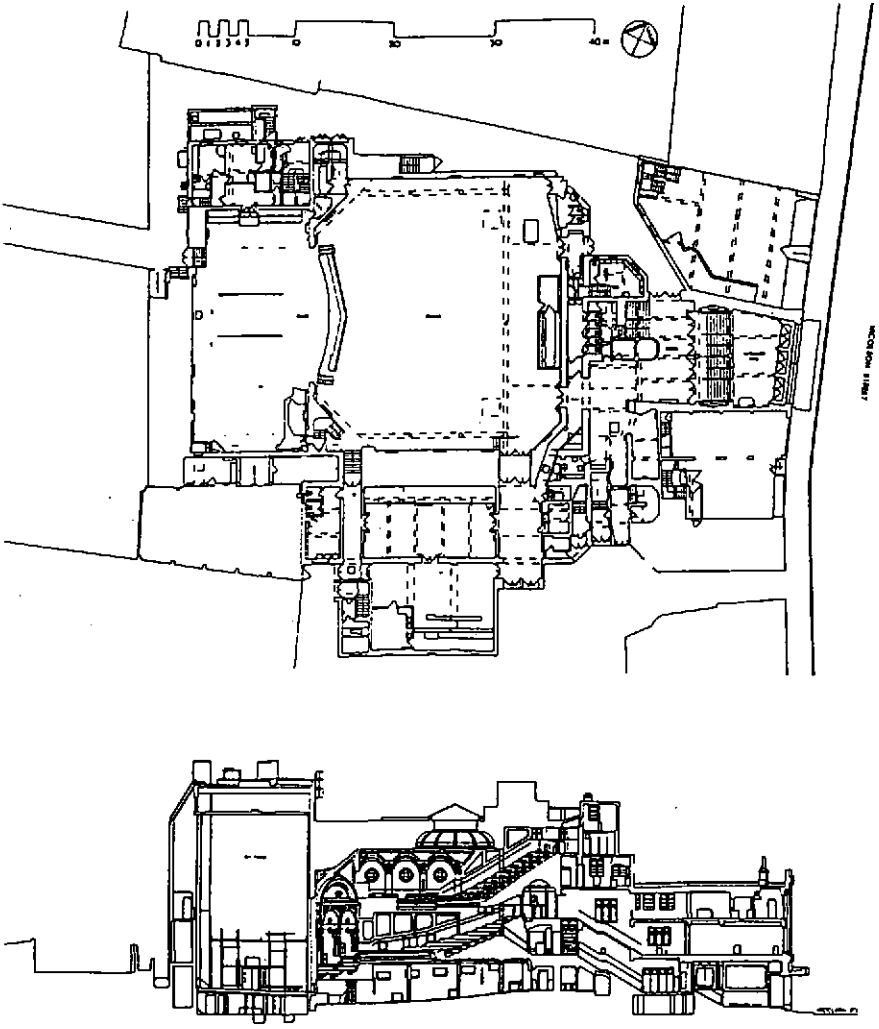

Figure 1. Plan and Section of Former Empire Theatre

EDINBURGH FESTIVAL THEATRE

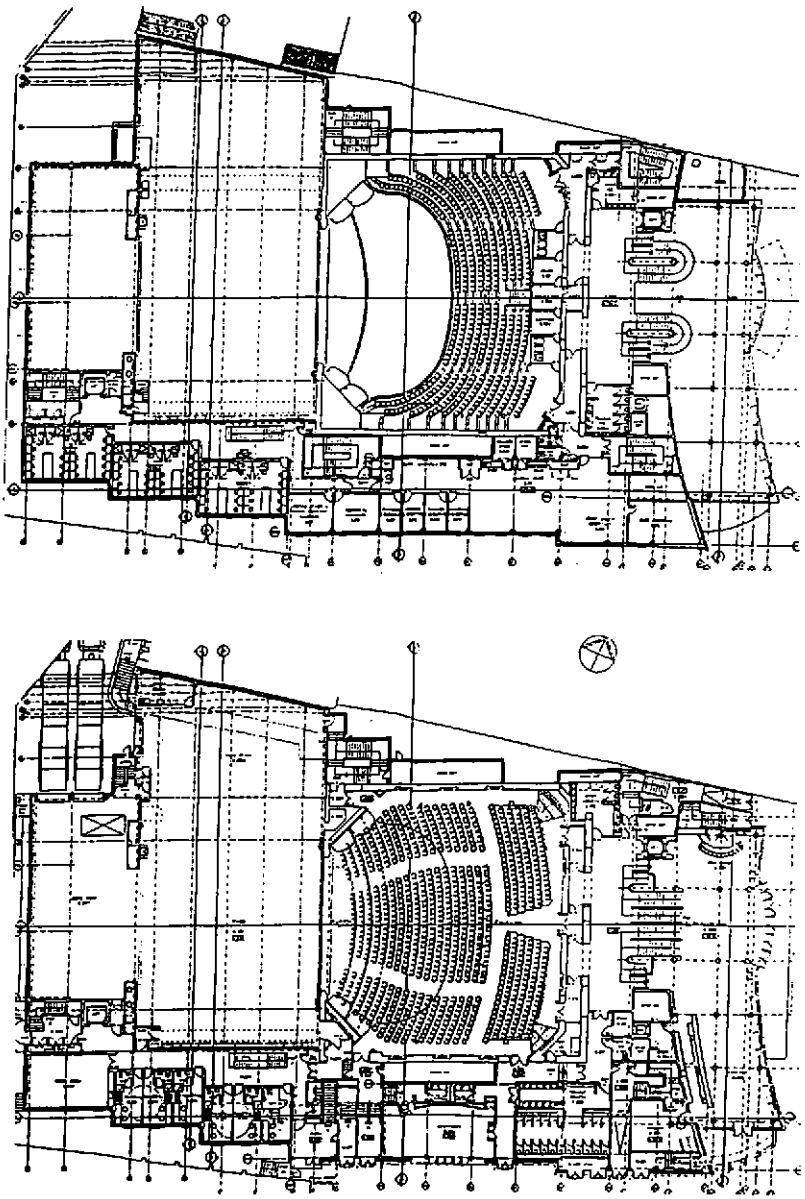

Figure 2. Plans at Stalls and Dress Circle Level, Edinburgh Festival Theatre

EDINBURGH FESTIVAL THEATRE

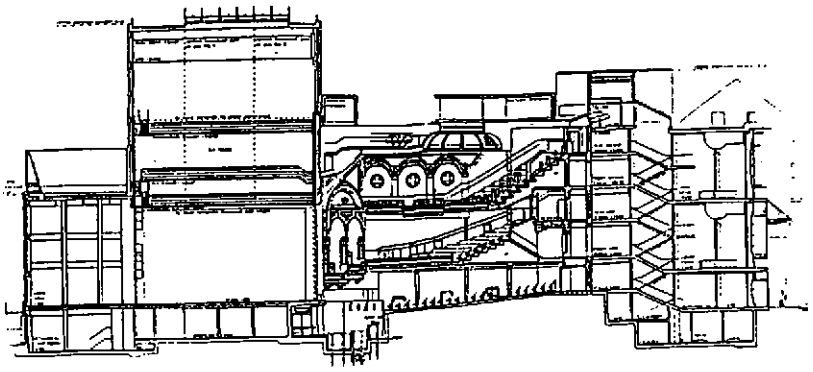

Figure 3. Edinburgh Festival Theatre: Longitudinal Section

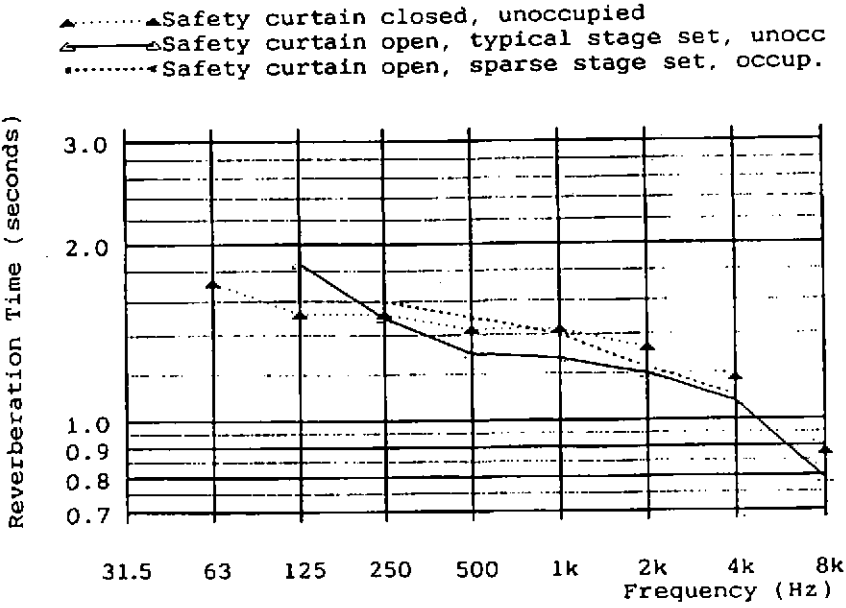

Figure 4. Reverberation Time in Completed Auditorium