Acoustic Design and Performance of The Bruce Mason Theatre

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Abstract: The Bruce Mason Centre Auditorium takes an innovative approach to variable acoustics with the use of a variable volume operable ceiling. The overall acoustic design objective was to achieve excellent acoustics with a high level of reverberance for symphony, and good speech clarity with a reduced level of reverberance for theatre and drama. The results of commissioning measurements carried out in the auditorium show that a high degree of variability between the acoustic conditions for Symphony Mode and Theatre Mode has been achieved and that the operable ceiling/variable volume concept is highly successful. This paper presents the design concept developed for the auditorium, the findings of a 1:25 scale acoustic model study, and the results of the acoustic commissioning measurements carried out in September 1996.

INTRODUCTION

Auckland's North Shore region has a strong community identity of its own, and has been in need of a mid-sized performing arts venue for some time. In 1993 the North Shore City Council approached Marshall Day Associates to assist with the design of a 900 seat multipurpose auditorium able to accommodate everything from boxing to Beethoven, with no compromises. The client was both informed and demanding. Marshall Day Associates was asked to outline the acoustic objectives for the primary uses of speech and music. The client then wrote these objectives into the contract for the Design/Build team. Marshall Day Associates was subsequently contracted to meet the objectives of the detailed Performance Brief: reverberation time (RT) of 1.7s. for symphony and 1.1s. for theatre; Early Decay Time (EDT) of 1.6s. for symphony and 1.0s. for theatre; Clarity (C_{80}) of > -1 dB for symphony and > +1 dB for theatre; Loudness (G) of 2 dB, and Lateral Fraction (L_f) of > 0.15 for symphony.

DESIGN CONCEPT

To achieve these goals, a variable volume design concept was developed by Marshall Day Associates and Avery/Jasmax Architects, which involves an operable shuttered ceiling arrangement.

In Theatre Mode the overhead reflecting panels create a lower ceiling plane which reduces the acoustic volume and reverberation time of the space, and provides strong overhead reflections of sound to enhance speech clarity. In Symphony Mode the hinged overhead reflecting panels can be opened upwards to expose the upper ceiling void and increase the reverberant volume and reverberation time of the room. With the panels open the strong overhead reflections of sound which are not considered desirable for music, are eliminated. The configuration of the auditorium in each of these modes is illustrated in Figure 1.

Other design features include: a rectangular plan form and upper side wall reflectors designed to provide early lateral reflections of sound, and an orchestral shell to provide appropriate conditions for ensemble and avoid sound being lost to flytower in Symphony Mode.

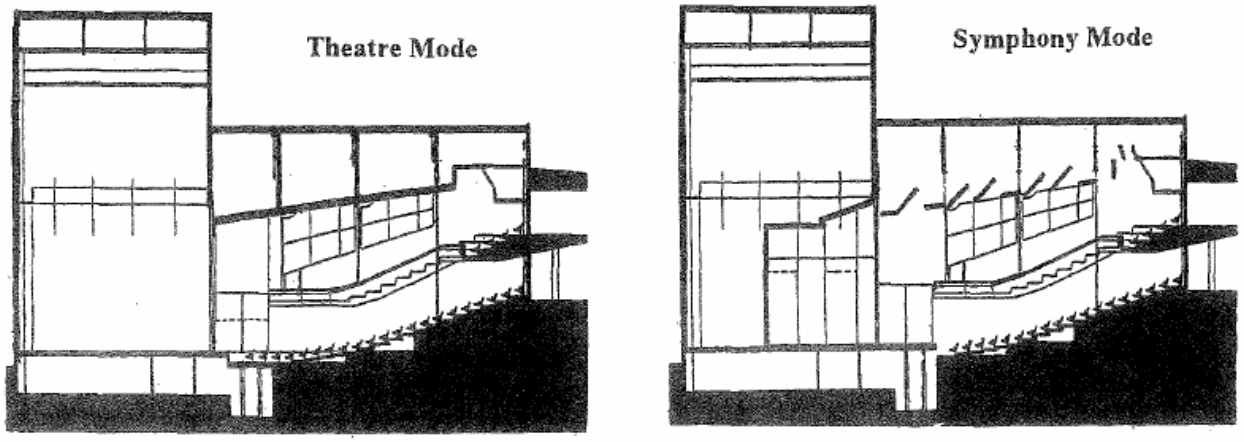


FIGURE 1. Theatre Mode and Symphony Mode

MODEL STUDIES

In the preliminary design phase of this project detailed reverberation time calculations and a comprehensive ODEON computer model study were carried out to determine the degree of variability in reverberation that could be achieved with the operable ceiling concept, and to assess the likelihood of compliance with the Performance Brief. During the detailed design phase a 1:25 scale acoustic model was carried out, using the MIDAS room acoustics measurement package developed by the Acoustics Research Centre at the University of Auckland and the University of Le Mans in France.

An interesting finding of the model study was the 'preferred ceiling panel arrangement' for Symphony Mode to achieve the greatest change in reverberation time (RT). It was originally expected that the longest RT in Symphony Mode would be achieved with the ceiling panels opened fully to vertical as this created the largest opening to the auditorium. However it was found that the longest RT was achieved with the panels angled at approximately 30-40°, and parallel to an imaginary ray drawn from a source position on the centre of the stage.

In Theatre Mode 15% of the ceiling panels are required to be open for lighting purposes. The model study confirmed the need for deployable acoustic absorption in the ceiling void to prevent double-slopes in the reverberant decay, due to the longer reverberation time of the ceiling space.

Overall the model results confirmed the viability of the shuttered ceiling concept and indicated the Performance Brief requirements could be achieved, including a 50% variability in reverberation between the major modes.

COMMISSIONING MEASUREMENTS

The building was officially opened in August 1996 for the modest total cost of NZ$ 12 million - approximately US$ 9000 per seat! Commissioning measurements were carried out in the unoccupied auditorium soon after. Starting pistol shots were recorded via paired Bruel and Kjaer half inch microphones onto digital audio tape, at seven representative seat locations and a 10m reference position, from 2 source positions. The measurement positions correspond with those used in the 1:25 scale model study. The results were again processed and analysed using MIDAS. The averaged results for Early Decay Time and Clarity (C_{80}) are graphed below in Figures 2 & 3.

FIGURE 2. Early Decay Time

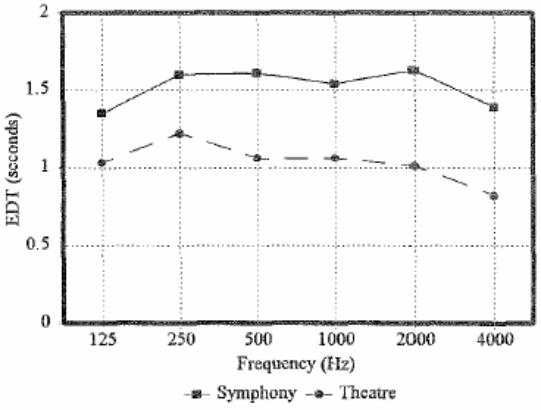
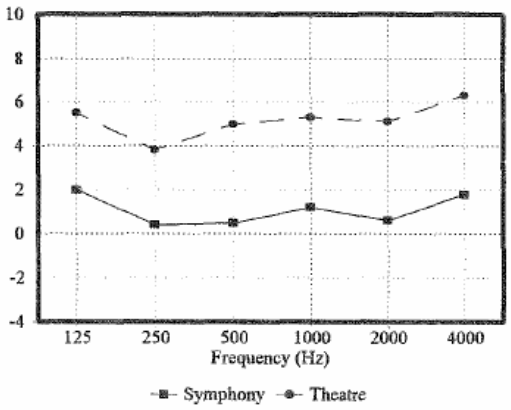


FIGURE 3. Clarity



As the subjective impression of reverberation has been found to correlate more closely with EDT than RT, Figure 2 is perhaps the most significant of the results, demonstrating that a high degree of variability in reverberation time between the major modes has been achieved.

The high measured values of clarity for Theatre Mode confirm the subjective impression of exceptional clarity and the observation that a quiet voice on stage can be clearly understood in the rear of the theatre. In Symphony Mode the values for clarity fall comfortably in the range (-1 to +2 dB), as preferred for symphonicmusic.

The measured values for loudness are uniformly high in both modes with an average value of 5 dB, and as a direct result of eliminating overhead reflections with the open ceiling panel arrangement, the MIDAS measure of spatial impression is very high for Symphony Mode.

In summary, excellent acoustics with a high degree of variability in acoustic conditions between Theatre and Symphony Modes has been achieved, and the shuttered ceiling concept has proved a highly successful and cost effective solution to the multipurpose dilemma.