ACOUSTIC DESIGN OF THE ROSE THEATRE BRAMPTON

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ABSTRACT

The Rose Theatre, Brampton is a community theatre of 930 seats intended for most types of performances including drama, musical theatre, road shows and the Brampton Symphony The theatre breaks convention by locating the Mix booth at the centre of the orchestra thus putting the Mixer out where he can hear what the audiences hears. The house is horseshoe-shaped and features one balcony, tiered seating, a full 45ft width (13.7m) Broadway style proscenium opening, an orchestra pit on a lift and a full catwalk level above the balcony. The deep Proscenium was used to direct energy from stage in the apron area as lateral reflections to seating.

Variable acoustics were accomplished with curtains which retract into pockets which when extended cover the rear wall of the audience seating and the wall surface above the catwalk level. A MathCAD routine to calculate the strength and location of reflections from convex reflectors was used on the proscenium reflectors and five sets of linear ceiling reflectors. The HVAC system was designed for RC20. A novel test procedure was developed for checking the aiming of the reflectors where a light source was aimed at the acoustic reflectors. The reflected light, simulating a reflected sound wave, could then be seen illuminating a portion of the audience area indicating the aiming of the reflector. The background sound level and reverberation time measurements confirmed the background sound level of RC 20 and reverb time ranging from 1.1 to 1.5 sec. Measurements of uniformity of sound in the house showed a variation of +/- 2 dB throughout the dress circle and balcony seating. The Auditorium is described by both performers and patrons as very intimate.

RESUME

Le théatre Rose de Brampton est un theater communautaire de 930 places adapté à la plupart des spectacles; pieces de theater, comedies musicales, variétés et l'orchestre symphonique de Brampton. Le théatre a défié les conventions en avançant la cabine de mixage au coeur de l'orchestre là où le mixeur peut entendre ce que l'auditoire mème entend. Le théatre est ce qu'il y a de mieux en la matière. La sale est en forme de fer-à-cheval et comporte un balcon, des rangées de sieges en gradin, une ouverture d'avant-scène de style broadwayien de 45 pied (13.7m), une fosse d'orchestre sur ascenceur et une passerelle audessus du niveau du balcon. On a tiré parti de la profondeur de l'avant-scène pour diriger l'énergie de la scène vers le tablier en reflection latérale vers les sieges. Grace à les rideaux rétractables dans les poches mais aussi capables de masquer le mur arrière de l'auditorium et aussi celui au-dessus de la passerelle on peut varier l'acoustique. On s'est servi d'une application MathCAD pour calculer la puissance et la location des reflections émises par les reflectors convexes applicables aux reflections de l'avant-scène et aux cinq ensembles linéaires de réflecteurs suspendues au plafond. Le système HVAC est conçu pour RC-20. Un nouveau procédé a été développé pour tester l'orientation des réflecteurs: Une source de lumière est dirigée sur les réflecteurs acoustiques, la lumière réfléchie, simulant une onde sonore réfléchie, peut être ainsi observée illuminant une partie de la sale et précisant l'orientation du réflecteur. Les measures du niveau de fond sonore et du temps de reverberation ont confirmé un niveau do fond sonore de RC-20 ainsu qu'un temps de reverberation oscillant de 1.1 à 1.5 secondes. Les measures de l'uniformité du son dans la sale ont démonstré une variation de +/- 2 dB tant à la corbeille qu'au balcon. Spectateurs et artistes qualifie la sale de plaisanment intime.

1. INTRODUCTION

The Rose Theatre Brampton is a 930 seat community theatre intended for most types of performances including drama, musical theatre, road shows and the Brampton Symphony Orchestra; virtually any type of show except opera. Natural sound is used as much as possible however, reinforcement and amplification is available for events such as rock music.

The Theatre is a "State of the Art" facility designed with all the features of a modern production house but in a much more intimate setting. As acoustical consultants the authors worked closely with the theatre designer, Novita Limited, and the architect, Page & Steele to develop an optimal auditorium providing the best it could for any function and uncompromising in its goals.

The house is horseshoe shaped and features one balcony, tiered seating, a full 45ft width (13.7m) Broadway style proscenium opening, an orchestra pit on a lift and a full catwalk level above the balcony (Figure 1). The stage house is 75ft (22.8m) high accommodating full sets and features catwalks at the proscenium, the house perimeter and a tension grid at the centre of house for maximum lighting flexibility. Additional details can be found in a companion paper "Environmental Noise and Vibration Control of the Rose Theatre, Brampton, Ontario" for discussion of design features controlling noise and vibration from an adjacent Main Line railway.

Figure 1: **House showcasing the horseshoe shape, orchestra pit and stage arrangement.**[1]

2. OVERALL DESIGN FEATURES

The house was designed for intimacy using a horseshoe shape which minimizes the seat-to-stage distances (45 feet to rearmost orchestra seat). Site lines for the orchestra seating were improved using tiered seat sections which results in smaller clusters of seats which enhances the sense of intimacy. The balcony wraps around the entire house with loose seats on the extensions to the proscenium and only seven rows of seats at the centre. The balcony is more steeply raked and lifted above the audience to give a high under balcony aspect ratio. The apron and forestage are thrust into the audience seating, made easier by the horseshoe shape. The forestage is a lift which is lowered to provide a full-depth orchestra pit which extends under the apron.

This theatre breaks convention by locating the mix booth at the centre of the orchestra putting the mixer out where he can hear what the audience hears. A series of acoustic reflectors directs sound energy from anywhere on the stage or orchestra pit to all parts of the Auditorium. These surfaces are located on the proscenium sides and top, side walls, balcony fascia, catwalks and in a series of five reflectors in the ceiling. The rear wall is concave but segmented into convex surfaces of 3m length. A variable acoustic environment is achieved using sound-absorptive curtains over the rear wall of the orchestra seating and the entire wall surface above the catwalk. The curtains are sectioned and manually retractable into closets allowing them to be effectively removed.

A secondary hall and rehearsal space is separated from the main auditorium by a corridor and is acoustically isolated from the main auditorium with room-in-room construction and a floating floor (since the transfer grid did not permit structural separation).

The main HVAC room is remote to the auditorium by 15 meters with ducting to the main auditorium and secondary hall. The stage air handling equipment is directly above the stage because it is necessarily large in size due to the stage heat load but connects directly to the stage.

3. ACOUSTIC CHALLENGES AND SOLUTIONS

In the Rose Theatre, the Mix booth is located in the centre of the house to give the mixers the same exposure to sound that the audience hears. In most, if not all Broadway Theatres, the Mix booth is located at the rear of the orchestra seating which, acoustically, is usually the worst possible location. In an ordinary auditorium with simple raked seating this could not be done because the mixers need to be somewhat above the audience to see the performance. Their movements and the light associated with the console would be distracting to patrons. However at the Rose, this design integrated the Mix booth with the tiered seating, putting a tier behind the Mix booth, thus restoring the site lines and eliminating the light and motion interference.

The full-height stage house which is needed for theatrical production leaves a symphony orchestra on the stage but in an essentially separate room from the house. This posed a conflict which was resolved by providing a full-sized removable orchestra shell.

For theatrical work, catwalks were required in the house ceiling for lighting positions. Acoustically, one or more reflecting surfaces were desired. The solution was to provide a series of curved reflectors across the auditorium at the roof level to diffuse sound energy to the audience. The lighting features tension grid which allows putting lights anywhere within a large area but this grid is also acoustically transparent. The soffits of the catwalks were finished in a convex reflective surface adding to acoustic diffusion. As the tension grid is only required at the centre of the auditorium, a series of acoustic reflectors was arranged in a horseshoe around the tension grid and used to direct sound to the audience, particularly the balcony. However, to provide these reflections, each reflectors was individually oriented to direct sound to specific areas. The calculation routine used for this purpose is described in section 3.2 below.

The deep proscenium of the Rose Theatre was used to direct energy from stage in the apron area as lateral reflections to seating in the middle of the house. Most reflecting surfaces direct sound towards the rear of the house and balconies where additional sound energy is needed. For the Rose Theatre there was also a need to provide access from the audience area to the stage, but this was made difficult by the wide orchestra pit lift. With the lift in its lower position, the stage could only be accessed from the side. The solution was a door which hid a corridor from the audience area to the stage immediately behind the proscenium. This additional depth to the stage was incorporated into the proscenium resulting in a 3m proscenium depth in the upstage direction. This depth provides a location for a large convex reflecting surface at both sides and top of the proscenium used to reflect energy to the middle of the house. This design was complimented by two additional sets of reflectors in the ceiling which cross the full width of the house above the forestage and the orchestra pit. These are used to direct energy from the orchestra pit to the house and balcony.

3.1 Acoustic Reflectors

The majority of the sound on the stage originates from the orchestra pit and from the centre of the apron to about 2 meters upstage of the curtain line, however, orchestral music can originate from anywhere on the stage. Loudspeakers are located in a cluster at centre stage above the proscenium. Speaker systems which would naturally be located at the proscenium sides are also brought in by road shows.

A series of ceiling reflectors starting at the proscenium was used to direct sound energy to all parts of the auditorium. Reflectors on the proscenium and two rows above the apron are described above. A third and fourth row of reflectors at the roof reflect and diffuse sound for the whole of house. A special fifth series of reflectors arranged in a horseshoe shape that is effectively concentric with the house seating are convex and 4m deep to direct sound to the balcony seating.

A variable acoustic environment was accomplished with curtains which retract into pockets which when extended cover the rear wall of the audience seating and the wall surface above the catwalk level. They are operated manually and are made in five meter long sections allowing flexibility in absorption. When retracted, the curtains reveal a series of convex shapes imposed upon the concave rear wall. This minimizes slapback to the stage, provides diffusion, and also provides diffuse reflections to rear seats which are -4 dB relative to the direct sound.

The side walls were constructed of concrete block finished with drywall and applied with wet parging eliminating any air pockets between the drywall and block. Focusing is minimized and “slapback” to the stage is minimal, occurring only at low frequencies. The auditorium ceiling is double-layer drywall and resiliently supported forming part of the acoustic isolation system for exterior noise control. Multi-layered drywall was used to minimize the selective sound absorption associated with drywall.

3.2 Analysis Details

Initially, a 3D model (Figure 2) was developed for the purpose of acoustic analysis. However, the desire was to use a large number of curved surfaces which could not be properly represented in acoustic modeling software such as EASE. That is, the modeling software treats curved surfaces as a series of planes and calculates a reflection from each as if it was a specular reflection without considering the diffusion associated with the curvature. Considering the complexity of the room and number of curved surfaces, it was decided to develop a MathCAD routine to calculate the strength and location of reflections from convex reflectors. Each convex reflector was identified by the arc chord length, location, and the slope of the chord. Considering a plane geometry within the room, a source location and the reflector geometry, the receiver location could be determined. Based on the curvature, sound diffusion could be determined. From this, one could determine the relative strength of the direct and reflected signals including the effect of the curvature. More usefully, the routine was modified to select source and receiver locations and then determine the reflector geometry required to direct sound of required strength at the receiver location. For the four sets of linear reflectors (two proscenium, two in ceiling), a small number of calculations provided all of the required information to identify an individual seat and determine reflections received at that seat from several reflectors and the strength of those reflections relative to the direct sound. To these are added the lateral reflections from side walls and tier walls.

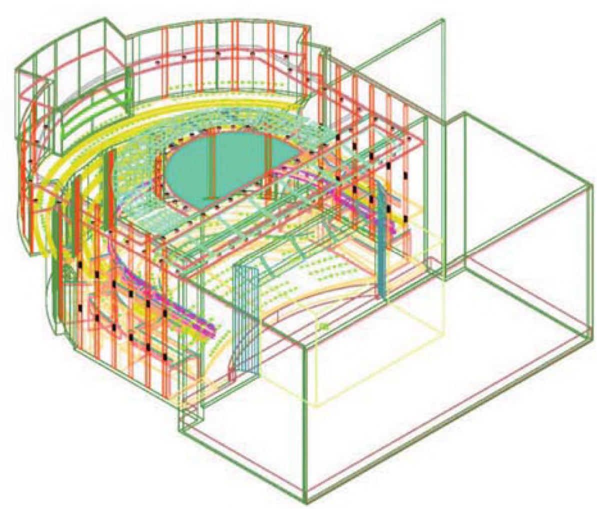

Figure 2. Initial 3D Model of the Rose Theatre Brampton

Figure 3 shows a sample reflection in elevation. The origin is the front of the apron stage at elevation zero. The incident ray shown in red starts 2m upstage (-2m) is reflected from the upstage end of the reflector at an elevation of 14m to a location 11m downstage of the apron. A similar calculation for the downstage end of the reflector gives the distribution of sound from this reflector.

In the case of the “horseshoe” reflectors located beyond the tension grid, a separate series of calculations was required for each of the reflectors. Each was oriented to direct sound from either the forestage or orchestra pit to a particular area of the rear audience or orchestra seating.

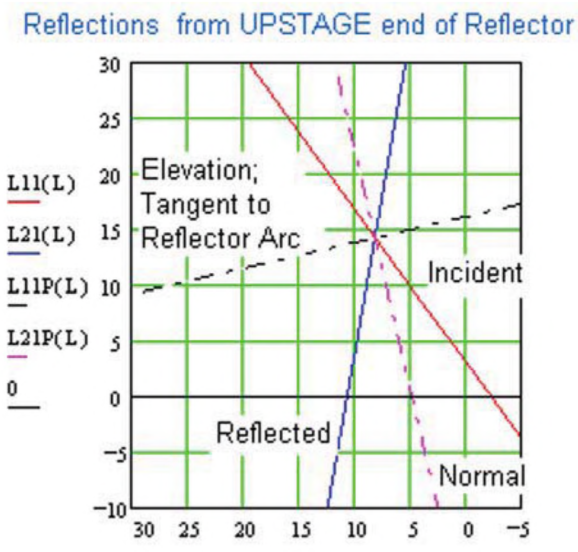

Figure 3. Graphic Output from MathCAD Reflection Routine

The HVAC system was designed for RC20 in the auditorium. This value was appropriate considering the size of the auditorium and the short distance to the rearmost seats. The mechanical equipment room could not be isolated as a separate structure from the auditorium because the entire building is effectively located on a single foundation as described in the companion paper. A room-in-room system was used for the mechanical room for noise control. Space limitations in the building limited the size of mechanical equipment. Thus, it was not possible to select the quietest equipment, particularly for the AHU supplying the main auditorium. Consequently a double silencer system was developed for the 15 metre ducts leading from the mechanical room to auditorium, both silencers being required to provide high insertion loss. These silencers were developed for the project by the manufacturer and were performance tested in an independent lab before being accepted

4. NOVEL TECHNIQUE FOR ACOUSTIC TESTING

A novel test procedure was developed for checking the aiming of the reflectors. The reflectors were covered temporally with a reflective Mylar plastic. With the room darkened, a high power, high directivity light source was aimed at the reflectors. The reflected light, simulating a reflected sound wave, could be seen illuminating a portion of the audience area indicating the aiming of the reflector. Adjustments were made to fine-tune the aiming. As a second check, a series of wooden markers were placed on the stage floor thus illuminating the stage. From the audience seats, one can see the stage floor directly on the Mylar surface on the reflectors. From each seat, reflections of the stage floor can be seen in several reflectors indicating that sound energy is being directed from several reflectors to each seat. The photo (Figure 4) shows the light source being used to test the aiming of the reflectors.

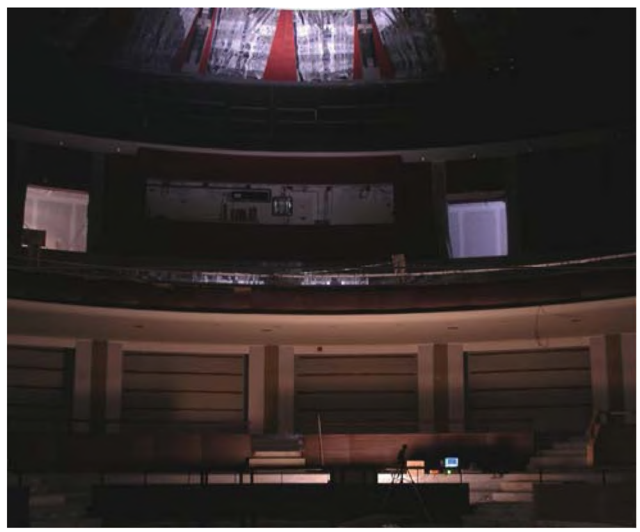

Figure 4. Illustration of light source being used to test the aiming of reflectors. Light behind camera aimed at reflectors at top, reflects to balcony seating, centre (foreshortened).

Background sound level and reverberation time measurements confirmed the background sound level of RC 20 and reverb time ranging from 1.1 to 1.5 sec at 500Hz (Figure 5). Similarly, measurements using the MLSSA testing system confirmed the multiple reflections at each seat and also calculated acoustic parameters such as centre time and C50 and C80.

5. ROSE THEATRE, USERS COMMENTS

Over time, the Rose Theatre sound system staff have developed five different configurations for the variable acoustics: the curtains are either fully removed, fully drawn or one of three intermediate positions are used depending on the type of performance. The variability in curtain arrangement points to a degree of sophistication that demonstrates the value of the variable acoustic feature.

Musicians normally expect some slapback from the rear wall to the performer on stage and some houses are known to be difficult to work in because of the strength of these reflection. However, at the Rose Theatre, the slapback is described as minimal and is comprised primarily of low bass frequencies which do not interfere with speech or musical timing.

The Auditorium is described by both performers and patrons as very intimate. Patrons regularly comment on hearing the nuances of performance and acoustic details, even the "zip" of a finger sliding on the strings of an unamplified acoustic guitar can be heard in the rear most balcony seats. Measurements of uniformity of sound in the house showed a variation of only +/- 2 dB throughout all of the dress circle and balcony seating. The Rose Theatre, Brampton was designed to be a State-of-the-Art facility and has fulfilled that objective in every aspect, particularly in acoustics

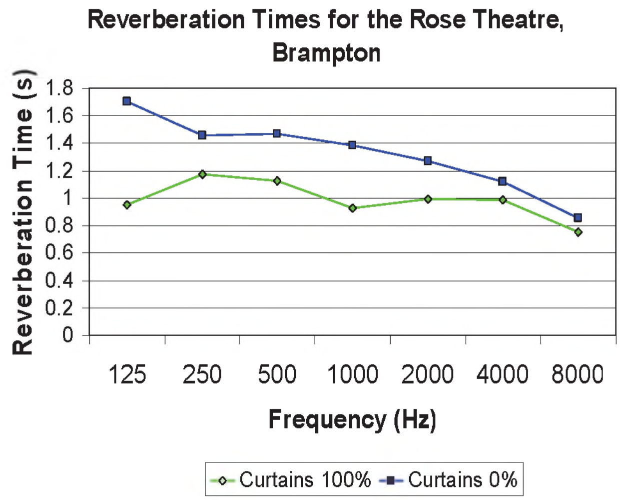

Figure 5. Reverberation times for the Rose Theatre Main Auditorium, with the curtains out, and with the curtains withdrawn, on the Balcony.

6. REFERENCES

1: **http://rosetheatrebackstage.blogspot.com/**

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