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ACOUSTIQUE CANADIENNE publie des articles arbitrés et des informations sur tous les domaines de l'acoustique et des vibrations. On invite les auteurs à soumettre des manuscrits, rédigés en français ou en anglais, concernant des travaux inédits, des états de question ou des notes techniques. Les soumissions doivent être envoyées au rédacteur en chef. Les instructions pour la présentation des textes sont exposées à la fin de cette publication.

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GUEST EDITORIAL / ÉDITORIAL INVITÉ

Canada has a vibrant acoustics consulting community and this issue provides several good examples of the variety of work being undertaken by these firms. Canadian acoustical consultants work in firms which vary in size from one man companies to large multi-national engineering firms with thousands of employees, many of which work around the world bringing Canadian expertise to other countries. The large number of acoustical consultants in Canada is also indicative of the continuing need for services in this area and the interesting technical jobs which it spawns. Canada has a good reputation for producing acousticians in spite of the small number of universities in Canada which have dedicated programs in acoustical engineering.

Much of the credit for the variety of firms goes to various provincial governments, starting in the mid 70's with Ontario, who recognized the importance of controlling the impact of noise on their citizens and started to ask for noise studies when new highways, industries and residential developments were undertaken. Noise is now a recognized part of many Federal and Provincial environmental assessments and most of this work is done by the acoustical consulting community. They are also involved in design of theatres, hotels, condominiums, factories, offices, quarries, mines. Their work includes occupational noise assesement and control design for environmental noise abatement, office and residential privacy, HVAC noise reduction, performance spaces and much more. They are also involved in developing and applying noise standards in Canada and internationally.

The papers presented here cover a range of topics. There is a correction to the textbook information on transformers, a case study for a highway project and two papers about the design of a new theatre discussing both the acoustic considerations of the space as well as the isolation of the theatre from environmental noise and vibration. All are representative of the high caliber and down to earth practicality of the acoustical consulting community. In addition, the importance of clear communication in this field is amply demonstrated by the straightforward text of the papers, which required minimal editing before going to print.

If one were to examine where noise standards and assessment practices are in Europe, it is evident that North America still has some catching up to do. As an example, this consulting issue of Canadian Acoustics is lacking a paper on occupational noise. It is not that acoustical consultants never get involved with this topic, but no governments in Canada require acoustical design of workplaces and this is reflected in the lower prevalence of this work and the continued number of compensation claims for occupational hearing loss. By contrast EU regulations require manufacturers to provide sound level data for all equipment used in their industry and several countries have minimum requirements for sound absorption

Le Canada possède une vibrante communauté de consultants en acoustique et cette édition fournit plusieurs bons exemples de la variété du travail réalisé par ces firmes. Les consultants canadiens en acoustique travaillent dans des firmes qui varient en taille du travailleur autonome à de larges firmes d'ingénierie multinationales comprenant des milliers d'employés dont plusieurs travaillent à travers le monde, fournissant l'expertise canadienne à d'autres pays. La grande quantité de consultants en acoustique au Canada est aussi un indicateur de la constante demande pour des services dans ce domaine et pour les passionnants emplois techniques qui y sont générés. Le Canada a la réputation de former de bons acousticiens malgré le faible nombre d'universités qui ont des programmes dédiés en ingénierie acoustique.

Une grande partie du crédit pour cette variété d'entreprises va à différents gouvernements provinciaux qui, en commençant au milieu des années 70 avec l'Ontario, ont reconnu l'importance de contrôler l'impact du bruit sur leurs citoyens et on commencé à demander des études de bruit pour de nouveaux projets d'autoroutes, industries ou développement résidentiels. Le bruit fait maintenant partie de plusieurs évaluations environnementales fédérales et provinciales et la majeure partie de ce travail est réalisé par la communauté des consultants en acoustique. Ils sont aussi impliqués dans la conception de théâtres, hôtels, condominiums, usines, bureaux, carrières et mines. Leur travail inclut l'évaluation du bruit en milieu de travail et la conception du contrôle pour la réduction du bruit environnemental, l'intimité au bureau et dans les résidences, la réduction du bruit des systèmes de ventilation, la conception des lieux de performance artistique et plus encore. Ils sont aussi impliqués dans le développement et l'application des normes standards au Canada et à travers le monde.

Les articles qui sont présentés ici couvrent une variété de sujets. Il y a une correction sur l'information sur les transformateurs fournie dans les livres, une étude de cas pour un projet d'autoroute et deux articles traitant de la conception d'un nouveau théâtre et qui discutent autant des considérations acoustiques de l'espace que de l'isolation du théâtre du bruit et de la vibration environnementaux. Tous sont représentatifs du haut calibre et du sens pratique de la communauté des consultants en acoustiques. De plus, l'importance d'une communication claire dans ce domaine est amplement démontrée par la directivité des textes de ces articles qui n'ont demandé que de légères révisions avant d'être mis sous presse.

Si on examinait où en sont les normes et les pratiques d'évaluation du bruit en Europe, il serait évident que l'Amérique du Nord a du rattrapage à faire. À titre d'exemple, cette édition de « Canadian Acoustics » n'a pas d'article sur le bruit en milieu de travail. Ce n'est pas que les consultants in industrial spaces. However, if the quality of the papers published in this issue is any indication, the Canadian consulting community will be up to the challenge when the day for tighter controls comes.

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en acoustique ne sont jamais impliqués pour ce sujet particulier mais plutôt parce qu'aucun gouvernement au Canada n'exige une conception acoustique des milieux de travail et ceci est reflété par la faible prévalence de ce type de travail et par les demandes d'indemnisation continues pour la perte d'audition. En contrepartie, la réglementation européenne exige que les manufacturiers fournissent les données de bruit pour tous les équipements utilisés dans leurs industries et plusieurs pays on des exigences minimum pour l'absorption du bruit en milieu industriel. Cependant, si la qualité des articles publiés dans cette édition peut prouver quelque chose, c'est que la communauté canadienne de consultants en acoustique sera à la hauteur du défi lorsque les exigences pour le contrôle du bruit seront resserrées.

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ENVIRONMENTAL NOISE AND VIBRATION CONTROL OF THE ROSE THEATRE, BRAMPTON, ONTARIO

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ABSTRACT

The Rose Theatre in Brampton, Ontario was to be constructed twenty meters away from a CN main railway line (which includes commuter and freight rail traffic) and on top of a pre-existing underground parking garage which was to remain intact and in operation during the course of construction. A full concrete slab could not be supported by the pre-existing parking garage columns; therefore, a transfer grid, designed by the structural engineer, was employed and as a result a typical "room-within-a-room" construction could not be conventionally achieved. Railway airborne noise is controlled to meet the interior objective of RC 20 by providing a "floating" shell enveloping the entire building. Exterior concrete pre-cast panels are resiliently supported and resiliently connected back to the building and the entire roof slab was vibration isolated from the structure. For railway-induced vibration, the building was supported on a transfer grid which was in turn supported by 250 mm thick rubber vibration isolation pads. The entire building, including exterior shell, stairs and elevators is vibration isolated from ground-borne rail vibration. The measured vibration levels (and the noise radiated by vibrating surfaces) in the theatre were controlled to well within the design objective.

RESUME

Le théatre Rose de Brampton devait étre construit à vingt mètres d'une voie principale du CN (sur laquelle circulent trains de marchendises et trains de voyageurs) et en aplomb d'un parking souterrain pré-existant devrant rester intact et opérationnel durant toutes les étapes de la construction. Il était impossible de faire supporter une large chape de béton par les colonnes du garage pré-existant, il a donc fallu que l'ingénieur conçoive une grille de transfert si bien que construire une "pièce au sein d'une autre" sur la modèle conventionnel ne pouvait étre envisagé. Les bruits ambiants provenants de la voie ferrée sont maitrisés à l'aide d'un "bouclier flottant" enveloppant tout l'édifice en vue de respecter un objectif interieure de RC-20. Les panneaux extérieurs en béton préfabriqué sont montés sur supports isolants et connectés au bâtiment par isolants. La dale du toit a été isolée de toute vibration de la structure. En ce qui concerne les vibrations provenant du chemin de fer, l'édifice prend appui sur une grille de transfert elle-mème s'appuyant sur des tampons de vibration en caoutchouc de 250mm d'épaisseur. Tout l'édifice, envelope extérieure, escaliers et ascenceurs inclus est à l'épreuve des vibrations imprimées par les rails. Les niveaux de vibration measurés (et les bruits diffusés par les surfaces vibrantes) dans le theatre ont été ramenés bien en-de-ça des objectifs du design.

1 INTRODUCTION

Swallow Acoustic Consultants Limited (SACL) was the Acoustic Consultant for The Rose Theatre, Brampton project. All acoustics, noise and vibration control aspects for the theatre were addressed (auditorium room acoustics, mechanical noise control, environmental noise control). This case study discusses the environmental noise and vibration control aspect of the project. Please also refer to a companion paper titled "Acoustic Design of the Rose Theatre, Brampton".

The Rose Theatre is located in the vicinity of Queen Street East and Main Street North, Brampton – approximately twenty metres from a Canadian National (CN) main railway line. The railway line includes commuter (GO) train and freight train traffic. The freight trains are powered by up to four locomotives, which produce very high sound levels, particularly in the low frequencies.

Pre-design noise and vibration measurements at the site indicated that both the railway airborne and structure-borne (through ground vibration) noise were of great concern, and extensive noise and vibration control was required to meet the objectives in the theatre.

The site contained a pre-existing underground parking garage, which The City of Brampton requested remain fully operational during construction. In addition, the allowable mass of the theatre was constrained to not exceed the structural capacity of the pre-existing parking garage columns. For this reason, a transfer grid, designed by the structural engineer, was employed and as a result a typical "room-within-a-room" construction could not be conventionally achieved, as it would require a gap in the transfer grid – a structural impossibility.

The environmental noise control design consisted of vibration isolation of the entire support structure of the theatre and the entire exterior shell including stairs and elevators.

2 DESCRIPTION OF FACILITY

The theatre consists of a 5,950 square meter (64,000 square feet) main space with an 880 seat Auditorium and 160 seat Secondary Hall. The Auditorium is in a horseshoe shape with a single shallow balcony designed for excellent sight lines and acoustic properties. The stage contains a full fly-tower. The Secondary Hall is intended both as a separate venue for film, dance, recitals and as a rehearsal space for the main auditorium. The main entrance hall's exterior envelope consists of a dominantly glazed exterior envelope, while the rest of the theatre's exterior is made up of pre-cast concrete panels.

3 CRITERIA

The design goal was to attenuate environmental noise transmitted into the Secondary Hall and Auditorium to inaudible sound levels. Because the noise criterion due to HVAC in the Auditorium and Secondary Hall was selected to be RC-20, the objective to control the railway noise and vibration was therefore selected to be approximately RC-15 (or to below perceptible sound levels in the auditorium).

The environmental noise control design was limited to rail and road traffic noise, as these sources were determined to be the major environmental noise sources affecting the site. Other sources, such as aircraft noise were determined to be rarely audible in the vicinity of the theatre.

4 MEASUREMENTS AND ASSESSMENT

Pre-design noise and vibration measurements were taken at various locations on site – particularly at locations on the parking garage column caps.

Sound level measurements indicated that the dominant noise source was freight train traffic, with high levels of low frequency noise – Approximately 105 dBL at 80 Hz. Freight trains were measured to be in the range of 90 dBA at the approximate location for the nearest exterior wall (northwest corner of the building). The sound levels at the southeast side of the building were measured to be approximately 85dBA, partly contributed by the train noise reflected off the existing buildings facing the theatre. The measurement at this location was significant as this is the location of the entrance hall, which consists of a glazed exterior wall, with the major concern being that the noise would be transmitted into the entrance hall, continuing into the Auditorium and Secondary Hall. The frequency content of the measured train sound levels at the location of the north west corner of the theatre are included with Chart 1.

Vibration measurements were conducted at several locations throughout the site – particularly at locations in the vicinity of the auditorium. Measurements were taken both at mid-span locations (where the vibration is greatest) and on column caps and retaining walls (where the theatre structure is supported) of the existing underground parking garage, located below the site.

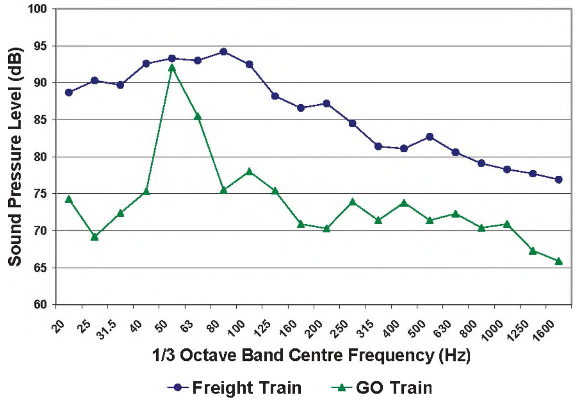

Chart 1: Train Sound Level Measurement Results; Rose Theatre Site, Brampton (2000).

Rail vibration was measured to be 0.15 mm/s RMS, with a maximum vibration velocity of 0.1mm/s at 31 Hz. A summary of train vibration measurements are included in Chart 3 (refer to Section 7.0). The corresponding sound pressure level resulting from the vibration of the ground was calculated to be at a sound level of approximately RC-45. Although some reduction via the building components was expected, a room located on the upper floor of the parking garage (i.e. the auditorium) would still be expected to exhibit sound levels on the order of RC 35 to 40 due to train vibration.

The results of the sound and vibration level measurements indicated that a standard (non-vibration isolated) construction of the theatre would exceed the design objective and train noise would be clearly audible in the Auditorium and the Secondary Hall.

5 ISOLATION DESIGN

5.1 Ground-Borne Vibration Isolation

The vibration isolation design was conducted using an impedance model method of calculation. The calculation models the ground-borne vibration propagating through the parking garage columns into the building. Vibration reduction occurs at impedance mis-matches, for example at the column/floor interface. Vibration isolation pads were introduced to the model at the top of the parking garage.

Calculations indicated that a 20 dB reduction in the range of 25 to 80 Hz could be achieved by installing vibration isolation pads with a static deflection of 25mm. The calculated reduction of 20 dB in vibration was considered to be sufficient to attenuate vibration induced sound levels from RC-35 to RC-15, thus meeting the criterion in the auditorium. A schematic of the impedance model is displayed in Figure 1, and a chart of the calculated noise reduction is displayed in Chart 2.

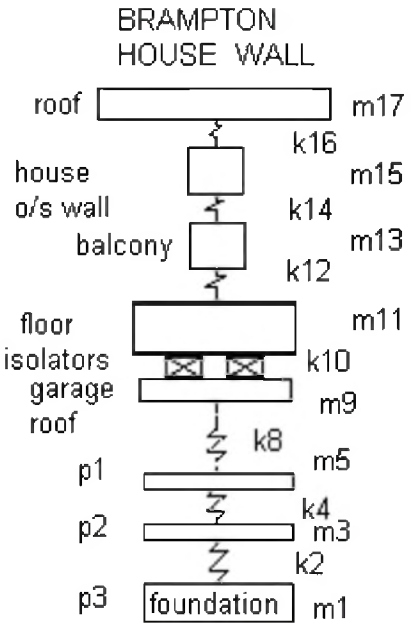

Fig. 1: **Impedance Model Schematic**

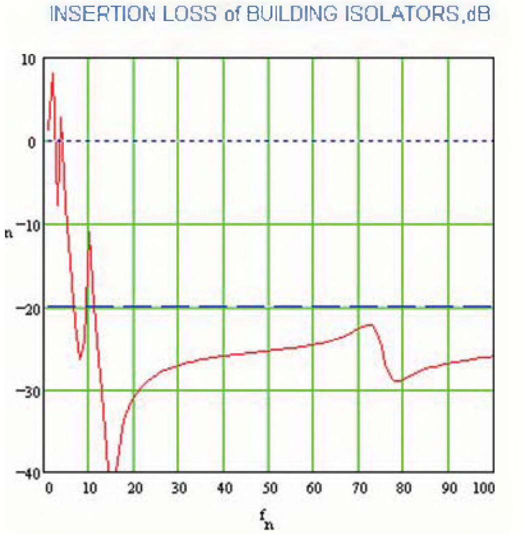

Chart 2: **Calculated Attenuation through Bearing Pad Isolators**

A transfer grid was designed by the structural engineer. As the vibration isolation pads cannot be loaded to the same stress as concrete, the existing parking garage column caps were increased in size to accommodate the vibration isolation pads. Refer to Figure 2 for a photo of a bearing point including isolation pads, and a view of the structural transfer grid. The building isolation pads are laminated steel and natural rubber, made in seven different load capacities. Column loads varied greatly so a selection of different pads was used at each column cap to match the load.

To accommodate for seismic loading, shear pads were also introduced to the design. The pads were installed pre-compressed between two plates by welded iron rods, and once in place the rods were removed. The provision for snow loading was also taken into account in the design of the roof isolation pads.

Fig. 2: **Column Cap with Isolation Pads; Structural Transfer Grid Visible Above**

5.2 Exterior Wall Isolation

Sound level measurements indicated that a conventional construction to attenuate airborne noise due to the rail traffic would be prohibitive (e.g. unrealistically thick walls and roof would be required). Therefore, a design incorporating a resiliently connected exterior shell for the theatre was investigated. The pre-cast concrete panels, which were also isolated from the ground by vibration isolation pads, were resiliently fastened to the structure. Refer to Figure 3 for a photo of the pre-cast panel vibration isolation, showing the gravity pad and the panel tie-back isolation. The exterior partition construction consists of the sandstone finish, pre-cast panels (225mm concrete) fastened resiliently to the structure via the vibration isolation system, semi-rigid insulation in the air space (250mm airspace) and an interior partition consisting of concrete block.

Fig. 3: **Pre-Cast Panel Vibration Isolation**

Calculations indicated that the "weakest link" of the exterior envelope would be through the extensive exterior glazing in the entrance hall. The train noise could reach a sound level equivalent to NC-45 in the entrance hall. This was taken into account when designing the vomitories; including upgrading the wall construction, and the installation of acoustic wall panels throughout the vomitory creating a sound lock to attenuate noise passing through an open door (i.e. a patron is entering/exiting during a performance).

5.3 Roof Isolation

The roof was supported on vibration isolation pads with a static deflection of 9mm. An off the shelf commercial isolation pad was selected for the roof isolators, and custom isolators were constructed to support the roof curb. To accommodate for the snow load, a "bobbin" was placed on the interior of the dome shaped pad in order to withstand the loading of high snow fall.

6 IMPLEMENTATION OF ISOLATION

6.1 Testing of Building Isolation Pads

Because the entire structure of the theatre was to be supported by the vibration isolation pads, extensive testing was set as a requirement to the manufacturer. Randomly selected building isolation pads were tested incrementally to 150% of the calculated load. Testing of randomly selected samples of each type of pad were witnessed by SACL engineering staff, and testing reports for all pads were also reviewed by SACL engineers.

6.2 Isolation Pad Placement and Pouring of the Transfer Grid Slab

Each bearing point of the structure was meticulously inspected to ensure that the proper vibration isolation pads and configuration of the pads were installed. The isolation pad serial numbers, type designation, and a photograph of the installation were taken and catalogued prior to pouring the transfer grid structure.

To maintain the isolation gap while pouring the concrete transfer grid, a variation of sand casting was employed: With the forms in place, the void was filled with sand to a level matching the top of the isolation pads. The sand was then mechanically compacted, and covered with a sheet of plastic. The concrete was poured in place, and once cured; the sand was washed out of the void leaving a clear isolation gap. A photo of a bearing point vibration isolation pad configuration, with the compacted sand also in place, is shown in Figure 4.

6.3 Construction Site Inspection

Weekly site inspection was conducted to ensure that the vibration isolation gap was maintained and free of flanking paths. As the techniques employed in maintaining the isolation gap were not typical, the contractors required on-going guidance in order to maintain the vibration isolation. For example, the piping and electrical conduit required an isolation detail when passing from the non-isolated parking garage to the isolated slab above.

Fig. 4: Structural Isolation Pads, immersed in Compacted Sand

7 SUBSTANTIAL COMPLETION – NOISE AND VIBRATION MEASUREMENTS

Noise and vibration measurements were conducted when the theatre was at substantial completion. Vibration measurements indicated that the noise resulting from ground-borne vibration in the auditorium would meet RC-15. The vibration measurements, referenced to the original assessment measurements are included in Chart 3.

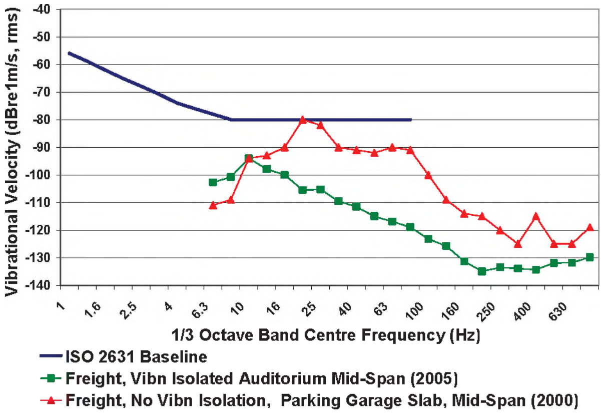

Chart 3: Freight Train Vibration Levels

SACL engineers listened for trains (during several freight train pass-by) in the auditorium and secondary hall. Subjectively, it was concluded that the train noise was inaudible in the RC-20 auditorium.

8 CONCLUSION

The noise and vibration control design met the objectives for environmental noise control in the Auditorium and Secondary Hall of the Rose Theatre Brampton.

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.

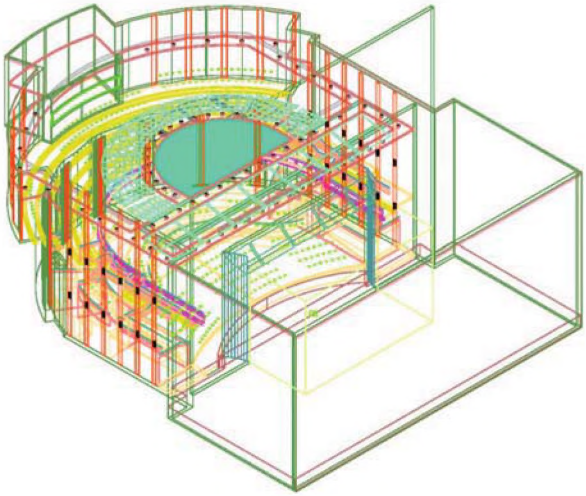

Figure 2. Initial 3D Model of the Rose Theatre Brampton

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.

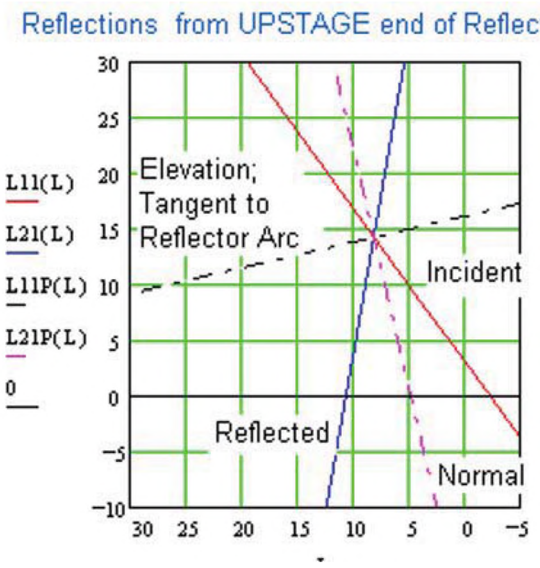

Figure 3. Graphic Output from MathCAD Reflection Routine

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.

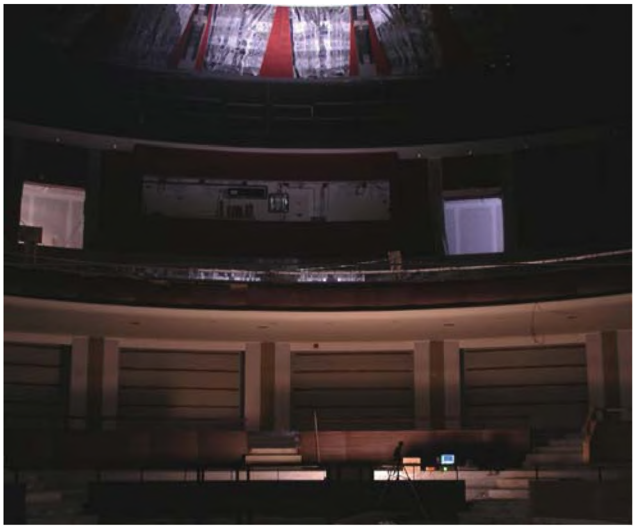

Figure 4. Illustration of light source being used to test the aiming of reflectors. Light behind camera aimed at reflectors at top, reflects to balcony seating, centre (foreshortened).

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

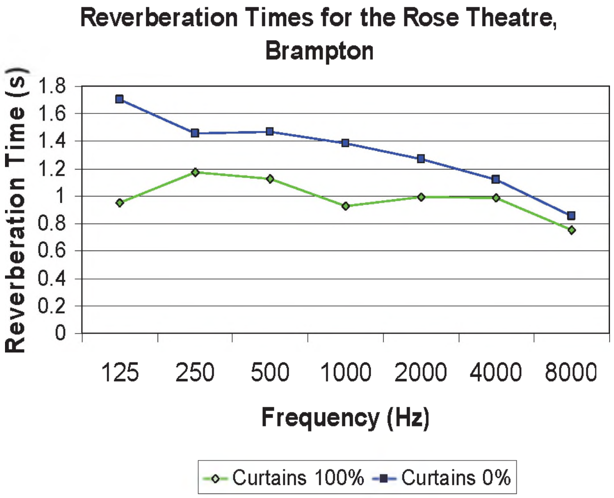

Figure 5. Reverberation times for the Rose Theatre Main Auditorium, with the curtains out, and with the curtains withdrawn, on the Balcony.

6. REFERENCES

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

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TOWARD A REALISTIC ESTIMATE OF OCTAVE BAND SOUND LEVELS FOR ELECTRIC TRANSFORMERS

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ABSTRACT

The typical starting point, when evaluating the sound emissions of a proposed transformer, is to obtain the manufacturer's sound level data or develop an estimate using generic prediction equations from a published textbook. If sound level information is available from the transformer manufacturer – whether measured or estimated – it is usually given only in terms of an overall A-weighted ("dBA") value. So, for detailed analysis in octave frequency bands, textbook information is still usually required, in terms of the spectral weightings needed to apportion the single dBA level into its component octave band sound levels. Unfortunately, the information in the published reference texts varies enormously with regard to the suggested spectral weighting corrections. The corrections in some texts are internally inconsistent, and the discrepancy among different texts (even those which cite the same primary references) is severe enough to call the whole body of data into question. This paper enumerates the inconsistencies and discrepancies within and among several commonly used acoustical engineering text books and compares the textbook levels to a wide body of data collected at numerous outdoor transformer installations throughout Ontario. Suggestions are provided for realistic spectral weightings and sound level estimates for transformers, on the basis of the measured data.

RÉSUMÉ

Le point de départ typique lors du processus de prédiction des émissions sonores d'un futur transformateur est d'obtenir des données de niveaux sonores du fabricant ou de développer une estimation en utilisant des équations de prédiction génériques à partir d'un manuel publié. Si des données de niveaux sonores sont disponibles auprès du fabricant de transformateur – qu'elle soit mesurées ou estimées – elles le sont généralement seulement en termes de valeurs pondérées selon la courbe A. («dBA»). Ainsi, pour une analyse détaillée par bandes d'octaves, il est habituellement nécessaire de convertir une valeur dBA avec l'aide d'une pondération spectrale suggérée par un manuel publié. Malheureusement, les informations contenues dans les textes de référence publiés varient énormément en ce qui concerne les corrections suggérées pour la pondération spectrale. Les corrections dans certains textes sont en soi incompatibles, et l'écart entre les différents textes (même ceux qui citent les mêmes références primaires) mérite d'appeler l'ensemble des données en question. Ce document énumère les contradictions et les divergences au sein et entre plusieurs manuels d'ingénierie acoustique couramment utilisés et compare les manuels publiés à un vaste ensemble de données de transformateur à ciel ouvert collectées en Ontario. Des suggestions réalistes, basées sur les données mesurées, sont fournies à titre de coefficients spectraux et d'estimations de niveaux sonores pour les transformateurs.

1 INTRODUCTION

In many jurisdictions, sound level limits or acoustic assessment criteria are cited in terms of an overall A-weighted single number sound level – particularly in the case of assessing environmental noise to the outdoors. This type of single number sound level represents a weighted sum of the acoustic energy across the entire audible frequency spectrum, typically from about 20 Hz to about 20 kHz. In general, an A-weighted, summed sound level correlates reasonably well with the perceived loudness of the sound, and therefore also with its potential to cause disturbance or annoyance. For this reason, the overall A-weighted sound level has become the most common descriptor used in assessing environmental noise impact.

But, in the context of predicting sound levels from a planned, new sound source or designing noise control measures, a single-number A-weighted sound level may not suffice, because many of the important factors affecting the propagation of sound are frequency dependent. That is, acoustic mechanisms like shielding by obstacles, attenuation by soft ground, atmospheric absorption and meteorological effects all attenuate high frequency sound to a differing degree than low frequency sound. Therefore, in many cases, the acoustical consultant needs to know the un-summed sound levels of a source across the frequency range of interest – i.e., a set of octave band or 1/3-octave band sound levels.

The modern test standards that provide methods for measuring and quoting the source sound levels of electric transformers [1, 2, 3] include provisions for measuring and publishing octave band, 1/3-octave band and narrowband sound emission levels for transformers. However, the long established and overwhelming norm among transformer manufacturers is to publish only the single-number A-weighted sound level sum.

So, in order to obtain a sound level spectrum, for use in calculating sound propagation, the acoustical consultant typically must resort to using a set of octave band spectral corrections to apportion the A-weighted sum into an estimate of its spectral frequency distribution. Many of the common acoustical textbooks and handbooks provide correction factors for transformers, aimed specifically at deriving an octave band spectrum from a single A-weighted value [4, 5, 6, 7, 8]. To use the corrections, the consultant can simply add (arithmetically) the factor for each octave band to the overall A-weighted sum, resulting in a set of octave band sound levels (typically eight levels).

2 PUBLISHED CORRECTION FACTORS

Table 1 lists the basic octave band correction factors from five published texts and handbooks. We will refer to the basic correction factors as "C1" in counter-distinction to alternative correction factors offered in some of the texts, for special applications (designated herein as "C2" and "C3").

There are some broad similarities between the various references, insofar as each spectrum of corrections peaks in the 125 Hz octave band, which is to be expected because transformers tend to hum at the first harmonic of the alternating-current line frequency (120 Hz and 60 Hz, respectively in North America). But also apparent from Table 1, and perhaps more important, are the vast differences in the values of the suggested corrections. There is a 20 decibel range at the dominant frequency of 125 Hz, which is distressing to a consultant who needs to make a reasonably accurate estimate of the transformer sound emission spectrum.

Moreover, the alternative factors provided in three of the references increase the spread among the potential schemes. Table 2 summarizes these alternative factors. References [4], [7] and [8] suggest that the basic factor, C1, be used in general applications, while factor C2 should be used in small indoor spaces where standing waves could be present and factor C3 should be used in critical locations where a problem would result if the transformer should become noisier over time.

3 DISCUSSION OF DISCREPANCIES

In considering which, if any, of the published correction spectra is realistic and appropriate to use in an acoustic analysis, we can take note that not all of the schemes are "energy neutral." That is, if the set of correction values from some of the references is used to apportion the single-number A-weighted sound level sum into its component octave band levels, and those octave band levels are then A-weighted and logarithmically summed, the result differs from the original A-weighted sum. Ideally, there should not be such a difference between the starting and ending A-weighted sum; there should be no acoustic energy gained or lost when breaking a sum into its parts, or adding the parts back together. Table 3 shows the A-weighted residue resulting from the various correction schemes.

Reference [5] is the only one with a zero residue, which means that it is the only scheme that does not increase or decrease the acoustic energy in the octave band spectrum relative to the original A-weighted sound level sum.

If we hypothesize that the intent of some of these correction schemes is not solely to apportion the A-weighted sound level into its component parts, but also to include margins of conservatism or other engineering adjustments (as is discussed by references [4], [7] and [8] in the case of C2 and C3), then it would be reasonable to expect that those schemes would not be energy-neutral – they should tend have a positive residue. The problem is that the C1 and C2 corrections in reference [8] have a negative residue, which would tend to underestimate the sound emissions of the transformer. As well, the C1 schemes proposed by references [4], [7] and [8], which do not purport to include adjustments, do not have zero residues.

Table 1: Published Octave Band Corrections, C1, in Decibels Relative to Overall A-weighted Sum

Frequency [Hz]	Ref [4]	Ref [5]	Ref [6][A]	Ref [7][B]	Ref [8]
31	-1	-3		9	-11
63	5	3		15	-5
125	7	5	17	17	-3
250	2	0	5	12	-8
500	2	0	-4	12	-8
1k	-4	-6	-8	6	-14
2k	-9	-11		1	-19
4k	-14	-16		-4	-24
8k	-21	-23		-11	-31

A. The values in reference [6] are given at the discrete harmonic frequencies of a transformer (multiples of 120 Hz), which fall within the 125, 250, 500 and 1000 Hz full octave bands, respectively.

B. See the Appendix for notes on the factors from reference 7.

On the basis of internal consistency alone, the correction scheme presented in reference [5] appears to be realistic, in that it neither adds energy to nor subtracts energy from the spectrum, relative to the A-weighted sum. However, given the disagreement between the schemes, the use of any one may be suspect, without delving further into their origin. In that regard, Figure 1 reveals an interesting relationship among four of the five references. With the exception of reference [6] the corresponding correction spectra are all exact, scaled images of one another. Or, in other words, they all represent the identical spectral shape, with a frequency-independent constant difference among them. This exact correspondence is too close to be a coincidence, and in fact we will see that it is not a coincidence.

Table 2: Published Alternative Octave Band Corrections C2 and C3, for Use in Special Locations/Applications, in Decibels Relative to Overall A-weighted Sum

Frequency [Hz]	Ref [4]		Ref [7][B]		Ref [8]	
	C2	C3	C2	C3	C2	C3
31	-1	-1	9	9	-11	-11
63	8	8	18	18	-2	-2
125	13	13	23	23	3	3
250	8	12	18	22	-2	2
500	8	12	18	22	-2	2
1k	-1	6	9	16	-11	-4
2k	-9	1	1	11	-19	-9
4k	-14	4	-4	6	-24	-14
8k	-21	-11	-11	-1	-31	-21

B. See the Appendix for notes on the factors from reference 7.

Table 3: A-weighted Residues Resulting from the Application of the Various Correction Schemes and Re-summing Logarithmically

Reference	C1	C2	C3
[4]	2	7	13
[5]	0	--	--
[6]	3	--	--
[7]	12	17	22
[8]	-8	-3	2

None of references [4] through [8] is a primary reference, insofar as presenting direct measurements and analysis of transformer sound levels. Instead, each of those references presents information previously published in other sources. References [4] and [8] cite reference [7] as the source of their data, so we would expect their results all to be identical; indeed, the corrections in [4], [7] and [8] have identical spectral shapes but differ by a significant bias, which remains unexplained. Reference [7] does not cite the origin of its information, although comments in the References section of [8] suggest that [7] was prepared by the firm Bolt, Beranek and Newman ("BBN"). References [5] and [6] quote primary preferences [9] and [10] respectively, as the origin of their information, although [9] and [10] are no longer in print and not readily available. Interestingly, both references [9] and [10] were prepared by BBN. So, it is apparent that all of the correction schemes presented above were derived from information originally compiled by BBN. This common origin explains the common spectral shape among the correction schemes, but does not explain the bias differences or tendency of most of the schemes to add/subtract energy relative to the A-weighted sum.

In an effort to resolve these discrepancies, we attempted to obtain copies of the out of print BBN references, [9] and [10]. Through inter-library loan from the Texas A&M University Library and the Edison Electric Institute Library, respectively, it was possible to obtain a copy of reference [10], published in 1984, and an older version of that same document [11], published in 1978, both of which were prepared for the Edison Electric Institute by BBN. The information presented in references [10] and [11] is identical, and given that reference [11] is the oldest of all of the texts we were able to obtain, it appears to be the closest possible candidate as the origin of the correction schemes presented in the other texts. Unlike the secondary texts, reference [11] explains that the correction factors were derived from a compilation of empirical data gathered from: the available literature, the authors' project files, equipment manufacturers, member companies of the Edison Electric Institute, and site measurements specifically conducted for the preparation of that text.

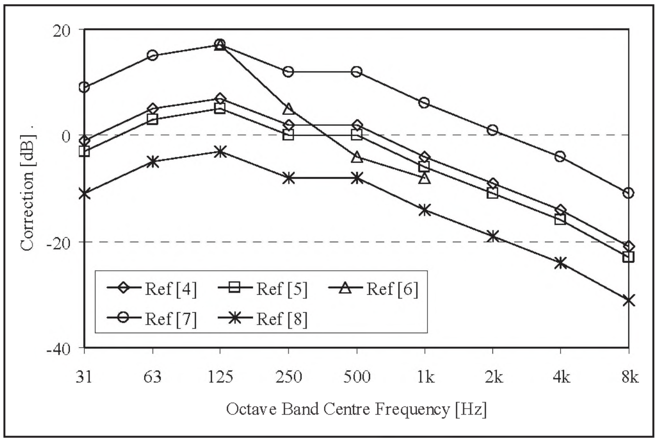

Figure 1: Basic Octave Band Corrections, C1

The correction values in reference [11] are identical to those in reference [5], which is the only set of corrections that does not add/subtract energy from the spectrum, relative to the overall A-weighted sum. Furthermore, reference [11] appears to be either a primary source or very close to a primary source of this information, purportedly based on a compilation of empirical measurement data. Thus, a reasonable conclusion is that the preferred set of correction values is the spectrum published in references [5] and [11].

The corrections from reference [4] are relatively close to the preferred spectrum – greater by just 2 dB in each band. The reason for this 2 dB difference is not known. As discussed further in the Appendix, the large differences of references [7] and [8], relative to the preferred spectrum appear to result simply from errors. References [7] and [8] appear to include conversion errors (between ft^2 to m^2) of 10 dB, which when corrected, results in spectra matching those of reference [4].

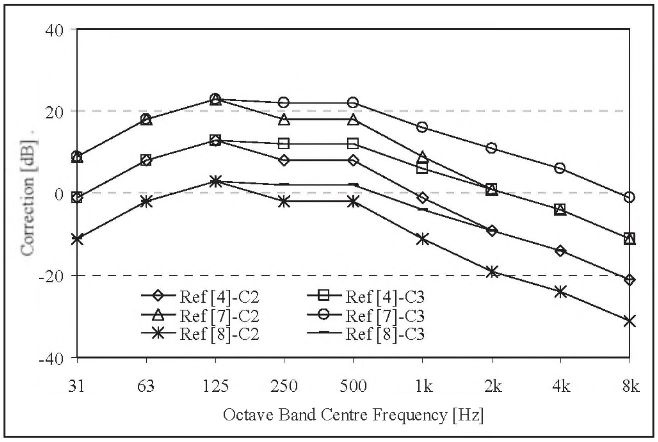

Figure 2: Alternate Octave Band Corrections, C2 & C3

The alternative corrections (C2 and C3) seem dubious, not only because they all add/subtract energy relative to the A-weighted sum, but also because they appear to include adjustments or safety margins that are not explained in the texts and are likely better handled explicitly by the acoustical consultant performing the analysis, based on the situation and his experience and judgment.

4 RECENT MEASUREMENTS

For further evaluation of the published correction factors, or as an alternative to the published data, we have compiled a body of data measured by the authors, involving 36 transformers at 16 different sites throughout the Province of Ontario. The transformers ranged in capacity from 5 Mega-Volt-Amps ("MVA") to 750 MVA. Most of these units were equipped with propeller style cooling fans. Where possible, sound level measurements were conducted with the fans on and off so that the frequency spectra of the transformer core and the cooling fans could be investigated separately. In some cases, the fans could not be turned off, and in such cases the fans were often the dominant source of sound.

The majority of the sound level measurements were conducted using sound intensity instrumentation and methods, generally following the procedures of ISO Standard 9614-2 [12], in order to obtain the best possible rejection of interfering background sound. In some cases, only sound pressure levels were measured, using standard procedures, in which case care was taken to ensure that interference from nearby sound sources was avoided.

In addition to comprising a data set for comparison against the published texts (which were all seemingly derived from the same BBN data set), an ancillary benefit of this new compilation of transformer spectral data is that it presumably represents a more current population of transformers. The previous references were based on transformers measured more than 30 years ago.

The results are summarized in Figures 3, 4 and 5, and in Table 3. The data in Figures 3 and 4 represent the same group of transformers – those for which the fans could be turned on and off, such that separate compilations of spectral weightings could be made. The data in Figure 5 are based on the transformers which could only be measured with the fans operating.

For each transformer, the spectral correction in a given octave band was simply calculated as the arithmetic difference of the octave band sound level minus the overall A-weighted sound level sum. The set of ensemble of corrections in a given octave band across all transformers was then averaged arithmetically, to yield the results in Figures 3 through 5 and Table 3. The data points marked as dots in Figures 3 through 5 are the spectral corrections for individual transformers, while the lines are the ensemble averages.

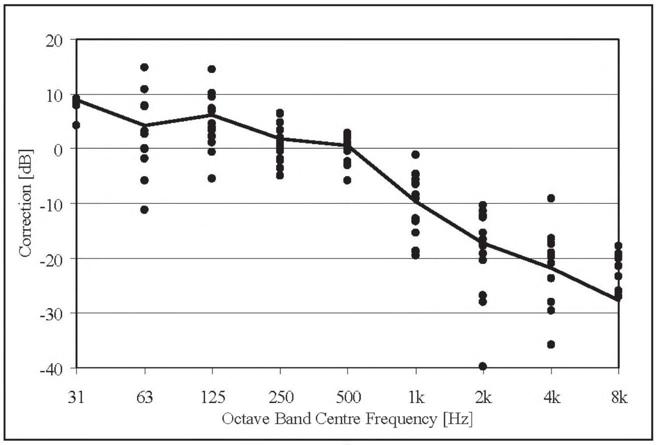

Figure 3: Spectral Corrections from Measurements by HGC Engineering – Transformer Core Only; Fans Off

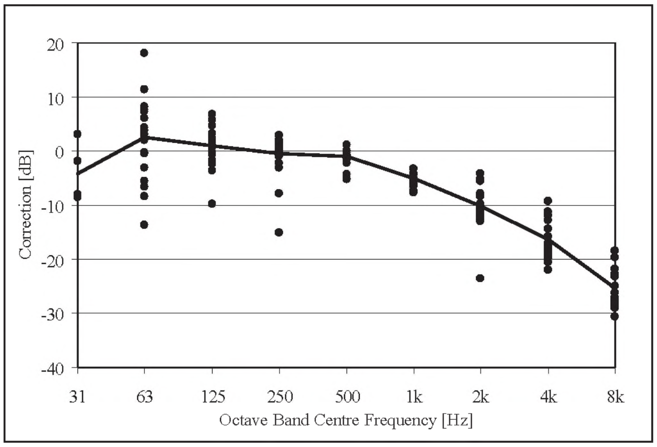

Figure 4: Spectral Corrections from Measurements by HGC Engineering – Fans Only (contribution of core deducted)

The agreement among the three correction spectra listed in Table 3 and the spectrum of the preferred spectrum (reference [11]) is relatively good, as shown in Figure 6. The agreement is particularly good between the two spectra that contain fan sound and that of reference [11]. This result is reasonable, in light of the fact that the measurement data in reference [11] included fan sound.

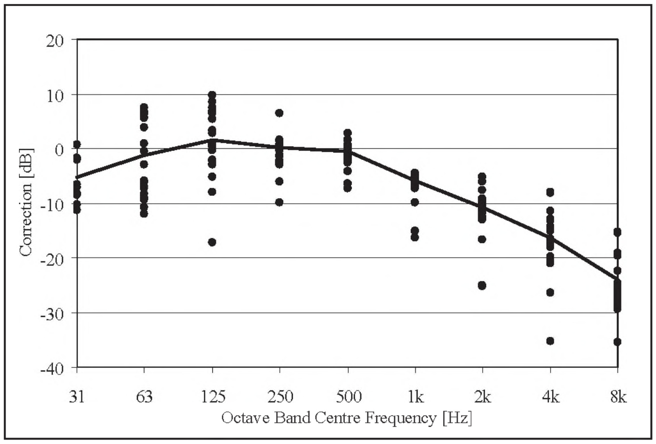

Figure 5: Spectral Corrections from Measurements by HGC Engineering – Transformer Core and Fans Combined

Table 3: Spectral Corrections for Transformers in Decibels Relative to the A-weighted Sum Based on Measurements by HGC Engineering

Frequency [Hz]	Transformer Core Only (Fans Off)	Cooling Fans Only (Core Deducted)	Transformer Core and Fans Combined
31	9	-4	-5
63	4	3	-1
125	6	1	2
250	2	-1	0
500	1	-1	0
1k	-10	-5	-6
2k	-17	-10	-11
4k	-22	-16	-16
8k	-28	-25	-24

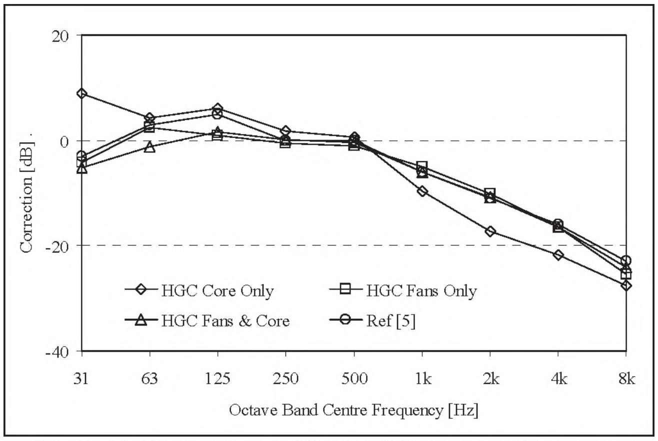

Figure 6: Comparison of Spectral Corrections Based on Measurements by HGC Engineering to Reference [11]

The spectral corrections in the 31 Hz octave band, as shown in Table 3 and Figures 3 through 6 are likely somewhat less reliable than in the other bands, because the majority of measurements included sound levels only from 63 Hz to 8 kHz, meaning that there were fewer data points available in the 31 Hz range. However, this restriction on accuracy may be of minimal consequence because the 31 Hz octave band rarely influences the overall A-weighted sound level significantly for transformers. The value of the A-weighting curve at 31 Hz is -39.4 dB, which de-emphasizes the contribution of the sound in the 31 Hz octave band in the sum.

5 CONCLUSIONS

From a review of several commonly used textbooks and the literature cited by those texts, we conclude that the most reliable published correction spectrum is the one proposed by references [5] and [11] – i.e., the corrections shown in column 3 of Table 1.

Contradictions, errors and unsupported adjustments abound in the published sources, so it is important for the consultant to understand and verify the correction spectrum that is to be used. One way to do so is to ensure that there is no appreciable residual value when re-calculating the A-weighted sum of the apportioned octave band levels, relative to the starting value. Without such a verification, the errors present in some of the texts [7 and 8], could result in octave band levels that are overstated or understated by as much as 10 dB, which is significant.

The new correction factors presented herein do not differ significantly from those of reference [11]. One advantage to the new factors is that separate correction spectra are available for the cooling fans and the transformer core. In many cases, the transformer manufacturer's sound level data will include separate sound levels for the fans and core. So by using the separate correction spectra, the fans and core can be modeled and analyzed individually, which may afford additional accuracy for some projects, particularly those in which the fan noise is dominant.

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ACKNOWLEDGEMENTS

The authors wish to thank Dr. W. Dale Stevens of the Department of Psychology, Harvard University for assistance in obtaining references [7] and [11] via inter-library loan. Thanks are also owing to John Monczka of Hydro One, Dejan Zivkovic of the Ontario Ministry of Environment and Gord Reusing and Tim Wiens of Conestoga Rovers and Associates, for assistance in discovering and comparing the discrepancies among the published texts.

APPENDIX

Some explanation of the correction factors from reference [7] are warranted, to avoid a misinterpretation of the manner in which they are presented in this paper. As presented in reference [7] (Table 7-30, page 7-34 of that text), the correction factors appear at first glance to be identical to those presented in reference [4] – i.e., basic correction factor C1 of -1 dB at 31 Hz, +5 dB at 63 Hz, +7 dB at 125 Hz, etc. However, unlike reference [4], reference [7] proposes these correction factors for use in an equation involving US units of measurement, not SI units. Specifically, [7] states the following:

$$L_W = L_{P(NEMA)} + 10\log A + C,$$

where L_W is the octave band sound power level, $L_{P(NEMA)}$ is the overall A-weighted sound pressure level sum measured around the transformer, in accordance with reference [1], A is the area enveloping the transformer *in square feet* and C is the appropriate octave band correction factor.

Because L_W and L_P have reference values in SI units, the use of an area measured in square feet presents a problem, because the authors of reference [7] did not add a unit conversion factor to their equation. The result is that, if the correction factors presented in reference [7] are used with the equation presented in reference [7], the calculated octave band values will be erroneously inflated by an amount equal to ten times the logarithmic ratio of 1 square foot to 1 square meter, which is +10.32 dB. In order to make the octave band correction scheme in reference [7] directly comparable to those of the other texts we adjusted their octave band correction factors to compensate for the error in their equation.

The identification of the unit conversion error in reference [7] is supported by yet another text, reference [13] (also authored by BBN). Reference [13] presents the same equation as reference [7] for deriving the octave band sound power levels from the A-weighted sound pressure level using an area measured in square feet, but reference [13] properly adjusts its spectral correction factors to compensate for the conversion from US to SI units. Thus, for example, the basic correction factors in reference [13] are: -11 dB at 31 Hz, -5 dB at 63 Hz, -3 dB at 125 Hz, etc. These corrections are 10 dB less than those presented in reference [7], which is correct if they are to be used with an equation involving US units for surface area, thus producing results identical to those of reference [5].

It is also interesting to note that the correction factors in reference [13] are identical to those presented in reference [8]. However, reference [8] instructs that those factors be used with an equation involving SI units for surface area, which is incorrect.

Thus, with the aid of reference [13], it is apparent that both [7] and [8] make unit conversion errors, but in opposite directions. The scheme in reference [7] results in octave band levels that are overstated by 10 dB and the scheme in reference [8] results in octave band levels that are understated by 10 dB. With the correction of these errors, the factors presented in references [5], [7], [8] and [13] are all identical, and the basic correction factors of these references are all within just 2 dB of the preferred factors in references [7] and [11].

LIONS BAY NOISE MITIGATION PROGRAM

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ABSTRACT

The Ministry of Transportation (MoT) of the Province of British Columbia (B.C.), Canada, noise abatement policy requires that community noise impacts of highway projects involving new or substantially upgraded highways be assessed and mitigation implemented where warranted. Increasing community demands for noise mitigation, however, may exceed policy standards and pose greater challenges for designers. This paper presents an extraordinary noise model developed to mitigate residential areas of the Village of Lions Bay on the rugged B.C. coastline along the Sea-to-Sky Highway connecting Vancouver, B.C. to Whistler, B.C., Canada home of the Vancouver 2010 Winter Olympic and Para-Olympic Games. The CadnaA Version 3.9.15 software was used to develop a new four-lane split-grade alignment model incorporating two mini-interchanges. With the objective of achieving a 10 dBA noise reduction benefit, mitigation in the form of quiet pavement (OGAFC), traffic calming and 5 meter high sound walls were introduced into the model which included 115 mountain side residential receptors along a 2 km corridor at elevations of up to 35 meters above the highway. Noise reduction benefits and impacts for dwellings were further analyzed to determine contributions during specific stages of project development by creating a modular, multi-layer noise model of Lions Bay. This work was carried out under the sponsorship of BC MoT.

RÉSUMÉ

Le Ministère de Transport (MoT) de la Province de Colombie Britannique (B.C.), Canada, la politique de diminution de bruit exige que les impacts de bruit de communauté de projets de route aient impliqué nouvel ou substantiellement actualisé les routes sont évaluées et la réduction a exécuté où mérité. La communauté croissante exige pour la réduction de bruit peut dépasser cependant les normes de politique et pose de plus grands défis pour les dessinateurs. Ce papier présente un modèle de bruit extraordinaire a développé pour adoucir des secteurs résidentiels du Village de Baie de Lions sur le robuste B.C. le littoral le long de la Mer-à-la Route de Ciel connecte Vancouver, B.C. à Whistler, B.C.., la maison de Canada du Vancouver 2010 Hiver Jeux Olympiques et Para-Olympiques. Le logiciel de 3.9.15 de Version de CadnaA a été utilisé pour développer un nouveau quatre modèle d'alignement de degré de division d'allée incorpore deux mini-échanges. Avec l'objectif d'atteindre un 10 avantage de réduction de bruit de dBA, la réduction sous forme de trottoir calme (OGAFC), la circulation calmant et 5 mètre hauts murs solides ont été introduits dans le modèle qui a inclus 115 montagne récepteurs résidentielles latérales le long d'un 2 couloir de km aux élévations de jusqu'à 35 mètres au-dessus de la route. La réduction de bruit profite et influe pour les résidences ont été plus analysé pour déterminer des contributions pendant les étapes spécifiques de développement de projet en créant un modulaire, le modèle de bruit de multi-couche de Baie de Lions. Ce travail a été exécuté sous le sponsorat d'av BC MoT.

1 INTRODUCTION

1.1 Background

In preparation for the Vancouver 2010 Winter Olympic Games to be held in the resort municipality of Whistler, British Columbia, Canada, the Sea-to-Sky Highway Improvement Project was initiated in 2005. This regional linear-development project reduces travel time along the mountainous coastline from Vancouver to Whistler while enhancing safety to and from the winter venues. The Lions Bay Mitigation Program evolved from a preliminary noise mitigation plan based on the BC MoT Policy [1], which led to a series of public consultations to explore effective and feasible mitigation measures that were supported by residents. This paper presents the modeling techniques used and challenges encountered in achieving the objectives of the program. In addition, the capabilities of the modeling techniques will be displayed.

1.2 Lions Bay Mitigation Program Objectives

During the detailed design phase, a four-stage approach to mitigation was proposed. The primary objective of mitigation was to achieve a 5 dBA noise reduction through the use of quiet pavement and a speed reduction from 80 to 70 kmph. Subsequent stages were to achieve an additional 5 dBA noise reduction through the introduction of a split grade section, sound walls and other barrier enhancements. Priority would be given to fronting residential facades whose noise levels approached or exceeded Leq(24) 55 dBA in the design horizon year.

1.3 Project Description

Figure 1.1 provides a view of the new alignment (from the Vancouver end towards Whistler) which shows the final mitigated design with the split grade section in the foreground. The attributes of this alignment and the existing highway through the Lions Bay corridor are as summarized in Table 1.1.

Figure 1.1 shows that much of the intervening ground between the roadway and the residences was rocky and steep and offered little opportunity for the ground effect to occur. Aged retaining walls were commonly found at the base of the mountain slope and along the lower side of the alignment. The right-of-way (ROW) was moderately forested in most areas.

88 multi-storied residences were included in the core study along the village corridor. Of these, 55 were located at higher elevations on the mountain slope and many had elevated sundeck and patio exposures, typically 25 meters above the roadway. The remaining dwellings were located on the lower side at or below project grade. The mitigation program's objectives were to be achieved at fronting facades on both sides of the alignment.

2 MODELING METHODOLOGY

2.1 Overview

The noise environment was predicted using computer modeling techniques. A seven-part noise model was developed.

Figure 1.1: View of Sea-to-Sky Highway through Lions Bay from Vancouver End towards Whistler, showing Proposed Four Lane Configuration with 750 m Split Grade Section.

This multi-layered approach was adopted to project residential noise levels at certain stages during the pre-project, pre-mitigation and the noise mitigation design. Noise reduction benefits and impacts would emerge as changes in residential noise levels as improvements were added. The acoustical modeling software CadnaA Version 3.9.15 was ideally suited for this purpose.

A modular approach was used for improved quality control and assurance. The CadnaA software provided the opportunity of maintaining classes of modeling objects in separate modules that were shared by the models and that could be updated with design changes and other project information.

2.2 Noise Model

The attributes of the noise model are listed in Table 2.1. From the first row of the table, the Baseline-Model represents pre-project conditions or the existing design in 2004 featuring two lanes of conventional pavement with a posted speed of 80 kmph. In the second row, the Base-Model projects the existing design to the design horizon year 2018 (10 years

Table 1.1: Existing and Proposed Alignment through Lions Bay

Attribute	Existing Alignment	Proposed Alignment
Lane Configuration	2 lane standard	4 lane standard/split grade
Pavement Type	Aged Conventional HMA	New OGAFC
Average Daily Traffic (vpd)/Year	14,363/2004	19,680/2018
Average Hourly Traffic (vph)/Year	598/2004	820/2018
Day/Night Traffic Split	~10:1	~10:1
Percent Heavy Vehicles/Year	2%/2004	3%/2018
Posted Speed (kmph)	80	70
Highway Grade	<2%	<2%
Elevation (m above Sea Level)	60-79	60-79
Length (km)	2	2
Sections on Span	3	3

Table 2.1: Noise Model – Mitigation Initiatives Underlined

Model Name	Alignment	Traffic	Barriers	Pavement/Speed	Cross Section	Sound Walls	Barrier Enhancements
Baseline	Existing 2 lane	2004	Existing CRB/CMB	Conventional/ 80 kmph	On grade	-	-
Base	Existing 2 lane	2018	Existing CRB/CMB	Conventional/ 80 kmph	On grade	-	-
Basic Design	New 4 lane	2018	New CRB/CMB	Conventional/ 80 kmph	On grade	-	-
First Stage Mitigation	New 4 lane	2018	New CRB/CMB	OGAFC/ 70 kmph	On grade	-	-
Second Stage Mitigation	New 4 lane	2018	New CRB/CMB	OGAFC/ 70 kmph	Split grade	-	-
Third Stage Mitigation	New 4 lane	2018	New CRB/CMB	OGAFC/ 70 kmph	Split grade	2.3 - 5 m	-
Fourth Stage Mitigation	New 4 lane	2018	New CRB/CMB	OGAFC/ 70 kmph	Split grade	2.3 - 5 m	1.5-2.5 m

after project completion as per BC MoT noise abatement policy). The Base-Model establishes pre-project noise levels with 2018 traffic. In the third row, the Basic Design-Model departs from the existing design with the proposed new four-lane alignment incorporating improved roadside and median safety barriers. In the fourth row, First Stage Mitigation introduces quiet pavement in the form of Open Graded Asphalt Friction Coarse (OGAFC) and a speed reduction from 80 to 70 kmph in order to reduce source emissions. In addition, at this stage, the replacement of a weathered wooden roadside barrier with a new concrete barrier was required. During Second Stage Mitigation a 750 m long split grade section was proposed at the Vancouver end of the village corridor, to provide additional screening for adjacent residences on both sides of the highway (see Figure 1.1). The split grade face developed a maximum height difference of 2 m at its mid-section. During Third Stage Mitigation, standard concrete sound walls with heights ranging from 2.3 to 5 m above local ground level were proposed and optimized for location, height and length using CadnaA. All potential locations from the roadside to the ROW were explored. Fourth Stage Mitigation included further barrier enhancements to augment sound walls. Enhancements included, for example, 2.3 m high roadside barriers on span at the two creek crossings in central Lions Bay.

All models computed first order reflections. The last three models were also run in absorptive mode to assess the advantage of lining vertical screening surfaces with absorptive materials. Such surfaces were numerous and included – existing retaining walls at the base of the mountain slope and along the sides of the creek beds, the split grade face, the mini-change abutments, the sound walls and barrier enhancements.

3 SUMMARY OF MODELING RESULTS AND INTERPRETATION

The results from the seven-part noise model are summarized in Figures 3.1 and 3.2 with 2018 Base-Model noise levels in dBA inscribed next to the receptor site numbers. Each series depicted shows the fluctuations in noise benefits and impacts along the corridor during a particular stage of pre-project, pre-mitigation or noise mitigation design. The first of the series, labelled Growth, reflects the 1.6 dBA increase in noise levels at all locations that will accompany traffic growth over the 14 years, 2004 to 2018. The second of the series, labelled Basic Design, indicates the noise benefits/impacts that the pre-mitigation design would bring. In this regard, (see Figure 3.1) 45 of 55 receptors on the mountain slope side would receive either benefits or impacts of less than 1 dBA, eight would receive benefits in the range 1 to 3 dBA and two would receive impacts in the range 1 to 1.6 dBA.

The origins of these effects are revealed in the accompanying 3D visualizations taken from the perspective of the receptor sites. For example, the 1.1 dBA benefit at Site 41 is attributed to a decrease in this receptor's exposure resulting from the displacement of the near lane to a location under the top-of-cut that provides increased screening (see Figures 3.3a and b). By contrast, the impact at Site 14 of 1.6 dBA is attributed to increased exposure from the widening of the highway, as evident when Figures 3.4a and b are compared. This effect is also seen at Site 26 to a lesser degree.

Figure 3.2 shows that for the majority of receptors on the lower side, the basic design would provide noise reduction benefits - a trend that is primarily due to design features including decreases in exposure resulting from the widening/

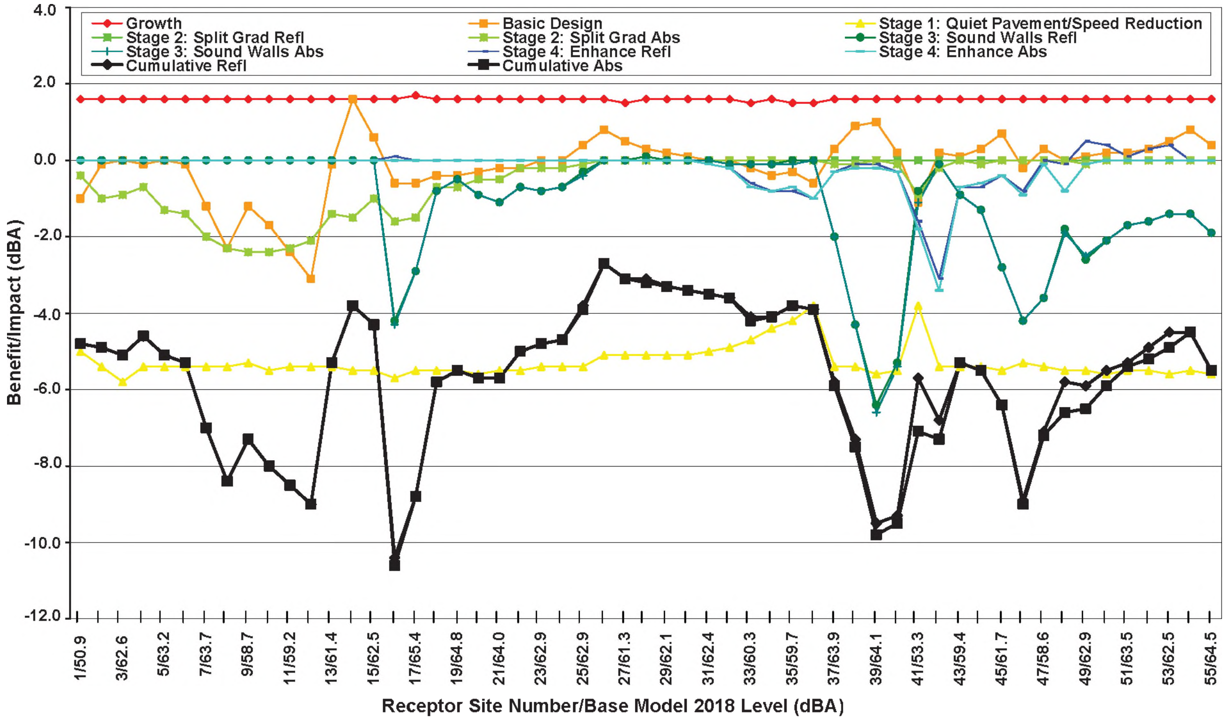

Figure 3.1: Noise Benefit/Impact vs Residential Site Number - Higher Side on Mountain Slope

realignment and increased screening from improved roadside barriers mounted on lower side retaining walls.

The Quiet Pavement/Speed Reduction series of Figures 3.1 and 3.2 exhibit the relatively consistent mitigation effect that the first stage of mitigation would provide; that is noise reduction benefits in the range of 4 to 5 dBA at fronting residential facades on both sides. Fluctuations are believed to be due to the interactions involving the altered source spectra from tires on OGAFC at a reduced speed and screening along

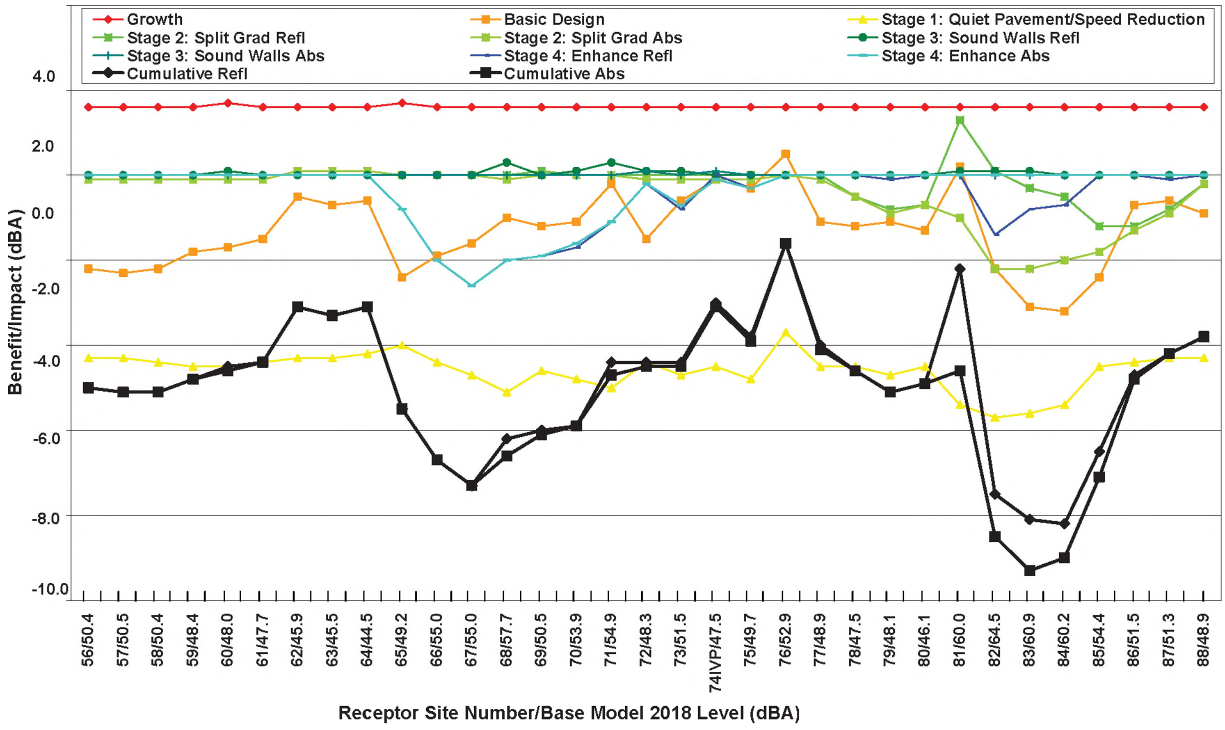

Figure 3.2: Noise Benefit/Impact vs Residential Site Number - Lower Side

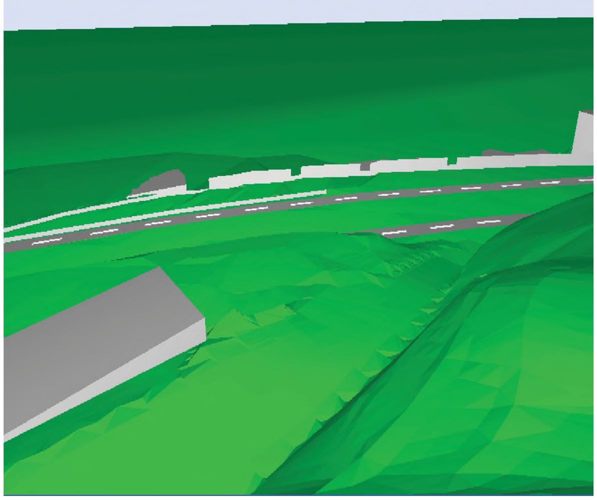

Figure 3.4a: View from Site 43 from Base Model Existing Two Lane Configuration showing Screening of Near Lane by Top-of-Cut and the Details of a Weathered Wooden Fence to be Replaced under Stage 1 Mitigation.

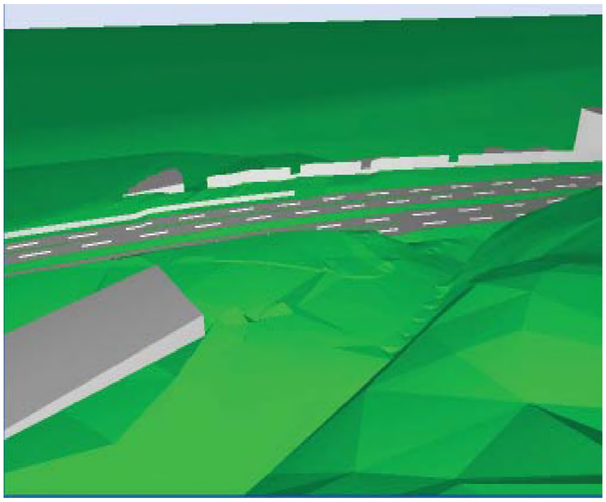

Figure 3.3b: View of Site 43 depicting Project Benefit from Basic Design Model due to a Further Displacement of the Near Lane under the Top-of-Cut.

the noise propagation path.

The two Split Grade series of Figure 3.1 indicate that with either reflective or absorptive screening, the 750 m long split grade section incorporating a 2 m high face and 1.5 m high median barrier provided benefits up to 2.4 dBA for receptors located on elevated sundecks on the mountain slope. The split grade design also provided benefits up to 1.2 dBA (see Figure 3.2) for receptors located on the lower side if the median barrier, split grade face and mini-change abutment were reflective and 2.2 dBA if these vertical surfaces were absorptive.

The two Sound Wall series in Figure 3.1 show the effectiveness of third stage mitigation. Due to cost, sound walls were only proposed for mountain slope residences with greater exposures. However, due to the substantial receptor heights involved in some residential areas, 5 m high sound walls were deemed ineffective (see Figure 3.5). In other areas, CadnaA predicted that reflective sound walls would provide benefits starting at 1 dBA up to 6.4 dBA with absorptive sound walls providing up to 6.6 dBA.

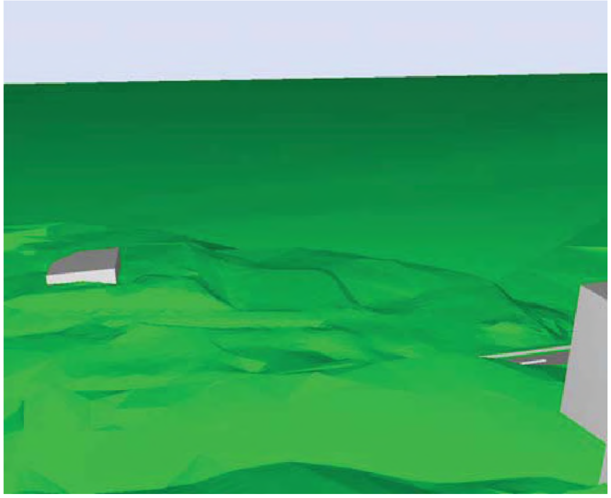

Figure 3.4a: View from Sundeck of Site 14 overlooking Existing Alignment toward Green Ocean and Blue Sky from Base Model (Existing Two Lane Configuration).

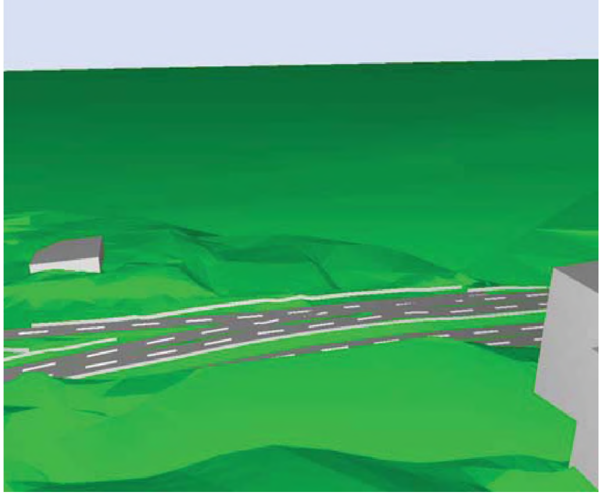

Figure 3.4b: View from Site 14 depicting Project Impact from Basic Design Model (Four Lane Configuration).

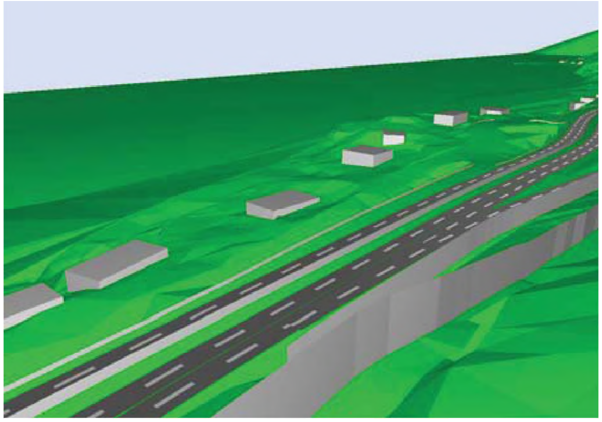

Figure 3.5: View from Sundeck of Site 5 depicting Two Ineffective Sound Wall Options on the Right Hand Side and the 1.5 m High Split Grade Median Barrier (Four Lane Configuration).

The two Enhancement series exhibit the effectiveness of the fourth and final stage of mitigation. The enhancements included lower profile barriers proposed in strategic locations on either side of the alignment. For example, a reduced 2.3 m high barrier-on-span was proposed to screen emissions from creek bridge decks that were known to limit the effectiveness of the higher sound walls. A 2.3 m high barrier was also proposed at a key location along the propagation path between the split grade face/mini-change abutment to exposed receptors at grade on the lower side. The purpose of this barrier enhancement was to screen reflections from these vertical surfaces and was therefore not relevant in the absorptive case.

The two-bolded series in Figures 3.1 and 3.2 obtained by adding the benefits/impacts on a site-by-site basis indicated the cumulative effects of the pre-project, pre-mitigation and four-stage mitigation design. It may be seen from the Figure 3.1 series that the mitigation program's primary objective of achieving an initial 5 dBA noise reduction was met or exceeded at numerous receptor locations on the mountain slope except where there were substantial impacts from the widening and realignment. The Figure 3.2 series shows that receptors on the lower side that did not receive a 5 dBA noise reduction had base (2018) noise levels that were substantially below Leq(24) 55 dBA.

4 CONCLUSIONS

The Lions Bay Mitigation Program was shown to reduce 2018 traffic noise levels by at least 4.5 dBA for 41 of the mountain slope residences and by at least 6 dBA for the majority of residences on the lower side with base (2018) levels approaching or exceeding Leq(24) 55 dBA.

While the primary objective of achieving an initial 5 dBA noise reduction was substantially attained, the overall objective of a 10 dBA noise reduction could not be met consistently along the project corridor although it was approached at 9 locations on the mountain slope where noise levels were reduced by 8 dBA or more.

The multi-layered modeling technique together with the visualization features of CadnaA made it possible to diagnose the origins of noise benefits/impacts from the basic pre-mitigation design through the four staged mitigation design down a corridor, which included complex source/receiver geometry. With the visualization features of CadnaA it was possible to confirm that it would not be possible to achieve noise reductions over 5 dBA at many mountain slope locations without considering sound wall heights in excess of 5 m.

ACKNOWLEDGMENTS

The author gratefully acknowledges the support and guidance of the Province of British Columbia, Canada, Ministry of Transportation.

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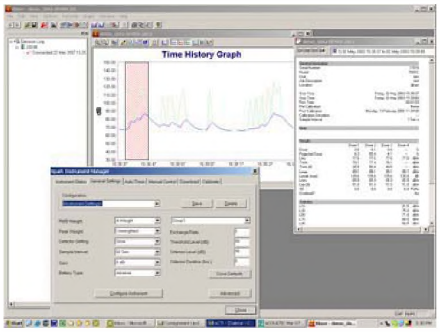

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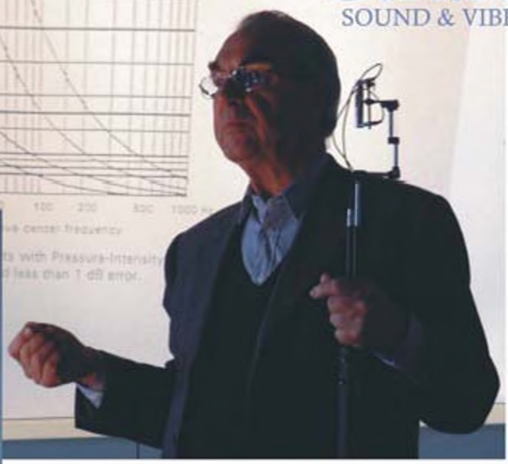


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ROBERT BRADFORD NEWMAN AWARD

Benjamin Gaum of Ryerson University is the winner of the 2009 Medal for his thesis 'Sound Created Form'

Compiled By Ramani Ramakrishnan (including materials from the ASA website)

Benjamin Gaum with the Newman Medal *(Photo Credit - Davis Marques)*

(from l to r): Dr. Kendra Schank Smith (Chair, the Department of Architectural Science), Dr. Ramani Ramakrishnan (Thesis Supervisor), Benjamin Gaum and Dr. Mohamed Lachemi (Dean of the Faculty of Engineering, Architecture and Science) who awarded the medal.

Robert Bradford Newman, a founding member of Bolt Beranek and Newman Inc., was a faculty member of the School of Architecture and Planning, MIT, and of the Graduate School of Design, Harvard University for thirty years. He was widely known as a teacher with extraordinary ability to communicate the essentials of architectural acoustics.

A committee of his friends has developed this program to honor outstanding students at schools of architecture and architectural engineering throughout the world. Students selected for the Newman Medals must have demonstrated excellence in this discipline and in the application of acoustical design principles in the course of their study.The fund will annually provide individual medal awards at qualifying institutions. The Robert Bradford Newman Student Medal for Merit in Architectural Acoustics recognizes excellence in the study of acoustics and its application to architecture. The program honors outstanding students at schools of architecture and architectural engineering throughout the world.

Benjamin Gaum of the Deaprtment of Architectural Science, Ryerson University, Toronto, won the Newman medal for his Master's thesis, "Sound Created Form," under the supervision of Prof. Ramani Ramakrishnan, who is also the current Editor-in-Chief of the *Canadian Acoustics* journal.

Ben's study focussed on the analysis of different temporary structures that act as main venues for various jazz festivals across Canada with the goal of trying to make a philosophical, experiential and physical connection between music, sound and architecture. The interest in temporary structures as opposed to permanent structures will address the issue of flexibility within a structure to respond to specific environmental, acoustical and architectural impacts and how might these impacts affect the overall form. The temporary form allows for a much greater ease of formal exploration both before the erection of the structure but possibly during a performance as well, posing the question, "can a building be tuned?"

Ben's work was presented in the 2009 Acoustics Week in Canada conference held in Niagara-on-the-Lake in October 2009 and a full article will be submitted to *Canadian Acoustics* for possible publication.

OBITUARY / OBITUAIRE - GEORGE WONG

George S.K. Wong, a member of the Canadian Acoustical Association, passed away peacefully at Saint-Vincent Hospital on December 12, 2009 at the age of 74. Dr. Wong's four-decade career as a prominent specialist in the field of acoustical standards was highlighted by the publication of AIP Handbook of Condenser Microphones: Theory, Calibration and Measurements in 1994, which has been considered by many as the authoritative handbook in the field.

Dr. Wong was born in Hong Kong, China. He majored in Mechanical Engineering at the University of Manchester, earning a M.Sc. degree in 1963 and a Ph.D. degree in 1965.

George's professional career as a scientist began in 1966 at the National Research Council of Canada, where he worked on mechanical metrology at the Mechanics Section, Division of Physics. Seven years later, his emphasis turned to matters of acoustics when he joined the Acoustics Section. There he made important, often ground-breaking contributions to the understanding of microphone behavior, the speed of sound in gases, acoustical instrumentation, and acoustical measurement techniques. In 1984, George determined that the speed of sound in air is nearly a half mile per hour slower than physicists, acousticians and aerodynamic engineers had thought for four decades. In a book Canada Firsts by Ralph Nader, the author wrote,

"For forth-four years, scientists and engineers, indeed anyone who used the figure of the speed of sound, believed it to be 741.5 miles per hour, or 331.45 meters per second. It took a Canadian, Dr. George Wong, working in 1984 on the problem of calibrating microphones as accurately as possible, to find that this figure is slow by about a half mile per hour."

On July 1 (Canada Day), 2006 the National Post published a list called "Canada's Top 10." It included 10 "Canadian Firsts" in innovation since 19 century. The seventh in the list is George's calculation of the speed of sound in 1984, ahead of light bulb by Henry Woodward in 1874.

George originated and led the NRC team for the development, maintainance and dissemination of acoustical measurement standards. The team continues to provide measurement standards for acoustics, ultrasound and vibration at NRC's Institute for National Measurement Standards. George's appointment to the top rank of Principal Research Officer in 2002 demonstrated the recognition of his work by his peers.

George was an outstanding researcher as evidenced by at least 41 peer-reviewed publications and 7 book chapters. He was a chair, convenor or member in 25 technical committees and working groups of standards organizations that include OIML, SIM, CIPM, ANSI, IEC, ISO, and CSA. He wrote the Acoustical Standards Newsletter and was an Associate Editor (of Standards News) for the Journal of the Acoustical Society of America.

After his retirement in March 2009, George devoted his time to the enjoyment of family life, especially playing with his adoring grandchildren. He had finished the model train that he had started to build a decade before. He enjoyed his passion for the do-it-yourself, though his mobility was limited after a stroke in October 2006. George is survived by his wife Emily, his children David and Patrick, and five grandchildren. All of them share wonderful memories of fulfillment of George.

A tribute by Lixue Wu and Peter Hanes

National Research Council of Canada

Ottawa

Canadian Acoustical Association
Association Canadienne d'Acoustique

PRIZE ANNOUNCEMENT • ANNONCE DE PRIX

Prize

Edgar and Millicent Shaw Postdoctoral Prize in Acoustics
Alexander G. Bell Graduate Student Prize in Speech Communication and Hearing
Eckel Graduate Student Prize in Noise Control
Fessenden Graduate Student Prize in Underwater Acoustics
Raymond Hetu Undergraduate Student Prize in Acoustics

Prix

Prix Post-doctoral Edgar et Millicent Shaw en Acoustique
Prix etudiant Alexander G. Bell en Communication orale et audition (2e ou 3e cycle)
Prix etudiant Eckel en Controle du bruit (2e ou 3e cycle)
Prix etudiant Fessenden en Acoustique sous-marine (2e ou 3e cycle)
Prix etudiant Raymond Hetu en Acoustique (1er cycle)

Deadline for Applications:
April 30th 2010

Date limite de soumission des demandes:
30 Avril 2010

Consult CAA website for more information
Consultez le site Internet de l'ACA pour de plus amples renseignements
(http://www.caa-aca.ca)

Local marine bio-acoustic source.
(Photo: Gary Woodburn, Tourism Victoria)

— SECOND ANNOUNCEMENT —

ACOUSTICS WEEK IN CANADA

Victoria BC, 13-15 October 2010

Acoustics Week in Canada 2010, the annual conference of the Canadian Acoustical Association, will be held in Victoria BC from 13 to 15 October 2010. This is the premier Canadian acoustical symposium, and this year's exceptional waterfront setting on Victoria's beautiful Inner Harbour will make it an event you won't want to miss. The conference will include three days of plenary lectures, technical sessions on all areas of acoustics, the CAA Annual General Meeting, an Exhibition of acoustical equipment and services, the Conference Banquet and other social events. In keeping with Victoria's ocean setting and the natural beauty of the region, the conference will feature increased focus in the areas of marine and environmental acoustics.

Venue and Accommodation – The conference will be held at the Laurel Point Inn, www.laurelpoint.com, a landmark Victoria hotel. As the sole occupant of a small peninsula separating Victoria's Inner and Outer Harbours, surrounded by quiet gardens and ponds and bordering the seawall walkway, the Laurel Point Inn represents an exceptional location on Victoria's historic waterfront. The Inn is located a short walk from all city centre attractions including the Parliament Buildings, Royal BC Museum, Government Street pedestrian mall, and Inner Harbour marina and causeway, as well as the Ogden Point breakwater, Fisherman's Wharf, and Beacon Hill Park. The Inn boasts 200 luxurious guest rooms, each with balcony and harbour views. The state-of-the-art conference facilities are clustered around the glass-enclosed Terrace Ballroom where meals and the Exhibition will be held. Participants registering with the hotel before 12 September 2010 will receive the special conference room rate of $109/night (single or double occupancy, including complimentary wireless internet and many other amenities). Staying at this outstanding conference hotel will place you near your colleagues and all conference activities, and will help make the meeting a financial success to the benefit of future CAA activities. Reduced room rates are in effect from 10 to 18 October, so consider extending your visit to Victoria for a short holiday!

Plenary Lectures – Plenary lectures are planned in areas of broad and relevant appeal including Marine Bioacoustics, Environmental Acoustics, and Noise Control.

Inner Harbour and Parliament Buildings at dusk.
(Photo: Tyler Ahlgren, Tourism Victoria)

Ogden Point breakwater—a great place for a stroll.
(Photo: Richard Funnell, Tourism Victoria)

Laurel Point Inn and Terrace Ballroom.

Technical Sessions – Technical sessions will be organized in all major areas of acoustics, including the following topics:

- Architectural and Classroom Acoustics
- Bio-Acoustics and Biomedical Acoustics
- Engineering Acoustics and Noise Control
- Physical Acoustics and Ultrasonics
- Musical Acoustics
- Psycho- and Physio-Acoustics
- Hearing and Speech Sciences
- Underwater Acoustics
- Acoustic Signal Processing

If you would like to propose and/or organize a special session on a specific topic, please contact the Technical Chair as soon as possible.

Exhibition and Sponsorship – The conference will include an Exhibition of acoustical equipment, products and services on Thursday 14 October 2010. If you or your company are interested in participating in the Exhibition or in sponsoring conference social events and/or sessions, which presents excellent promotional opportunities, please contact the Exhibition Coordinator.

Social Events – The conference will begin on Wednesday morning with an opening ceremony and welcome. Thursday evening is the traditional CAA Banquet and Awards Ceremony which will feature outstanding cuisine with a West Coast flair.

Courses/Seminars – If you would like to offer a course/seminar in association with Acoustics Week in Canada, please contact the Conference Chair. Assistance can be provided in accommodating such an event, but it must be financially independent of the conference.

Student Participation – Student participation is strongly encouraged. Travel subsidies and reduced registration fees will be available. A hotel room sharing program will be organized to reduce costs. Student presenters are eligible to win prizes for the best presentations at the conference.

Paper Submission – The abstract deadline is 15 June 2010. Two-page summaries for publication in the proceedings issue of *Canadian Acoustics* are due 2 August 2010. Details will be given on the conference website.

Registration – Details of registration fees and the registration form will be available soon at the conference website. Early registration at a reduced fee is available until 12 September 2010.

Fall colours at Butchart Gardens.
(Photo: Nick Redding, Tourism Victoria)

Local Organizing Committee

- Conference Chair: Stan Dosso [sdosso@uvic.ca]
- Technical Chair: Roberto Racca [roberto.racca@jasco.com]
- Exhibition: Clair Wakefield [exhibits2010caa@wakefieldacoustics.com]
- Treasurer: Lara Berg [lara.@jasco.com]
- Secretary: Michael Wilmut [mjwilmut@uvic.ca]
- Registration: Lori Robson [registart2010caa@wakefieldacoustics.com]
- Website: Brendan Rideout [brendan.rideout@gmail.com]

Conference Website: www.caa-aca.ca

Source bio-acoustique locale.
(Photo: Gary Woodburn, Tourism Victoria)

— SECONDE ANNONCE —

SEMAINE CANADIENNE D'ACOUSTIQUE

Victoria CB, 13-15 Octobre 2010

La Semaine Canadienne d'Acoustique 2010, la conférence annuelle de l'Association Canadienne d'Acoustique va prendre place à Victoria CB du 13 au 15 Octobre 2010. C'est le premier symposium d'acoustique canadienne, et l'exceptionnel bord de mer donnant sur le magnifique port nautique de Victoria en fera cette année un évènement que vous ne voudrez pas manquer. La conférence incluera trois jours de conférences plénieres, des séssions techniques dans tous les domaines de l'acoustique, la réunion générale annuelle de l'ACA, une exposition d'équipements et services acoustiques, le banquet de la conférence et d'autres évènements sociaux. Etant donné l'environnement océanique de Victoria et la beautée naturelle de la region, la conférence va se distinguer par un interêt accentué pour les domaines de l'acoustique marine et environnementale.

Centre de conférence et Logement – La conférence va prendre place à l'hôtel Laurel Point Inn, www.laurelpoint.com, un hôtel historique de Victoria. Le Laurel Point Inn est un endroit exceptionnel sur le front de mer de Victoria. Il est l'unique occupant d'une petite péninsule separant le port en deux, entouré de jardins et étangs silencieux, et idéalement situé le long de la promenade de la digue. L'hôtel est à quelques minutes à pied de toutes les attractions du centre-ville, incluant les Bâtiments Parlementaires, le Musée Royal de Colombie-Britanique, le centre commercial de la rue du Gouvernement, la Marina de l'Arrière-port, ainsi que la jetée de Pointe Ogden, le Quai des Pêcheurs, et le Parc de Beacon Hill. L'hôtel offre 200 chambres luxueuses, chacune avec balcon et vue sur le port. Les salles de conférence haut-de-gamme sont regroupées autour de la terrasse vitrée de la salle de ball où les repas et l'évènement vont prendre place. Les participants réservant l'hôtel avant le 12 septembre 2010 recevront un tarif préférentiel de $109/nuit (ocupation simple ou double, incluant la connection internet sans fil et pleins d'autres avantages). Rester à cet hôtel extraordinaire va vous placer prêt de vos collègues et de toutes les activitées de la conference, et va contribuer à faire de cette réunion un succès financier pour le bénéfice des activités futures de l'ACA. Les chambres à prix réduits sont disponibles du 10 au 18 octobre, donc n'hésitez pas à prolonger votre visite à Victoria pour prendre quelques jours de vacances.

Sessions Plénières – Des conférences plénières sont prévues dans des domaines d'intérêt général incluant la bio-acoustique marine, l'acoustique environmentale et le contrôle du bruit.

Arriere-port et Batiments Parlementaires au crepuscule. (Photo: Tyler Ahlgren, Tourism Victoria)

Jetée de Pointe Ogden.—un magnifique endroit pour se promener. (Photo: Richard Funnell, Tourism Victoria)

Hôtel Laurel Point et Terrasse vitrée.

Sessions Techniques – Des séssions techniques seront organisées dans tous les domaines principaux de l'acoustique, incluant les thèmes suivants:

- Acoustique Architecturale et Acoustique des Salles de Classes
- Bio-Acoustique et Acoustique Biomédicale
- Ingénierie Acoustique et Contrôle de Bruit
- Acoustique Physique et Ultrasonore
- Acoustique Musicale
- Psycho- et Physio-Acoustique
- Sciences Auditives et de la Parole
- Acoustique Sous-Marine
- Traitement de Signal Acoustique

Si vous désirez proposer et/ou organiser une séssions spéciale, contactez le Président Technique aussi tôt que possible.

Exposition et Commandite – La conférence incluera une exposition d'équipements, produits et services acoustiques, qui prendra place le jeudi 14 Octobre 2010. Si vous ou votre entreprise êtes interessés à participer à l'exposition ou à commanditer les évènements sociaux de la conférence et/ou les séssions, qui permettront d'excellentes opportunités promotionnelles, contactez le coordinateur de l'exposition.

Activités – La conférence commencera le mercredi matin avec une cérémonie d'ouverture et de bienvenue. Jeudi soir se tiendra le traditionnel banquet de l'ACA et la cérémonie de remise des prix ou vous pourrez déguster l'extraordinaire cuisine façon Cote-Ouest.

Cours/Séminaires – Si vous souhaitez offrir un cours/séminaire en association avec la Semaine Canadienne d'Acoustique, contactez le Président de la Conférence. De l'assistance est disponible pour organiser cet évènement, mais il doit être financièrement indépendant de la conférence.

Participation Etudiante – La participation étudiante est fortement encouragée. Des indèmnitées de voyages et des frais réduits d'inscription seront disponibles. Un programme de partage de chambres d'hôtel sera organisé pour réduire les coûts. Les étudiants donnant une présentation sont élligibles pour gagner des prix pour les meilleures présentations de la conférence.

Soumission d'Article – L'échéance pour la soumission des résumés est le 15 Juin 2010. Les résumés de deux pages pour publication dans le numéro d'actes de conférence de *Acoutique Canadienne* sont dus le 2 août 2010. Les détails seront donnés sur le site internet de la conférence.

Inscription – Les détails sur les frais et formulaires d'inscription seront bientôt disponibles sur le site internet de la conférence. Les pré-inscriptions à prix réduits sont disponibles jusqu'au 12 septembre 2010.

Comité Local d'Organisation

Président de la Conférence:	Stan Dosso [sdosso@uvic.ca]
Président Technique:	Roberto Racca [roberto.racca@jasco.com]
Exposition:	Clair Wakefield [exhibits2010caa@wakefieldacoustics.com]
Trésorier:	Lara Berg [lara.berg@jasco.com]
Secrétaire:	Michael Wilmut [mjwilmut@uvic.ca]
Inscription:	Lori Robson [registrar2010caa@wakefieldacoustics.com]
Website:	Brendan Rideout [Brendan.rideout@gmail.com]

Site web de la conference: www.caa-aca.ca

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INSTRUCTIONS TO AUTHORS FOR THE PREPARATION OF MANUSCRIPTS

Submissions: The original manuscript and two copies should be sent to the Editor-in-Chief.

General Presentation: Papers should be submitted in camera-ready format. Paper size 8.5” x 11”. If you have access to a word processor, copy as closely as possible the format of the articles in Canadian Acoustics 18(4) 1990. All text in Times-Roman 10 pt font, with single (12 pt) spacing. Main body of text in two columns separated by 0.25”. One line space between paragraphs.

Margins: Top - title page: 1.25”; other pages, 0.75”; bottom, 1” minimum; sides, 0.75”.

Title: Bold, 14 pt with 14 pt spacing, upper case, centered.

Authors/addresses: Names and full mailing addresses, 10 pt with single (12 pt) spacing, upper and lower case, centered. Names in bold text.

Abstracts: English and French versions. Headings, 12 pt bold, upper case, centered. Indent text 0.5” on both sides.

Headings: Headings to be in 12 pt bold, Times-Roman font. Number at the left margin and indent text 0.5”. Main headings, numbered as 1, 2, 3, ... to be in upper case. Sub-headings numbered as 1.1, 1.2, 1.3, ... in upper and lower case. Sub-sub-headings not numbered, in upper and lower case, underlined.

Equations: Minimize. Place in text if short. Numbered.

Figures/Tables: Keep small. Insert in text at top or bottom of page. Name as “Figure 1, 2, ...” Caption in 9 pt with single (12 pt) spacing. Leave 0.5” between text.

Line Widths: Line widths in techincal drawings, figures and tables should be a minimum of 0.5 pt.

Photographs: Submit original glossy, black and white photograph.

Scans: Should be between 225 dpi and 300 dpi. Scan: Line art as bitmap tiffs; Black and white as grayscale tiffs and colour as CMYK tiffs;

References: Cite in text and list at end in any consistent format, 9 pt with single (12 pt) spacing.

Page numbers: In light pencil at the bottom of each page.
Reprints: Can be ordered at time of acceptance of paper.

DIRECTIVES A L’INTENTION DES AUTEURS PREPARATION DES MANUSCRITS

Soumissions: Le manuscrit original ainsi que deux copies doivent être soumis au rédacteur-en-chef.

Présentation générale: Le manuscript doit comprendre le collage. Dimensions des pages, 8.5” x 11”. Si vous avez accès à un système de traitement de texte, dans la mesure du possible, suivre le format des articles dans l’Acoustique Canadienne 18(4) 1990. Tout le texte doit être en caractères Times-Roman, 10 pt et à simple (12 pt) interligne. Le texte principal doit être en deux colonnes séparées d’un espace de 0.25”. Les paragraphes sont séparés d’un espace d’une ligne.

Marges: Dans le haut - page titre, 1.25”; autres pages, 0.75”; dans le bas, 1” minimum; latérales, 0.75”.

Titre du manuscrit: 14 pt à 14 pt interligne, lettres majuscules, caractères gras. Centré.

Auteurs/adresses: Noms et adresses postales. Lettres majuscules et minuscules, 10 pt à simple (12 pt) interligne. Centré. Les noms doivent être en caractères gras.

Sommaire: En versions anglaise et française. Titre en 12 pt, lettres majuscules, caractères gras, centré. Paragraphe 0.5” en alinéa de la marge, des 2 cotés.

Titres des sections: Tous en caractères gras, 12 pt, Times-Roman. Premiers titres: numéroter 1, 2, 3, ..., en lettres majuscules; sous-titres: numéroter 1.1, 1.2, 1.3, ..., en lettres majuscules et minuscules; sous-sous-titres: ne pas numéroter, en lettres majuscules et minuscules et soulignés.

Equations: Les minimiser. Les insérer dans le texte si elles sont courtes. Les numéroter.

Figures/Tableaux: De petites tailles. Les insérer dans le texte dans le haut ou dans le bas de la page. Les nommer “Figure 1, 2, 3,...” Légende en 9 pt à simple (12 pt) interligne. Laisser un espace de 0.5” entre le texte.

Largeur Des Traits: La largeur des traits sur les schémas technique doivent être au minimum de 0.5 pt pour permettre une bonne reproduction.

Photographies: Soumettre la photographie originale sur papier glacé, noir et blanc.

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The Canadian Acoustical Association
l'Association Canadienne d'Acoustique

Application for Membership

CAA membership is open to all individuals who have an interest in acoustics. Annual dues total $80.00 for individual members and $35.00 for Student members. This includes a subscription to ***Canadian Acoustics***, the Association's journal, which is published 4 times/year. New membership applications received before August 31 will be applied to the current year and include that year's back issues of ***Canadian Acoustics***, if available. New membership applications received after August 31 will be applied to the next year.

Subscriptions to *Canadian Acoustics* *or* Sustaining Subscriptions

Subscriptions to ***Canadian Acoustics*** are available to companies and institutions at the institutional subscription price of $80.00. Many companies and institutions prefer to be a Sustaining Subscriber, paying $350.00 per year, in order to assist CAA financially. A list of Sustaining Subscribers is published in each issue of ***Canadian Acoustics***. Subscriptions for the current calendar year are due by January 31. New subscriptions received before August 31 will be applied to the current year and include that year's back issues of ***Canadian Acoustics***, if available.

Please note that electronic forms can be downloaded from the CAA Website at **caa-aca.ca**

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l'Association Canadienne d'Acoustique
The Canadian Acoustical Association

Formulaire d'adhésion

L'adhésion à l'ACA est ouverte à tous ceux qui s'intéressent à l'acoustique. La cotisation annuelle est de 80.00$ pour les membres individuels, et de 35.00$ pour les étudiants. Tous les membres reçoivent ***l'Acoustique Canadienne***, la revue de l'association. Les nouveaux abonnements reçus avant le 31 août s'appliquent à l'année courante et incluent les anciens numéros (non-épuisés) de ***l'Acoustique Canadienne*** de cette année. Les nouveaux abonnements reçus après le 31 août s'appliquent à l'année suivante.

Abonnement pour la revue *Acoustique Canadienne* et abonnement de soutien

Les abonnements pour la revue ***Acoustique Canadienne*** sont disponibles pour les compagnies et autres établissements au coût annuel de 80.00$. Des compagnies et établissements préfèrent souvent la cotisation de membre bienfaiteur, de 350.00$ par année, pour assister financièrement l'ACA. La liste des membres bienfaiteurs est publiée dans chaque issue de la revue ***Acoustique Canadienne***. Les nouveaux abonnements reçus avant le 31 août s'appliquent à l'année courante et incluent les anciens numéros (non-épuisés) de ***l'Acoustique Canadienne*** de cette année. Les nouveaux abonnements reçus après le 31 août s'appliquent à l'année suivante.

Pour obtenir des formulaires electroniques, visitez le site Web: **caa-aca.ca**

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Cocher vos champs d'intérêt: (maximum 3)

1. Acoustique architecturale
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