NOISE CONTROL ISSUES IN A STEEL-FRAME INSTITUTIONAL BUILDING

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1 Introduction

The replacement of Oak Bay High School's original 1930's and 1950's buildings with a single school/community facility was largely completed for the start of the 2015-16 school year. The new building features two gymnasia, a large atrium/common space, band and choral rehearsal rooms, drama and dance studios, and a 400-seat community theatre. The classrooms, laboratories and Community and First Nations spaces are housed in two and three-storey sections of the building.

The building is of steel-frame construction with floor sections of concrete-topped, corrugated steel (Q-deck). In most interior locations, the steel columns and diagonal cross-bracing are located inside conventional steel stud and gypsum board walls. Because of the need to accommodate structural steel elements of various widths and achieve a range of lab-rated Sound Transmission Class (STC) targets (from STC 53 for classrooms to STC 60 for the wall separating the Theatre form the Atrium), a large number of unique wall sections were required. The band, choral and dance spaces are over 6 m high with exposed steel roof trusses.

The steel-frame constructions described above led to several acoustical separation issues including excessive sound transmission directly through the demising walls between certain adjacent spaces, sound transmission between third floor classrooms via the Q-deck roof, and via large, round supply air ducts serving the band and dance spaces. These issues, and how they were overcome, are discussed below.

2 Acoustic Separation Issues

2.1 Steel Framing Effects on Wall STC's

The structural steel framing (columns and cross bracing) supporting the building had to be accomodated within the cavities of the steel stud and gypsum board demising walls. While these demising walls do not support the building, the heights of the walls separating the various laboratories as well as the band, choral, and dance spaces, required that the studs be load-bearing (i.e., not lightweight). The acoustical separation was then compromised in two ways :

- Excessive transmission via the load-bearing studs,
- Resilient channel ineffective - "squashed" between steel framing and gypsum board.

The wall cavities should have been wide enough to accommodate the steel framing elements, however, it was subsequently learned that the framing sizes had been increased late in the design process and it is possible that the wall cavity widths were not adjusted accordingly. The effect was to limit the Apparent Sound Transmission Class (ASTC) ratings achieved in field tests as follows:

- Wall between laboratories achieved ASTC 37 when lab-rated objective was STC 53,
- Wall between Theatre and Atrium achieved ASTC 37 when lab-rated objective was STC 60.

Figure 1 shows an example of the problems created in accommodating the steel cross braces within the Theatre/Atrium wall.

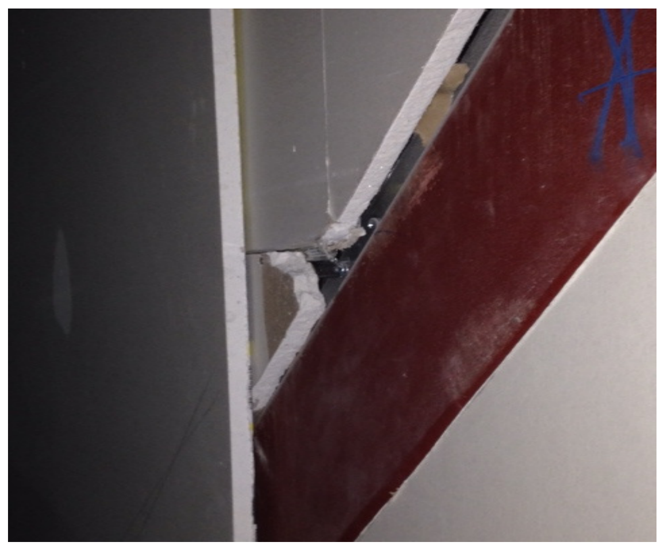

Figure 1: Bridging of Theatre/Atrium wall cavity by structural steel cross bracing.

2.2 Effect of Q-deck Roof on Acoustic Separation

When an insulated double-stud (steel studs and drywall) wall separating two classrooms on the third floor was field tested, it yielded STC 38, in spite of being laboratory rated at well over 50. Since this double stud wall contained no structural steel elements, it was at first unclear why it performed so poorly. Upon investigating more closely, it was found that sound was primarily being radiated from the Q-deck ceiling, which was the underside of the school's roof, and was concealed by a conventional T-bar acoustic ceiling. Unlike the floor assemblies between the first and second and second and third levels, the roof assembly has no concrete topping layer, only rigid insulation and roofing

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material. Without the mass and stiffness provided by a concrete topping, the Q-deck was able to respond to sound field in the source room and provide a structure-borne sound path between the two rooms. Upon reviewing the structural plans, it was seen that, in only a few situations, were the Q-deck corrugations perpendicular to the demising wall, thereby facilitating the transmission of vibration/sound between rooms. Where the corrugations ran parallel to the wall, sound transmission was greatly reduced.

2.3 Sound Transmission via Supply Air Ducts

Figure 2 shows the supply air ducts serving the school's performing arts area. The ducts shown are located in the band room. They pass through the wall at the right and continue into the dance and drama studios beyond. This wall had a STC objective of 55, but when first tested it yielded only STC 45. Investigations showed that, while the supply air ducts were round and featured spiral-wound sheet metal, sound created in the band room was able to pass through the duct walls, travel along the duct and pass through the demising wall. There sound was transmitted through the duct walls again and into the dance studio. Music created in the dance studio did the same, but in the opposite direction.

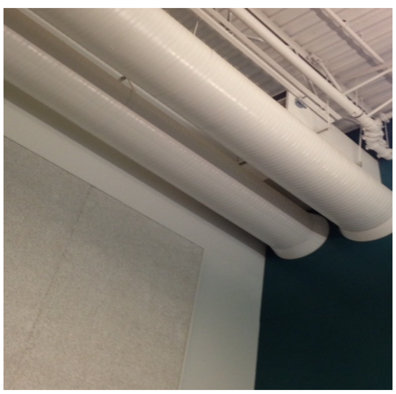

Figure 2: Supply Air Ducts passing between Band Room and Dance Studio.

3 Noise Control Measures

3.1 Improving the Transmission Loss of Walls

The problems created in certain demising walls by the presence of structural steel elements and inadequate cavity width were overcome by creating separate, free-standing (self-supporting) barrier layers (steel studs and gypsum board or dense board) over one side of each wall. The newly created wall cavities were insulated. In some cases the existing gypsum board surface was first removed so that a wider cavity could be created, in other cases, where space was less critical, the existing gypsum board was retained. The most challenging situation was that between the Theatre and the Atrium, both because of the size of the wall (see Figure 3) and because of the high STC objective. For this reason, a localized mock-up section was first created and tested before the entire wall was treated.

These wall treatments generally increase classroom wall performance from about ASTC 37 to ASTC 47. In the case of the Theatre/Atrium wall, the ASTC was increased from 37 to 55. Testing a wall of this size is challenging, however, the wall now functions satisfactorily.

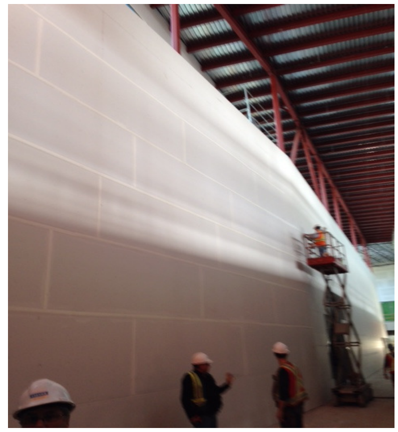

Figure 3: Atrium/Theatre wall under construction - Atrium side.

3.2 Treating Q-Deck Sound Transmission

The problem of sound transmission between some third floor classrooms via the Q-deck roof was addressed by back loading the acoustic ceiling tile with 13 mm gypsum board. While it may not have been necessary, the builder back loaded the tiles on both sides of the wall. The result was to increase the ATSC from 37 to 46.

3.3 Treatment of Supply Air Ducts

Several options were considered, including internal duct lining, external duct lagging and silencers. Rather it was decided to build a acoustically-lined gypsum board bulkhead around the two ducts within the band room only. This treatment may be seen in Figure 4. The outcome of this treatment was to increase the ASTC between the band room and dance studio from 45 to 51. However, the ASTC rating would likely have been higher but for the presence of HVAC noise in the dance studio.

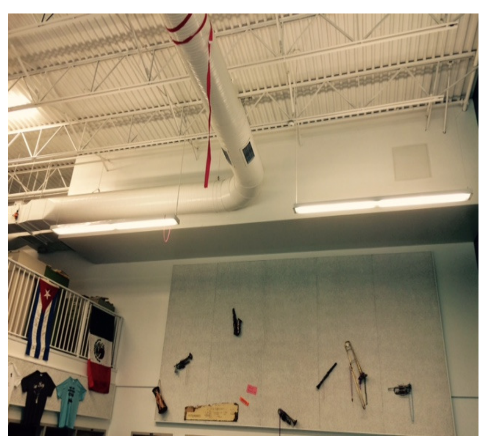

Figure 3: Bulkhead Around Supply Air Ducts in Band Room.