

RWDI: ACOUSTICS, NOISE, AND VIBRATION CONSULTANTS

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Résumé

RWDI est une firme de consultation multidisciplinaire canadienne ayant des bureaux partout au Canada (y compris des bureaux à Vancouver et à Victoria) qui offrent des services de consultation en acoustique. Dans cet article, nous présentons le large éventail d'expériences, de projets et de services réalisés par RWDI. La majeure partie de notre expertise concerne l'acoustique environnementale et architecturale et le contrôle du bruit et des vibrations mais inclue également des projets d'envergure dans le domaine des constructions en bois massif, du contrôle de la conformité aux codes et aux règlements, ainsi que l'élaboration de politiques. L'ensemble des projets entrepris par RWDI contribue à supporter diverses communautés grâce à notre soutien technique en conception et en construction.

Mots clefs : acoustique, bruit, vibration, architecture, environnement, bois massif, codes, règlements, politique, mesure, essai, conception

Abstract

RWDI is a Canadian multi-disciplinary consulting firm with offices across Canada that provide acoustic consulting services, including offices in Vancouver and Victoria. The broad range of projects, services, and experience are highlighted. The core of our work is in environmental and architectural acoustics, noise, and vibration projects, but is further detailed in highlights of our work in mass timber construction, code and bylaw testing, and policy development. It is concluded that the work we do ultimately contributes to helping improve our communities through technical support to the design and construction community.

Keywords: acoustics, noise, vibration, architecture, environment, mass timber, codes, bylaws, policy, measure, test, design

1 Introduction

RWDI is a Canadian owned and operated specialty consulting firm that began in 1972 as a snow loading consultancy out of Guelph, ON, and has expanded to include many specialty science and engineering consulting services with offices across Canada and around the world. In 2013 the Vancouver office began a focused growth in acoustics with the hire of Steve Meszaros (previously with RWDI in Guelph from 2000-2009). RWDI then acquired Dan Lyzun & Associates Ltd. of Vancouver (est. 2002) in 2014, and Wakefield Acoustics Ltd. of Victoria (est. 1988) in 2016.

Since its inception, RWDI's BC acoustics team has had continuous growth and is supported by an even larger team that includes staff in RWDI's Calgary, Toronto, and Guelph offices, as well as staff as far afield as Denmark.

The acoustics team is a strong support to RWDI's promise of being 'exceptional without exception' while also striving to be the consultant of choice within our local communities. RWDI's influence on our communities reaches far beyond the walls of our offices, and we feel a

sense of pride when living, working and moving within the peace, quiet and enjoyment of spaces and places we've worked hard to help create. The subsequent sections are a summary of some of the work being done by our team.

2 Environmental noise and vibration

Major infrastructure projects (highway, transit, civil and energy works, marine ports, airports), industrial plants, commercial developments and even recreational facilities can create significant noise and vibration impacts at neighbouring residential and other noise-sensitive land uses. Such impacts may occur during both the construction and ongoing operation of these facilities.

Federal, Provincial, Regional and Municipal requirements dictate that such impacts should be assessed and mitigated. RWDI conducts such assessments independently in situations where noise and/or vibration are the primary concerns (such as facility construction or operations), or commonly as part of a multi-disciplinary team when a proposed project is subjected to a formalized environmental, social, and economic review process.

In carrying out such assessments, RWDI would typically conduct field measurements of pre-project (baseline) noise and/or vibration levels in potentially-affected communities. A large inventory of precision instrumentation and state-of-the-art modelling software is at

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our disposal to assess existing environments and predict future noise and vibration levels at locations of interest. This allows us to provide mitigation solutions that are customised to each project's specific requirements.

The experience of the RWDI team includes many major infrastructure projects in southwestern BC over the past two decades. Some of these include the Sea to Sky Highway Improvement Project, the Port Mann/Hwy 1 project, and the George Massey Tunnel Replacement Project. Currently, RWDI is involved in assessing community noise and vibration levels for the Roberts Bank Terminal 2 Project, Trans Mountain Expansion Project, Site C Clean Energy Project, Capital Regional District Sewage Treatment Project, Pattullo Bridge Replacement Project and the Hwy 1/Mountain Highway Interchange Project.

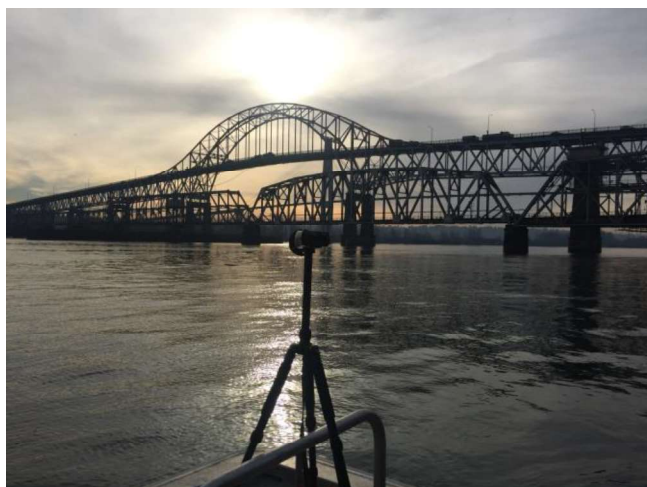


Figure 1: Measuring noise from the Pattullo bridge

3 Architectural acoustics and vibration

Architectural acoustics and vibration work deals with buildings of all type and scale with a broad range of issues that are interconnected. This section provides insight into some of the acoustics and vibration work done for building design with a focus on the intended use and the experience of the end user in mind.

Noise control and zoning bylaws drive most requirements for noise ingress controls for residential land-uses situated in noisy areas. The interior sound isolation requirements for party walls are dictated by the BC Building Code.

Mechanical noise emissions to the exterior are also dictated by local bylaws but internal mechanical noise is non-regulated. In these cases we look to various published guidelines such as those from ANSI, ASHRAE etc., as well as best practice guidelines from other jurisdictions as appropriate.

Room acoustics projects range from board rooms and offices (private and open plan), to classrooms, music rooms, studios, performance spaces, pools, arenas, and more. These are always rewarding projects to work on as they allow for a degree of artistic creativity. RWDI has strong relationships with local and international architects, where we collaborate

to specify surface finishes and geometry for spaces that are both acoustically effective and aesthetically pleasing.



Figure 2: Room acoustics measurements in a concert hall with an omni-directional source

Only residential partitions are mandated by the BC Building Code; however, designing for indoor noise targets and creating comfortable working spaces requires in-depth knowledge of sound transmission control. Space constraints of high density living creates non-compatible adjacencies that are unavoidable. Some such complex adjacencies we've worked on include a generator room adjacent to a bedroom, music rehearsal spaces adjacent to classrooms, noisy MRI equipment adjacent to a lecture theatre, and a noisy roadway adjacent to a hearing testing facility, to name a few. Creating some of the quietest spaces and/or attenuating some of the loudest sounds requires ingenuity when combined with normal building design constraints.

Isolating machinery from building structures is paramount in all cases to minimize transmission of mechanical vibration into a building's structure where it can then efficiently propagate and radiate as structure-borne noise throughout the building. Elevators are a common source that requires careful isolation to avoid complaints from penthouse occupants.

Impact noise in residential spaces, is a common complaint in multi-family buildings. This is exacerbated by the trend to replace carpet with hard flooring. Like impact noises from gyms (weights dropping and treadmills), these are problems that are difficult to address without significant upgrades.

Vibration in buildings can be problematic where vibrations could adversely affect occupants or vibration sensitive equipment. RWDI models vibration from both internal (e.g., mechanical, footfall) and external (e.g., road, rail) sources and their propagation through soil, soil-structure, and building structures. Our experience in this type of work has enabled us to help design structures that meet very stringent research and occupant comfort requirements.

Wind-induced noise or aeroacoustics is a specialty service of RWDI, combining our wind engineering, climate statistics, fluid dynamics, and acoustics abilities. This service focuses on exterior building elements and design details that have the potential for creating noise when the wind blows. Desktop reviews lead to identification and risk ratings of various elements. Recommendations for design

changes are provided for those elements at greater risk of making noise in the wind, and critical elements are tested in the wind tunnel to quantify their noise generating potential and to test the performance of solutions.

None of the above services stand alone. In combination they provide spaces that are comfortable, functional, and meet the needs of their occupants. We have many notable and unique projects that include a parkade rooftop daycare, the tallest wood structure building in the world, world-class research facilities, and many recreational, school, residential, healthcare, institutional, and commercial facilities.

4 Mass timber construction

RWDI has been involved in many projects using Nail Laminated Timber (NLT), Cross Laminated Timber (CLT) and hybrid constructions; the most notable being the “tallest wood frame construction building in the world”, the Brock Commons student residence at UBC.

Architects are increasingly opting to use exposed wood finishes as driven by the “wood first” provincial mandate. CLT and NLT provide attractive options for exposing the structural members, which reduces the need for and cost of furring walls and finishes. CLT walls are also becoming increasingly common on projects in the Lower Mainland. However, wood structural elements such as NLT and CLT, while they may be constructed to have the strength and durability akin to concrete, have markedly different acoustic properties.

Airborne noise isolation

Airborne sound isolation in CLT walls is similar to basic insulated-cavity wall construction if there is at least one side of the CLT covered with furring and a layer of gypsum wallboard, or similar. This allows the other side to remain exposed in areas that do not require high levels of sound insulation. However, in order to meet building code requirements (currently STC 50 for party walls) either both sides of the CLT need to be covered in furring walls, or one side needs to be structurally isolated from the CLT. In such cases, exposed CLT does not seem to be the prudent choice. For CLT ceilings, the underside of the CLT should generally be covered to meet code requirements. As such, exposed CLT ceilings are only typically seen in penthouse units where there are no occupants or noisy equipment above.

Impact noise isolation

The driving factor in the construction of party floor separations using mass timber tends to be impact noise isolation. Mass timber floors provide poor impact noise isolation when compared to their concrete counterparts. Typically, an insulated suspended acoustic barrier ceiling (e.g., GWB) is required below with a high quality acoustic underlay or carpet above to reduce impact noise to reasonable levels. Even given careful consideration, however, it is still difficult to achieve impact noise isolation

levels that are acceptable to occupants of multi-family residential units without the use of a concrete topping to increase the total mass of the floor assembly. Encouragingly, we are seeing increased innovation on the part of architects and developers to provide acoustically effective construction without foregoing the benefits of mass timber construction.

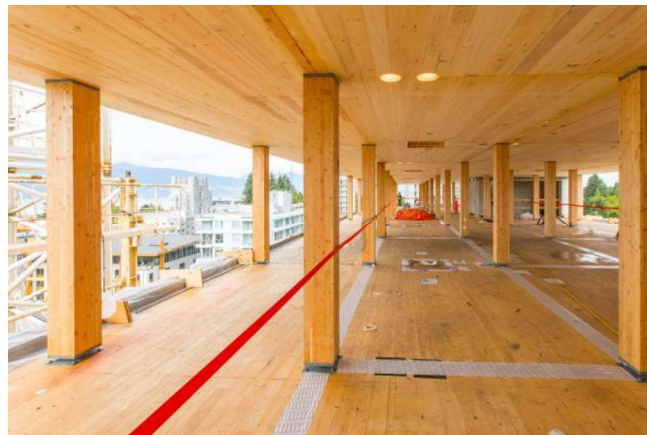


Figure 3: Brock commons, before wood was covered

5 Codes and bylaw testing

Building code testing (ASTC, AIIC)

RWDI provides acoustical testing services to validate building designs in terms of the sound transmission class (STC) of party walls and floors, the impact insulation class (IIC) of party floors, and to verify that exterior noise emissions from building services will not exceed municipal noise bylaw limits.

In BC, the building code currently requires that party wall partitions within multi-family dwellings provide a minimum of STC 50. To verify that the air-borne sound insulation provided by partitions meet this requirement, RWDI conducts STC testing in accordance with ASTM E336 “Test Method for Measurement of Airborne Sound Insulation in Buildings”. An STC test conducted “in-situ” (as opposed to within a laboratory) is referred to as an apparent sound transmission class (ASTC) test. Unlike laboratory-tested STC ratings, ASTC ratings include secondary sound transmission paths due to sound flanking along common floors, ceilings and side walls. In cases where the ASTC is deficient, RWDI works with the owners to find solutions that will increase the air-borne sound insulation provided by the partition to acceptable levels.

While the B.C. Building Code does not include a requirement for party floor IIC ratings, it does recommend that bare floors (tested without carpet) should achieve IIC 55. RWDI conducts IIC tests in accordance with ASTM E1007 “Standard Test Method for Field Measurement of Tapping Machine Impact Sound Transmission Through Floor-Ceiling Assemblies and Associated Support Structures”. Similar to the case of STC field-tests, measured IIC performance in buildings is referred to as the apparent impact insulation class (AIIC). The test procedure is similar to that for an ASTC test, with the primary difference being

that the sound source is a standardized tapping machine, which uses metal cylinders to rhythmically strike the surface of the floor being tested.

In addition to providing AIIC test services, RWDI provides recommendations to architects and builders to maximize the AIIC of party floors. These recommendations often include evaluation of acoustical underlayment for use beneath finished floors.

Both ASTC and AIIC testing have been done on numerous residential projects in early construction to verify that a design meets Code, in post-construction to assess final performance, and in litigation cases where occupants are unsatisfied with the performance of their residence.

Noise bylaw testing

Certain municipalities in Canada, including the City of Victoria and those in the Lower Mainland, have noise bylaws that include quantitative noise level limits. Many of these municipal bylaws divide the city into “noise districts” which have different allowable noise levels based on land use.

RWDI is often requested to evaluate compliance with noise bylaws. Our experience with measurement, modelling, and design help us with interpretation of bylaws and in solving noise problems in an efficient and effective way.

6 Policy development

As a result of RWDI’s extensive experience in the area of environmental noise and acoustics, RWDI has been instrumental in the development of noise policies and guidelines widely used within BC. RWDI has been tasked by various governing and regulatory bodies such as the B.C. Ministry of Transportation and Infrastructure (MoTI), B.C. Ministry of Energy, Mines and Petroleum Resources (MoEMPR), Vancouver Fraser Port Authority (VFPA), and the City of Vancouver (CoV) to develop or update noise policies. These policies reflect local conditions while generally aligning with national and/or international noise control objectives. RWDI’s experience includes the development of the following:

- Policy for Assessing and Mitigating Noise Impacts from New and Upgraded Numbered Highways (MoTI, 2014)
- Best Practice for Wind Power Project Acoustic Assessment (MoEMPR, 2012)
- Project & Environmental Review: Guidelines – Environmental Noise Assessment (VFPA, 2015)
- Soundsmart: City of Vancouver Noise Control Manual (CoV, 2005)

Further, RWDI has provided feedback on updates to the B.C. Oil and Gas Commission’s Noise Control Best Practice Guideline. RWDI personnel were also integral in the development of the Nail-Laminated Timber Canadian Design Construction Guide which provides best practice techniques for controlling acoustic issues that arise in timber framed construction.

Policy Objectives

The MoTI policy was developed to establish community noise objectives and provide a broad range of mitigation options for projects involving numbered highways. The goal is to avoid unacceptable noise levels at noise sensitive locations near highways.

The MoEMPR document was developed to recommend a best practice for conducting sound assessments of wind power projects that meets requirements and intent of the Land Use Operational Policy – Wind Power Projects, the requirements of the BC Clean Energy Project Development Plan Information Requirements, and provides sufficient technical analysis for reviewers to evaluate wind energy projects.

The VFPA policy is intended to assist applicants for projects on lands and waters managed by VFPA in the assessment of potential noise impacts associated with the operation of their proposed projects.

CoV’s SoundSmart manual was developed to familiarize residents with urban noise and its sources, how it affects people and how both exterior and interior noise can be controlled. The manual also provides guidance to prospective homebuyers and tenants on how to avoid living situations that they may find too noisy.

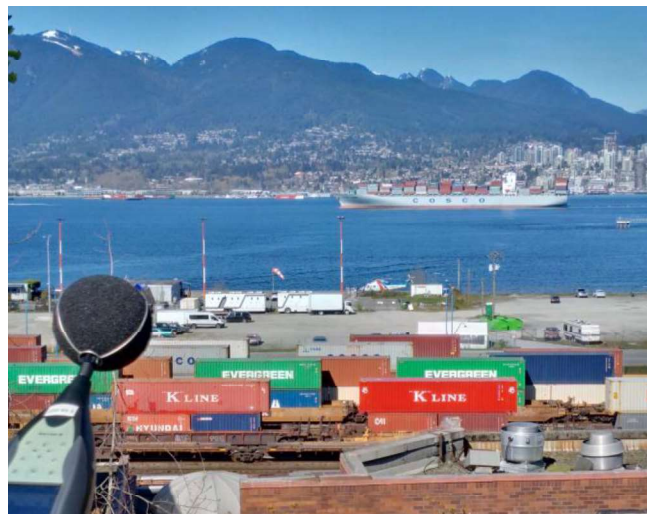


Figure 4: Rooftop noise measurements for CoV

7 Conclusion

We have provided a brief outline of some of the exciting work that RWDI has done in the fields of acoustics, noise and vibration in the province of British Columbia.

We are constantly applying our experience and knowledge in new and exciting ways to support the goals of our clients. Collaborating with the design and construction community allows us to improve the environment that surrounds us all, and to ultimately improve peoples’ lives.

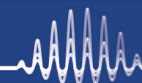
RWDI’s acoustics, noise and vibration team is a small part of a greater company of world-leading experts. This unique position provides us with opportunities to work on projects from around the world and bring that experience back to our local projects.

Acknowledgments

The authors would like to thank our colleagues who make it a joy to come to work, our clients for bringing us onto their teams and entrusting us with their unique problems, and to the science and engineering community, past, present, and future, to whom we are indebted for the state of understanding from which we benefit.

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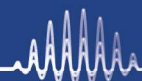
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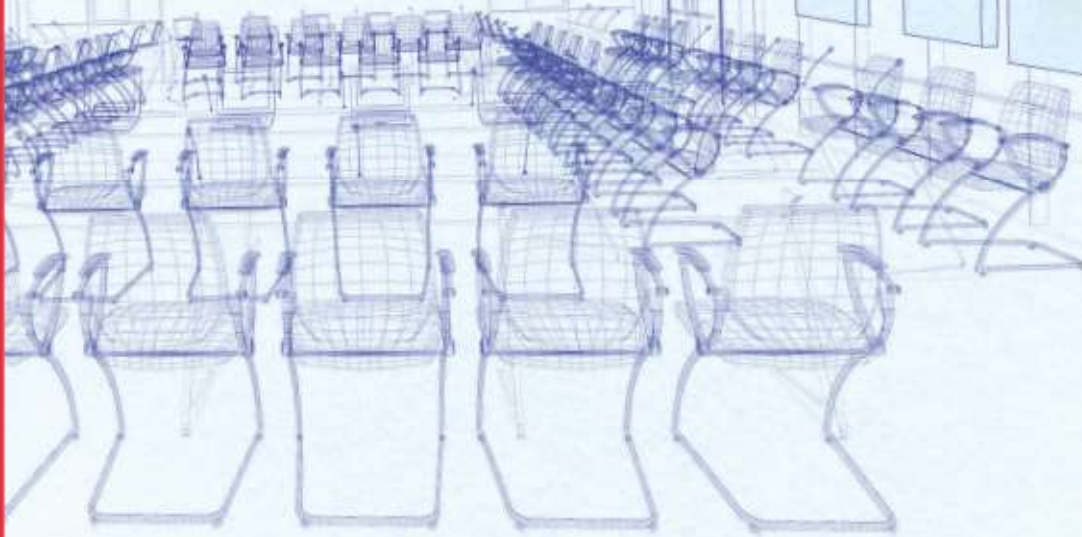


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