SOUND AND VIBRATION IN BUILDINGS AND THE ENVIRONMENT: RWDI

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Abstract

RWDI is a specialty provider of consulting engineering and science. In addition to offices in Guelph, Toronto and Hamilton it has offices across Canada and globally. The company is recognized internationally for its work to push the boundaries of engineering and practical scientific knowledge. Sound and vibration at RWDI spans the company's subject areas of environment, buildings, wind load and its effects. This article illustrates some types of sound and vibration work conducted at RWDI.

Keywords: acoustics, noise, vibration, aeroacoustics, footfall, mitigation, monitoring, ECA, NAAP, tuned-mass damper

Résumé

RWDI est un fournisseur de services spécialisés et expert-conseil en ingénierie et autres sciences, ayant un siège social situé à Guelph et possédant plusieurs bureaux satellites partout au Canada et dans le monde. RWDI est mondialement reconnu comme étant une entreprise qui pousse les limites d'ingénierie et des sciences. Chez RWDI, l'expertise en bruit et vibrations se retrouve dans plusieurs de nos domaines de services, soit par exemple, l'environnement, les bâtiments et les effets de charges dues aux vents. Cet article illustre les différents types d'études sur le bruit et les vibrations menées par RWDI.

Mots clefs : acoustique, bruit, vibrations, aéroacoustique, bruit de pas, moniteur de bruit, l'amortisseur de masse à l'écoute

1 Introduction

The consulting firm RWDI, also known as Rowan Williams Davies & Irwin, began in Guelph Ontario and has grown to a staff of more than 400 people located in offices and testing facilities nationally and internationally. The principal Canadian locations are in Guelph, Toronto, Calgary, Vancouver, Hamilton, Windsor, Ottawa, and Thunder Bay.

Sound and vibration services are integral to the company's specialty consulting services relating to the environment, buildings, and the interaction between them. RWDI's international reputation for work that pushes the boundaries of engineering and practical scientific knowledge is regularly called upon to deal with new or unique problems. The development and testing of innovative ideas is supported by a substantial capability for computational and physical modelling.

2 Architectural and Building Acoustics

Design of an acoustic environment involves integration of the structural, mechanical and architectural aspects. Residential projects typically focus on noise control, structure-borne noise and sound flanking paths. Design of performance spaces develops a match of acoustic atmosphere to the type of space through a balance between room volume and shape, ceiling and wall orientations, and surface finishes in order to control reflections and reverberation. Optimization of the materials and speakers is supported by computational acoustic techniques and ray tracing models like the one shown in Figure 1. Existing spaces can be better understood using specialized tools and in-situ testing.

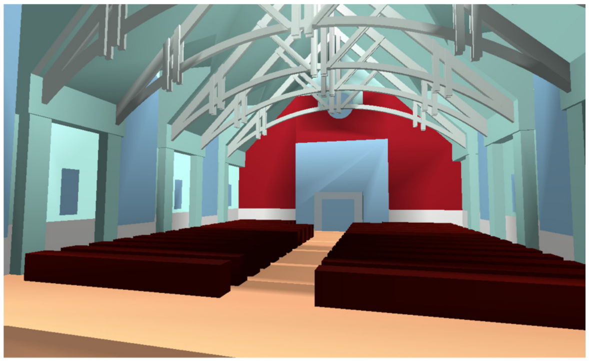

Figure 1: Acoustical Model of a Chapel.

3 Vibration

Mechanical and anthropogenic sources of vibration influence the function and use of our living and working spaces. This is of particular interest for human comfort or operation of MRI, CAT and PET scanners or microscopes. Activity such as walking or recreation in a building can induce vibration that is experienced in other spaces. Interior

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vibration can also propagate from poorly isolated mechanical equipment in the building or from adjacent sources such as roadways, railways or subways. Similarly, vibration can have negative impact on wildlife habitat. RWDI's team quantifies the effect by measurements or modelling and provides mitigation strategies where needed.

4 Structural Motion

The prediction, evaluation and control of structural motion is an important factor in the design of tall buildings and long-span bridges. Modern structures are built for controlled flexibility in response to wind and seismic forces. Determining how a specific structure's design interacts with the wind is the specialty of several teams at RWDI. Testing in wind tunnels, using scale models, can be used to inform the design. Management of the vibration can then be designed into the structure.

In some situations it is desirable to introduce vibration damping systems to buildings or bridges. These use a moving mass as a counterbalance. Examples would be tuned-mass dampers or tuned water-sloshing dampers. The resulting reduction in motion increases human comfort. In the case of the Taipei Financial Center, the damper (shown in Figure 3) is also a tourist attraction surrounded by a restaurant.

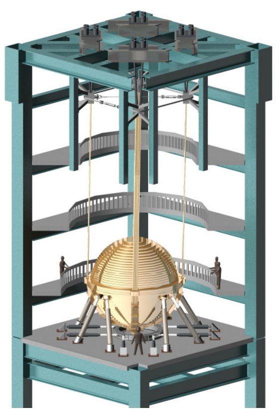

Figure 3: Schematic of a Tuned Mass Damper.

5 Environmental Noise

Outdoor sound is assessed for human annoyance or impact on wildlife in the course of environmental compliance approval, environmental assessment, compliance audit, land-use planning and public consultation projects. RWDI goes beyond the standard measurement and modelling techniques where a better description of the situation needed. This has included areas of complex meteorological influence, or the use of an acoustic camera for convoluted noise sources.

Where noise mitigation is needed, RWDI works interactively with clients to develop strategies and noise abatement action plans using our experience with large and complex mitigation projects. In a recent example, very large sound level reductions requirements were achieved for high plume exhaust fans in cooperation with a specialized mitigation supplier.

6 Aeroacoustics

With the recent proliferation of increasingly novel architectural building designs, aeroacoustic noise and wind-induced vibration in architecture occurs more frequently. Wind flowing across or around external building features such as sunshades, rain screens, mullions and other decorative building elements cause component vibration and intense acoustic tones or whistles (as shown in Figure 2). A number of high-profile incidents have occurred over the past few years. The resulting noise can be audible hundreds of meters from the source, causing complaints and significant disruption to both building occupants and neighbors. Wind-induced vibration may result in concerns with fatigue or component failure. Issues related to wind-induced noise and vibration are often difficult to mitigate, requiring costly retrofits, if addressed after construction is completed.

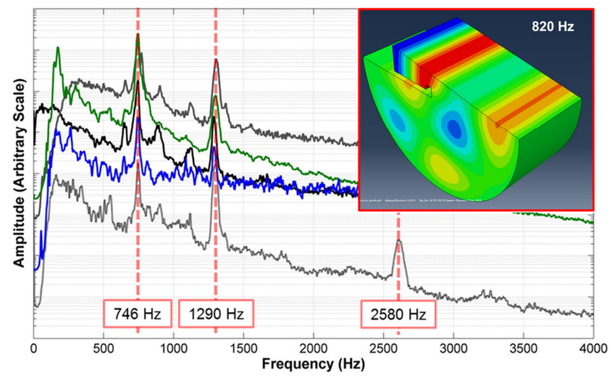

Figure 2: Measured Aeroacoustic Cavity Noise with FEA Prediction.

7 Monitoring

Long term permanent or semi-permanent monitoring is used to show the ongoing achievement of specific criteria in the face of dynamic circumstances. The system provides a record of the operation, or warnings where the criteria are exceeded. Automated monitoring can therefore facilitate complex construction or demolition activity close to sensitive locations. Operators of high performance structures and buildings use monitoring systems to ensure that their buildings continue to perform as intended. Wind farm compliance audits also use automated monitors. RWDI has developed custom systems to address needs across all of its sound and vibration services.

Figure 4: Automated Construction Monitoring System.