ANNOUNCING THE PUBLICATION OF THE SIXTH EDITION OF RR-331: THE GUIDE AND A HISTORY OF THE TRANSITION TO THE ASTC RATING

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Résumé

La sixième édition du rapport de recherche RR-331 : Le Guide est annoncé et un historique des recherches menées au Conseil national de recherches du Canada pour soutenir l'introduction de l'évaluation ASTC dans le Code national du bâtiment : Canada est présenté.

Mots clefs : ASTC, Code national du bâtiment : Canada, Conseil national de recherches Canada, Le Guide

Abstract

The sixth edition of the research report, RR-331: The Guide is announced and a history of the research conducted at the National Research Council Canada to support the introduction of the ASTC rating in the National Building Code of Canada is presented.

Keywords: ASTC, National Building Code Canada, flanking, National Research Council Canada, The Guide

The Acoustics Group at the Construction Research Center is pleased to announce the publication of the sixth edition of the research report, RR-331 The Guide. The latest editions of RR-331 and the companion RR-33x reports can be downloaded from the NRC Publications Archive: https://publications-cnrc.canada.ca/eng/home/. The new edition of RR-331 includes updates to both the guidance for calculating the ASTC rating for different building constructions and to the accompanying worked examples. References to the withdrawn standard, ISO 15712 have been replaced with references to the equations found in the newer ISO 12354 standard. The new edition also includes a history of the minimum requirements for airborne noise in the National Building Code of Canada and the decades of research conducted at the NRC to support the transition to the ASTC rating in 2015. The history is being shared with the readers of Canadian Acoustics as part of this announcement of the new edition of RR-331.

Prior to 1941, the lack of consistency or rules for the construction of houses in Canada resulted in the occurrence of significant quality failures amongst the housing stock. To address this problem and the crisis of homelessness during the Great Depression [1], the first National Building Code of Canada (NBC) was published in 1941 under the joint sponsorship of the Department of Finance and the National Research Council of Canada [2]. The new building code included protection from neighbor noise by requiring a "sound transmission loss, or sound reduction, of not less than 45 decibels". ASTM International would not introduce the new sound transmission class rating until 1961 [3] and so the 1941 NBC defined the sound transmission loss as the arithmetic average of the sound transmission loss values measured in at least nine one-half octaves with twice as many measurements made at frequencies below 1024 Hz as above it. Appendix I of the NBC included figures and the accompanying sound transmission loss ratings of typical wall constructions, many of which included wood studs, wood lath and coats of lime plaster without thermal insulation in the wall cavities.

The next edition of the NBC published in 1960 added the wording that "walls and floors…separating dwelling units, sleeping rooms occupied separately or suites in residential buildings shall be designed to prevent the transmission of objectionable noise between occupancies" [4]. The requirements for the sound insulation were changed from a sound transmission loss value to a maximum airborne level of extraneous noise based on the use of a space. For example, rooms for sleeping were allowed to have a maximum airborne level of extraneous noise of 30 dB for single rooms or 40 dB for dormitories. There was also a maximum permissible airborne noise level produced by occupancy of 80 dB for the sleeping rooms.

These requirements remained in place until 1970 when the NBC added the requirement that the "sound transmission class ratings for construction shall be determined in accordance with ASTM E-90-66T" [5]. A minimum sound transmission class of 45 for walls and floors between dwelling units was required. The tables of Part 9 of the NBC included sound transmission class ratings where rating I was for a sound transmission class of 50 or higher, considered to give "good resistance to transmission of airborne sound", rating II was for sound transmission class ratings between 45 and 50 considered to provide "fair resistance to airborne sound" (note that this was the minimum requirement of the NBC) and rating III was for a sound resistance rating less than 45 which was not acceptable.

The 1975, 1977, 1980 and 1985 editions of the NBC would keep the sound insulation requirements unchanged. It wasn't until the 1990 edition that the requirements were changed so that the "sound transmission class ratings shall be

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determined in accordance with ASTM E413 using results from measurements in accordance with ASTM 90 or ASTM E366." The requirements stated that an STC rating of at least 50 was required for walls and floors between dwelling units and a STC rating of at least 55 was required for walls between dwellings and elevator shafts or refuse chutes [6]. It was around this time that a series of consortiums led by various combinations of Mohamed Sultan, Dave Quirt and Alf Warnock extended and updated the table of STC ratings in Part 9 of the NBC.

The NBC would continue to state the minimum requirements for sound insulation in terms of the STC rating until the 2015 edition [7] when the Apparent Sound Transmission Class (ASTC) rating was introduced. This change in the requirements from the STC rating to the ASTC rating was only achieved after decades of research funded through collaboration between the acoustics group at the National Research Council Canada and industry groups.

Alf Warnock led the initial push to establish flanking studies at the NRC and in 1993, the very first flanking transmission laboratory in the world, a four-room facility was established at the NRC. The four-room flanking transmission laboratory was developed by Robin Halliwell with the occasional support by Dave Quirt. The four-room facility would be used extensively by industry consortia in the 1990s for the evaluation of the effect of fire stops on the acoustical separation between dwellings. See for example, the publications by Trevor Nightingale and Mohamed Sultan [8] and by Trevor Nightingale and Robin Halliwell [9] which describe how a fire stop at the wall / floor junction can degrade the apparent sound insulation of party walls. This finding became the motivation for future research and for changing the acoustical requirements in the NBC from a STC rating to an ASTC rating that included the contribution of the flanking paths.

Subsequent research began to look at the junction details. From around 1995 to 2009, Trevor Nightingale led consortiums of partners brought together to fund the research as acknowledged in the research reports that were produced (see for example [9–12]). Additional partnerships were developed to support the research as different details of the construction were investigated including the junctions, the gypsum board and interlayers.

In 1995, Trevor Nightingale published a paper in Applied Acoustics [13] which demonstrated that the draft EN 12354-1 standard [14] tended to underestimate the transmission loss of a flanking path due to the simplifications made in the model to eliminate the use of the radiation efficiencies which are often not known and are difficult to measure. In a paper coauthored by Eddy Gerretsen and Trevor Nightingale [15] it was noted that the underlying assumptions and simplifications applicable to heavy, monolithic constructions such as concrete may not be directly applicable to lightweight constructions.

The development of the standards ISO 10848 parts 1 and 3 [16, 17] allowed for a path forward around these issues for lightweight elements by creating a framework for measurements of the flanking level differences between flanking surfaces. The direct measurement of the sound pressure level in the source and receiver rooms eliminated the need to calculate or measure the resonant component of the sound reduction index and the radiation efficiencies of the elements included in the flanking path. However, the measurements became more complex than those for heavy, monolithic constructions since the measurement of the flanking paths required the ability to apply shielding to all of the paths in the source and the receiver rooms not included in the flanking path under consideration. The shielding was also required if sound intensity was used to measure the flanking transmission loss [18].

The need arose for a facility that was both more flexible than the four-room facility and that could allow for more complex measurements including the ability to add a structural load to the walls. Fortunately, there was enough interest amongst the consortium of industrial partners to build a new flanking transmission laboratory. The eight-room flanking transmission laboratory was constructed in 2004 and 2005 under a program led by Trevor Nightingale with strong support by Robin Halliwell. Also involved in the work were Timothy Estabrooks, Brian Fitzpatrick, Frances King, Donald MacMillan and Joshua Wu [19]. The facility was commissioned in December 2005 and the first measurements were made in 2006.

One of the uses for the new flanking transmission laboratory was a research program to look at the design details for sound insulation of wooden multi-use buildings for Japan and Korea. The laboratory study demonstrated that it was possible to meet the stringent heavy impact sound insulation requirements of Japan and Korea with wood framed construction. There were other aspects to the work as well including a subjective study of different impact noise sources [20] and an investigation [21, 22] of the applicability of the bang machine described in the standards JIS 1418-2 [23] and KS F 2810-2 [24].

In 2006, as part of the fourth phase of the timber framed research, Dave Quirt and Trevor Nightingale collaborated to develop the Guide for Sound Insulation in Wood Frame Construction [25]. Phase five of the research developed the first version of the online Guide. These were the precursors to the RR-33x series of research reports which would provide guidance for the most common types of residential constructions. The Guide for Sound Insulation in Wood Frame Construction and the online guide were important not only due to the knowledge they contained, but also because they developed the understanding for how to present data which would be used for the RR-33x series. It was around this same time that the creation of an interactive web-based design software was discussed [26].

It was also around this time that Trevor Nightingale submitted a code change request to Codes Canada to replace the acoustic requirements in the National Building Code of Canada which were written in terms of the STC rating with the ASTC rating which included the contribution of structure-borne noise via the flanking paths. In 2007, the acoustic group was asked to draft background discussion papers on the costs and benefits of the proposed updates for both airborne and impact sound for the Standing Committee on Environmental Separation. The task was discussed by various Codes Committees and the Task for Airborne Sound Transmission was eventually approved.

The first meeting of the Task Group on Airborne Sound Transmission took place on the 7th of September, 2010 and production of a detailed technical guide to be referenced in the NBC was proposed in that meeting. The detailed technical guide, now known as Research Report RR-331, Guide to Calculating Sound Transmission in Buildings was developed as part of a special interest group, the SIG-ASTC group which included the partners listed in the acknowledgements at the front of Research Report RR-331. The first SIG-ASTC group (the first of four) was convened by Berndt Zeitler in 2012 with the support of Trevor Nightingale. Dave Quirt conducted much of the analysis work and he developed a solution for dealing with the issues of sound leakage through some concrete block masonry and cross-laminated timber elements. The first edition of RR-331, published in 2013 was authored by Dave Quirt, Berndt Zeitler, Stefan Schoenwald, Ivan Sabourin and Trevor Nightingale.

The 2015 edition of the NBC introduced the ASTC rating. The Code directly references RR-331 in section A-5.8.1.4 where it is described as being a source of "technical concepts, terminology, and calculation procedures relating to the detailed and simplified ASTC calculation methods." This Guide includes numerous worked examples and references to readily-available sources of pertinent data.

With the change in the acoustical requirements for dwellings in the NBC to the ASTC rating, the requirements were more representative of the situation in actual dwellings, but the trade off was that the design of dwellings for protection from neighbor noise became more complicated. No longer could an architect, designer or builder simply choose a wall with a laboratory measured STC rating of 50 from a catalogue to meet the requirements of the NBC. Now, the transmission of structure-borne noise needed to be estimated or found in data from special flanking facilities, depending on the type of structure. Fortunately, The Guide and the RR-33x series of research reports explain how to use the ISO prediction method in the context of the ASTM descriptors used in North America as well as data for the calculations.

Section A-5.8.1.4 of the 2015 NBC also notes that "For many common constructions, the calculations required by Article 5.8.1.4. can be performed using software tools, such as soundPATHS, which is available on NRC's Web site." The web application, soundPATHS [27] was conceived as part of the projects on flanking in timber-framed constructions and the first version was developed by Dave Quirt and the NRC group at the University of Western Ontario in London. The work on soundPATHS was introduced to the world in 2009 by Dave Quirt [28] during the Internoise conference in Ottawa where Trevor Nightingale was co-president and Bradford Gover was technical program co-chair. soundPATHS was completely revised in 2019 to make it more accessible and to include more junction and element data.

The sixth edition of RR-331 represents a significant update to the Guide. References to the withdrawn standard, ISO 15712 have been replaced by references to the latest ISO 12354 standard. In addition, numerous changes have been made based on feedback from both the industry consortium, the SIG ASTC group which funded the work as well as end users who have made comments and recommendations for improvements.

The RR-33x research reports are all living documents with more data added as it becomes available from ongoing research projects. To continue to support the acoustic requirements in the NBC, the NRC has recently completed the construction of a new four-room flanking transmission laboratory to replace the original four-room and eight-room facilities. An additional two-room flanking facility is also under construction as are new facilities to measure the sound transmission loss of wall elements and the sound transmission loss and impact noise of floor elements. These new facilities and the research they will make possible represent the continued commitment by the NRC to support the wellbeing of Canadians and the growth of Canadian industry.

While RR-331 only focuses on the calculation of the ASTC rating for airborne noise, there is research underway to develop similar guidance for impact noise. Protection from impact noise such as people walking or dropping objects on floors is not yet considered in the National Building Code of Canada, but that is expected to change in the future. An industry consortium SIG Impact has been created to develop guidance and a companion document to RR-331. The new guide for impact noise will be published after impact noise requirements have been added to the National Building Code of Canada, most likely in the 2030 edition at the earliest.

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