DEVELOPMENT OF BIO-BASED RENEWABLE BUILDING SOUND INSULATION PRODUCTS

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Résumé

FPInnovations est l'un des plus grands centres de recherches forestières privés sans but lucratif au monde. En interne, les départements « Système de construction » et « Biomatériaux du bois » se sont alliés pour d'une part mieux comprendre l'atténuation du son dans tous types de bâtiments et d'autre part développer des bio-matériaux innovants répondant à ces besoins spécifiques. Cette synergie se développe des analyses laboratoires aux tests *in situ* pour développer une expertise cohérente au service des ingénieurs, architectes et manufacturiers.

Mots clefs : Isolation acoustique des bâtiments, bio-matériaux, CLT, ossature légère, indice d'isolement aux bruits d'impact (IIC), indice de transmission du son (ITS)

Abstract

FPInnovations is one of the largest private, non-profit forest research centres in the world. Internally, the departments "Building system" and "Wood biomaterials" joined forces to firstly understand the attenuation of sound in constructions and in parallel develop innovative bio-materials that meet these specific needs. This synergy is growing from laboratory analysis to *in situ* testing in order to develop a coherent expertise for engineers, architects and manufacturers.

Keywords: Building sound insulation, bio-material, CLT, light wood framing, Impact Insulation Class (IIC), Sound Transmission Class (STC)

1 Introduction

Building sound insulation is an important serviceability consideration for the design of multi-family and residential midrise and tall occupancies. Building sound insulation consists of three elements: knowledge of insulation materials, solutions of sound insulated wall and floor assemblies that are made of structural components and insulation materials, and proper installation *in situ*. To understand the fundamentals of building sound insulation is the first step towards development of building solutions and insulation materials.

For airborne noise, the 2010 National Building Code (NBC) requires that a dwelling unit shall be separated from every other space in a building in which noise may be generated by construction providing a sound transmission class rating (STC) not less than 50. The 2010 NBC does not set a requirement for impact noise (structure borne noise) protection, but recommends that bare floors tested without a carpet should achieve an impact insulation class (IIC) of 55.

A forthcoming change in the 2015 NBC will recognize Apparent Sound Transmission Class (ASTC) and Apparent Impact Insulation Class (AIIC) instead of STC and IIC. ASTC and AIIC are a single number rating of the sound insulation performance of the combined wall and floor systems in buildings as perceived by the occupants (i.e. taking into account the direct sound and flanking sound transmission paths).

FPInnovations and the Canadian Wood Council are working with the National Research Council (NRC) to develop the design guideline that can be used in the construction of buildings using various materials, including light-frame wood assemblies and Cross Laminated Timber (CLT), to meet target ASTC and AIIC values.

The knowledge and data gaps of sound insulation performance are summarized below:

- Lack of information on the field sound insulation performance of a wide range of light frame wood floors and walls;
- Lack of information on the sound insulation performance of innovative wood systems, such as heavy timber and wood-concrete composite floor systems;
- Lack of information on the effects of various sound absorption materials on airborne sound insulation performance of wood walls and floors;
- Lack of information on the effects of finishings, finishing membranes, toppings, and topping underlayment materials on wood-based floor sound insulation;
- Lack of information on the interaction of the floor-ceiling assemblies made of variable finishing-membrane-topping-underlayment material with gypsum board ceilings and the base floor structures for the optimized impact sound insulation performance in terms of satisfactory sound insulation, while taking into account cost and ease of installation.

FPInnovations is undertaking a series of studies to bridge the knowledge and data gaps using a two-fold approach.

2 Experimental Approach

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First solutions have been developed in mock-ups, then follow-up tests have been conducted in the buildings where the solutions were implemented, to measure the sound insulation performance indicated by ASTC and AIIC ratings and to examine whether the solutions work equally well, or better than those in the mock-ups. It was found that the insulation materials play significant roles in wood building sound insulation and there is a lack of bio-materials with high sound insulation performance on the market.

Therefore, the Wood biomaterial department started working on the development of new acoustic materials to improve the sound insulation in wood building. The first phase was to define the relevant material properties that impact the sound insulation performance of a system (floor/ceiling or wall assembly). Then an on-going research program was initiated in order to develop a mathematical model to quantify the interrelation among raw materials properties, process parameters, characteristics of bio-based building sound insulation products and their final acoustical performance.

3 Brief Summary of Findings

3.1 Wood Building Sound Insulation Performance

Light-frame wood-joisted floor (illustration on Figure 1)

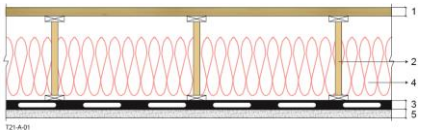

Figure 1: Structure for light-frame wood joisted floor/ceiling [1]

With good flanking control, to achieve ASTC and AIIC rating above 50, a decoupled drywall ceiling and a properly designed four-layer sandwich above the floor were required. The sandwich was composed of a finishing, membrane, topping, and underlayment.

Cross Laminated Timber and heavy timber floor

For both CLT floors and heavy timber floors with wood exposed on ceiling side, to achieve ASTC and AIIC rating above 50 is a challenge. It requires an intelligently designed four-layer sandwich topping on the floors, and knowledge of the sound insulation performance of the finishing, membrane, topping, and underlayment. With a dropped acoustical ceiling, using acoustical hangers, it was relatively easy to achieve ASTC and AIIC ratings above 50.

Wood-concrete composite floor (illustration on Figure 2)

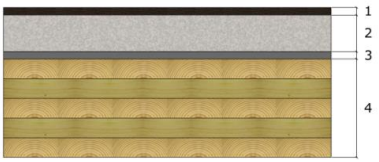

Figure 2: Concrete topping on a Cross Laminated Timber floor [1]

A 100 mm thick heavy concrete slab bonded to an 89 mm wood deck can achieve ASTC and AIIC ratings above 50 quite easily, without requiring a dropped ceiling. Such composite floors were the simplest wood floor systems studied so far. The floor was composed of only four layers: the finishing, concrete, insulator, and wood slab, but it achieved satisfactory sound insulation. This is an attractive approach for sound insulation design of wood slab floors with wood exposed on the ceiling side.

3.2 Performance of Bio-based Sound insulation materials

Different types of bio-based sound insulation materials were made of wood fibres and tested in applications such as membrane for floor finish, and underlayment. Their performance was compared to that of commercial products that are typically used in these applications (rubber, cork, bitumen, plastic foams or synthetic fibres). These tests were conducted on a full scale floor-ceiling system made of CLT, a heavy topping and a four-layer sandwich consisting of a finish, a membrane, a topping and variable underlayments including the commercial and the FPInnovations developed bio-based sound insulation underlayment.

During the testing, as the structural element (CLT) was not modified, the improvements of sound insulation rely on the underlayment which plays a role in the dampening of vibrations through the floor system..

Preliminary FIIC (Field impact insulation class) results on the CLT floor with a concrete or a dry topping showed that bio-based sound insulation underlayment had similar or better impact sound insulation performance than the commercial insulation materials. Researches are now focusing on developing specific bio-materials for each area of application (membrane for finish flooring, underlayment for topping in wood floors and absorptive material for wall and floor cavities).

4 Conclusion

With the increase of multi-family buildings, sound insulation is becoming a major issue for constructors. The sound insulation materials with high performance and less environmental impact can make a significant contribution to address the issue. FPInnovations, is working to develop knowledge and practical solutions for better acoustic performance in all types of constructions.

Final delivery of this on-going research will be the development of fit-for-purpose accoustic products with a comprehensive user guide for designers and builders.

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