HYBRID ASSESSMENT METHOD WEB APP FOR IMPACT NOISE INSULATION PERFORMANCE PREDICTION IN BUILDING

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1 Introduction

To carry out a successful acoustic design of a building, noise impacts between rooms need to be controlled. The acoustic performance is now considered as mandatory for new buildings. ASTM E989-21 defined different ratings to assess the impact noise performance between two rooms such as IIC/AIIC. Considering the lack of existing tools to assess these criteria, and some difficulties to use the existing ones, Atelier 7hz induced an innovation project to develop a new Canadian software. The aim of the project is to create a web app to help acoustic and vibration professionals predict impact sound insulation performance between two rooms.

Existing Software Limitations

Different kinds of acoustic software exist to predict impact Insulation Class. Considering the parameters variability, it is difficult to get consistent results for an existing configuration in situ. Software based solely on theoretical calculations needs a lot of different data that are difficult to get. That's why a hybrid calculation method using a mix of measured data and calculation model has been developed to assess existing assemblies' performance. This kind of software exists in Europe using European standards, but the IIC criterion defined in ASTM standards is not implemented.

Hybrid method

The hybrid method used in the software is based on the addition of measurement databases and calculation models:

- AIIC/IIC performance measurements: using the performance data of a similar situation
- Floor covering and ceiling additional performance calculation model,
- ΔAIIC/IIC performance measurements: using the performance data of a similar floor covering and ceiling.

2 Web App description

2.1 Web app global principle

The web app is divided into two parts. The first part is the interface to enter a floor-ceiling assembly to assess. The search option will question the database for similar assemblies and their impact noise insulation performances and display several results. The resemblance between assemblies is determined by an algorithm. After choosing one similar assembly, it is possible in the second part of the app to remove, replace, or add layers from the floor, or the ceiling and the software will compute the new performance based on two methods. The calculation can be done using the Cremer method, which is a numerical method. The other way to get the new performance is using a second database that stores ΔNISPL for different flooring and ceiling materials and computing the new IIC/AIIC value. It is also possible to enter a new measured existing assembly and all its measurement parameters including ANISPL and modify it.

2.2 Division of Floor-Ceiling Assembly

To create the database, a standard typology for floor-ceiling assemblies had to be defined (Figure 1). By looking at an assembly from top to bottom, it can be divided into three sections, the floor, the structural core, and the ceiling. The floor may be composed of up to one soft floor covering such as carpet or vinyl, followed by one or more rigid-elastic complexes each of which is composed of one or more rigid layer followed by one or more resilient membranes. The required structural core is composed of one or more rigid surface as engineered wood or concrete slab, optionally followed by joists and furring channels. The ceiling may include the cavity under the structural core which can be empty or filled, one or more rigid surfaces attached to the structure, a ceiling fixation system such as resilient bars or suspension springs, one or more rigid surface attached to the fixation system.

Floor	Floor covering
	n Rigid-elastic complexes
Structural core (required)	n Rigid surface (required)
	Joists and furrings system
Ceiling	Empty or filled cavity
	n Rigid surfaces
	Ceiling fixation system
	n Rigid surfaces

Figure 1: Division of each layer of the assembly

2.3 Similarity algorithm principle

A complex part of the web tool was to develop the similarity algorithm to determine the resemblance between two floor-ceiling assemblies. The first version of the algorithm uses two different kinds of criteria: exclusive and sorting criteria. Exclusive criteria must be fulfilled to assure a match. The sorting criteria are used to order the assemblies that respected the exclusive criteria to present the best match first. Figure 2 shows the global flow of the algorithm. The different exclusive criteria are listed below:

1. Core structure which can be concrete, heavy wood such as CLT and glulam, or light wood such as plywood and joists;
2. Floor covering;
3. Same number of rigid-elastic complexes;
4. Same type of ceiling: no ceiling, a rigid ceiling or resilient system.

Four criteria have been used for ordering, they are currently being used in succession and are the following:

- Area density of the floor and core structure combined;
- Total area density of the ceiling;
- Empty ceiling cavity or cavity filled with absorbing material;
- Type of resilient system in the ceiling if there is one.

The following step is to implement a point-based system which would attribute points for each of these criteria and refine the ordering of the matches to find the best possible one. Other criteria should also be added.

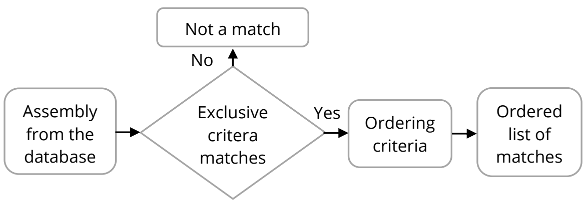

Figure 2: Global flow of the similarity algorithm

3 Method

3.1 Impact Insulation Class IIC/AIIC database

To be able to use measurement results in the software, it is important that the context of the measured situation is precisely described. In addition to numerical results (NISPL), the important data needed for the database is the detailed composition of the floor-ceiling assembly, including the material of each layer, its thickness and area density. Elastic properties are a plus that can be used for calculations. All data comes from tests done following the ASTM method using a standard tapping machine.

A relatively large database has been already built with data coming from multiple different sources. However, more data still needs to be added as the reliability of the tool is very dependent on the amount, the quality, the variety and the accuracy of data in the database. Finding complete data is difficult as test results often got missing data that are needed for the tool. A large part of data comes from measurements done by the NRC, which are tests done in a laboratory with standardized methods. Other data comes from different sources (Acoustic engineering firms, laboratories, material manufacturers).

3.2 Floor Covering Performance Calculation Model

The Cremer/Ver method has been followed to assess the rigid-elastic complex performance in the app. The attenuation ΔL at frequency f is then:

$$\Delta L = \mathrm{K} \log\left(\frac{f}{f_1}\right)\ dB$$

With:
K a constant depending on the kind of reaction. K=40 for the locally reacting floating floor more adapted for a heavy structure. K=30 for the resonantly reacting floating floor more adapted for small surfaces and a lightweight structure;
$f1$ the resonance frequency of the rigid-elastic complex:

$$f_1 = \frac{1}{2\pi} \times \sqrt{\frac{s''}{m_1}}\ hz$$

With:
$m1$ the surface mass of the floating coating (in kg/m2);
s'' the dynamic stiffness of the resilient layer (in N/m3).

4 Call for participation and further developments

Because the database is an important part of the process, any detailed in situ measurements are welcome. If acoustic and vibration experts reading this paper have this kind of data, they are friendly welcome to contact Atelier 7hz. Access to the web app could be arranged.

Further developments will focus on enlarging the database, separate IIC and AIIC measures and adding the possibility of adding flanking, ceilings noise impact performance calculation model, adding a list of suppliers, side-rooms impact noise assessment and auralization.

5 Conclusion

This new in development Canadian web app to assess impact noise insulation performance is based on a hybrid method combining an extensive measurement database and calculation models for rigid-elastic complexes (Flooring) and ceiling types. With this new software, it is possible to navigate quickly onto a large measurement database and partially modify some assemblies to assess different cases performances.

Acknowledgments

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