Assessing the Field Impact Sound Insulation Provided by Floor Coverings in Concrete Condominium Buildings

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ABSTRACT

Several regulations and co-property acts allow condominium owners to install hard floor coverings provided that a minimum impact sound isolation rating is achieved. Many construction professionnls recommend such surfaces based on tests performed using the procedures described in ASTM E 492 or ASTM E 1007. During the present study, thirty-five bare concrete slabs with thicknesses ranging from 200 to 250 mm (8 to 10 in.) were randomly tested in different buildings in Montreal using the procedures outlined in ASTM E 1007. The large variations noted in the measured NISPLs and FIIC ratings suggest that the results of tests made in strict conformance with ASTM E 1007 are anecdotal and cannot be used by acousticians and construction professionals to predict the impact noise isolation provided by a floor covering installed on a "typical" 200 mm (8 in.) to 250 mm (10 in.) thick concrete slab. This paper presents the results of these measurements and proposes a statistical approach to predict the probability that a floor installed on a typical 200 to 250 mm thick concrete slab will achieve the noise isolation target set forth in the regulation, or in the co-property act (usually FIIC 55 in Canada and FIIC 50 in USA).

RÉSUMÉ

Plusieurs textes de loi ou actes de copropriété d'édifices de condominiums réglementent l'installation des surfaces de plancher dures dans les logements en spécifiant le degré d'isolation des bruits d'impact que doivent fournir ces revêtements. Les professionnels de la construction et les acousticiens qui sont mandatés pour recommander les modes d'installation les plus susceptibles d'atteindre les indices d'isolation des bruits d'impact visés se basent le plus souvent sur les résultats d'essais effectués conformément aux normes ASTM E 492 et E 1007. Au cours de la présente étude, des essais d'isolation des bruits d'impact ont été effectués sur trente-cinq dalles de béton sans revêtement de plancher choisies au hasard dans différents édifices de Montréal, en suivant les prescriptions de la norme ASTM E 1007. Les variations importantes notées dans les NISPLs et les indices de transmission des bruits d'impact FIIC suggèrent que les résultats d'essais effectués selon l'ASTM E 1007 sur des revêtements de plancher installés sur une dalle de béton de 200 à 250 mm (8 à 10 po) d'épaisseur, sont anecdotiques et qu'ils ne sont d'aucune utilité pour prédire l'isolation des bruits d'impact que procurera un revêtement de plancher installé sur une dalle de béton typique de 200 mm (8 po) à 250 mm (10 po) d'épaisseur. Cet article présente les résultats des essais d'isolation des bruits d'impact effectués et propose une approche statistique pour prédire le pourcentage de probabilité qu'a un revêtement de plancher d'atteindre l'objectif d'isolation des bruits d'impact imposé par la réglementation ou l'acte de copropriété de l'immeuble (en général FIIC 55 au Canada ou FIIC 50 aux États-Unis).

INTRODUCTION

Several regulations and co-property acts allow condominium owners to install hard floor coverings provided that a minimum impact sound isolation performance is achieved. The minimum rating required is expressed in terms of Impact Insulation Class (IIC) measured in accordance with ASTM E 492[1] or Field Impact Insulation Class (FIIC) measured in accordance with ASTM E 1007[2]. At the moment, the National Building Code of Canada does not regulate the impact insulation required between two dwellings but suggests IIC 55[3] as a minimum. In the United States, many regulations impose IIC 50 as a minimum rating to be achieved by floor/ ceiling assemblies separating two dwellings of a condominium or apartment building. In many instances, the co-property administration selects the acoustical membrane on which the hard washable floor finishes (wood slats or tiles made of ceramic, marble, stone or granite) must be installed, based on the results of impact insulation tests performed in accordance with References 1 and 2 on a floor structure similar to that of the building, most often a 200 mm to 250 mm (8 to 10 in.) thick concrete slab. In some buildings an impact noise isolation test conducted as per ASTM E 1007 is required after the floor is installed to ascertain that the criterion has in fact been met; in the event that the minimum FIIC rating required by the co-property is not met, a co-owner could be forced to cover the newly installed floor with carpet, or to have it replaced at his or her expense.

In the last 40 years the method for measuring impact noise isolation in North America has not changed much: a standardized impact generator designed to sequentially drop five 0.5 kg hammers from a height of 40 mm above the floor at a rate of ten impacts per second is installed on the floor/ceiling assembly to be tested and the Impact Sound Pressure Levels (ISPLs) are measured in the room located below for the 1/3rd octave bands whose center frequencies range from 100 Hz to 3150 Hz. These levels are then normalized as a function of 10 metric sabins to obtain the Normalized Impact Sound Pressure Levels (NISPLs). The first single number rating used to rate impact insulation was the Impact Noise Rating (INR); it was replaced in 1970 by the Impact Insulation Class (IIC), which is calculated as described in ASTM E 989[4] and which is still in use today.

Most condominium administrators and many construction professionals including acousticians are still under the impression that one can predict the impact insulation provided by a floor covering installed on a typical 200 mm concrete slab or from tests performed using the procedures in ASTM E 492 or ASTM E 1007. Intuitively, one would expect that similar structures should provide similar impact insulation: for instance, if a floor covering installed on the 200 mm (8 in.) thick concrete slab of a given project tested FIIC 55, it is expected that the same floor covering should provide approximately the same rating when installed on the 200 mm (8 in.) concrete slab of a different concrete building. As it will be demonstrated in this paper, this does not seem to be the case.

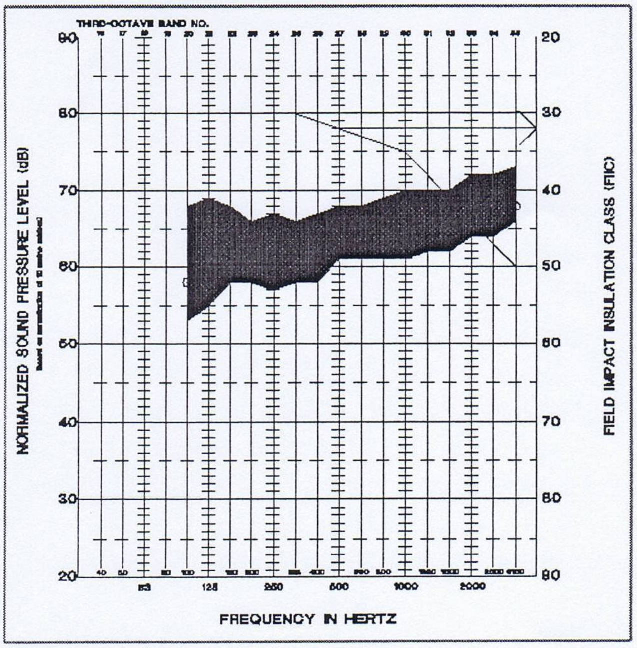


Figure 1. Average Normalized Impact Sound Pressure Levels (NISPLs) and range between the maximum and minimum NISPLs measured on eight concrete slabs varying in thickness from 200 to 250 mm (8 to 10 in).[5]

FIELD MEASUREMENT

During a research project[5] completed in 2002 which was aimed at validating noise isolation criteria in condominiums buildings, significant variations were observed in field measurements performed on eight 200 to 250 mm (8 to 10 in.) bare concrete slabs with no ceiling underneath. The spread in the Normalized Impact Sound Pressure Levels provided by these eight concrete slabs appears in Figure 1. The Field Impact Insulation Class (FIIC) rating measured on these nominally identical concrete slabs varied from FIIC 27 to FIIC 34 with an average of FIIC 32. The shaded area on Figure 1 represents the range between the minimum and the maximum NISPL measured; the thick solid line is the average NISPL corresponding to a FIIC rating of 32.

These results provided incentive to collect more data on the impact noise insulation provided by bare concrete slabs: a bank of NISPLs measured as per ASTM E 1007 was created on a total of thirty-five bare concrete slab varying in thickness from 200 to 250 mm (8 to 10 in.), including the eight mentioned previously. Figure 2 below illustrates the average NISPLs, standard deviation, and range between the minimum and maximum NISPLs measured (an average of FIIC 33 with a spread of FIIC 24 to 39).

By comparing the data of Figures 1 and 2, one notes that the average NISPLs has not changed much (FIIC 33 vs FIIC 32); however, the spread of the data has increased very significantly. Figure 3 below shows the actual scattering of the NISPLs measured on the thirty-five concrete slabs tested.

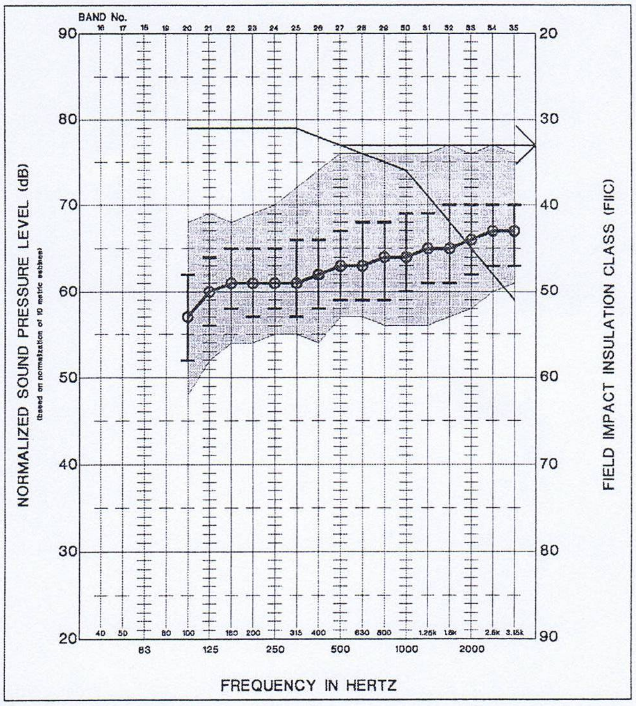


Figure 2. Average Normalized Impact Sound Pressure Levels, standard deviation and range between the minimum and the maximum NISPLs measured on thirty-five concrete slabs varying in thickness from 200 to 250 mm (8 to 10 in.)

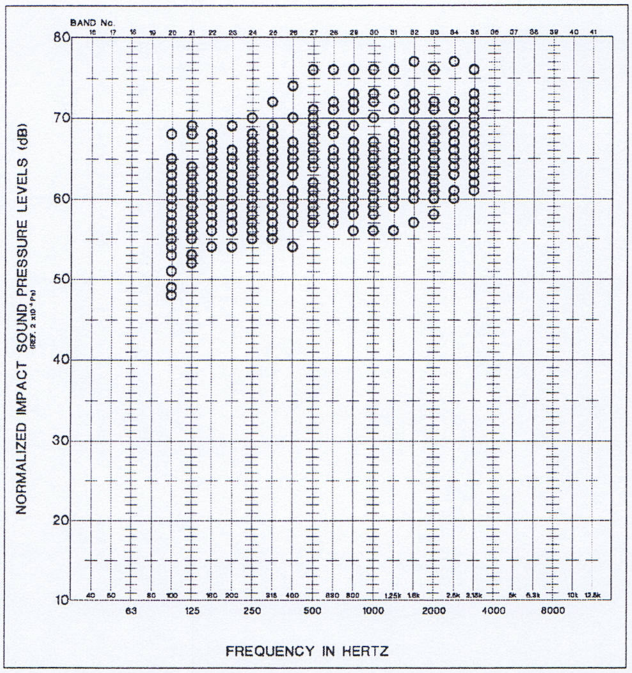


Figure 3. Scattering of the Normalized Impact Sound Pressure Levels measured on thirty-five concrete slabs varying in thickness from 200 to 250 mm (8 to 10 in.)

ASSESSING THE FIELD IMPACT NOISE ISOLATION PERFORMANCE USING A STATISTICAL APPROACH

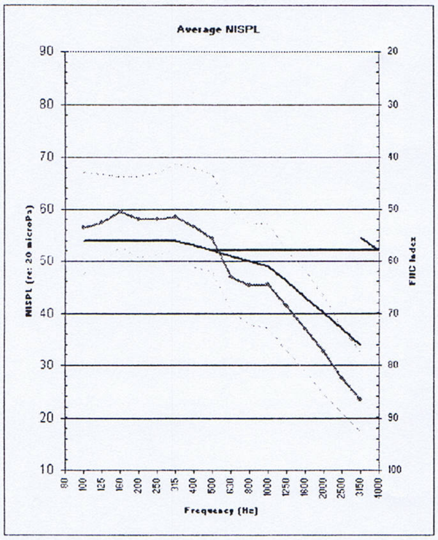
During the course of this study, a spreadsheet was created to calculate the impact insulation performance provided by a floor covering installed on a 200 mm (8 in.) to 250 mm (10 in.) concrete slab using the NISPLs plotted in Figures 2 and 3, and the impact noise insertion loss provided by the floor covering itself such as that measured in laboratory conditions as per ASTM E 21796. This spreadsheet evaluates the FIIC rating which one would measure if the floor covering were to be installed on a slab with the average NISPLs plotted in Figure 2. It also calculates the FIIC ratings using the minimum and maximum NISPLs measured, and those obtained if the floor covering were installed on each of the thirty-five slabs measured, and displays the statistical distribution of the FIIC ratings calculated with the probability of attaining a specific rating. An example of the output of this spreadsheet for a typical 3/8" thick engineered wood floor on a thin "acoustical membrane" is shown in Figure 4 below, using a target rating of FIIC 55.

As can be seen in Figure 4, the statistical distribution approach allows to realistically predict the performance of a floor covering, when installed on an 200 to 250 mm (8 to 10 in.) thick concrete slab, and to rule out any floor covering which owes its high (or low) FIIC rating to the slab on which it was tested. In this specific example, the FIIC which would be obtained for the floor covering on an average slab is FIIC 58 while the probability of meeting the FIIC 55 target is 77% given the variations in the NISPL and FIIC ratings of the thirty-five bare concrete slabs used to perform the evaluation. The maximum and minimum FIIC ratings calculated for this specific floor covering are respectively FIIC 64 and FIIC 49 leading to a spread of 15 points, the same as that measured for the bare concrete slabs.

DISCUSSION

Figure 5 compares the average field NISPL curve obtained in this study for a 200 to 250 mm (8 to 10 in.) bare concrete slab to the NISPLs of the ASTM E 2179 reference floor.

	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	FIIC
INSERTION LOSS:	1	3	2	3	3	3	6	9	16	19	19	24	28	33	39	43	
Average NISPL:	56	57	60	58	58	58	56	54	47	45	45	41	37	33	27	23	58
Min NISPL boundary:	48	50	53	51	51	52	49	48	40	38	37	33	29	24	21	17	65
Max NISPL boundary:	67	67	66	66	67	69	68	67	60	57	57	52	48	43	37	32	48



No. of results greater than or equal to F55	27 (out of 35)
Percentage of results greater or equal to FIIC 55:	77 %
Mean FIIC value (from distribution):	58

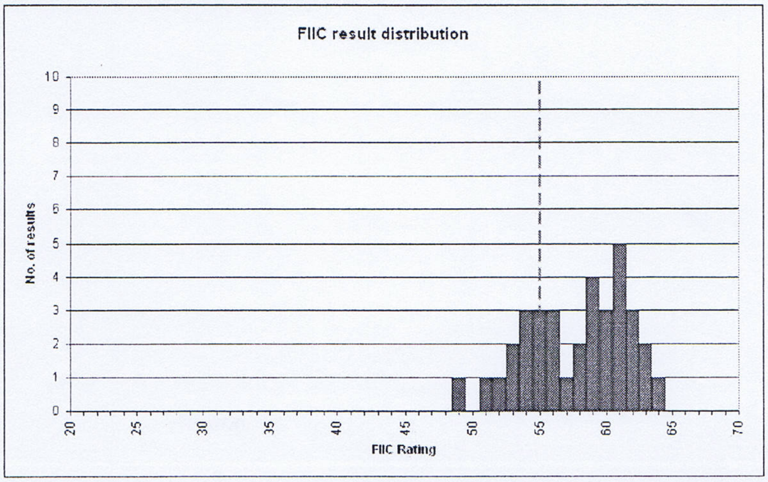


Figure 4. Example of a FIIC Statistical distribution analysis.

As can be seen the average NISPLs collected on site during this study are substantially lower than those listed in Table 1 of the ASTM E 2179 standard; this implies that the IIC ratings provided by floor coverings in real conditions should be substantially better than those calculated using the ASTM E 2179 reference slab.

CONCLUSIONS

During this very preliminary study, important variations were noted in the field NISPLs measured on thirty-five 200 to 250 mm (8 to 10 in.) thick structural concrete slabs; further research is required to determine the factors responsible for these variations. Such variations tend to demonstrate that single tests made in strict conformance with ASTM E 1007 are anecdotal and cannot allow acousticians and construction professionals to assess the impact noise isolation that a floor sample composed of a hard surface installed on an acoustical membrane will provide in new concrete constructions. To determine the impact noise isolation efficiency of an "acoustical" floor covering installed on a concrete slab, it is mandatory to first measure the impact noise isolation provided by the concrete slab and then to test the floor covering on the same concrete slab to obtain the impact noise insertion loss provided by the floor covering. This procedure can be done in real conditions or in laboratory conditions using the procedures listed in ASTM E 2179.

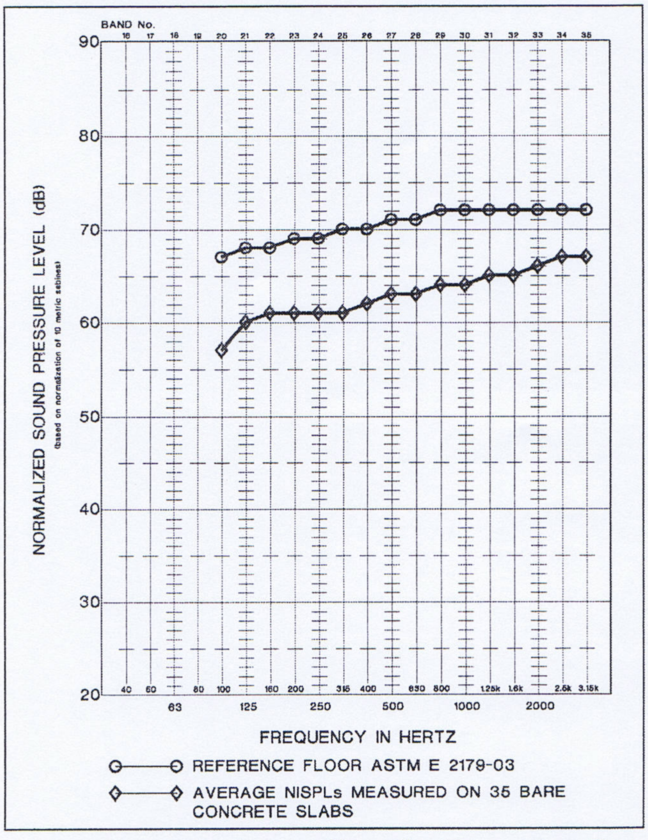


Figure 5. Comparison between Normalized Impact Soun Pressure Levels assumed for the reference floor (from table 1 of ASTM E 2179-03) and average NISPLs measured on thirty-five concrete slabs varying in thickness from 200 to 250 mm (8 to 10 in.)

For buildings not yet constructed, one can use the NISPL data collected on a relatively large number of bare concrete slabs to statistically determine the probability that the building impact noise isolation criteria will be met using a specific floor covering composed of a hard washable surface installed on an acoustical membrane. For new projects, it is the author's opinion that the floor coverings recommended to potential condominium buyers should offer a minimum of 75%, and preferably a 90% probability of reaching the targeted impact noise isolation rating.

Impact noise is a primary complaint of condominium owners. Further research is needed to investigate the impact insulation provided by floor structures in concrete, steel and wood construction. There is a need for developing a data bank on the field NISPLs measured on support structures most often encountered in the condominium construction industry to allow for the determination of the probability that a floor covering will meet the impact noise isolation targeted, whether regulatory or simply a recommendation.

The ASTM E 1007 standard is an acceptable procedure to verify that a floor/ceiling assembly complies with the impact noise isolation requirements of a co-property. However, as demonstrated in this study, results of tests performed on floor coverings in accordance with this standard without prior testing of the bare slab on which the floor covering is installed should not be used by acousticians, construction professionals, and condominium administrators, for the purpose of selecting floor coverings meeting the impact noise isolation criteria of a condominium building.

REFERENCES

1 ASTM E 492 Standard Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine

2 ASTM E 1007 Standard Test Method for Field Measurement of Tapping Machine Impact Sound Transmission Through Floor-Ceiling Assemblies Associated Support Structures

3 NBC of Canada Appendix A, article A-9.11.1.1. 1)

4 ASTM E 989 Standard Classification for Determination of Impact Insulation Class (IIC)

5 MJM Conseillers en Acoustique Inc. : "Projet de recherche sur la qualification du degré de confort acoustique procuré par les immeubles multilogements phase II", Montréal, 17 décembre 2002, recherche externe SCHL. (available only in French)

6 ASTM E 2179 Standard Test Method for Laboratory Measurement of the Effectiveness of Floor Coverings in Reducing Impact Sound Transmission Through Concrete Floors