Anatomy of an IIC Rating

Sharon Paley, Ecore International, Lancaster, Pennsylvania

In architectural acoustics, impact insulation class (IIC) ratings are a well-established design metric used for any multifamily or multitenant building. As consultants, we are familiar with prescribing the appropriate IIC requirements for new projects, but few guidelines exist explaining how to methodically predict them or even design floor-ceiling assemblies for them. Many variables and questions remain unaddressed, including the effect of adhesives and various floor coverings on the final outcome. This article presents an introductory look into the "Anatomy of an IIC Rating." Laboratory test data are used to develop potential classifications of common elements and possible trends to explore.

The ASTM IIC test method (E492)[1] was originally approved in 1973 and is designed to measure the impact sound transmission performance of an isolated floor-ceiling assembly. The spectrum of the noise transmitted into the receiving room below the test specimen is affected by a number of factors, including the size and mechanical properties of the floor-ceiling assembly, the acoustical response of the room below, the placement of the tapping machine, and the nature of the actual impact itself. However, it is the first factor (size and mechanical properties of the floor-ceiling assembly) that draws our attention here.

IMPACT-NOISE REDUCTION FOR CONCRETE FLOORS

Impact Noise Transmitted to Room beneath Various Concrete Floor Constructions Compared with That for the Bare Concrete Slab

(R. Lindahl and H. J. Sabine)

Nature of Floor Construction Laid on Concrete Slab	*Impact-Noise Reduction in Decibels*	*Comment of Observer*
None (bare concrete)	0	Bad
Asphalt tile (5/32-inch)	0	Nearly as bad
Asphalt saturated felt (1/8-inch)	2	Nearly as bad
Rubber tile (3/16-inch)	7	Better than concrete
Heavy carpet (no pad)	10	Good
Linoleum (3/16-inch) on felt	12	As good as carpet
Asphalt-saturated fiberboard (1/2-inch)	12	As good as carpet
Hardboard (3/16-inch) over fiberboard (1/2-inch)	17	Better than carpet
Wood floor (3/4-inch) on sleepers (2-inch by 3-inch)	19	Very quiet
Cork tile (1/2-inch)	20	Very quiet
Wood floor (3/4-inch) on sleepers (2-inch by 3-inch), rock-wool fill	20	About same as construction without rock wool

Figure 1. Example of an impact noise reduction chart – Table 12.1 from Acoustical Designing in Architecture.

The standard is often misinterpreted as a simulation of the impact of human footfall on a floor-ceiling assembly; though the standard states, "*because of its portable design, the tapping machine does not simulate the weight of a human walker. Therefore, the structural sounds . . . caused by such footstep excitation is not reflected in the single-number impact rating derived from test results obtained by this test method. The degree of correlation between the results of tapping machine tests and the subjective acceptance of floors under typical conditions of domestic impact excitation is uncertain.*"

Despite this statement, IIC ratings have become widely adopted in the U.S., in particular for multifamily housing policy and criteria. Frequently cited is the Department of Housing and Urban Development's "Guide to Airborne, Impact, and Structure-Borne Noise Control in Multifamily Dwellings."[2] Another standard reference comes from the International Building Code "*1207.3 Structure-borne sound. Floor/ceiling assemblies between dwelling units or between a dwelling unit and a public or service area within the structure shall have an impact insulation class (IIC) rating of not less than 50 (45 if field tested) when tested in accordance with ASTM E 492.*"

Though the ASTM IIC test method has been in existence for more than 40 years and despite its everyday use, there remains one fact that cannot be ignored: there is no proven or well-documented method to accurately predict IIC ratings across the broad spectrum of building types and construction elements commonly used today. To establish a level of confidence regarding a particular assembly's IIC rating, one must turn to laboratory or field testing (either previous reports or new testing).

In acoustical reference books, discourses on IIC ratings are often limited to just a few pages explaining what the IIC rating is, how it is measured and calculated, and appropriate criteria for multifamily dwelling units. On occasion, some books will also provide an accumulated list of various assemblies such as the table shown in Figure 1 and their performance or estimated impact noise reduction for certain elements, but many of these references could stand to be updated with more modern building materials and methods.

Combining the importance of IIC ratings in building codes with a limitation of informative and modern educational sources for both acousticians and the general public, it is not surprising that there is sometimes a lack of clarity and understanding when it comes to implementing appropriate IIC goals in today's building methods. Specification writers, contractors, product manufacturers, and even the occasional acoustician can fall into the trap of misusing or misinterpreting acoustical test data.

In this article, we present findings of laboratory tests in four fundamental areas of investigation – the details of which are sometimes underestimated – to study their impact on IIC ratings. These areas are: floor coverings, ceilings, adhesives, and underlayment thickness. We hope that the following study might spark a move toward more research, education, and most importantly – the proliferation of reliable and up-to-date data regarding this seemingly simple principle of modern architectural acoustics.

Methodology

The basic methodology of this study is straightforward and not dissimilar to what many acoustic consultants might already do when researching the IIC rating of a particular floor-ceiling assembly: gather laboratory IIC test reports and compare the results. To minimize areas of inconsistency, we used the same laboratory and concrete slab for all results provided in this study. Deviant factors might include: the individual installing the flooring, environmental variations, and changes in the performance of the concrete slab(s) over time. In each area of investigation, the basic method was to conduct an identical series of tests while changing one factor (such as floor covering, for example) for each test.

Areas Of Investigation

Due to the difficulty and cost of accumulating third-party laboratory test data, it was prudent to proceed based on feasibility to our sales-related demand for specific test assemblies. A standard 6-inch concrete slab was the primary subfloor of choice.

Effect of Floor Coverings. To explore the area of floor coverings, we began with three products commonly used in multifamily dwellings: porcelain tile, luxury vinyl tile (LVT), and engineered wood. While a rudimentary understanding of acoustics and material properties is enough to know that engineered wood performs better than LVT, which would perform better than porcelain tile, the goal was to attempt to *quantify* the advantage one floor covering might have over another and to further dissect any such advantage into frequency bands, if possible, to characterize the acoustical properties of that product.

Details of the test assemblies follow. A recycled rubber underlayment was used for the acoustical mat, and recommended installa-

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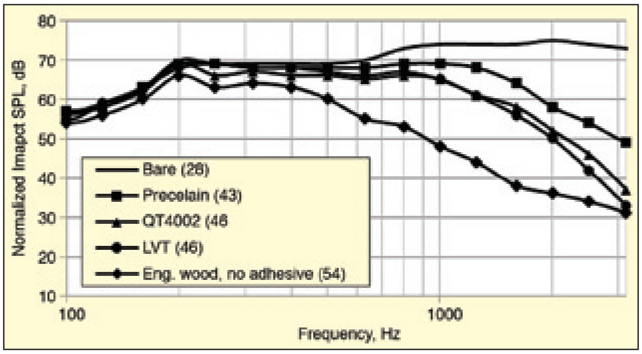

Figure 2. Comparison of different floor coverings on IIC ratings of 6-inch concrete slab.

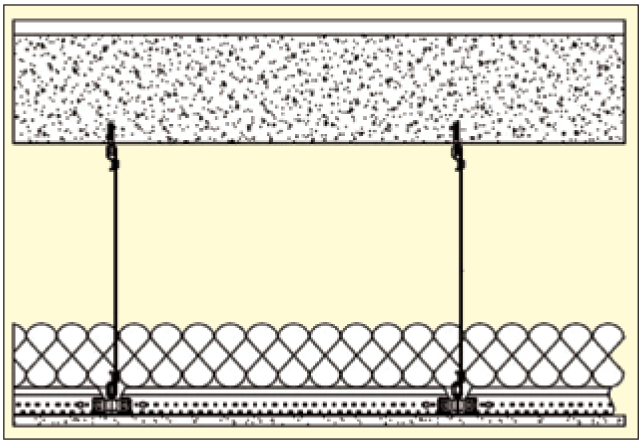

Figure 3. Cross-section of ceiling assembly.

tion methods were used with each covering:

- Bare 6-inch concrete slab, no ceiling.
- 7.2-mm porcelain tile with sanded grout and latex modified mortar, acrylic adhesive, 2-mm acoustical mat, acrylic adhesive, 6-inch concrete slab, no ceiling.
- 2-mm acoustical mat (no additional floor covering), acrylic adhesive, 6-inch concrete slab, no ceiling.
- 2.5-mm commercial LVT, acrylic adhesive, 2-mm acoustical mat, acrylic adhesive, 6-inch concrete slab, no ceiling.
- 12.7-mm engineered wood, 2-mm acoustical mat, 6-inch concrete slab, no ceiling.

All specimens perform similarly in the 100-400 Hz range. At 500 Hz and above, the floating engineered wood significantly deviates from the other assemblies. At 630 Hz and above, the porcelain tile, acoustical underlayment, and LVT all show marked improvement from the bare slab. These three coverings may be further broken down at 1000 Hz and above, where the acoustical mat and LVT show significant improvement over the porcelain tile. Note how closely the exposed acoustical mat and LVT specimens perform to one another. This is likely due to the less rigid nature (more internal damping) of both the rubber and LVT (see Figure 2).

Effect of Ceilings. A ceiling assembly was added to the test specimens, and the systems were retested. The ceiling assembly included hanger wires and a drywall beam and cross-tee system with a 12-inch plenum, R-13 fiberglass insulation, and 16-mm Type X gypsum board (see Figure 3).

The presence of the ceiling assembly improved IIC ratings across the board by an average of 15 dB and one-third-octave-band levels by an average of 20 dB as shwon in Figure 4. From 250 Hz upward, it is almost as if each curve were simply translated down by 20 dB. Overall it would appear that this type of ceiling assembly successfully provides a significant and consistent level of impact noise reduction across the entire frequency bandwidth for IIC ratings (100-3150 Hz).

Effect of Adhesives. The case of adhesives is of particular interest. Though commonly overlooked, we have noticed that the presence (or lack thereof) of adhesive could have a significant effect on IIC ratings. as shown in Figure 5. Porcelain tile was tested with

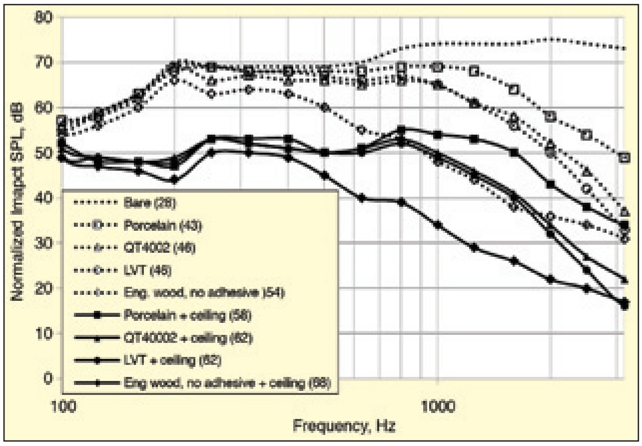

Figure 4. Adding isolated gypsum board ceiling assembly to 6-inch slab bows improvement achieved with variety of floor coverings.

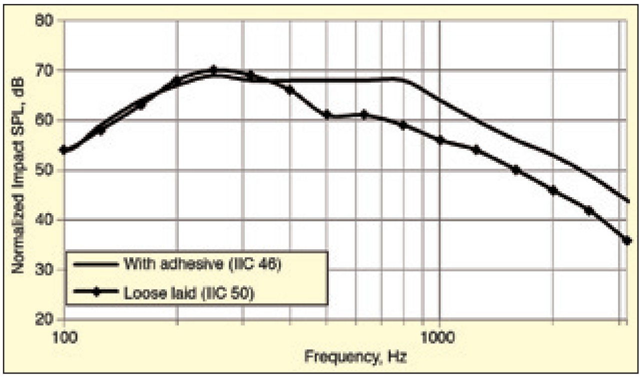

Figure 5. Effect of adhesive on IIC ratings of porcelain tile tested with 5-mm QT on 6-inch slab, no ceiling.

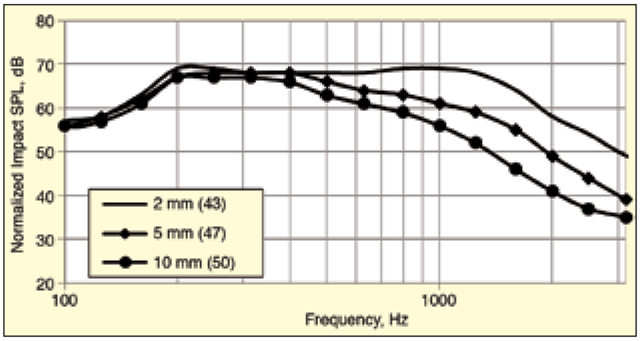

Figure 6. Effect of underlayment thickness on IIC ratings with porcelain tile on 6-inch slab, no ceiling.

a 5-mm recycled rubber underlayment on a 6-inch concrete slab with no ceiling. The ability to achieve an IIC 50 with a tile finish and the thinnest acoustical mat possible on 6-inch slab with no ceiling is considered something of a holy grail among underlayment manufacturers. The fact that one manufacturer's product was able to achieve this with just 5 mm versus the 10 mm usually required meant we had to take a closer look.

It was found that adhering the acoustical mat made all the difference in this particular situation. When installing the acoustical mat without any adhesive, then proceeding to grout and mortar the porcelain tile over top, laboratory tests are able to achieve the coveted IIC 50. But promoting this method of installation could be problematic.

Our company's technical services manager said, "membranes not secured to the substrate are considered a slip sheet . . . unsecured membranes under tile could potentially lead to cracking tile from rolling loads, etc." Although we have discovered a key to achieving higher IIC ratings under tile, installing the acoustical underlayment in this manner would not be recommended.

Effect of Underlayment Thickness. In Figure 6, results from porcelain tile testing with various underlayment thicknesses are presented. These tests are again conducted on 6-inch slab with no ceiling. In this case, an increase in underlayment thickness begins to improve IIC performance at 400 Hz and above. We also begin to notice what is described as the Law of Diminishing Returns, where a larger improvement results from the initial increase in thickness than subsequent increases.

Areas for Further Investigation

We have presented a brief introduction to the topic of IIC ratings and the data raised specific questions to explore in the future. With respect to floor coverings, could enough data be gathered to create a revised version of the Impact Noise Reduction table shown in Figure 6. What about the acoustical variation among products of the same category – that is, 2-mm LVT from different manufacturers? For ceilings, how much does the ceiling construction type affect IIC improvement? For adhesives, what effect do different adhesive types (acrylic vs urethane) spread thicknesses, or trowel sizes have on IIC ratings?

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The author can be reached at: sharon.paley@ecoreintl.com.