Construction Techniques for Effective Floor/Ceiling Noise Control

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Proper installation of all system components by building contractors is the key to meeting in-field acoustical ratings of floor/ceiling constructions. The use of innovative resilient channel/ gypsum board mounting clips and spacers assures that in-field impact isolation class and noise isolation class performance will closely match laboratory ratings, minimize installation problems and allow for inspection.

When I started in this business, I was taught that we provided a product that solved floor/ceiling noise control problems for multifamily construction. I quickly learned that we provided a product that was used in a *system* that required a number of other components to function properly. The system needed resilient channels and insulation. The depth of the joist affected the performance. The number of layers of gypsum board affected the performance. And the type of finished floor affected the performance. The effect of all of this became as mystical as the "holy ghost" description from my youth – an entity I knew was important but that no one could truly understand.

The educated conclusion that I've come to after years of testing floor/ceiling assemblies is that the mystery is not as elusive as it seemed from the description of published performance enhancements. The answer to controlling noise in a floor/ceiling assemblies was as much the responsibility of the developer as other members of the construction team. The proper installation of the ceiling and the floor is the key. This discussion will try to quantify the effects of field errors and provide some proprietary solutions for achieving the desired performance of field installations.

Installation Uncertainty

Floor/ceiling noise ratings have been the bane of multifamily construction for a long time. Almost 10 years ago, when noise control in wood frame constructions became popular for multifamily buildings, no one knew just how much we needed to learn. We threw some products at the topside of the floor/ceiling assembly thinking that the testing we had done in the lab was going to recur in the field. Unfortunately, we learned some significant lessons.

Due to a focus on speed, the installations had shorcuts. Everyone wanted to staple down the floor mat even though all of the instructions said no staples. No one wanted to do perimeter isolation. The perimeter was left in full contact in most applications when no one was watching. People left gaps between mat pieces as wide as the Mississippi. We had began to specify the right products in the industry only to find that we didn't install them correctly in the field.

So as a manufacturer of floor/ceiling installation products, we would test our assemblies and find the Impact Isolation Class (IIC) 55 laboratory test was a 42 in the field. The general contractor would check a portion of the floor and find the installation was incorrect. The flooring contractor would rip out the remaining floor to correct the deficiencies and the IIC 42 would move up to a 46 in the field. Floors pass, and we were off to the next assembly thinking there was just an inherent deficiency in tested assemblies in the field verses the laboratory.

In the back of my mind, I was constantly wondering why field performance was so lousy. I started to believe that we needed to do a fabulous job to make things work at the allowable level of IIC 45 in the field. Consequently, we trained our contractors, held seminars around the country, and assured every contractor who installed flooring materials was trained first in the classroom and then in the field. We worked hard to develop simpler systems to install and found spray adhesives for seaming, resilient perimeter isolation caulking and zip strips for selvedge edges. We made the floor side work well, but found in some cases the installed systems were still performing poorly in the field.

Then one day at the laboratory, we tested an assembly with: 1.5 in. of FIRM-FILL gypsum concrete, 0.40 in. QQ 60/040 MC sound control mat, 0.75 in. OSB sheathing, 14-in. 'I' joists, and two layers of 5/8-in. gypsum board hung on 0.50-in. resilient channels. Our assembly performed at an IIC 48 when we tapped on the bare gypsum. This immediately brought me to prayer and made me believe that performance of our floor/ceiling assembly was somewhat of a mystery, since the results were 5 to 8 points below what I would have expected. We worked forensically from there to find our problems. We found:

- Resilient channels in contact with support elements.
- Short-circuited screws 2 in. long for fastening the first layer of gypsum board (installers said 1 in. would not bite to resilient channels, so they used a screw length they knew would bite to the channel).
- Gypsum board in contact with support elements.
- Resilient channels that were smaller dimensionally than specified and not manufactured by the specified company.

Correcting all of these errors, our system performance now improved to an IIC 53 for bare gypsum concrete. This performance scenario seemed quite similar to what I had seen in the field and brought me to the conclusion that if a laboratory was having trouble with performance and workmanship, the performance and workmanship on the ceiling in the field must be worse. Since this test a number of years ago, I've seen the ceiling assembly as the culprit in poor results time and time again. Including:

- A large developer in northern California had a field testing failure due to short-circuited screws of improper length.
- A significant project in Pittsburgh had a field failure due to improper ceiling installation (found while comparing soundmat performance).
- An evaluation of a soundmat complaint in Illinois found that hat channels were installed instead of resilient channels.

The common issue was the performance of the system at low frequencies. To solve these problems, I've seen consultants go round and round with different products and solutions that never seem to work. I've seen forensic investigators tear out floors, only to find relatively acceptable installations. Acoustical consultants have tried fancy sound-control gypsum board on the ceiling and cork or rubber mats under tile and vinyl as primary solutions to system performance. These never work. The culprit is always the same – ceilings are installed with improper details and short circuits.

I'm not the first to recognize these deficiencies of course. Tony Nash, principal from Charles M. Salter & Associates, found similar performance deficiencies when the perimeter of the ceiling was installed incorrectly.[1] Tony quantified the loss in IIC performance to be in the range of 5 points. The main culprit was the connection of resilient channels in contact with wall structural elements. In addition, he found gypsum board walls in contact with gypsum board ceilings the cause of poor performance. The Canadian Research Council in Ottawa has done some excellent work in this area.[2] They have a great article on ceiling performance available online for review that should have helped us avoid some of these field problems long ago. Jerry Lilly with JGL Acoustics has documented performance differences in the types of resilient channels and the noise reduction that can be gained by specifying the cor-

Based on a paper prresented at Noise-Con 2007, Institute of Noise Control Engineering, Reno, NV, 2007.

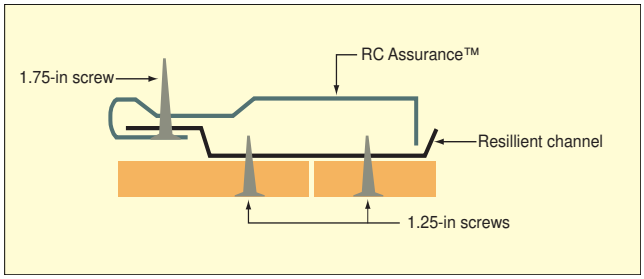

Figure 1. Installation details for RC Assurance using proper screws.

rect channels.[3]

When we first started training our flooring contractors, the problems were pretty dramatic. Contractors lacked basic cause-effect knowledge in the field, so an installer believed "what could a few staples mean?" And "so a little gypsum touches the wall."

And of course, the lawsuits will continue until the performance improves. That summarizes the consequences for that scenario. Now the drywall contractor is in the same dingy boat thinking, "1-in. screws? 1.5 in. must be better." and "that gypsum looks great even if it isn't caulked and the gypsum associations say joints must be tight." We have a lot of training to do to get this subcontractor group up to speed.

Noise Versus Fire Safety

In acoustics we include spacing around the ceiling to prevent flanking. We space our resilient channels from the wall elements, space our gypsum board ceiling away from those same framing elements, and space our gypsum board walls from our gypsum board ceilings. (See Figures 1 and 2.) We design in caulked joints to prevent airborne noise from passing through. All of this in the face of Underwriters Laboratory requirements for details.

We have an obligation to achieve fire safety along with noise control. These two building criteria are not mutually exclusive – we must have both. *Today, there is no allowance for tolerances or gaps in gypsum board installation without caulk.* Where gypsum board pieces are adjacent to one another, the fire code allows for no gaps without caulk – tightly butt two pieces and tightly butt the board to the framing. That is the UL requirement and the requirement of the Gypsum Manufacturers Association. If there is a gap, that gap must be caulked and there is only one caulked gap joint presently allowed from one manufacturer. Of course local codes do supercede this and consequently, gap joints occur in the field. So by design we accomplish our goals of gaps in our details. *It is safe to say that today we rarely see the field installation of ceiling materials as they have been detailed in our drawings.*

Actual Ceiling Installation Process

Now let's think about the installation of these gypsum components. Our contractors seem concerned with the following in this order:

1. Looks or aesthetics
2. Speed
3. Fire-related issues
4. Performance standards for acoustics

At least two people install one piece of gypsum board, and the installation of the ceiling is all done by manually holding the board in place and fastening a screw while the board is held. Installers are paid by the piece and are very concerned about speed of installation. How concerned is the installation crew about the gaps? How concerned are they when the first call-back is for aesthetic looks rather than noise? How concerned are they when they are paid to install by the piece, not the noise performance?

Performance Cost of Installation Errors

One of the things I've always wanted to quantify is how much the installation errors cost? I did some recent testing to find the number of short-circuited screws in a 100-ft^2 application to cause the first Impact Insulation Classification (ASTM E492-04 for IIC values) to fail.[4] My tests showed that only three incorrect screws were enough to cause failure. Just doing some quick math shows

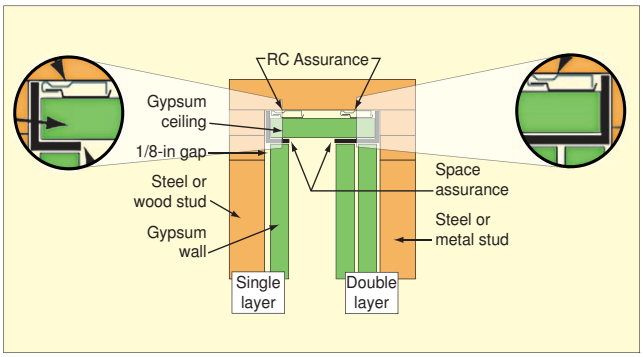

Figure 2. Installation details for RC Assurance and Space Assurance.

about a 3% error rate for a one-layer gypsum board ceiling application and a 1.5% incident rate in a two-layer application. This probably happens on every project.

When most of the screws are short circuited in a really bad installation, how much does that cost? The second laboratory test showed what happens when most of the screws are short circuited.[5] In the lab, this error rate is 4 IIC points in a nonsoundmat application and 8 IIC points in a soundmat application. The difference being that the mat tends to offset some of the negative effects at higher frequencies but leaves as much as an 11 dB performance difficiency at the lowest frequencies. This is the type of error that I have most commonly found in the field.

Let's face it, from the lab results, we know our system can work. We've designed components in the system that fail only because of installation; we know that from the field results. We have installers that have placed acoustics at the bottom of the priority list and we are getting bottom-priority results. We need to make some changes to the ceiling details. In my opinion, the acoustical consultants are the front line in this. But let's face it, general contractors are hesitant to pay consultant rates for field work. But, with the added importance of noise control, forensic investigations become even more costly. Daily inspections of on-site installation performance do not occur frequently enough.

We need a system that is easy to install and relieves the contractor of most burdens of error. The cost to the developer and general contractor should not increase. The cost to the developer and general contractor did not increase when the flooring contractors installed QUIET QURL and FIRM-FILL gypsum concrete correctly – proper installation is assumed and is paid for by the general contractor. The idea that we need an expensive system for ceiling isolation is not warranted – we get great performance from properly specified and installed resilient channels.

The objectives of an effective floor/ceiling noise isolation system are:

- A system that minimizes flanking and is less dependent on installation details such as: resilient channels to the framing elements; gypsum board ceiling to the framing elements; and gypsum board ceiling to the gypsum board wall.
- A simple system for resilient channel installation that allows for the use of a slightly longer screw for channel 'grab.'
- A method of preventing the screws used to fasten gypsum board from penetrating to the joist assembly.
- A system that is easy to inspect or at least allows for inspection.
- And while we're at it, we should get the specifications for the resilient channel that we recommend. Many studies have shown that correct selection and installation does make a difference.[3]

RC Assurance

Keene Building Products developed RC Assurance to correct for resilient channel installation errors and to allow for inspection. The 22-AWG metal clips create a barrier at the intersection of the joist and the resilient channel, preventing short circuiting of the gypsum board to the joist. The product is designed to work with 1.25-in. screws, helping with 'bite' during installation. An additional feature of RC Assurance is the push-down flange that prevents channel ride. Channel ride is an installation error that

allows the resilient leg of a channel to come in contact with all of the joists.

Should the contractor use a screw of an incorrect length, RC Assurance will not allow the screw to properly set. Screws of 1.5 in. or greater won't work in the application; the screw head will protrude from the board.

RC Assurance is listed in 27 Underwriter Laboratories assemblies and is used in flooring and wall applications to prevent short circuiting. Compared to other ceiling assemblies, RC Assurance will be about 75% less expensive than the ceiling assemblies that use rubber isolators or spring hangers. Total cost per square foot of construction will be less than $0.25, installed. The pieces cost between $0.25 and $0.45, depending on quantity ordered and method of purchasing.

Unlike resilient channel alone, RC Assurance can be inspected without a full ceiling tear out by looking at the screw pattern and gauging the distance of the gypsum board from the joist at any penetration. An impenetrable barrier exists at the point of intersection. No special installation technique is required. RC Assurance clips slide onto the resilient channel during installation and require no laser alignment or additional screws. Without RC Assurance, proper installation and short-circuiting cannot be properly inspected.

Space Assurance

Keene Building Products' Space Assurance takes the perimeter isolation techniques for flooring noise control and applies them to the ceiling. We would not try to isolate the floor without perimeter isolation, but we do rely heavily on the ceiling installer to create some important gaps for noise control. Space Assurance creates the space and allows for inspection – two key elements that are lacking today.

The noncombustible fabric (3 in. wide and 0.25 in. thick) is installed before any of the ceiling components by mechanical fasteners or spray adhesive. The resilient channels are installed by butting the channel against the Space Assurance. The gypsum board is installed butted up against the Space Assurance – a gap is now assured between the gypsum board and the structure. The excess hangs down and is used to create the gap between the gypsum board ceiling and the gypsum board wall – another important gap is now assured and can be inspected. This assembly has been burn tested by Underwriters Laboratories and found to pass the tests required for a joint assembly without the use of additional caulk.

With Space Assurance, we can inspect the ceiling, we can properly gap the ceiling and we can forget about caulking the ceiling. This new assembly meets the acoustic performance requirements but also meets UL requirements for flame spread in a floor-ceiling-wall joint.

Summary

Doing things right the first time is always the best approach. Making installation easier for the contractor is an ideal goal and one that Keene takes seriously. Any contractor can install any product incorrectly – no matter the precautions. *Assure* and *inspect* installations for the very best results. Those are the goals of these innovative new floor/ceiling noise isolation products and their applications.

References

1. Nash, Anthony, "Resilient Ceiling Construction in Residential Buildings," 4th Joint ASA/ASJ Meeting, 152nd Meeting of ASA, 2006.
2. Warnock, A. C. C., Update 35, "Controlling the Transmission of Impact Sound Through Floors," Available on line: http://irc.nrc-cnrc.gc.ca/pubs/ctus/35_e.html.
3. Lilly, Jerry, "Resilient Channel Update," Available on line: http://jgla-coustics.com/acoustics-frameset.htm.
4. Kline, James R., and Schoof, Patrick J., "Impact Sound Transmission Test and Classification of a Wood Joist Floor/Ceiling Assembly," Intertek Report No. 3110939CRT-001e, Cortland: Intertek ETL Semko, 2007.
5. Kline, James R., and Schoof, Patrick J. "Impact Sound Transmission Tests and Classification of a Wood Joist Floor/Ceiling Assembly With and Without Flooring Products," Intertek Report No. 3127659CRT-001, Cortland: Intertek ETL Semko, 2007.

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