Preventing Annoying Floor Vibration

by
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Under certain conditions, a residential floor can vibrate when someone is walking through a room, exercising, etc., resulting in vibrations that can prove annoying to other occupants. The vibrations can also cause items such as furniture and contents or decorations to rattle. For the most part, the problem of annoying vibration can be avoided in the design stage.

Some people are much more sensitive to floor vibration than others, and no practical set of rules will guarantee that 100 percent of all possible occupants will be satisfied with the performance of a floor. However, some simple rules-of-thumb for joist design will yield floors that most occupants judge to be acceptable. In this article, simple design rules to minimize the chance of annoying floor vibrations in residences are presented.

Prescriptive Rules-of-Thumb

When designing a residential floor:

- **Always use a live load of at least 40 pounds per square foot (1.92 kN/m^2).** Table R301.4 of the 2000 *International Residential Code*® (IRC) allows 30 pounds per square foot (1.44 kN/m^2) for "sleeping rooms", but when this lower load is used in design, the joists will generally be more flexible and more likely to produce annoying vibrations. It should be borne in mind that the minimum requirements of building codes primarily address safety; they do not address design methods for preventing potentially annoying vibrations in residential floors.
- **Increase the joist depth by one size.** If the code requires a 2 by 8 joist at 16 inches (406 mm) on-center, then use a 2 by 10 joist of the same grade and species, or a 14-inch-deep (356 mm) floor truss when a 12-inch-deep (305 mm) truss would meet code requirements. This rule should provide excellent results when used in conjunction with a 40 pound-per-square-foot live load.

- **Glue and screw the sheathing.** Floor sheathing should always be glued down. Screws work better than nails for long-term bounce control.

Reducing the on-center spacing—from 16 inches to 12 inches, for example—is probably the least efficient way to improve floor performance. Occupants feel "bounce" as the result of a foot impacting an individual joist, and even at 12 inches on-center, the joists are not close enough for the shock of a foot to be carried by two joists.

Practical Rules-of-Thumb for Solid-Sawn, Truss, and I-Joist Floors

Solid-Sawn Joists

In 1964, the Federal Housing Administration published *Minimum Property Standards for One and Two Living Units,* which recognized that solid-sawn joist spans over 15 feet (4572 mm) in length may be inadequate to prevent annoying floor vibration. The agency proposed a rule limiting live-load joist deflection on a graduated scale from *L*/360 at 15 feet to *L*/480 at 20 feet (6096 mm), and a total deflection of no more that 0.5 inch (13 mm) for spans over 20 feet. I propose a more simple rule-of-thumb for the design of solid-sawn joist up to 20 feet in length (a practical maximum span):

Using a 40 pound-per-square-foot (1.92 kN/m^2) live load, limit live-load deflection to* L*/480 for all spans up to 20 feet (6096 mm).

This rule is very easy to remember, and it can be easily applied to span tables based on a *L*/360 deflection limit. As it turns out, a maximum joist span, *S*, under a *L*/360 live load limit matches a maximum joist span of 0.91 times *S* under a *L*/480 live load limit. Here is how to design a joist under the *L*/480 limit using a *L*/360 table:

1. From the framing plan, determine the clear span (face-of-support to face-of-support) of the proposed joist. Assume the clear span is 15-feet, 1-inch (4597 mm).
2. Divide the 15-feet, 1-inch, span by the factor 0.91 (15 x 12 + 1 = 181 inches/0.91 = 198.9 inches). The artificial span for joist selection from an *L*/360 table is then 198.9 inches or 16 feet, 7 inches (5055 mm).

3. Find a joist species, size and grade that will span 16 feet, 7 inches, under a live load of 40 pounds per square foot. This joist will check under a *L*/480 deflection check.

Wood Trusses

An important step in preventing annoying vibrations in floor truss systems is the application of a strongback. People are highly sensitive to vibrations in the range of 8 to 10 Hz. Published research by Dr. Dan Dolan, P. E. and others has found that when joists in occupied homes vibrate at a frequency of 14 Hz or more, the vibrations are not noticed or judged to be annoying. Strongbacks control annoying vibrations by stiffening the floor truss, which causes it to vibrate at a higher frequency and thus not be felt by the occupants.

The strongback should be a minimum of 2 by 6 in size, installed at the center of the span and securely nailed to a vertical web—usually at the chase opening (if the floor truss configuration provides only diagonal webs, a vertical 2 by 4 scab can be nailed to the top and bottom chord and used in lieu of the vertical web.) I recommend that the strongback be nailed to each truss web with 3-10d Common nails (0.148”x3”) or 4-10d Box nails (0.128”x3”). It is important that there be no gaps between the strongback and the truss webs, as they reduce the effectiveness of the nail connections. Simpson Strong-Tie ¼”x3” SDS screws is a good option to nails for producing stiff connections between the strongback and vertical truss webs. For spans longer than 20 feet (6096 mm), the strongback should still be installed near the center of the span, but I recommend installing an additional 2 by 6 strongback or one 2 by 8 in place of the two 2 by 6s.

Wood I-Joists

Preventing annoying I-joist vibration is generally more complicated than other cases, but the “Prescriptive Rules-of-Thumb” provided earlier still apply. My best advice is to consult the I-joist manufacturer on the subject of vibration control. A simple way to get good results is to use the tables designed for *L*/480 deflection. I-joists stamped under the APA-The Engineered Wood Association (www.apawood.org/) standard for performance-rated I-joists is designed to meet the *L*/480 limit. The APA standard also uses 40 pounds per square foot as the minimum live load for any floor (as recommended in this article).

Another design system for vibration control in wooden I-joist floors is TrusJoist's TJ-Beam software. TrusJoist has done extensive testing of floor performance and has developed its own "TJ-Pro" rating system. Using the TJ-Beam software, a user can select a number between 20 and 70, with higher values offering the greater levels of protection against potential floor problems as judged by an occupant. For example, a design that is rated at 55 is expected to be judged as being "Good to Excellent" by 96 percent of the population, while 2 percent should judge such floors to be "Marginal" and 2 percent should judge the floors to be "Unacceptable." This system allows the homeowners, through their contractors or architects, to select the level of floor performance that meets their expectations. The software also contains a number of toggles that allow the designer to tweak the floor performance of a given joist depth and series. Toggles include deck thickness, type of deck attachment (nails only, or glued and nailed), and the presence or absence of a direct-applied ceiling, bridging or blocking.

Summary

Preventing annoying floor vibrations in residential applications is an easy matter at the design stage, and additional construction costs are typically minimal. In many instances, a good design for solid-sawn joists can be achieved by shortening the span a couple feet or, in a worst-case scenario, selecting a joist that is one size deeper than that required by the building code. In general, a design live load of 40 pounds per square feet is recommended for checking the live-load deflection limit of *L*/480; floor sheathing should be screwed and glued to the joists for superior performance.

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