BCI® Joist Span to Depth Ratio in BC Calc®

BC Calc software calculates a span to depth ratio when analyzing BCI® floor joists in addition to bending moment, shears and deflection,. The ratio is not compared to any limit; it is simply the length of the longest span in inches divided by the depth of the BCI selected (in inches). The span to depth ratio is displayed to help designers avoid potential floor problems due to vibration.

Floor vibration problems are generally started by a person walking across the floor (impact loading from foot traffic). All floors vibrate to some degree when dynamically loaded. However, it is floor systems with longer duration and lower frequency vibrations that generate complaints from homeowners. It is important to note that the presence of floor vibration is not an indication that the joists are close to failure. However, noticeable floor vibration can be unacceptable to the homeowner.

Noticeable vibration is more likely to occur in floors that include structural members with a relatively high strength to weight ratio. Such is the case for shallower depth wood I-joists.

The way a floor system reacts to foot traffic is affected by several factors – joist depth, dead load of the floor system, room size, and the attachment of a ceiling. Vibration complaints are more likely to occur in larger rooms that are located over a crawl space or unfinished basement. With no gypsum board directly attached to the underside of the joists and no partition walls resting on floor, the weight of the floor system is relatively light. In most cases, an increase in floor weight actually helps floor performance by dampening (reducing) vibration.

Attaching drywall directly to the bottom of the joists has another benefit for floor performance. In many cases joists are not installed perfectly plumb. Therefore a vertical load has a tendency to rotate the joist slightly. If the bottom of the joist is not stabilized laterally, “torsional flutter” may occur in the joist. This slight amount of lateral movement will increase the “perceived” amount of floor vibration.

The span to depth ratio is not affected by the on-center spacing of the joists - When a person walks across a floor, impact loads are placed on joists. Even though reducing the on-center spacing decreases the amount of uniform load on a joist, the magnitude of an impact load remains unchanged. When designing a floor system where vibration may occur, increasing the depth of the joist and the on-center spacing may be the best solution - both structurally and economically. For example, 9 1/2” joists at 16” on-center and 11 7/8” joists at 19.2” on-center will deflect about the same amount under uniform load but the 11 7/8” joist floor will have a better “feel”.

Field experience has shown that typical vibration problems may occur when the span to depth ratio exceeds 15 for 9 1/2” joists and 15.5 for 11 7/8” joists. Again, problems are mostly dependent upon the absence of drywall attached to the bottom flanges in larger rooms (family room, living room, master bedroom). For floor systems with attached ceilings, experience shows that the span to depth ratio threshold increases to about 18 times the depth. BC Calc does not calculate a span to depth allowable percentage simply because there are no existing limits. Presently, floor vibration is not addressed by any of the current building codes in the United States (IBC, IRC, UBC, etc.). However, other countries have adopted vibration criteria into their respective building codes. It is likely that the U.S. building codes in the future will adopt similar vibration design provisions. When this occurs, the adopted provisions will be implemented into BC Calc.

If you have any further questions regarding floor vibration, please feel free to call Boise Cascade Engineering at (800) 232-0788.