Meet The Experts
at MSC's Online Chats

IN keeping with our tradition of providing the latest information on the design, fabrication and construction of structural steel buildings, *Modern Steel Construction* magazine is sponsoring a series of on-line chats, each one featuring industry-recognized experts in the topic at hand.

The chats are typically held on alternating Tuesdays, from 2:00 to 3:00 p.m. central time. The inaugural chat was held June 12, 2001, and featured Thomas M. Murray, Ph.D., P.E., a professor of civil engineering at Virginia Tech. Dr. Murray, one of the authors of AISC's *Design Guide No. 11: Floor Vibrations Due to Human Activity*, is the country's leading expert in the field of floor vibrations in steel buildings.

The following transcript from the on-line chat has been edited for clarity.

—Editor

Thomas M. Murray, Ph.D., P.E.

For a list of future chat topics, e-speakers, dates and times, visit www.aisc.org/chat.html.

Q: Professor Murray, is there any current research in floor vibration on non-composite steel joist system?

A: Non-composite steel joist systems behave the same as composite systems. The amplitude of motion is so small that even tack welds between the deck and joist top chord are sufficient to provide composite action. Therefore, the answer is no.

That is there is no need for additional research. We are working on the effects of seats on girder stiffness, however.

Q: What is the status of the research on the effects of seats on girder stiffness?

A: We are just beginning the project, which is being sponsored by VULCRAFT. We have built three "footbridge-type" floors with different joist spacings to see what effect spacing has on stiffness and therefore frequency.

Q: What do you think is an effective way to solve floor vibration problem on existing structure? In other words, will it be effective if you stiffen the girders or beams? Or do you increase the dead load (slab thickness) thus increase damping ?

A: The best way to fix an existing structure is to use damping posts, but the owner may not permit. The next best way is to use a queen post hanger truss as shown in Figure 7.1 (c) of AISC's *Design Guide No. 11 Floor Vibrations Due to Human Activity*.

Queen post hanger trusses have been used in several buildings and if done correctly work very well.

Q: Could you explain what a damping post is? Is it different than a regular column?

A: A damping post is just a small column with some sort of a damping element on top.

I recommend that the *l/r* value be above 200 so that a large force cannot be transmitted. We have used various types of damping elements with success.

Q: Would the criteria outlined in Design Guide 11 vary for a floor that is hanging, say from a truss? (Assuming the floor diaphragm is adequately tied into the lateral system to prevent any sway/instability.) In other words, do the columns being in tension have any adverse/other affect on the floor system?

A: The hangers would have little effect, but movement of the supporting truss could have a significant effect.

The whole system would need to be evaluated. The criteria in the design guide applies, but the calculation method would be very different.

Q: Being a Civil Engineer, but not Structural, I have had little experience with calculation of floor vibrations. Under what types of floor systems, (joists/joist girders; beams/girders; composite systems, etc.) are the most susceptible to vibration problems.

A: I do not think we should consider types. Most problems come from light floor systems supporting electronic offices. I have encountered problems with both types of floor systems you mentioned. Either type can be made to satisfy the Design Guide criteria.

Q: When doing a steel floor layout what type of criteria should be considered to minimize the vibrations from the start of the design process.

A: I would always span the girder in the short direction to start width. A long span girder will have a low natural frequency, which makes it more difficult to satisfy the criteria. Beam spacing should not be a concern in the beginning.

Q: Can the type of floor deck (composite vs. non-composite) influence the vibration characteristics of a floor system? For example, if you consider a floor system with steel joists spaced at 3′ o.c. with a 2″ deck + 2″ concrete will a composite deck improve the floor's behavior over a simple form deck?

A: The type of deck itself does not affect the vibration. However, in your example, the composite moment of inertia of the 2+2 solution will be greater than form deck plus 2″ or so. Which means you will have a higher frequency and thus a better floor.

Q: You may adjust the natural frequency of a floor system by adding mass or by using stiffer members. Which method works best?

A: Using stiffer members works better. A higher frequency floor is always a better floor.

Q: What methods have been effective in mitigating vibrations after floor concrete has been placed? Core drilling to add additional shear studs? Or adding material to top and bottom flanges?

A: Adding shear studs does not help, since a floor acts as if composite (for floor vibrations) with or without studs. Adding material to the bottom flange may help, but a queen post hanger truss is the best solution we have found to date unless a damping post can be added.

Q: On a 9m span beam I found that is really difficult to satisfy the criteria, to satisfy it we need a beam much heavier than the one we need for resistance and deflection, for instance for resistance we need a W16x36 and for vibration we require a W27x84, and the criteria was not satisfied anyway.

A: Something is not correct here. You should not have any problem satisfying a 9m (27′) span.

Q: Which damping do you recommend for school classrooms, for instance?

A: I do not understand what you mean by "which damping"? Please clarify.

Q: I mean the criteria specify a minimum damping that should be satisfied, but against what I should compare it?

A: I believe you are using $D > 35A_o f + 2.5$. I do not recommend that criterion anymore. The criteria in AISC *Design Guide 11* are much better. In the Design Guide criteria I would use 2-2.5% modal damping for schools.

I used that criteria [$D > 35A_o f + 2.5$] because it is included on ETABS software. I'd try [the new Design Guide criteria.]

Q: Could you explain what are the major problems with the old criteria?

A: All floor vibration criteria must be calibrated using real floors. Floor systems have changed: longer spans, lighter systems, lighter loads, less damping. The older criteria are not working and unfortunately folks are getting into trouble with them. Also, we think we know a lot more now as compared to 20 years ago.

Q: On the new criteria - Fig.2.1 (Design Guide 11), I understand we get higher tolerance in peak acceleration for high natural frequency; but why is it high at low frequency too?

A: Our internal organs have a natural frequency between 4 and 8 Hz. When we are vibrated in that frequency range we do not like it; below or above is less annoying. Note that the criterion for walking excitation automatically takes the entire curve into account.

Q: I have a project where we have a vibration consultant recommended pan-joist over structural steel. It is a laboratory facility. [The consultant's] concern is footfall vibration, and he recommended 30′ maximum bays (both steel and concrete) with 300 micro-inches as the vibration constraint.

He was not forthcoming with further criteria; he bumped steel sizes at three locations, increased the f'_c in the steel deck, and added continuity steel.

A: I may have to agree. Floors for sensitive equipment need to be very stiff. 300 micro-inches/sec is a tough criterion.

Q: On the pan-joist 4+20 x 30+6 , they added a wide intermediate rib. Anyway, I don't see an advantage to concrete except for mass, stiffness seems to be comparable; continuity is better in concrete and maybe redistribution.

A: The design guide criterion for sensitive floors predicts more velocity when the mass increases.

Q: It seems from my review, it is all span, stiffness, continuity and redistribution that we have to choose as our weapons. [The consultant] recommended span as the main control (I agree—L^3). On this project, [there was] no compromising on this criteria. Was I missing something in that I thought steel performance would be comparable to concrete?

A: No, not at all. But really stiff members are required and therefore the cost may become the controlling factor.

(Another participant suggested that the designer consider isolation tables for electron microscopes and other sensitive equipment since they are relatively inexpensive and can be purchased for around $5,000.)