

How and what to communicate for efficient joist design



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Bruce Brothersen, P.E. (BB), engineering manager at Vulcraft-Utah discussed how and what to effectively communicate about steel joist designs with consulting structural engineer John Lawson, S.E. (JL). A portion of their conversation is included here; see this article online to read their full discussion.

BB: On what types of construction do you specify open web steel joists and joist girders?

JL: Most often we specify steel joists and joist-girders on all our flat roof systems. Panelized hybrid roof systems are the most popular in the Southwest and this is our bulk of steel joist usage. In addition to roof systems, our office will engineer mezzanines and floors in multi-story office buildings with steel joist products due to their economy for long spans.

BB: What advantages do you see in the use of open web steel joists?

JL: When repetitive layouts are available in floor and roof systems, open web steel joists are the most economical choice. In addition, here in high-seismic California, the tilt-up wall-to-roof attachment is superior to wood anchorage configurations.

BB: What are the challenges you see in the use of open web steel joists?

JL: The economy of open web steel joists begins to suffer in non-repetitive highly complex projects. In these situations, rolled steel shapes are often more practical to specify.

Steel joist are difficult to work with when tenant improvements add new heavy loads to existing joist jobs. Because the joist suppliers use specialty software programs, project engineers are often unable to accurately analyze or strengthen existing joists for new loading configurations. Their benefit in efficiency is their downfall when future modifications are needed.

Another challenge is when clear height issues arise. With architects and owners demanding higher ceilings and lower floor-to-floor heights, joist and joist-girder depths are more difficult to accommodate than using rolled shapes. While it is true that smaller mechanical ductwork can route between the joists webs, our experience is that the typical larger ductwork is difficult to accommodate this way.

One last challenge to mention has to do with efficient joist depths. Because most of our work involves custom depths with high seismic axial loads, it is often not clear what the most efficient joist depth is on a particular project. As the project engineer, we rely upon the joist supplier to provide us with that optimum depth; however, the joist supplier's profit is tied to the steel tonnage, so there may be a conflict of interest.

BB: What advice do you have for specifying joists?

JL: Learn what the efficient joist and joist-girder depths are for typical spans with typical loadings. Also, joists cannot easily accommodate every loading and configuration, so learn what their limitations are.

BB: What is your approach to supplying information needed by the manufacturer of open web steel joists?

JL: We provide a joist and joist-girder table right on the plans indicating all applicable design load requirements. In addition, we locate sprinkler mains as given to us by the fire protection consultant so that their weights and brace loads are accounted for upfront. We do not want to wait and add design criteria to the joist supplier's submittals, thus potentially delaying the job.

BB: How do you specify wind/seismic loads?

JL: Gravity loads on joists are specified in pounds per linear foot, while girders have kip reaction callouts in conformance with standard SJI protocol. These loadings are given as being "unfactored." It is especially important to provide unfactored loadings for wind and seismic because the building code's loading combinations have numerous load factors for different situations. Joist suppliers have difficulty anticipating which load factors have been applied or not.

For seismic axial loads, provide the unfactored E for the joist supplier. Where joists provide tieback anchorage for concrete or masonry walls in high seismic zones, ASCE 7 Section 12.11.2.2.2 requires a special 1.4 force multiplier, and this needs to be included in the E value provided to the joist supplier.

In some instances, joists or joist-girders are used as seismic collectors, and these have an additional special loading combination that must be checked in high seismic zones. The project engineer must supply the joist supplier unfactored E_m in conformance with ASCE 7 Section 12.10.2.1.

In parts of the country where wind and seismic loads are of similar magnitude, axial loads may need to specify both load types if it is not readily apparent which load will govern the design.

Although not used very frequently, any bottom chord attachment at the end supports will create fixed-end moments resulting in frame action. This type of joist loading requires close communication between the joist supplier and the project engineer to ensure the intent of design is carried out.

Wind uplift forces are specified by our office in pounds per square foot when it has been determined to affect the design.

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