Structural Engineering &DESIGN

Designing steel joists with ease

HOW TO PARTNER ON CRITICAL INFORMATION FLOW

By Perry S. Green, Ph.D.

Effective and timely communication of accurate joist design information yields many benefits in terms of shorter schedules, improved reliability, and smoother project completion

Effective communication during the joist engineering stage is essential both to keeping the project schedules on track and to ensuring the joist designs meet the intent of the specifying professional, which is usually the project's structural engineer of record. There are so many impediments to effective communication during this critical stage of the project that various members of the team — joist designers, detailers, contractors, steel fabricators, and ultimately the specifying professionals — often fall back on rote procedures, standard notes, and catch-all qualifications. Unfortunately, parties are more often focused on making sure they are not blamed for anything than they are on effectively communicating the project requirements.

Project design teams repeatedly wonder why the lead times are so long for joist engineering to be completed and why the joist manufacturer cannot seem to supply joist panel layouts until almost time for the joists to be delivered. At the same time, the joist manufacturer's engineering departments speculate why it takes so long to acquire the information required to complete the joist detailing and design. Members of the Steel Joist Institute (SJI) recently discussed this seemingly industry-wide problem and found that innovative discussions and solutions are emerging as the various parties of the project design and construction team recognize the need for improved communication.

Unfortunately, there are no simple or instant solutions. There are, however, opportunities for significant improvements and substantial benefits when project team members search for ways to improve the lines of communication during the critical stage of joist engineering.

Three specific case studies have been developed to address communication. In each case, the joist manufacturer has partnered with another member of the project design and construction team to acquire the required information in a timely manner. The first case describes the partnering that has developed between a joist manufacturer and the project structural engineer. The second case is an example of partnering between a joist manufacturer and a steel fabricator/subcontractor, while the third case presents an example of partnering between a joist manufacturer and a metal building manufacturer. In each case, the extra efforts to improve the flow of information were rewarded with reduced schedules and increased efficiencies for multiple parties, as well as a higher level of confidence that the finished project met the intended design requirements. The first case is presented here, the other two are available with this article on www.gostructural.com.

The role of the joist manufacturer's design engineer

The primary role of a joist manufacturer's engineering department is to understand the project requirements for joist design and to design the joists to meet those requirements. In a very real sense, for projects with special joist design requirements, the specifying professional is delegating design responsibility of the steel joist portion of the structural system to the joist manufacturer's design engineer. This requires very clear communication between the joist design engineer and the specifying professional. Yet, multiple contractual layers of construction contractors and other design professionals separate the two parties, and the joist design engineer is often not permitted to make direct contact with the specifying professional.

Secondly, the joist manufacturer must share information about the joist designs with other members of the project design and construction team. While SJI standards help in the consistency of conditions and details, at times additional information is required for special or non-standard conditions. Items such as embedment plate size and placement in precast walls, design and fabrication of sprinkler systems, bolt-hole sizes and locations in structural steel beams, fabrication of column cap plates, approval of structural steel erection drawings, and city building permits often await finalization of joist detailing and design.

The joist manufacturer looks to the specifying professional to provide the joist design criteria, while at the same time the specifying professional often relies on subcontractors and material suppliers to provide many of the loads and load locations required for the joist design. Since the subcontractors and material suppliers are usually not even selected until well after the primary contracts have been awarded, it is not surprising that these parties are often waiting on each other to answer questions, with nobody providing answers. For example, frequently the joist manufacturer is waiting on seismic bracing loads for the fire sprinkler system while the fire protection contractor is waiting on panel layouts from the joist manufacturer for routing sprinkler lines; and similarly, the joist manufacturer often is waiting on column cap-plate dimensions from the steel fabricator, while the steel fabricator is waiting on bolt-hole sizes and locations from the joist manufacturer.

Partnering between a joist manufacturer and a project structural engineer

A joist manufacturer requires a large amount of accurate information to complete the placement drawings and joist design. The primary sources of this information are the contract documents and structural drawings provided by the specifying professionals. The more complete the information on the structural drawings, the smoother the project proceeds without the need for extensive requests for information (RFIs) and supplemental coordination of items, allowing for a smoother approval process. With complete joist design information on the structural drawings, the joist manufacturer is able to deliver the product to the jobsite with less effort by all project team members.

Contract documents and structural drawings are the primary sources of the information a joist manufacturer requires to complete placement drawings and joist design.

Bruce Brothersen, P.E., engineering manager at Vulcraft-Utah shares his experience with one structural engineering firm. According to Brothersen, Kramer Engineering, Inc., an Orange County, Calif.-based structural engineering firm with a reputation for understanding the informational needs for efficient joist design, has worked closely with Vulcraft to supply complete and concise joist design information on the structural drawings. According to John Lawson, S.E., formerly with Kramer Engineering, they have established in-house standards to ensure the required information is provided on each set of project structural drawings. Over the years, engineers at Kramer Engineering have developed a relationship of open communication with Vulcraft. It is common for an engineer at Kramer Engineering to call an engineer at Vulcraft to discuss project details so that the structural drawings are complete when they go out for bid. In turn, it is common for an engineer at Vulcraft to call an engineer at Kramer Engineering to discuss and receive direct clarification of a particular situation on the structural plans. The net result of this type of communication is significantly fewer RFIs. For comparison, a typical project for Vulcraft could have 10 questions about the structural drawings that need clarification. By contrast, a Kramer Engineering project will only occasionally have a single question or two. As an example of this type of communication, some questions arose recently about the effect that axial loads have with the 2007 California Building Code. Vulcraft, upon the request of Kramer Engineering, established some standards for transferring axial loads through joist seats for some typical loading and details that they use.

This type of back and forth communication between Vulcraft and structural engineering firms is not exclusive to Kramer Engineering. Many firms are doing the same things to provide the needed information on the structural drawings. On average, it takes about three weeks to get RFIs returned to Vulcraft after the concerns are identified. Structural drawings that take a proactive approach to the joist information require fewer items to be coordinated independently, and the result is faster drawing and approval times.

Brothersen and Lawson discussed several questions that have had a positive impact on getting the correct joist products to the jobsite on time. See “How and what to communicate for efficient joist design,” on page 30.

Conclusions

Effective and timely communication of accurate joist design information is an achievable goal. Whomever

the partner — structural engineer, metal building team, subcontractor, or fabricator — re-inventing the communication process requires each party to fulfill their roles, as well as a mutual trust in commitment to the new process. For all partners involved, the payoff is tremendous in terms of shorter schedules, improved reliability, and smoother project completion — and the dreaded plethora of RFIs may yet go the way of the typewriter!

How and what to communicate for efficient joist design

Bruce Brothersen, P.E.

John Lawson, S.E.

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.

***Bruce Brothersen, P.E.**, is the engineering manager at Vulcraft – Utah, and serves as the Chairman of the Steel Joist Institute Education Committee. He can be reached at bbrothersen@vulcraft-ut.com or 435-734-4535. **John Lawson, S.E.**, is a consulting structural engineer, formerly with Kramer Engineering, Inc., and an assistant professor at California Polytechnic State University in San Luis Obispo. He may be reached at jwlawson@calpoly.edu or 805-756-7123.*

***Perry S. Green, Ph.D.**, is the technical director of the Steel Joist Institute. He can be reached at psgreen@steeljoist.org or at 843-293-1995.*