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steel interchange

Bolted Web Connections for Moment-Connected Beams

Several slab-on-metal-deck composite beams need to be reinforced as part of the remodel of an existing building. Many of the beams are either partially composite or will be partially composite once reinforcing is added.

If a beam is partially composite, does the plastic neutral axis move into the steel? Are the shear connectors ductile enough to accommodate this behavior?

Also, is the paper "Design of Partially or Fully Composite Beams, with Ribbed Metal Deck, Using LRFD Specifications" (Vinnakota, S., et al., AISC *Engineering Journal*, 2nd Quarter, 1988) a good reference for this situation?

The answers to all of your questions are yes, but let me explain in greater detail. I'll begin by saying the paper you referenced is one of my favorite references for when I have to determine the composite behavior of my beams. You should also review the discussion on composite beams and diagrams included in the AISC *Steel Construction Manual*; see pages 3-12 through 3-14 of the 14th Edition.

Let's start with full composite design, where the strength of the shear connectors is not the limiting factor. The maximum tension strength of the steel is F_yA_s, and the maximum compression strength of the concrete is $0.85f'_cA_c$. A fully composite section has enough studs to develop the lesser of these strengths. If the steel section in tension is the lesser of the two strengths, the plastic neutral axis will be at or above the top of the top flange of the steel beam. If the concrete section in compression is the lesser of the two strengths, the plastic neutral axis will be located below the top of the top flange of the steel beam. The plastic neutral axis moves away from the weaker part into the stronger part because compression must always equal tension.

In a partially composite beam, the stud shear strength is the controlling strength in the design of the cross section. It will have a compression force in the concrete plus additional compression due to yielding in some portion of the steel section. The balance of the steel section will be yielding in tension with a force equal to the sum of the concrete and steel compression forces. The plastic neutral axis will be in the steel section at the location where the steel switches from tension yielding to compression yielding. The figure on the top of page 3-14 of the 14th Edition AISC *Manual* depicts this condition.

Shear stud connectors are sufficiently ductile to accommodate this behavior. That same ductility also works for you in fully composite design. If the connectors were not ductile, the ones closest to the beam ends would be required to resist a larger shear load than the ones closer to the beam interior. The Vinnakota paper outlines how all composite beam design depends on this ductility. The inherent assumption in the design approach is that when the connectors at the beam ends reach their yield strength, they will yield and allow the balance of shear force along the slip plane between the steel and concrete interface to redistribute to the next connector down the line. In determining our composite beam flexural strength, we assume that all the studs are resisting the same nominal shear force.

Susan Burmeister, P.E.

NDT and Approved Fabricators

Is nondestructive testing (NDT) waived for AISC Certified fabricators?

No. The requirements of Chapter N of the AISC *Specification* and Chapter J of the AISC *Seismic Provisions* apply equally to AISC Certified and noncertified fabricators. Chapter 17 of the *International Building Code* (IBC) permits the authority having jurisdiction (AHJ) to waive special inspections for approved fabricators. The IBC states:

"Special inspections required by Section 1704 are not required where the work is done on the premises of a fabricator registered and approved to perform such work without special inspection. Approval shall be based upon review of the fabricator's written procedural and quality control manuals and periodic auditing of fabrication practices by an approved special inspection agency…"

AISC Certification is a common means by which the AHJ determines approval for a waiver of special inspections. It should be noted that the approval of the fabricator is at the discretion of the AHJ.

Inspection activities are still performed by the fabricator when the waiver is granted—e.g., the waiving of special inspections simply changes the party conducting any required NDT; it does not eliminate NDT requirements. Section N1 of the AISC *Specification* states: "Nondestructive testing (NDT) shall be performed by the agency or firm responsible for quality assurance, except as permitted in accordance with Section N7." Section N7 states: "Quality assurance (QA) inspections, except nondestructive testing (NDT), may be waived when the work is performed in a fabricating shop or by an erector approved by the authority having jurisdiction (AHJ) to perform the work without QA. NDT of welds completed in an approved fabricator's shop may be performed by that fabricator when approved by the AHJ."

Larry S. Muir, P.E.

Bolted Web Connections for Moment Connected Beams

At beam-to-column moment connections in a project we're working on, the flanges will be field welded to the columns while the web shear connections will be bolted. The contractor would like to install the bolts at the web connection before he begins welding the flanges. Should we be concerned about inducing stresses in the flange weld due to the restraint from the web connection while the weld cools and shrinks?

Weld shrinkage can induce large stresses in both the beam flange and the bolted connection. However, the shrinkage force will easily overcome friction at the bolted faying surface, even if the bolts are pre-tensioned. To accommodate the weld shrinkage, it is common to use horizontal slots in the web connection, as discussed in the May 2012 article "Developing M_p" (available at **www.modernsteel.com**). According to the article, "It is usually advisable to use short slotted holes in the shear connection and leave the bolts snug tightened to better accommodate the weld shrinkage."

Bo Dowswell, P.E., Ph.D.

Fire Protection and Welding to Existing Structures

Are fire watchers required when welding inside an existing structure? Is this a requirement of AWS D1.1?

Fire watchers are likely required, and you can determine this using the following information.

First, ANSI Z49.1 addresses safety in welding, cutting and allied processes. It can be downloaded for free from AWS (**www.aws.org**). Clause 6.2.2 lists conditions that will require fire watchers to be posted. At least one of these conditions is likely to exist when welding to an existing structure.

Second, OSHA requirements also state: "Fire watchers shall be required whenever welding or cutting is performed in locations where other than a minor fire might develop," or when specific listed conditions exist. See 1910.252(a)(2)(iii)(A).

Relative to whether this is a requirement of AWS D 1.1, Clause 1.7 of AWS D1.1 states: "Safety and health issues and concerns are beyond the scope of this standard and therefore are not fully addressed herein. It is the responsibility of the user to establish appropriate safety and health practice." It then goes on to provide some resources related to safety and health, including ANSI Z49. Therefore, the requirements of ANSI Z49.1 probably cannot be considered requirements of AWS D1.1, but safety and health standards should always be adhered to.

Larry S. Muir, P.E.

Approval of Shop Drawings

We are receiving marked-up shop drawings with conflicting information from several parties on a current project. Some of the comments can only be addressed by changes to the contract. How many parties are permitted to submit comments?

The AISC *Code of Standard Practice* assumes the owner has designated representatives. These are referred to as the owner's designated representative for construction and the owner's designated representative for design, and these terms are defined in the *Code*.

Section 4.4 states: "Except as provided in Section 4.5, the shop and erection drawings shall be submitted to the owner's designated representatives for design and construction for review and approval… Approved shop and erection drawings shall be individually annotated by the owner's designated representatives for design and construction as either approved or approved subject to corrections noted…" Per the *Code*, you should expect to receive comments from these two parties, and it is reasonable to assume that they are the parties through whom all changes should flow.

You should probably speak to the owner's designated representatives to clarify which parties have authority to change the contract

Larry S. Muir, P.E.

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If you have a question or problem that your fellow readers might help you solve, please forward it to us. At the same time, feel free to respond to any of the questions that you have read here. Contact Steel Interchange via AISC's Steel Solutions Center:

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