Night School 26: Developing Eye for Connection Design
Additional Questions and Answers

What is the best connection design software?

1. I am not familiar with ALL connection design software so I could not declare any software to be the best.
2. In practice, I have only used software I have written – or that was written under my supervision.
3. I have reviewed a good bit of connection design software over the years… See Item 2.
4. I think the best thing software can do is be transparent. There appears to be some software that does nothing more than automate (plug-and-chug) AISC Design Examples. In effect, the software says: "You can have it my way… no extra onions, no hold the pickle… this is what I do and you either take it or leave it." This is simple enough for me to understand, and therefore I could judge whether the results are useful to me or not. I like this.
5. I think the worst thing software can be is a black box. Put stuff in -> get stuff out. Who knows where it comes from? One of my favorite questions: "I have designed the connection attached. Can you explain what my software is doing? I have to explain it to another engineer."
6. Connection design software will not get people killed, engineers will get people killed.

Baker et al. doesn't provide the proof of the theorem, but presents examples. Can this proof be discussed as a future topic, please? No. It is going to be hard enough to hold people's interest as I dissect the design examples in Session 6 and 7. I would never get away with talking about a proof. B.G. Neal provides proofs in the appendices to *Plastic Methods of Structural Analysis*. The book was apparently so popular that there was a paperback version from 1965 which is what I have. In 1957 *Nature* described the book as, "pleasant and readable" and "crisp and to the point" and its "matter is the stuff of the future". "It cannot be neglected…" Though unfortunately "…the excellent index does not contain the word 'joint'. Yet the design of the joints in a redundant structure is of vital significance if the structure is to behave as postulated…" I could not have said it better myself. I laughed. I cried. Great Summer Read! Get yours today. Limited availability likely. Past experience indicates the price will go up.

Instead of using ASME BTH-1, some contractors use Section J for lifting lugs design/evaluations. Any comments on that please? Thanks. The provisions of Specification Section J are not intended to be used to design or evaluate lifting lugs, though I have sometimes designed or evaluated lifting lugs using Chapter J. I was young and foolish. It was just a phase I was going through. Here are some more current thoughts:

www.aisc.org/globalassets/modern-steel/steel-interchange/2013/092013_si.pdf

In slide 43, what is meant by "whatever the opposite of steroids is"? To the hip and happening kids "on steroids" is used "to suggest a highly exaggerated, enhanced, or accelerated version of something". The instantaneous center of rotation method can be thought of as a lowly understated, impaired, or impeded version of what engineers normally think of when they think of finite element analysis. It was my attempt at a bit of levity.

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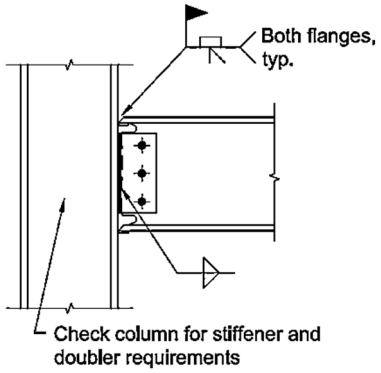

Per slide 22 (Session 1) FR Connection, are there explicit bolting requirements for the web shear plate (SC/PT/ST) given that the beam end has both welded flange connections and bolted web connection? Generally no. "A common misconception is that slip-critical joints are necessary at the web connection to limit the vertical movement of the beam after the flanges have been welded. This would presumably prevent secondary bending and shear stresses in the beam flange in the area between the column flange and the weld access hole. However, the tests showed no decrease in strength when bearing joints were used. Furthermore, most of the tests with slip-critical joints had slip occur at some point in the testing, effectively rendering the web connection a bearing joint anyway."

www.aisc.org/globalassets/modern-steel/steelwise/052012_steelwise.pdf

Is the configuration of Slides 81-92 covered in detail in DG 29? Yes. Note that this example was provided to you as part of the homework along with Design Guide 29 - Example 5.11. The first chapter of the Design Guide was also provided early in the Night School. This could be viewed as a preview of the Design Guide. Thank you, AISC, for your generosity.

I would be very interested in a discussion of transfer forces and how they are calculated, preferably with an example. I teach a connection design course and we briefly discuss transfer forces, and I'm looking for some inspiration to improve my course information – the concept often baffles students. **Also, I suspect some of us in the "other" category (from the initial polling questions) are in academics. Looking forward to this program! This is a topic that baffles a lot of engineers. In part, I think it baffles practicing engineers because it is a force that usually does not simply fall out of the structural analysis. As I mentioned in the Night School, Appendix D of AISC Design Guide 29 (a free download for members from www.aisc.org/dg) is dedicated to the topic of transfer forces. The following free resources also address transfer forces.

www.aisc.org/education/continuingeducation/education-archives/demystifying-connection-design-and-transfer-forces--n59a/

https://youtu.be/-_1h4muNI7k

www.aisc.org/globalassets/modern-steel/steelwise/2014/steelwise_nov-2014.pdf

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https://youtu.be/1jaHSQhGUgA

https://cloud.aisc.org/nascc/2020/O8_NASCC2020.mp4

Understanding transfer forces requires an understanding of:

1. statics.
2. load paths.
3. the differences that exist between what is modelled and what is built.
4. the function of the diaphragm and its interaction with the steel frame.

These are all concepts that structural engineers must understand, but too often do not.

Why are connection plates or angles still 36 ksi steel while members are 50 ksi? This question does not accurately reflect conditions in our industry. *Manual* Table 2-5 indicates that BOTH A36 and A572 Grade 50 are preferred materials for plates. For angle and channels, Table 2-4 indicates A36 is the preferred grade. Some fabricators have long preferred to exclusively use 50 ksi connection materials (including angles). Our industry is in transition. At some point in the relatively near future, it is likely that the majority of steel used in structural steel projects will have a yield strength of 50 ksi – but we may not be there yet.

Option 2 questions. I'm a structural engineer so I don't detail connections.

1. **What kinds of information do I need to give to the detailer for them to be able to design the details?** Section 3.1.1 of the *Code of Standard Practice* describes the information required for Option 2.

2. **Do the detailers provide calculations?** Section 3.1.1 of the *Code of Standard Practice* states, "When Option 2 or 3 is specified, the owner's designated representative for design shall provide… (e) What substantiating connection information, if any, is to be provided with the approval documents to the owner's designated representative for design." Therefore, if you want the detailer to provide calculation, then this needs to be specified in the contract documents. Keep in mind that while detailers can perform calculations, they cannot perform engineering work or make design decisions. Any calculations performed will "utilize information provided in the structural design documents… or other reference information as approved by the owner's designated representative for design…"

3. **Are the detailers able to help with a field solution for a connection that wasn't properly installed?** Detailers cannot perform engineering work or make design decisions. Experienced detailers can often assist in this process by suggesting field fixes that they have seen successfully

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used in the past, but ultimately an engineer must review and approve any such proposed solutions.

4. **Typically, which party of the contract (ie owner, architect, general contractor) pays the detailer's fees?** The fabricator typically hires and pays the detailer. Other arrangements are possible. Section 4.5 of the *Code of Standard Practice* addresses "Fabrication and/or Erection Documents Not Furnished by the Fabricator". In my opinion, and in my experience, engineers who take on detailing work do not always understand the liability they may be taking on when they choose to provide Fabrication and/or Erection Documents. Section 4.5 states, "The fabricator shall not be responsible for the completeness, coordination, or accuracy of fabrication and erection documents so furnished, nor for the general fit-up of the members that are fabricated from them." The Commentary discusses the need to clearly assign and manage various aspects of the process.

5. **If requested, will a detailer provide a stamped and signed version of the design?** No. Detailers are typically not engineers, and Option 2 does not involve engineering work.

Can the *Code of Standard Practice* be used in court if miscommunication leads to an accident and goes to a trial? I am not a lawyer and cannot give legal advice, but… YES.

If the *Code of Standard Practice* is explicitly part of your contract, then presumably contract law applies and the *Code of Standard Practice* will be applied by the courts.

Even if the *Code of Standard Practice* is not explicitly part of your contract, it's probably in your contract by default in the absence of specific instructions to the contrary in the contract documents. Former AISC counsel David Ratterman has stated, "Over time, the courts have established the *Code of Standard Practice* as the 'statement of custom and usage in the industry'… If there is a gap in the contract… but [it] is covered in the Code, the court will incorporate the Code into the contract".

However… the *Code of Standard Practice* respects the freedom for parties involved in the design, fabrication and erection of structural steel to agree to "specific instructions to the contrary" in the contract documents.

The *Code of Standard Practice* may not protect you if its provisions are clearly NOT part of your contract.

What and how are forces (and other connection criteria) to be provided in the drawings when connection design is delegated? What are the EoR's responsibilities relative to communicating connection criteria? Is providing UDL sufficient? Can you show examples of how the connection loads are presented on the construction documents?

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These topics were discussed a good bit during the Night School. I understand that they cannot be discussed enough. There are a range of positions on some of these issues. Also the complexity of projects can vary significantly, and therefore, so too can the form and type of criteria that must be provided. Rather than continue to provide my thoughts, I will refer to available thoughts by others. Links to presentations are provided below:

https://www.aisc.org/education/continuingeducation/education-archives/delegated-connection-design-what-are-the-eors-responsibilities-n41a/

https://www.aisc.org/education/continuingeducation/education-archives/improving-communication-skills---tips-for-structural-engineer-from-a-structural-engineer-n20/

https://www.aisc.org/education/continuingeducation/education-archives/effective-communication-of-connection-design/

https://www.aisc.org/education/continuingeducation/education-archives/the-ten-commandments-of-communicating-connection-design-n9/

https://www.aisc.org/education/continuingeducation/education-archives/drawing-and-specification-requirements-for-seismic-design/

https://www.aisc.org/education/continuingeducation/education-archives/delegating-connection-design-o4/

Are bolt holes sizes outside of those in the AISC Table J3.3 allowed? For example if you use a size between standard and oversize for a given bolt diameter. Yes. The use of smaller bolt hole sizes is not prohibited, but it is unusual. The Commentary to the RCSC *Specification* states, "The footnotes in Table 3.1 provide for slight variations in the dimensions of bolt holes from the nominal dimensions. When the dimensions of bolt holes are such that they exceed these permitted variations, the bolt hole must be treated as the next larger type." If the hole is larger than standard but smaller than oversize, then it should be treated as oversize relative to the need to make the joint slip-critical, etc. If the slot is larger than a short slot but smaller than a long slot, then it should be treated as a long slot.

Which documents, AISC or AWS, address weld symbols? AWS A2.4 and AWS D1.1 provide weld symbols and information about properly designating welds. AWS D1.1 treats the designation of welds in contract documents somewhat differently from the designation of welds in fabrication documents.

What is the best practice on the use of washers in bolted connections? This question also relates to the idea that bolted connections should be simple and the best way to keep bolted connections simple is to use snug-tight bearing connections whenever possible. Section 6.1 of the RCSC *Specification for Structural Joints Using High-Strength Bolts* (a free download from www.boltcouncil.org) states,

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"Washers are not required in snug-tightened joints, except…" for two conditions, one of which is pretty rare. When the joints must be pretensioned, Section 6.2 states, "Washers are not required in pretensioned joints and slip-critical joints, except…" for eight conditions. For some tensioning methods, proper placement of the washer is critical to the performance and can be complicated to work out. I am not aware of a universal "best practice". The requirements must be satisfied.

The topic today was too general for me. I would like more teaching on specific connections, more design examples. Are we going to have connection design examples? This question was received early in the Night School. I hope the inquirer understands why traditional design examples were not presented. AISC provides thousands of pages of design examples. In the Night School, and in the supplementary information, numerous attendee-submitted conditions will be addressed.

When would you specify a pretensioned connection but not a slip-critical? As indicated in the Night School most bolted connections designed to satisfy the AISC Specification can be designed as bearing and installed snug-tight. The *Specification, Section* J3.1, lists specific conditions for which bolts must be pretensioned or connections must be designed as slip-critical. Generally, unless a condition is listed, it can and should be permitted to be installed snug-tight. When included in the list of specific conditions, the connection would be designated accordingly in the contract documents.

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