

Web-based 3D Model Viewer for Illustrating Concepts in Structural Steel

AISC Educator Webinar Series

September 29, 2020



AISC Educator Webinar Series

Today's live webinar will begin shortly. Please stand by.

Today's audio will be broadcast through the internet. Please be sure to turn up the volume on your speakers.

Please type any questions or comments in the Q&A window.



Upcoming Student Webinar

Winning Writing Strategies for Students: SSBC Supplemental Competition and Beyond!

Thursday, October 1st at 2:30pm (Central)

- Presented by three practicing structural engineers
- Focused on strategies for assembling engineering reports
- Open to all students – not just those participating in the Supplemental Competition

aisc.org/ssbc




Student Steel Bridge
Supplemental
Competition
2021 Rules



Teaching Aid Library

- Case studies
- Photo library
- Videos
- AESS
- Seismic design
- Bolting & welding
- Bridge design
- *Manual* examples
- and many more!

aisc.org/teachingaids

IN THIS SECTION

- Adopt-a-School
- Educator Awards
- Educator Forum
- Faculty & Students at NASCC
- Partners in Education
- Scholarships
- Steel Sculpture
- Student Competitions
- Student Clubs

Teaching Aids

The AISC steel teaching aids have been developed to assist universities in preparing students to become professionals knowledgeable in the use of structural steel. Educators, students and others within the academic engineering community have the permission of AISC to download the steel teaching aids free of charge.

The teachings aids have been divided among three different academic disciplines, architecture, civil & architectural engineering, and construction management, in accordance with where the knowledge provided will be most relevant. Because of overlap among the disciplines, some teaching aids may appear in more than one category. Regardless of discipline, all of the teaching aids are valuable to anyone studying or teaching in the design and construction fields.

New: AISC provides grants for development of teaching aids

ARCHITECTURE **CIVIL & ARCH. ENGINEERING** **CONSTRUCTION MGMT.**

PowerPoint Presentations and Other Documentation

- Architecturally Exposed Structural Steel
- Digital Library Images

BECOME AN AISC MEMBER!

Learn about the many valuable benefits to becoming a student member of AISC! Best of all, for full-time U.S. students, it's free!

VIEW MORE

STEEL EDUCATORS' TIP SHEET

Sign-up to receive the Steel Educators' Tip Sheet.

Teaching Aid Library

New!

aisc.org/teachingaids

ARCHITECTURE CIVIL & ARCH. ENGINEERING CONSTRUCTION MGMT.

PowerPoint Presentations and Other Documentation

- [Architecturally Exposed Structural Steel](#)
- [Digital Library Images](#)
- [Financial Center: A Case Study of a Distinct Exposed Structural Steel Building](#)
- [Incorporation of Writing Assignments into Steel Design Courses](#)
- [Steel and Sustainability](#)
- [Steel Frames: the Design Studio Case Studies](#)
- [Structures of the Everyday](#)

Interactive Applets

[Web-Based 3D Model Viewer for Illustrating Concepts in Structural Steel](#)

Videos

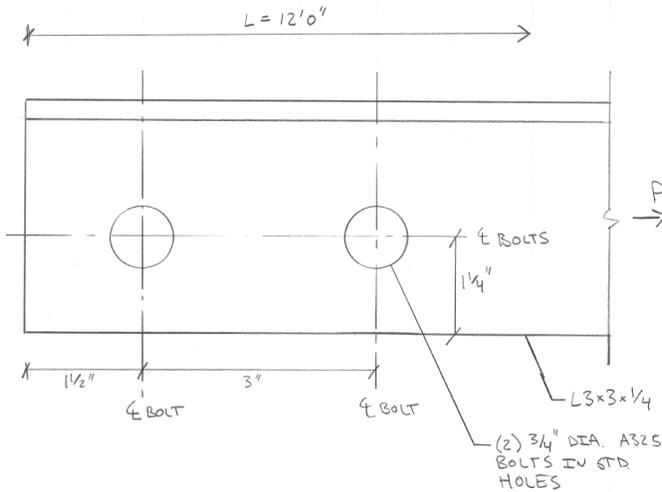
- [Lee Hall III - A Steel Structure from Idea to Reality](#)
- [Single-Story Building](#)

Speaker



Mark D. Denavit, PE, PhD
University of Tennessee, Knoxville
Assistant Professor, Civil and Environmental Engineering

Inspiration for the teaching aid



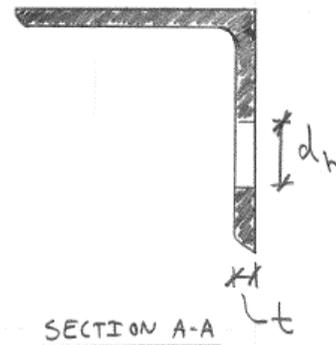
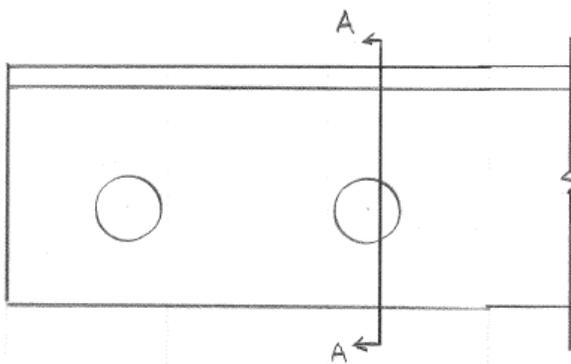
Tensile Yield

$$A_g = 1.44 \text{ in.}^2$$

Tensile Rupture

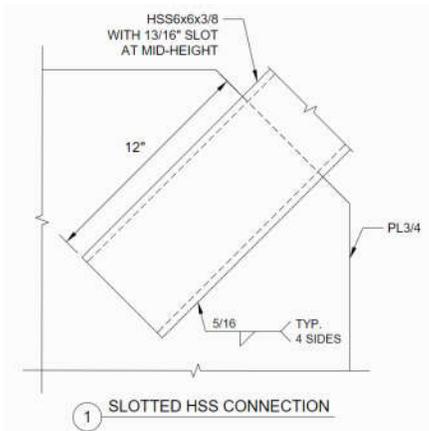
$$A_n = 1.44 \text{ in.}^2 - (2 \text{ bolt holes})(13/16 \text{ in.} + 1/16 \text{ in.})(0.25 \text{ in})$$

Many students are not seeing this

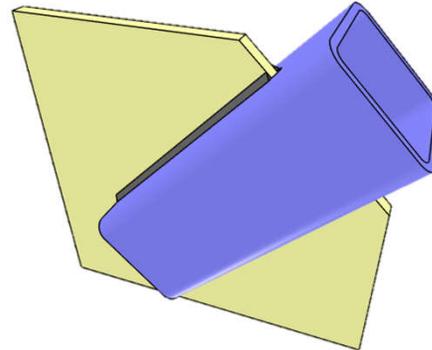


It is a matter of translation

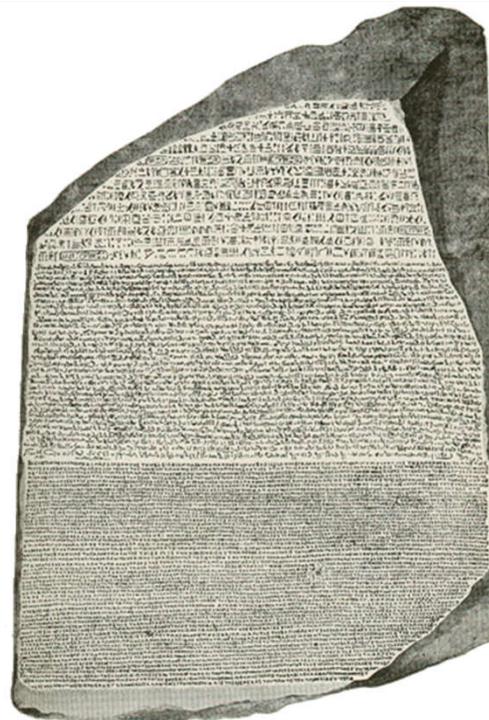
From convenient two-dimensional representations



to the three-dimensional reality.



A Rosetta Stone would help...

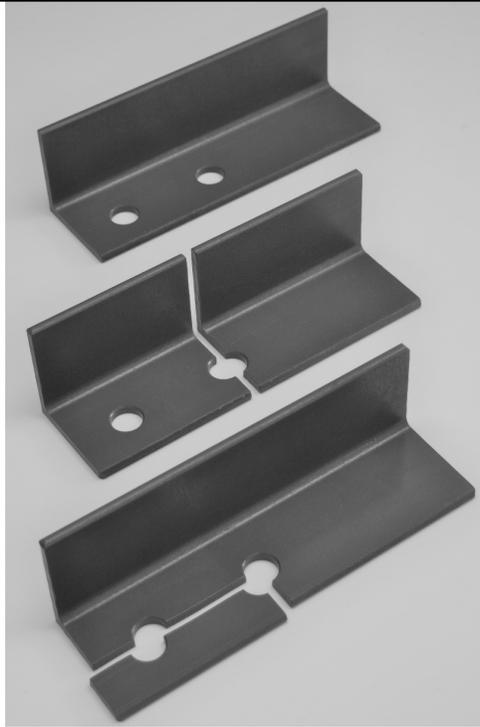


Physical models

- They work great!

However:

- They are heavy
- They are not free
- I only have one set

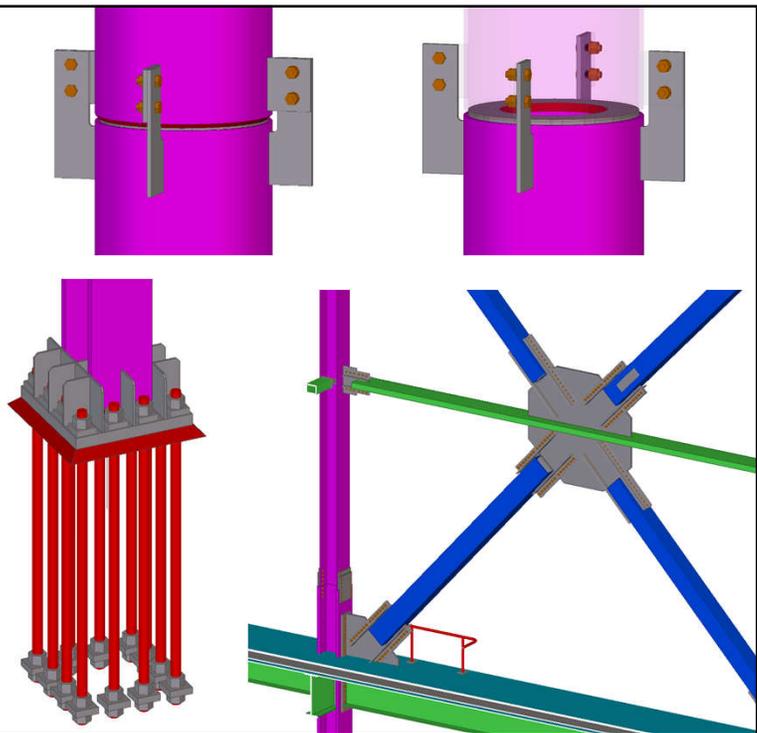


Digital models

- They also work great!
- Potential for incredible detail
- Lots of software options
- Relevant to industry practice

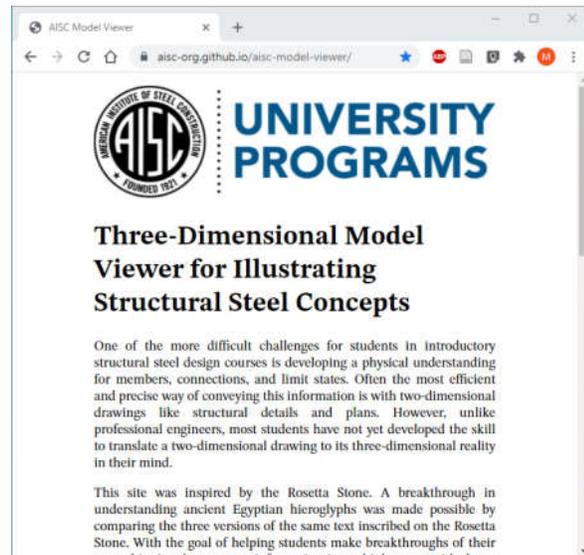
However:

- Not so easy to use (need specialized software)



Web-Based Three-Dimensional Model Viewer for Illustrating Structural Steel Concepts

- Easy to use
 - zero overhead, just go to the website on your computer or smartphone
- Not just models
- Extensible
- One thing well



Collections

Four collections were developed for the launch of the website, each focusing on a particular connection:

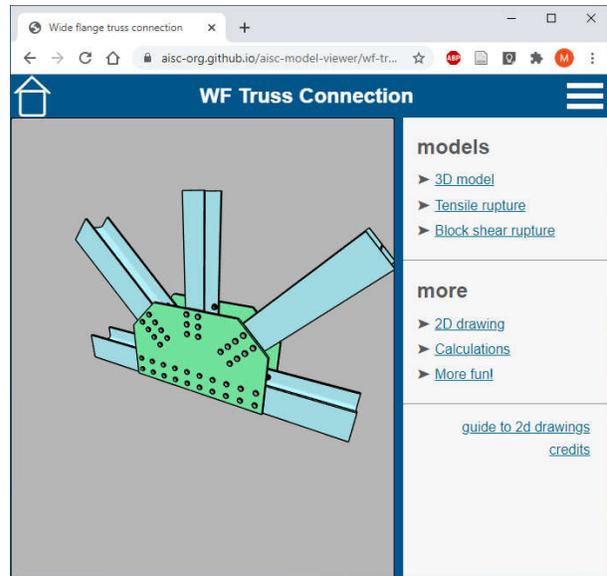
- Double Angle Connection
- Slotted HSS Connection
- WT Connection
- WF Gusset Plate Connection



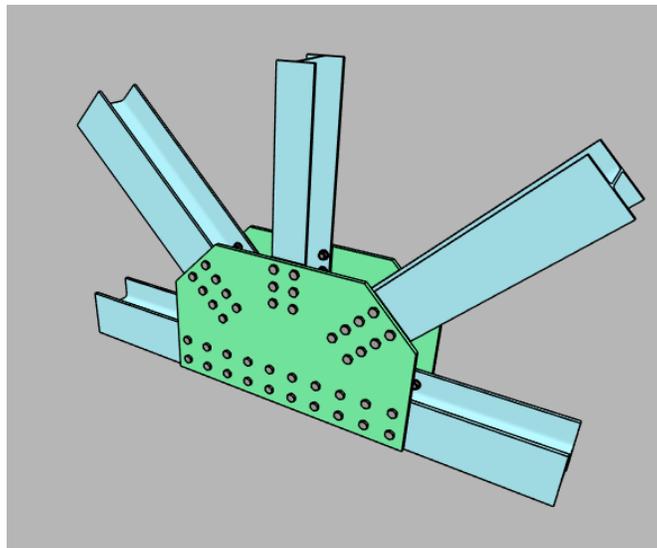
Collection contents

Each collection contains several assets:

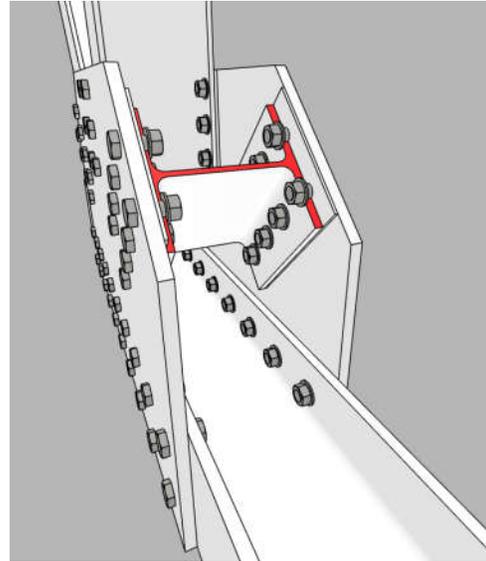
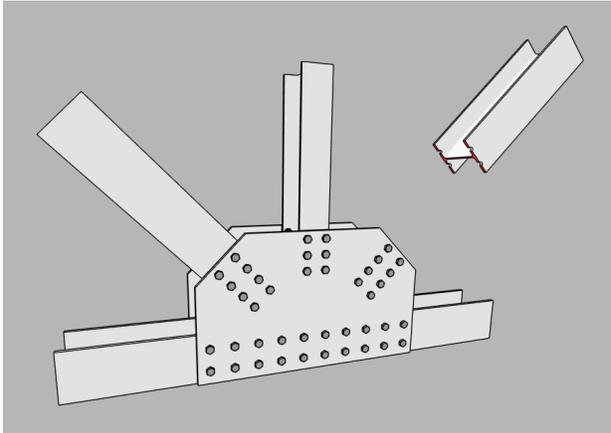
- Multiple three-dimensional models
- Two-dimensional drawings
- Calculations
- Photographs (if available)
- More fun!



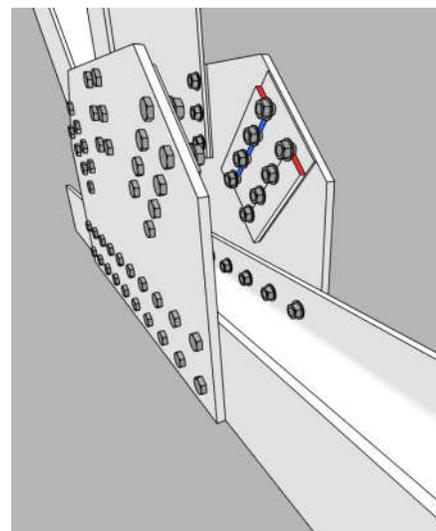
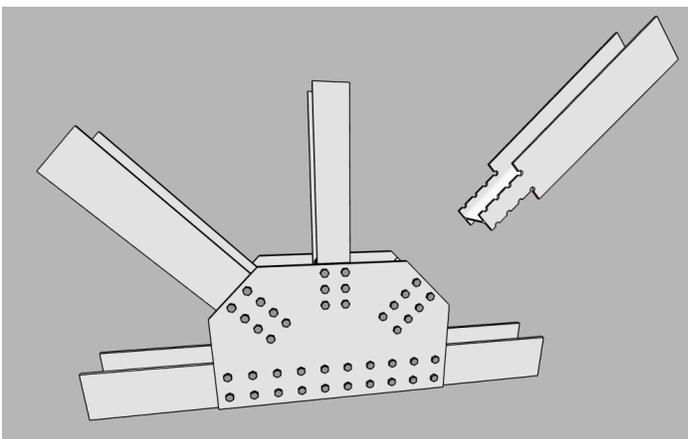
WF Gusset Plate Connection: 3D model



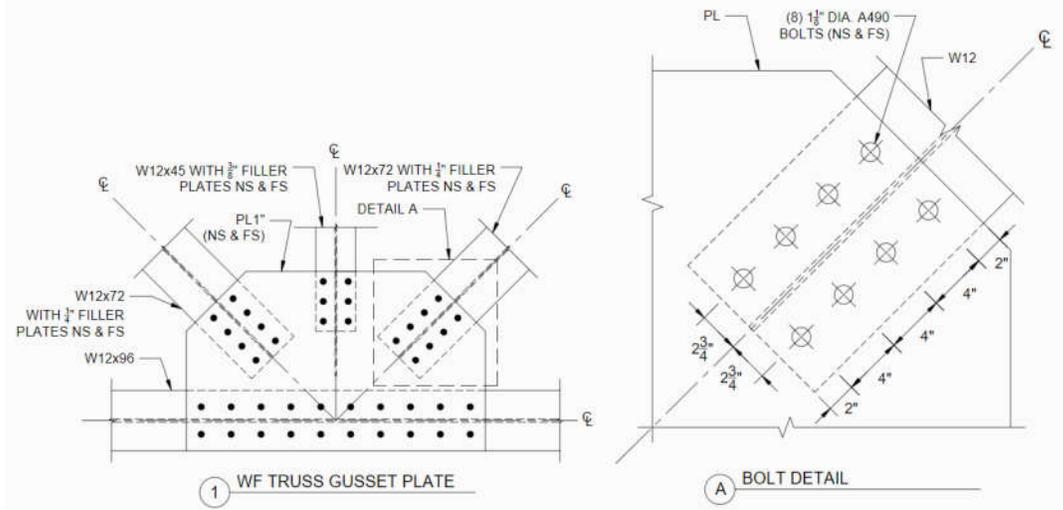
WF Gusset Plate Connection: Tensile rupture



WF Gusset Plate Connection: Block shear rupture



WF Gusset Plate Connection: 2D drawing



WF Gusset Plate Connection: Calculations

Tensile yield

Calculate the nominal strength using AISC Specification Equation D2-1.

$$P_n = F_y A_g$$

$$= (50 \text{ ksi})(21.1 \text{ in.}^2)$$

$$= 1060 \text{ kips}$$

Calculate the design strength by applying the resistance factor.

$$\phi P_n = 0.9(1060 \text{ kips}) = 950 \text{ kips}$$

Tensile rupture (model)

The net area A_n is shown in red. It is equal to the gross area minus the material removed for four bolt holes as defined in Section B4.3b of the AISC Specification.

$$A_n = A_g - 4(d_h + \frac{1}{16} \text{ in.})t_f$$

$$= 21.1 \text{ in.}^2 - 4(1\frac{1}{2} \text{ in.} + \frac{1}{4} \text{ in.} + \frac{1}{16} \text{ in.})(0.670 \text{ in.})$$

$$= 17.6 \text{ in.}^2$$

From the description of the element in AISC Specification Table D3.1 Case 7, calculate the shear lag factor, U , as the larger of the values from Case 2 and Case 7. Note that *Manuals* printed before June 2019 have an error in the figure for Case 2. [See the errata \(PDF\)](#)

Calculate the shear lag according to Case 2. For wide-flange shapes with the flanges attached to plates, the eccentricity of the connection \bar{x} is calculated by considering the W section as two WT sections.

Block shear rupture (model)

There is only one plausible block shear path for this connection, consisting of four (4) pieces of the wide-flange shape breaking off.

Calculate the gross area subject to shear.

$$A_{gv} = (4 \text{ pieces})(t_f)(14 \text{ in.})$$

$$= (4 \text{ pieces})(0.670 \text{ in.})(14 \text{ in.})$$

$$= 37.5 \text{ in.}^2$$

Calculate the net area subject to shear.

$$A_{nv} = A_{gv} - (4 \text{ pieces})(3\frac{1}{2} \text{ holes})(0.670 \text{ in.})(d_h + \frac{1}{16} \text{ in.})$$

$$= 37.5 \text{ in.}^2 - (4)(3\frac{1}{2})(0.670 \text{ in.})(1\frac{1}{2} \text{ in.} + \frac{1}{4} \text{ in.} + \frac{1}{16} \text{ in.})$$

$$= 25.2 \text{ in.}^2$$

Calculate the gross area subject to tension.

$$A_{gt} = 4(t_f)(\frac{b_f}{2} - 2.75 \text{ in.})$$

$$= 4(0.670 \text{ in.})(6.0 \text{ in.} - 2.75 \text{ in.})$$

$$= 8.71 \text{ in.}^2$$

Calculate the net area subject to tension.

$$A_{nt} = A_{gt} - 4(t_f) \cdot \frac{1}{2}(d_h + \frac{1}{16} \text{ in.})$$

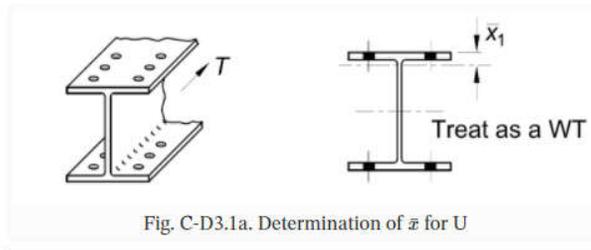
$$= 8.71 \text{ in.}^2 - 4(0.670 \text{ in.}) \cdot \frac{1}{2}(1\frac{1}{2} \text{ in.} + \frac{1}{4} \text{ in.} + \frac{1}{16} \text{ in.})$$

$$= 6.95 \text{ in.}^2$$

Calculate the nominal block shear strength using Specification Equation J4-5. The tensile stress is uniformly distributed, so use $U_{ts} = 1.0$.

WF Gusset Plate Connection: More fun!

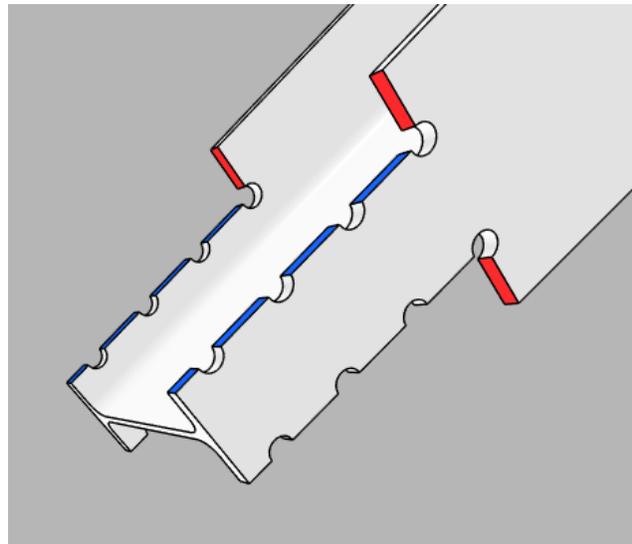
How were you supposed to know to treat the wide flange as two WTs for calculation of the shear lag factor, U ? It is not clear in Table D3.1 of the AISC *Specification*, but it is crystal clear in the commentary. The figure below is from the commentary on Chapter D. The commentary (the pages with grey edges in the AISC *Manual*) has lots of information and is a good first place to look for any question about the *Specification*.



Upsize holes make fit up easier. What would change about the strength calculations if upsize holes were used in this connection?

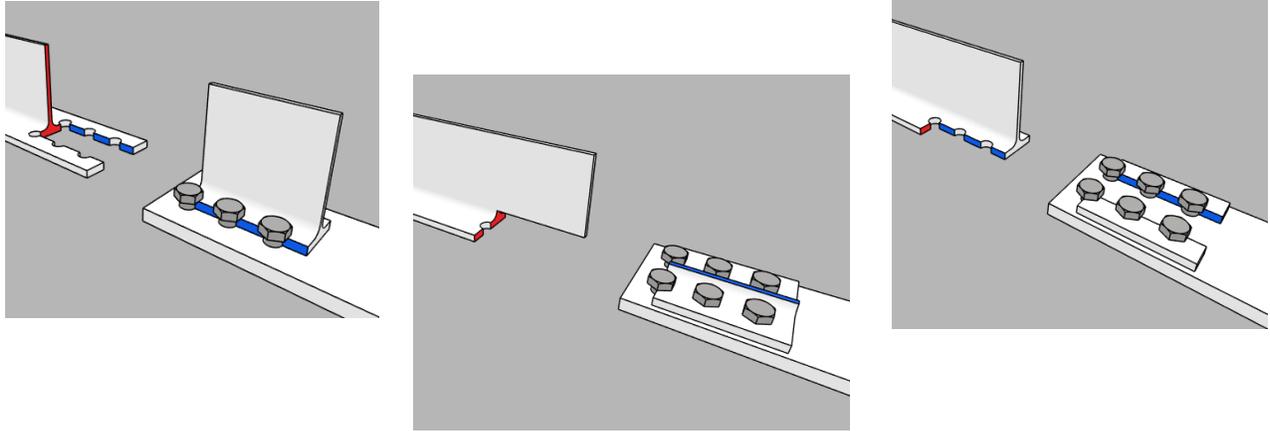
WF Gusset Plate Connection

This connection is often challenging since the controlling block shear failure includes failure planes on the near side and far side of a two-dimensional drawing.



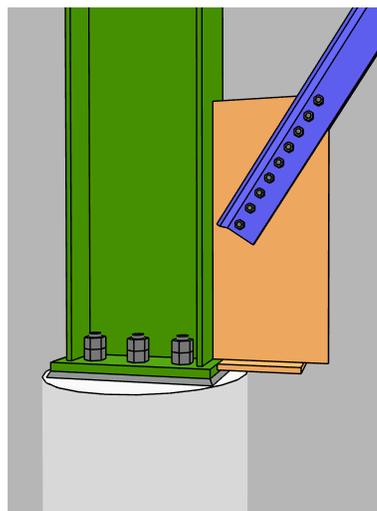
WT Connection

This connection features multiple possible three-dimensional block shear failure paths (including tension through the flange and shear in the web)



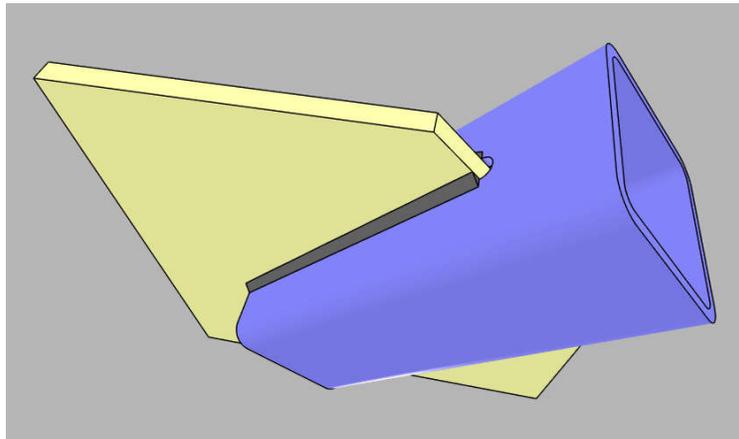
Double Angle Connection

This connection is based on one in Neyland Stadium which provides students at the University of Tennessee the opportunity to compare the model to the physical connection.

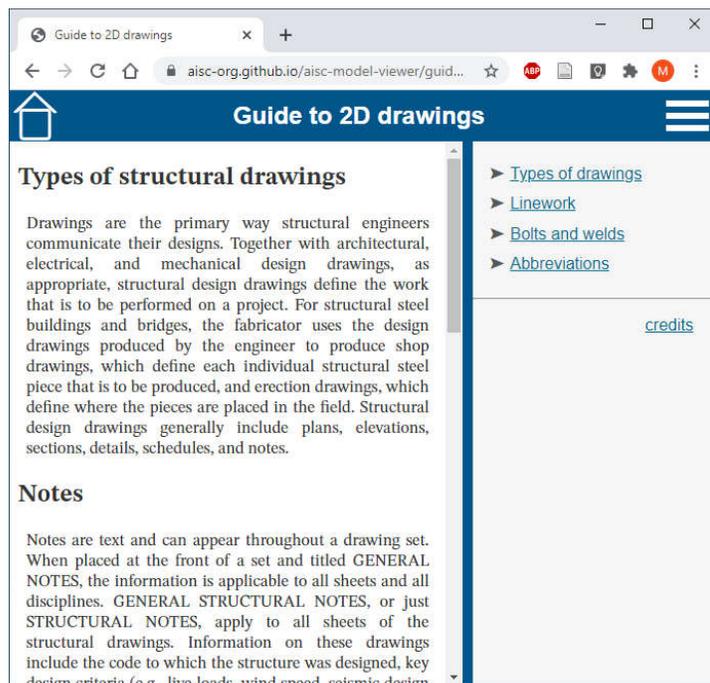


Slotted HSS Connection

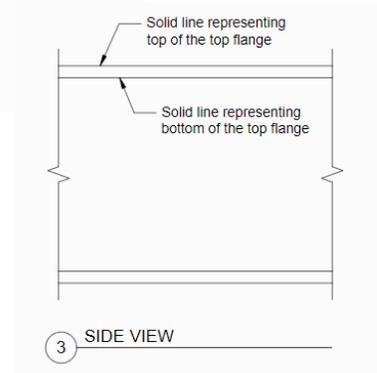
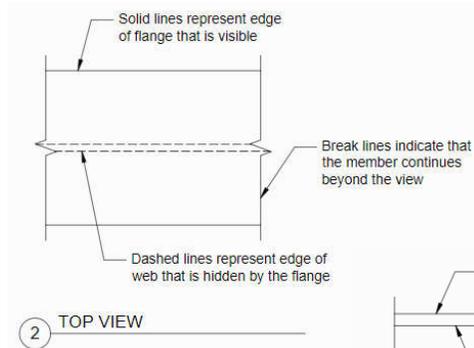
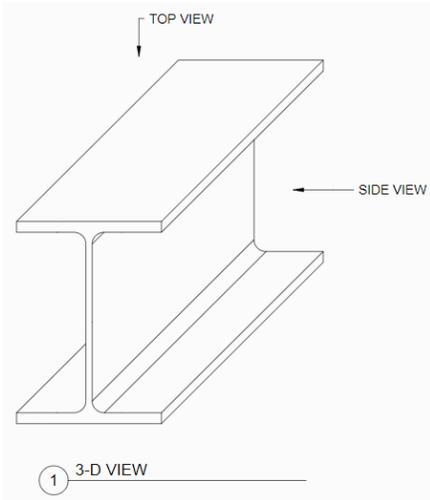
This connection shows removed material that is not due to bolt holes.



Guide to 2D drawings

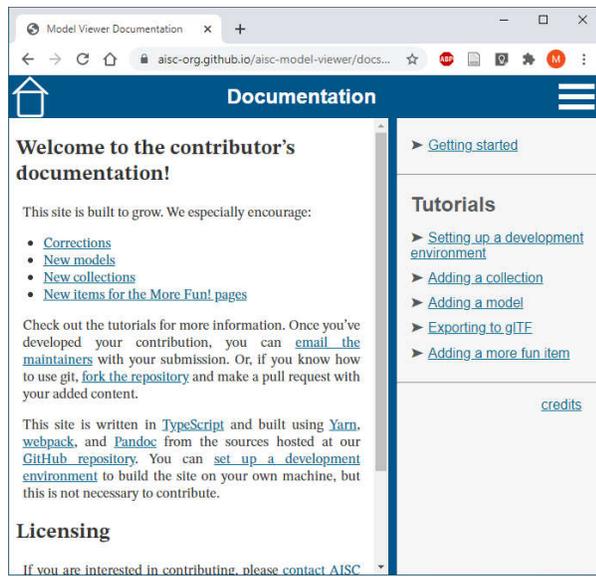


Guide to 2D drawings



Documentation and future development

- The teaching aid was built to grow
- Review and approval process still being worked out
- What ideas do you have?



How I plan to use this teaching aid

- Visual aid in lectures
 - No more trying to draw in three dimensions on the white board
- Office hours
 - Helpful tool for explaining net area and other concepts in a one-on-one setting
- Student use
 - It is there when they need it

Thank you to:

- Peter Talley, PhD student at University of Tennessee, Knoxville who developed the website and collections
- Jeff Keileh, Judy Liu, and Marci Uihlein for serving on the review committee and providing valuable feedback
- Tom Schlafly and Larry Muir for providing additional valuable feedback
- Kristi Sattler and the AISC Teaching Aid Development Program for supporting this project

AISC | Questions?



**Smarter.
Stronger.
Steel.**





Q & A

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More new teaching aids are coming!

Stay tuned for details about upcoming webinars

- Interactive Online Figures Demonstrating Key Concepts in Steel Design [*November 2020*]
- “Days of Steel” Videos [*January 2021*]
- Steel Connections: A Teaching Aid for Design Considerations [*January 2021*]
- Structural Fire Engineering Curriculum for Undergraduate Education [*January 2021*]
- Conceptualizing Steel Gravity Design [*May 2021*]



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Winning Writing Strategies for Students: SSBC Supplemental Competition and Beyond!

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Student Steel Bridge
Supplemental
Competition
2021 Rules



RePicture STEM Resume-Builder Program

- Research a project constructed in structural steel
- Develop a project page on RePicture's website
- Eligible to win great prizes!
- 2 rounds of competition this fall

aisc.org/RePicture



How to Contact Us

email: universityprograms@aisc.org

website: aisc.org/universityprograms

social media:     @aisc

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