EFFICIENT DESIGN OF HSS CONNECTIONS

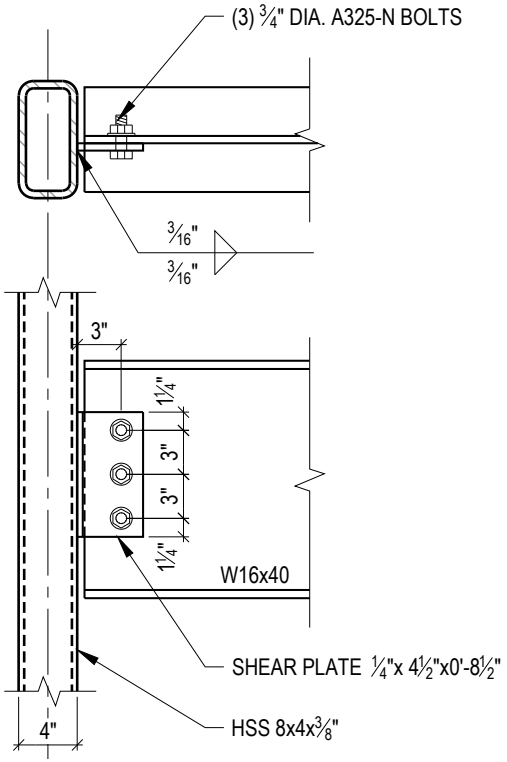
PRESENTED BY KIM OLSON, PE, FORSE CONSULTING, LLC

TRUE OR FALSE ??

HSS structures, in general, are more expensive than those made up primarily of wide flange sections

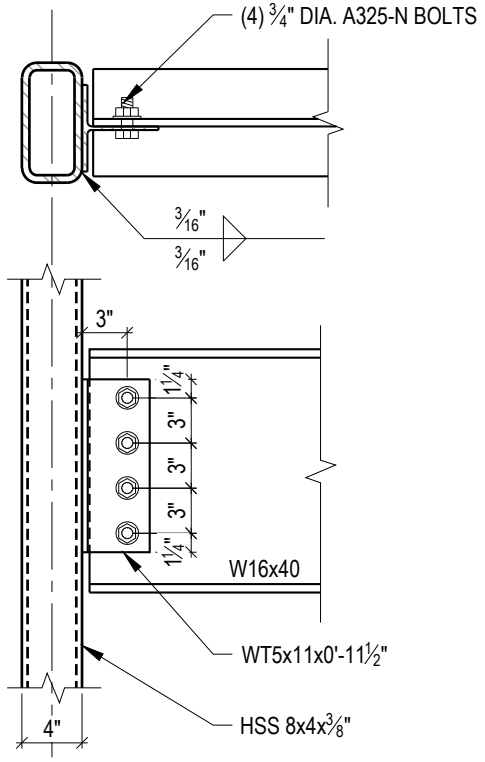
- Material
  - Columns
  - Beams
- Fabrication
  - Weld shop or bolt shop?

SHEAR CONNECTIONS



SINGLE PLATE CONNECTION

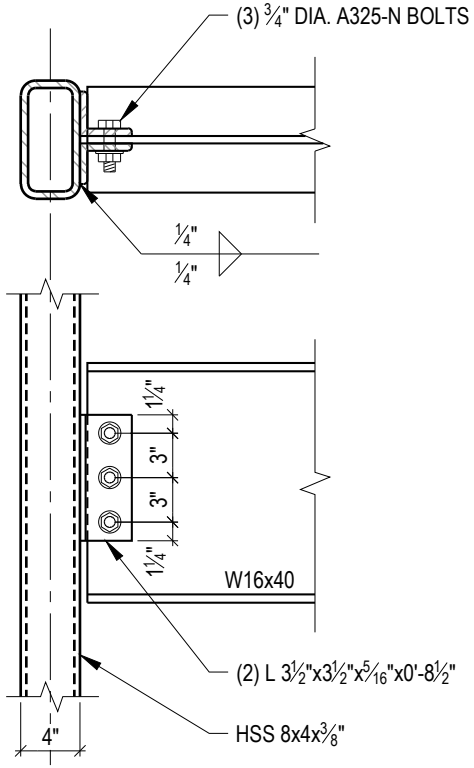
SCALE : 1" = 1'-0"



WT CONNECTION

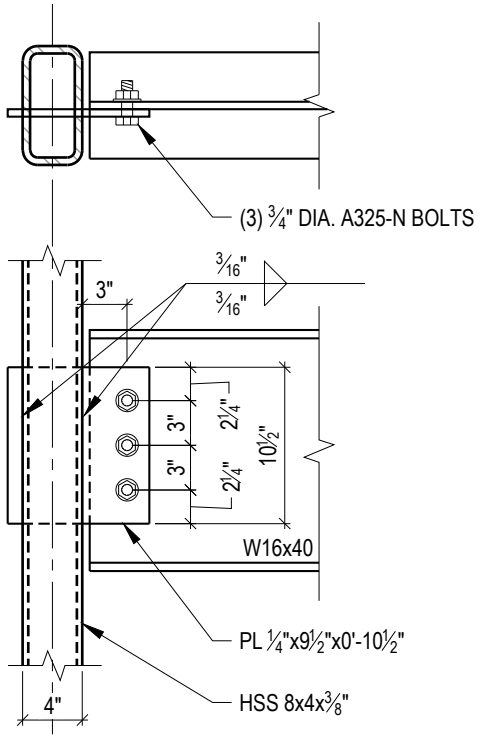
SCALE : 1" = 1'-0"

SHEAR CONNECTIONS



DOUBLE ANGLE CONNECTION

SCALE : 1" = 1'-0"



THROUGH PLATE CONNECTION

SCALE : 1" = 1'-0"

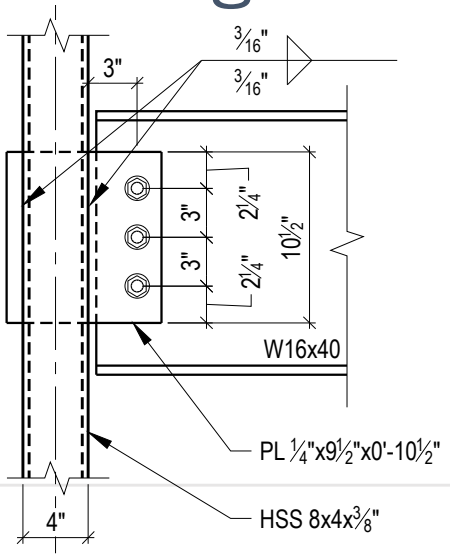
THROUGH PLATE SHEAR CONNECTION

Research found it is 4 times more expensive to specify a through plate than a shear plate welded to the face of the HSS wall.

Increase your wall thickness to avoid a through plate connection.

Watch your weld symbols.

2 directions.



THROUGH PLATE SHEAR CONNECTION

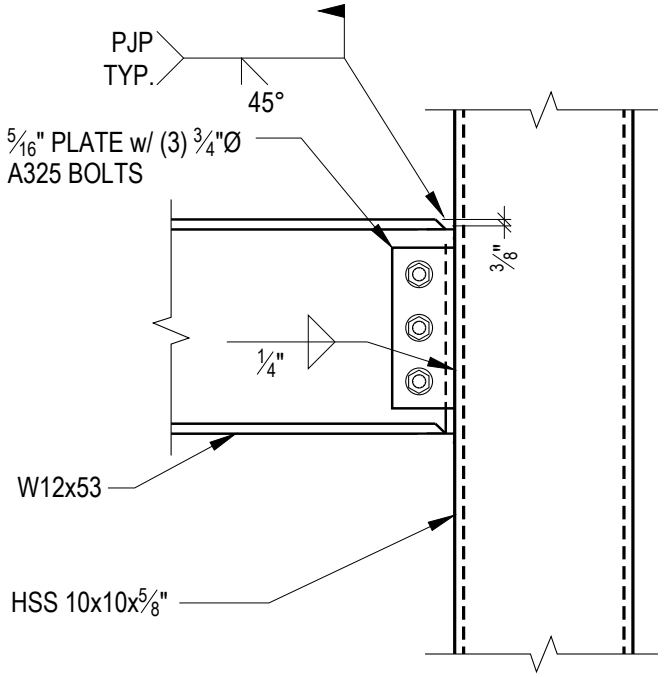
When to specify a through plate shear connection

- Axial loads
- Delegated connection engineer and column is too thin

When NOT to specify a through plate shear connection

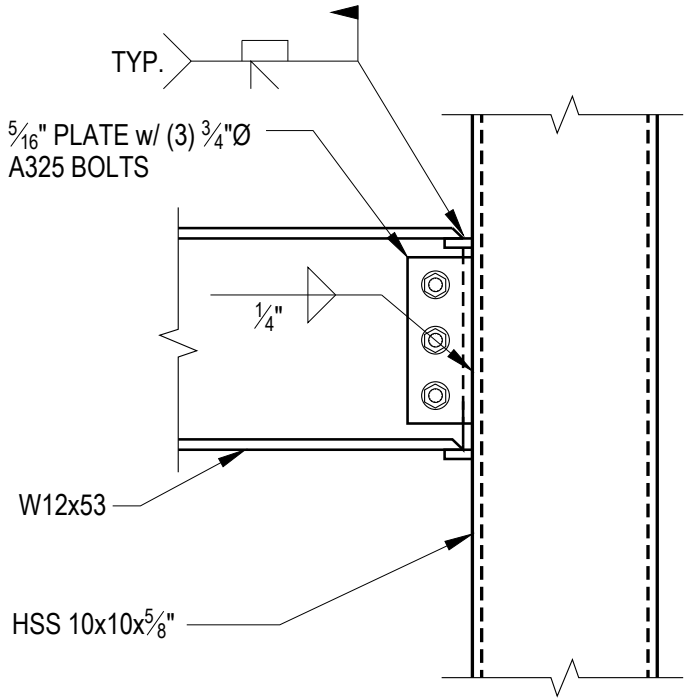
- As your standard connection!!!

MOMENT CONNECTION



PJP OPTION

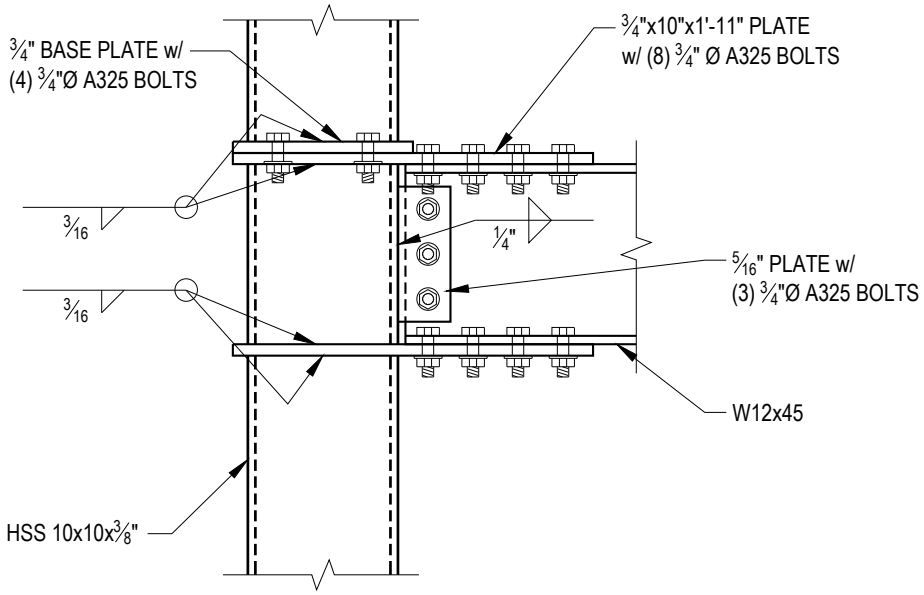
SCALE : 1" = 1'-0"



CJP OPTION

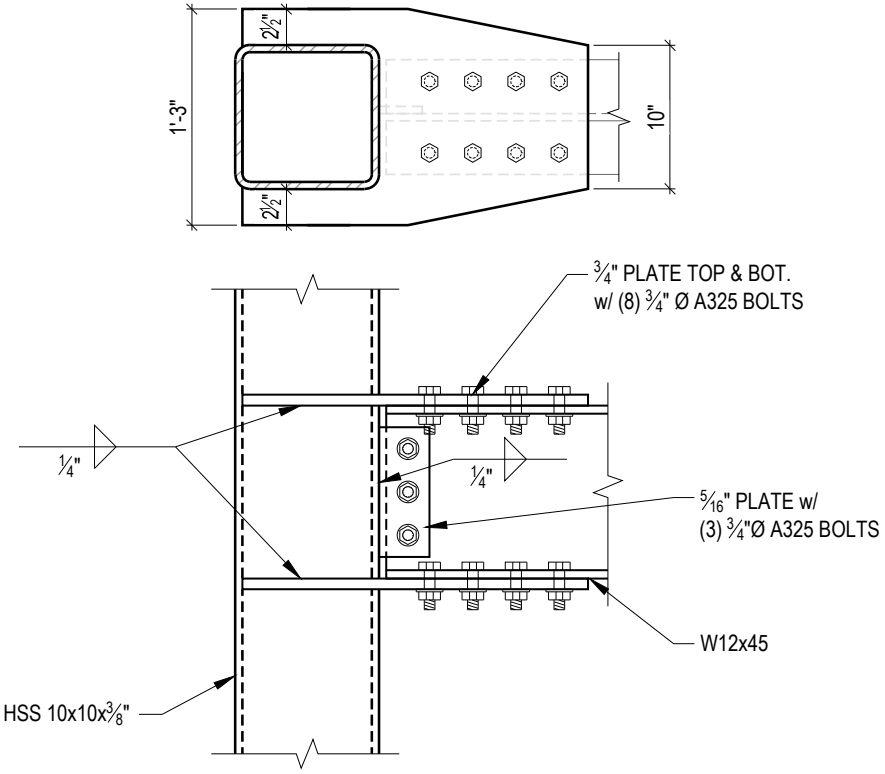
SCALE : 1" = 1'-0"

MOMENT CONNECTION



THROUGH PLATE OPTION

SCALE : 1" = 1'-0"



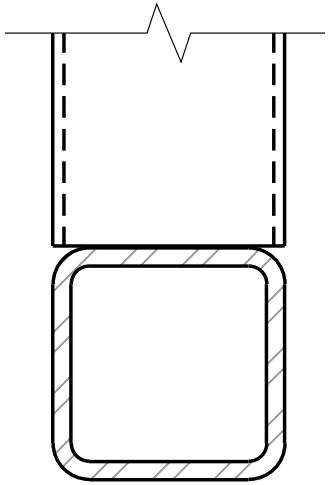
CUT OUT PLATE OPTION

SCALE : 1" = 1'-0"

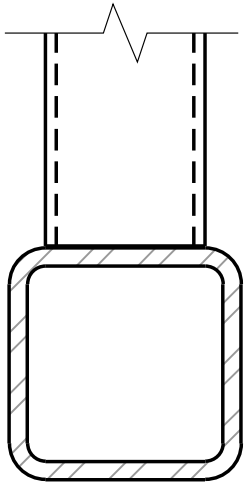
MOMENT CONNECTION COST COMPARISON

	PJP Weld	CJP Weld	Through Plate	Cut Out Plate
Column Wall t (in)	5/8	5/8	3/8	3/8
Relative Costs	1.0	1.43	1.59	1.38

WELDS
MATCHED VS STEPPED CONNECTION

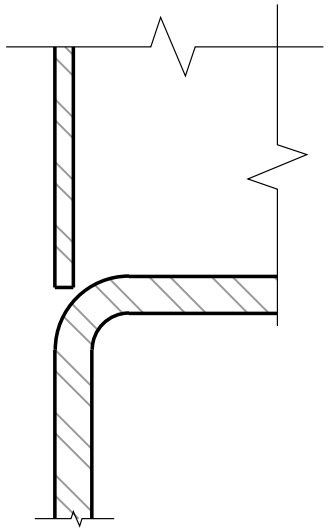


Matched Connection

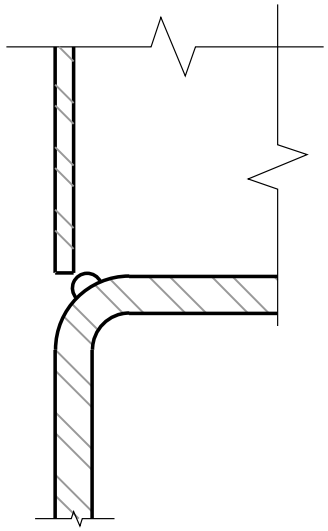


Stepped Connection

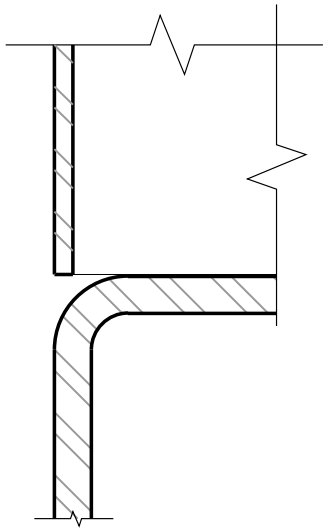
WELDS
MATCHED CONNECTION



Tube Profiling



Weld backing



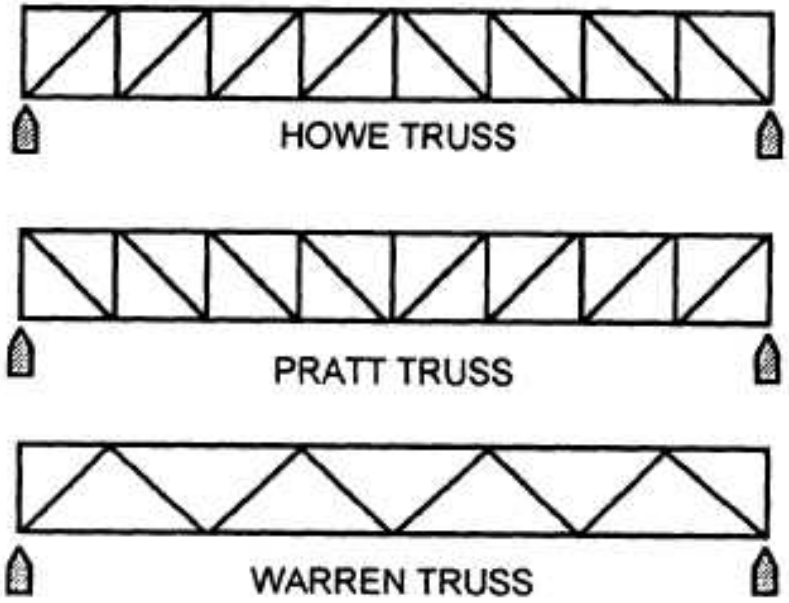
Steel backing

MATCHED VS STEPPED CONNECTION

TRUSSES

Minimum weight of the truss ≠ least cost

Fabrication costs factor heavily into finished structure cost



TRUSS CONNECTIONS- WELD SIZING

Size to develop the yield strength of the branch member

- Conservative
- Upper limit of weld size
- Appropriate if plastic stress redistribution is required for connection (moving loads)

Size to resist applied forces

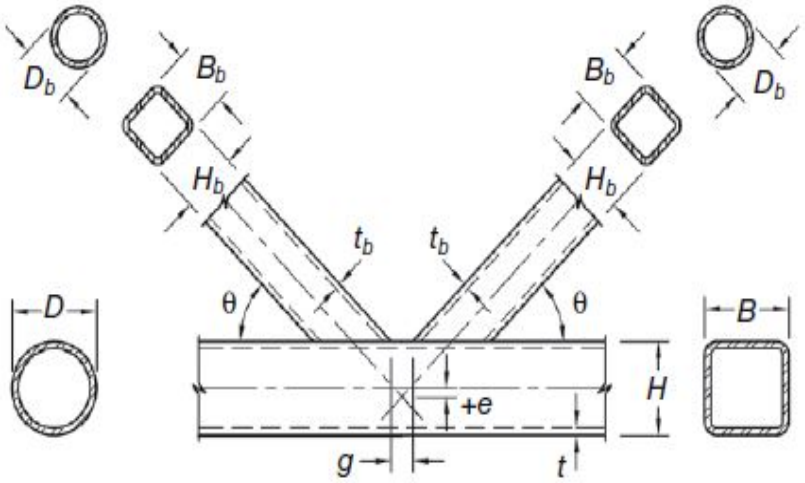
- Must account for effective weld lengths

Proper joint design should allow you to specify an economical fillet weld

TRUSS CONNECTIONS – WELD SIZING

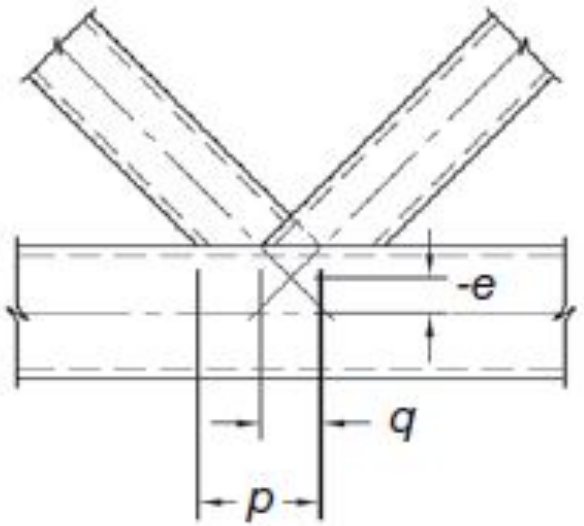
Gapped

- Less expensive



Overlapped

- Stronger joint
- Higher percentages of overlap, the higher the joint strength -> stiffer truss



PJP VS CJP WELDS

PJP welds are a good option if fillet weld sizes become large

CJP welds are generally not required and should be avoided

Increase HSS wall thickness if needed

Fillet weld ≈ 2 hours

fit up work for one guy

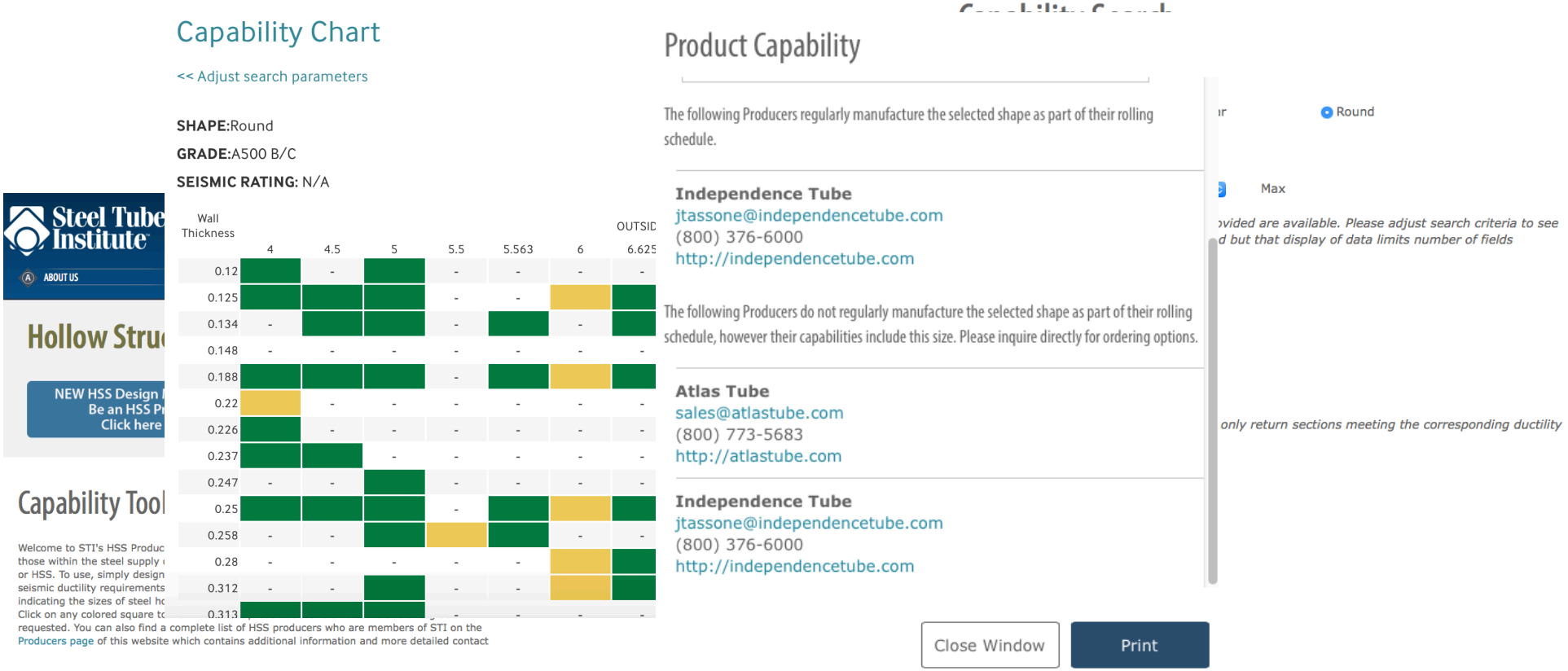
CJP weld ≈ 1 – 1.5 days

fit up work plus owner-incurred UT testing

PURCHASING HSS FROM A SERVICE CENTER

Lengths of members? Waste?

Available sizes – Capability Tool

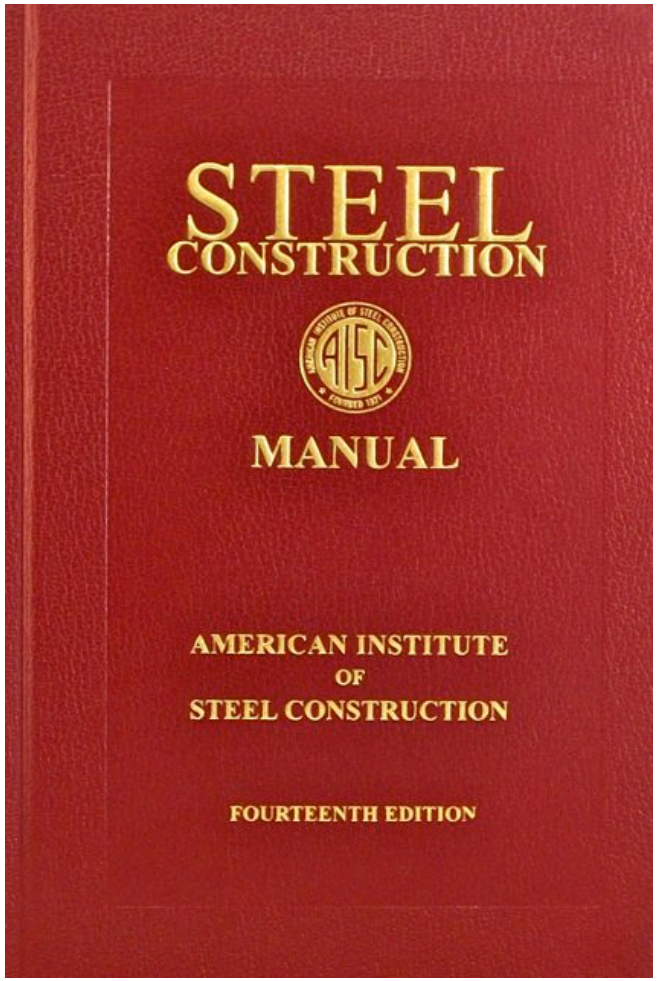


NOW TO THE REALLY EXCITING STUFF…

….. THE CODE!

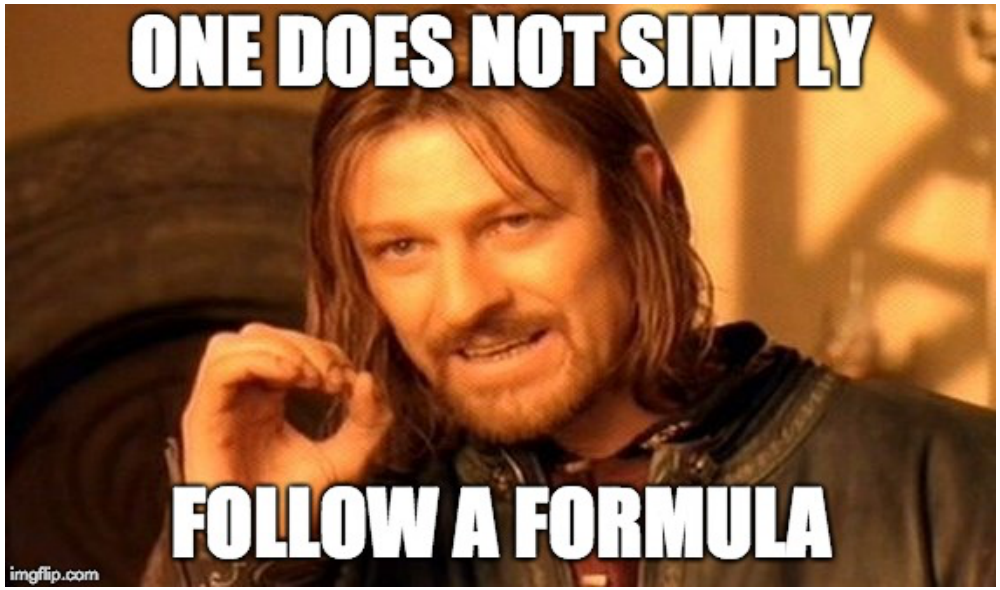
AISC 360-10, CHAPTER K

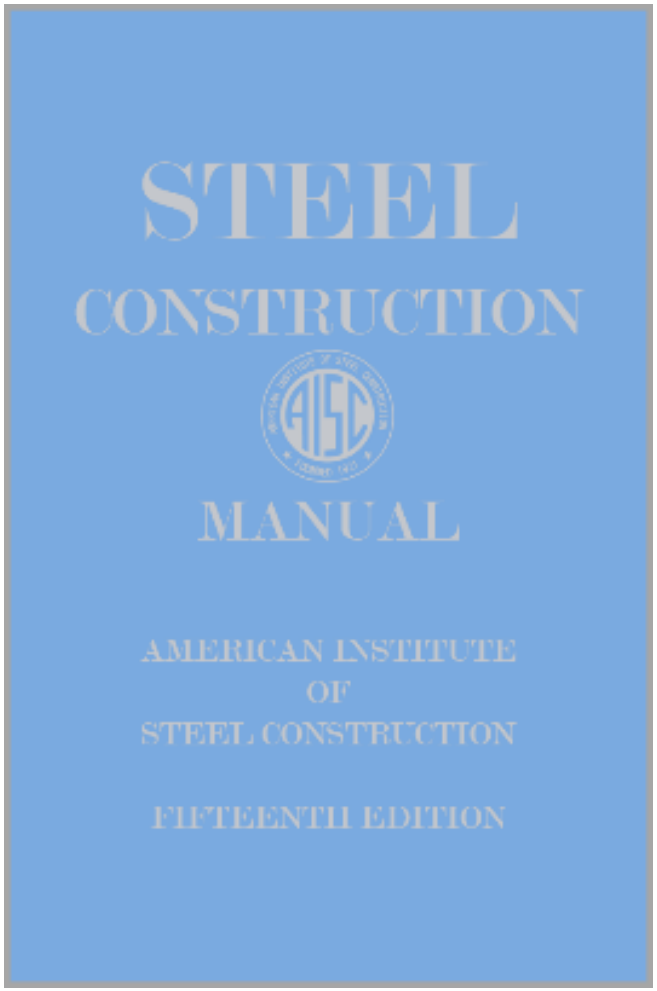
- Tables
  - Prescriptive
  - Unique to the Spec
- Repetitive
- Limits of Applicability



AISC 360-16, CHAPTER K

- "Additional Requirements for HSS and Box-Section Connections"
- Introduction clearly states the requirements of Chapter J also apply





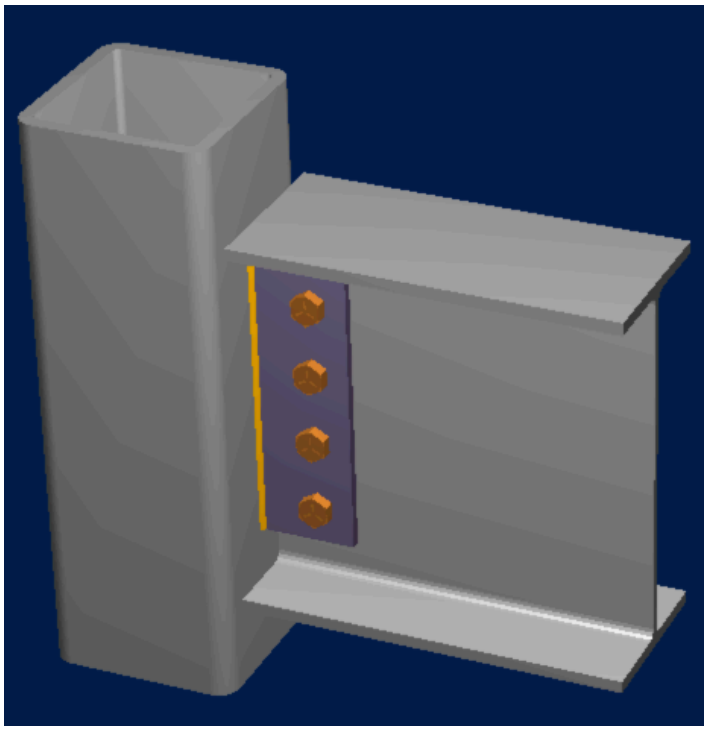
ROUND SECTIONS

- Largely unchanged
  - New Limit of Applicability
  - Shear tab not mentioned
  - Cap plate not mentioned

Packer, 2015

RECTANGULAR SECTIONS

- References Chapter J
- Fundamentally



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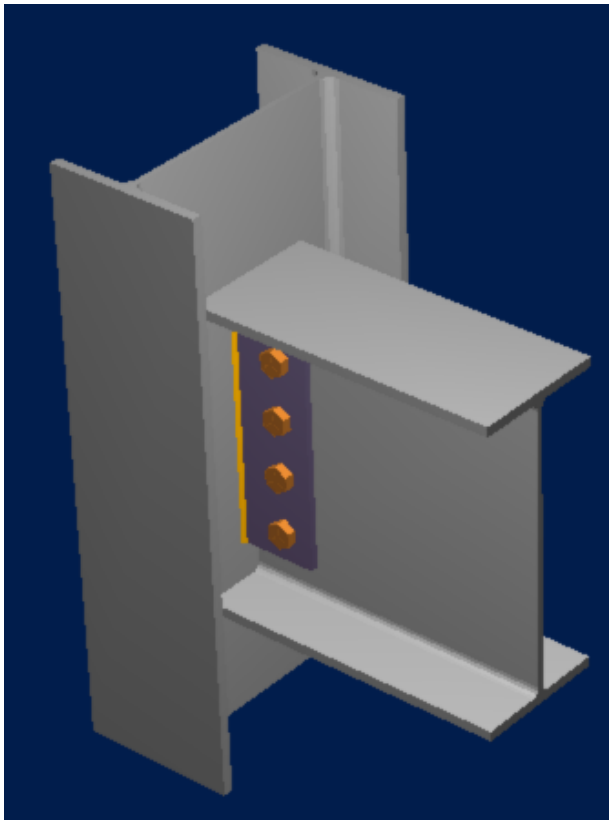
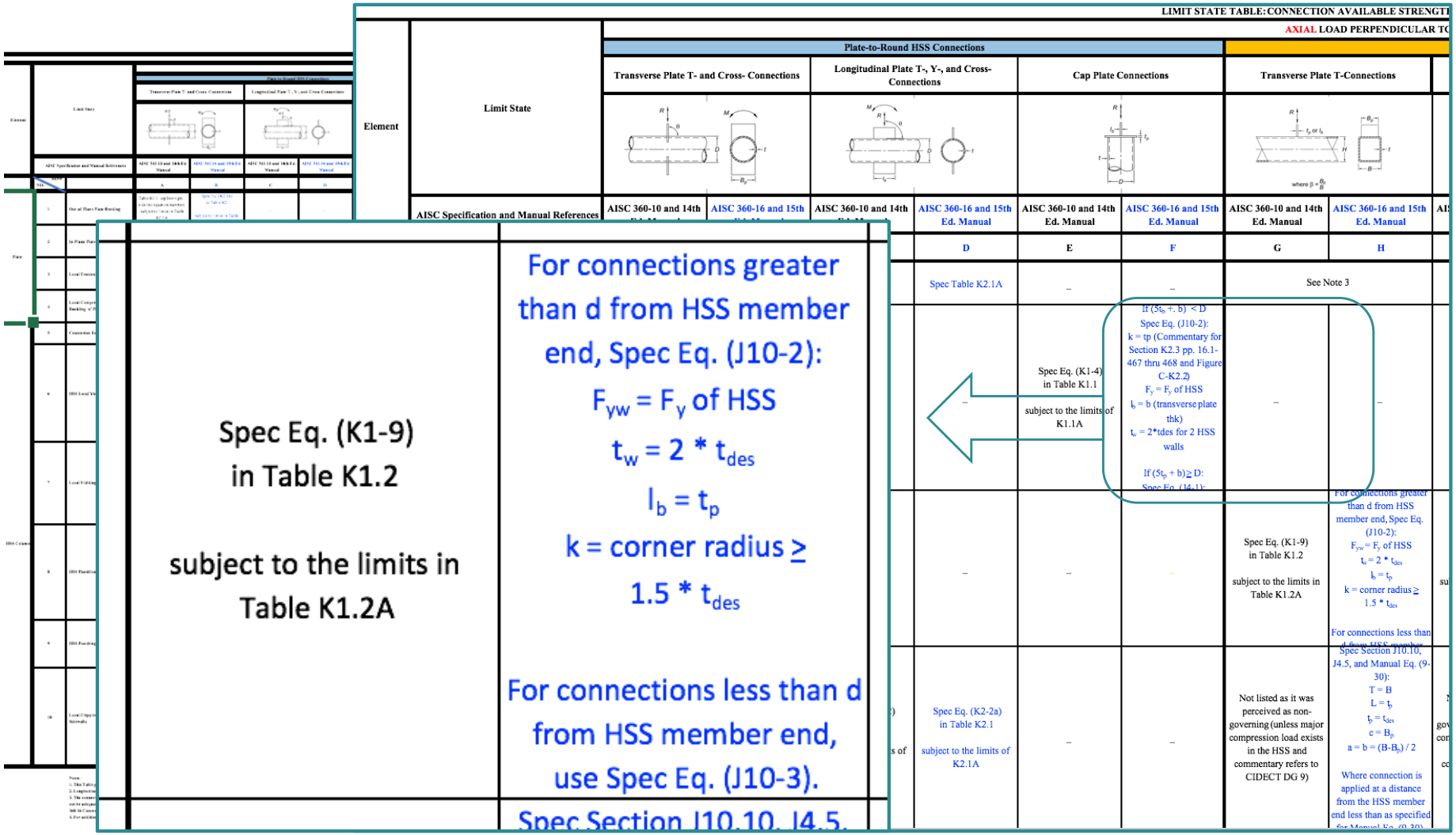


RESOURCE – LIMIT STATE TABLE - AXIAL



LIMIT STATE TABLE: CONNECTION AVAILABLE STRENGTH

AXIAL LOAD PERPENDICULAR TO

Element	Limit State	Plate-to-Round HSS Connections							
		Transverse Plate T- and Cross- Connections		Longitudinal Plate T-, Y-, and Cross-Connections		Cap Plate Connections		Transverse Plate T-Connections	
	AISC Specification and Manual References	AISC 360-10 and 14th Ed. Manual	AISC 360-16 and 15th Ed. Manual	AISC 360-10 and 14th Ed. Manual	AISC 360-16 and 15th Ed. Manual	AISC 360-10 and 14th Ed. Manual	AISC 360-16 and 15th Ed. Manual	AISC 360-10 and 14th Ed. Manual	AISC 360-16 and 15th Ed. Manual
		D		E	F		G	H	
Plate	Out-of-Plane Plate Bending	Spec Table K2.1A		–	–		See Note 3		
	In-Plane Plate Shear	–		Spec Eq. (K1-4) in Table K1.1 subject to the limits of K1.1A	If $(5t_p + b) < D$ Spec Eq. (J10-2): k = tp (Commentary for Section K2.3 pp. 16.1-467 thru 468 and Figure C-K2.2) F_y = F_y of HSS t_b = b (transverse plate thk) t_w = 2*tdes for 2 HSS walls If $(5t_p + b) \geq D$:	–		–	
	Local Yielding	–		–	–		Spec Eq. (K1-9) in Table K1.2 subject to the limits in Table K1.2A	For connections greater than d from HSS member end, Spec Eq. (J10-2): F_{yw} = F_y of HSS t_w = 2 * t_{des} t_b = t_p k = corner radius ≥ 1.5 * t_{des} For connections less than	
	Local Buckling	Spec Eq. (K2-2a) in Table K2.1 subject to the limits of K2.1A		–	–		Not listed as it was perceived as non-governing (unless major compression load exists in the HSS and commentary refers to CIDECT DG 9)	Spec Section J10.10, J4.5, and Manual Eq. (9-30): T = B L = t_b t_b = t_{des} c = B_p a = b = (B-B_p) / 2 Where connection is applied at a distance from the HSS member end less than as specified	

Spec Eq. (K1-9) in Table K1.2

subject to the limits in Table K1.2A

For connections greater than d from HSS member end, Spec Eq. (J10-2):

F_{yw} = F_y of HSS

t_w = 2 * t_{des}

l_b = t_p

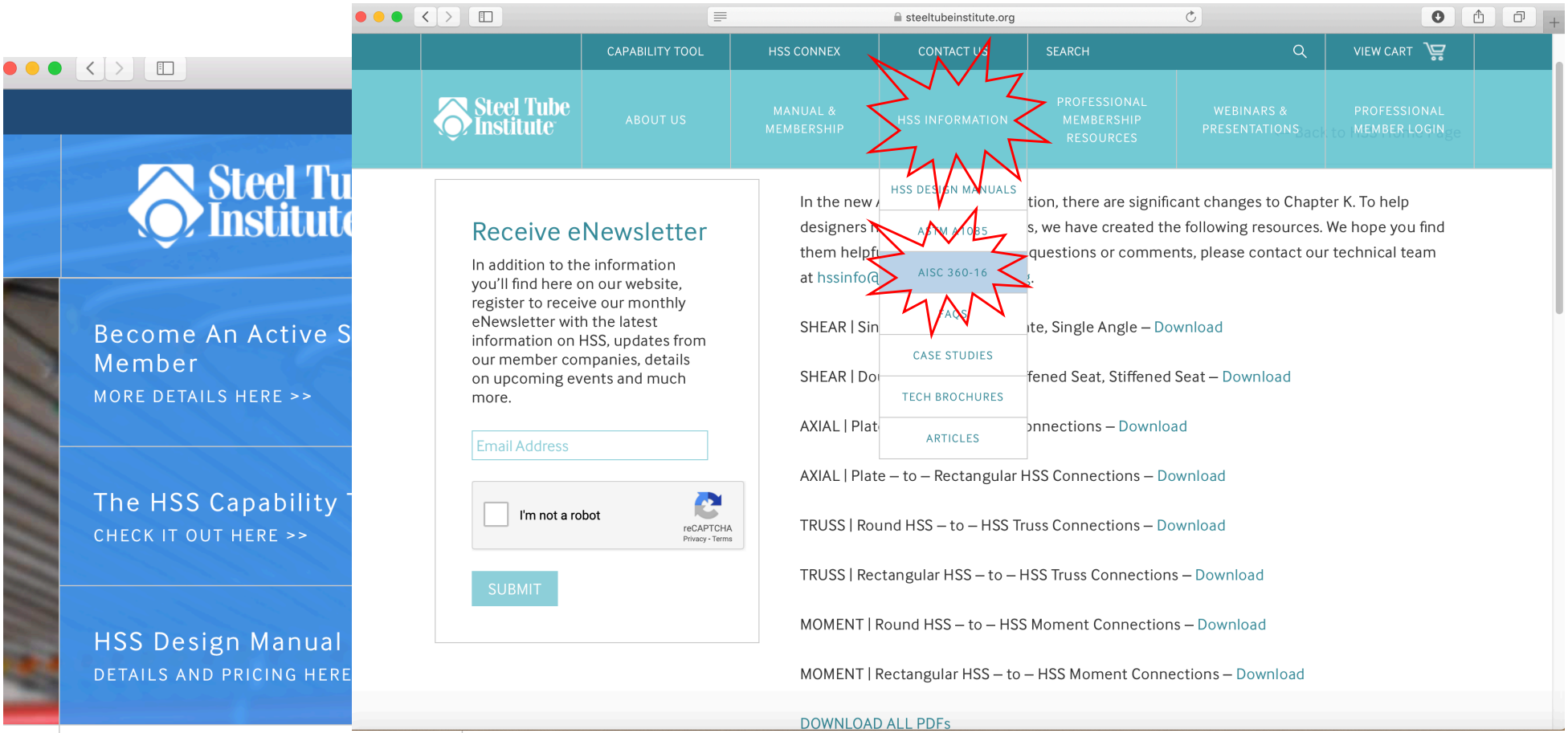
k = corner radius ≥ 1.5 * t_{des}

For connections less than d from HSS member end, use Spec Eq. (J10-3).

Spec Section J10.10, J4.5,

RESOURCE – LIMIT STATE TABLE

- https://steeltubeinstitute.org/hss/hss-information/aisc-360-16/



A500 GR B VS GR C SMACKDOWN

- DUAL CERT!!!
- Always specify Grade C!

Atlas Tube Canada ULC
200 Clark St.
Harrow, Ontario, Canada
N0R 1G0
Tel: 519-738-3541
Fax: 519-738-3537

Atlas Tube
JMC STEEL GROUP

MATERIAL TEST REPORT

Heat No	C	Mn	P	S	Si	Al	Cu	Cb	Mo	Ni	Cr	V
S55194	0.160	0.790	0.006	0.010	0.012	0.048	0.000	0.000	0.000	0.000	0.000	0.000

Material	Yield	Tensile	Eln.2in	Certification
4 X 2 X .188	055129 Psi	067817 Psi	35.0 %	ASTM A500-10A GRADE B&C

PARTING WISDOM

Due to the flexibility of their walls, local strength of an HSS at the connection may control the capacity of the connection.

This is very different than designing for Wide Flange (WF) supports.

Understanding this while sizing members will mean efficient and economical connections without the need for costly stiffeners or reinforcing.

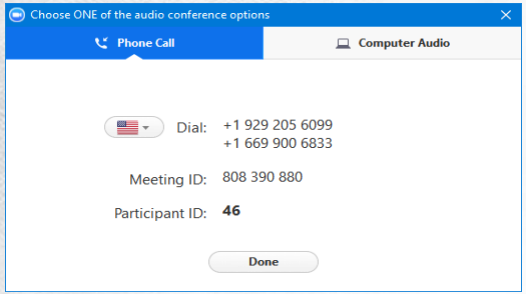
EFFICIENT DESIGN OF HSS CONNECTIONS

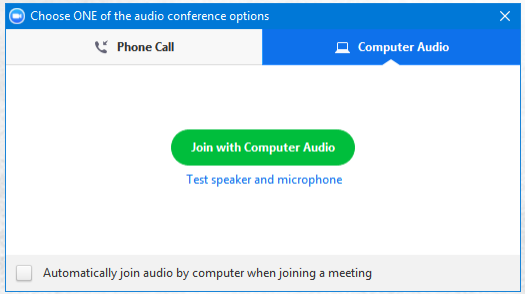
Ben Follett, PE
RISA

Kim Olson, PE
Steel Tube Institute

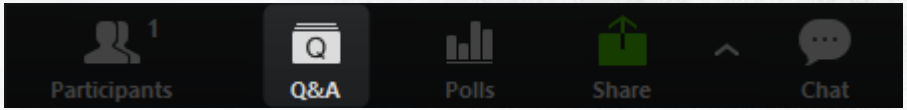
ZOOM WEBINAR SETTINGS

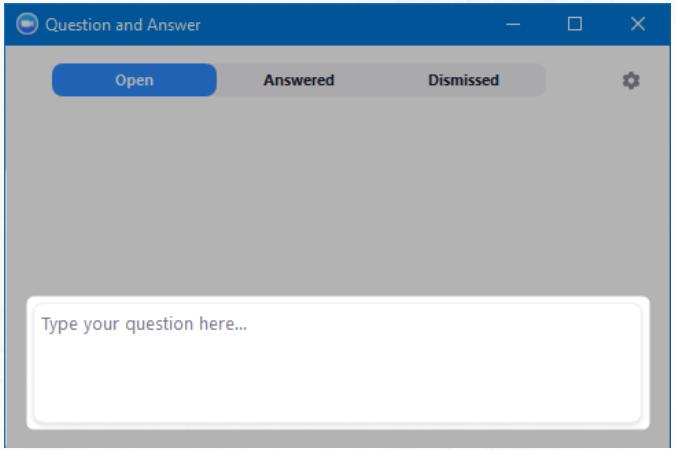
Audio Options:





Questions:



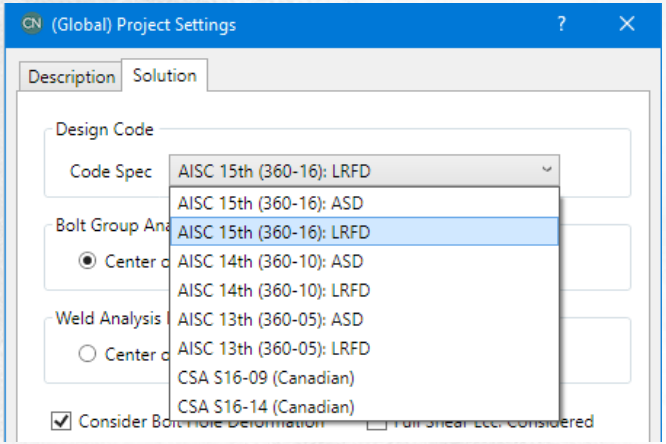


AVAILABLE DESIGN CODES

AISC 360-16/10/05 (ASD/LRFD)

AISC 341-10 (ASD/LRFD)

CSA S16-14/09



AVAILABLE HSS CONNECTION TYPES

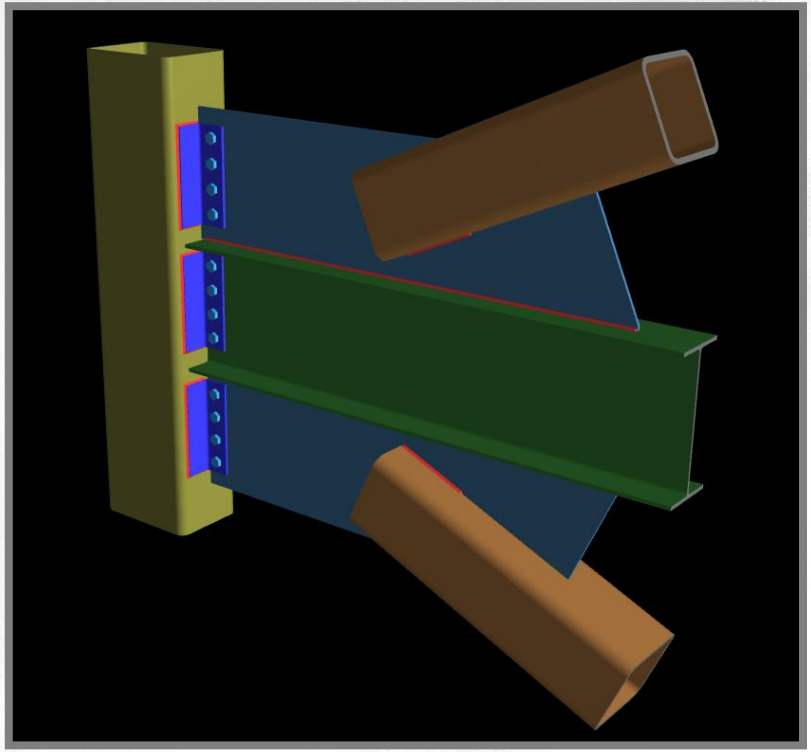
Shear Connections
- HSS Column/Beam Clip Angle
- HSS Column/Beam End Plate
- HSS Column/Beam Shear Tab

Moment Connections
- HSS Column/Beam Ext. End Plate
- HSS Column/Beam Flange Plate
- HSS Column/Beam Direct Weld

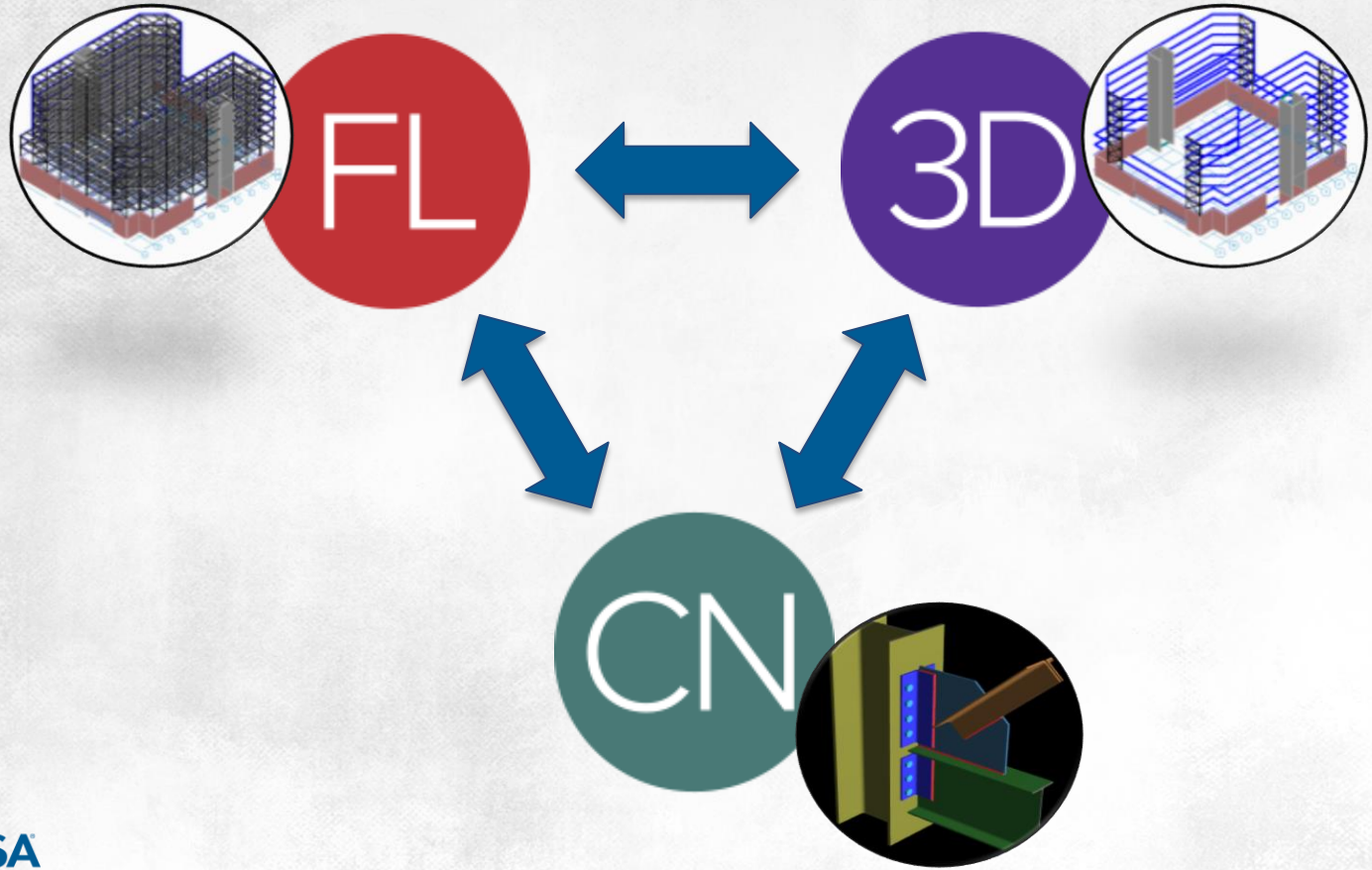
Truss
- HSS to HSS

Brace
- Vertical Diagonal Brace
- Vertical Chevron Brace
- Knee Brace

Baseplate
- HSS Column
- HSS Column w/ Vertical Brace



INTEGRATION



QUESTIONS...?