Night School 28: Vertical Bracing Connections

AISC Night School

Thank you for joining our live webinar. We will begin shortly. Please standby.

Vertical Bracing Connections, Session 8: Other Topics
May 24, 2022 | Carol Drucker

Smarter. Stronger. Steel.

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Course Description

Vertical Bracing Connections

Session 8: Other Topics
May 24, 2022

Beyond meeting the requirements of the Specification and Seismic Provisions, the demands of the fabricator will also influence the design of a connection. Topics such as field welding vs field bolting, eliminating doublers, and more will be examined. This session will also examine the basics of base plate gusset connection design.

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Learning Objectives

1. List what is included to establish the design requirements for connections.
2. List examples of fabricator preferences that influence connection decisions.
3. Explain differences between the KISS and UFM in connection design.
4. List design considerations in base plate gusset design.

Night School 28
Vertical Bracing

Session 8: Other Topics

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Smarter. Stronger. Steel.

Presentation Outline

Vertical Bracing

1. Project Methodology
2. UFM vs KISS
3. Items to Note
4. Potential Issues
5. Base Connections

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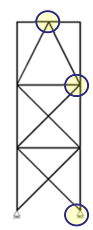
Connections – Vertical Bracing

Implementing Design



Project Methodology

Design Criteria

Mapping

Design

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Connections – Vertical Bracing

Implementing Design

Design Criteria

- System Requirements
- Forces
- Member Sizes

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Design Requirements

- Establish the Criteria
  - ASD or LRFD ✓
  - Load criteria ✓
  - Bolt pre-tensioning and/or slip critical requirements ✓
  - Shear loads for members in the braced frame ✓
  - Connection work points at member centerlines ✓
  - Transfer force notes ✓
  - Seismic response modification coefficient, *R* ✓
  - Surface coating requirements ✓

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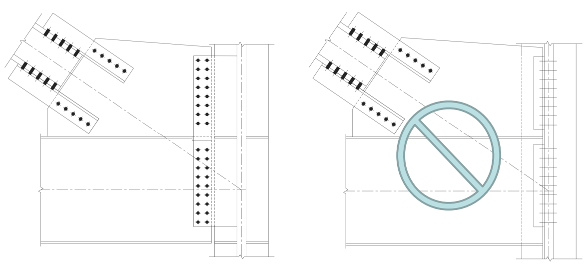
Design Requirements

- Establish the Criteria



Contractor

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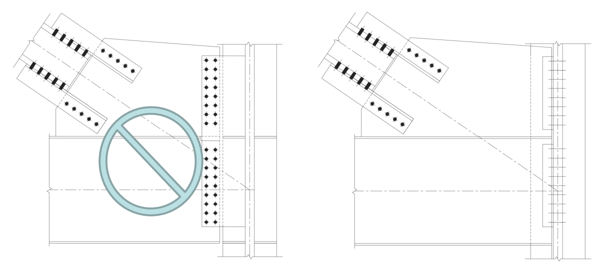
Design Requirements

- Establish the Criteria



Engineer

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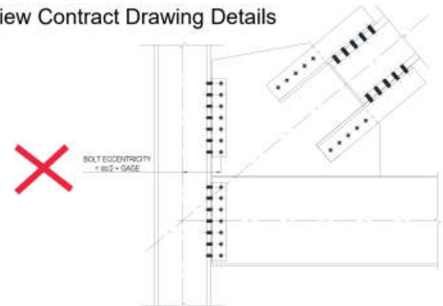
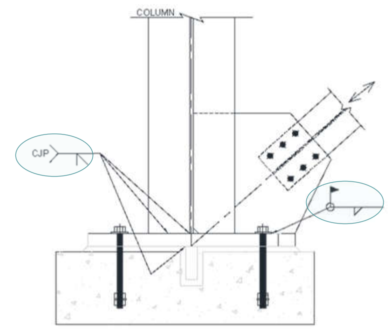
Design Requirements

- Establish the Criteria
  - Review Contract Drawing Details



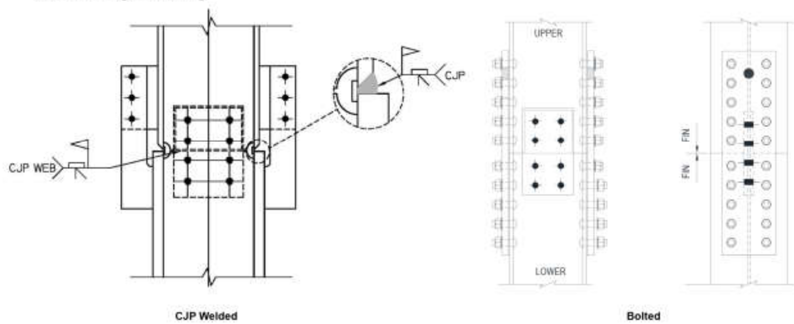
Design Requirements

- Value Engineering



Design Requirements

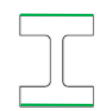
- Value Engineering



Welded Tension Column Splices

Step 1: Check for Tension using *S* and *Pmin*:

$$f_a = \frac{P_{\min}}{A_g} - \frac{M_x}{S_x} - \frac{M_y}{S_y}$$



Step 2: If tension, determine stresses in weld

$$f_x = \frac{V_x}{(2)(L_{weld})} + \frac{Torsion}{(d)(L_{weld})}$$

$$f_y = \frac{P_{\min\,flange}}{(2)(L_{weld})} - \frac{M_x}{(d - \frac{t_f}{2})(L_{weld})} - \frac{4M_y}{(2)(L_{weld})^2}$$

Step 3: Determine (*E*) required for shear and axial:

$$(E) = \frac{f}{(\phi)(0.6F_{EXX})}$$

Step 4: Sum squares and compare to AISC min. (Table J2.3)

$$E_{\min} = \sqrt{(E_{\min(shear)})^2 + (E_{\min(tension)})^2}$$

Fabricator Preferences

- Brace-to-Gusset Connection
  - Bolted
  - Weld
- Beam-to-Column Connection
  - Tabs
  - Clips
- Material Grade
  - Plate Grade: 50 ksi or 36 ksi
  - Angle Grade: 50 ksi or 36 ksi
- Bolt Hole Diameter and Type
  - Bearing Bolts and Standard Holes
  - Slip Critical Bolts and OVS holes

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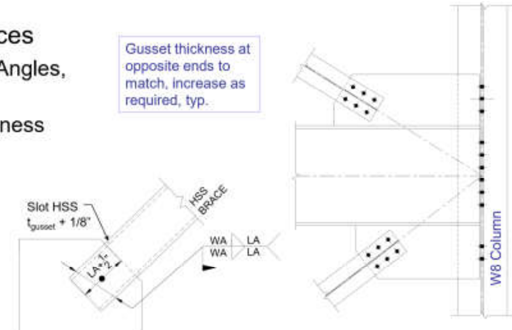
Fabricator Preferences

- Connection Preferences
  - Single Plate, Double-Angles, End Plates
  - Matching gusset thickness
  - Shipping limitations
- Detailing standards
  - Preferred angle sizes
  - HSS slot widths
  - Lap start/stops



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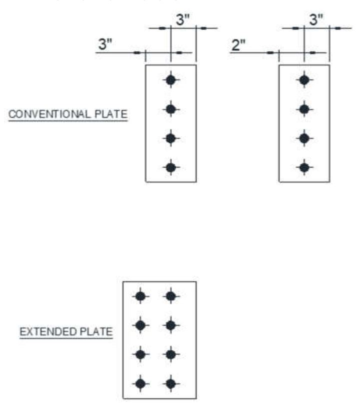
Fabricator Preferences

- Option for Slip Critical Class B bolts
- Single Plate Preferred Geometry



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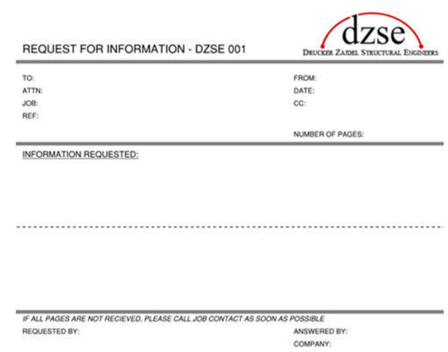
Design Requirements

- Start-up RFI



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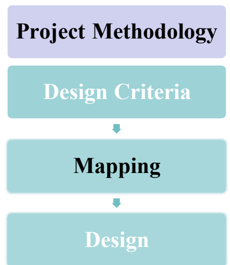
Connections – Vertical Bracing



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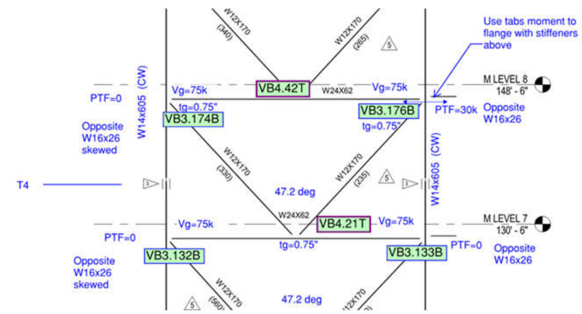
Connections – Vertical Bracing

- Map Connections



Elevation

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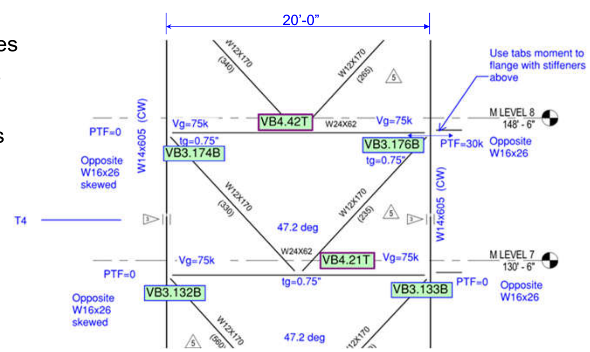
Vertical Bracing Elevations

- Corner Bracing
  - Map transfer forces
  - Map gravity loads
  - Map beam sizes
  - Map column sizes



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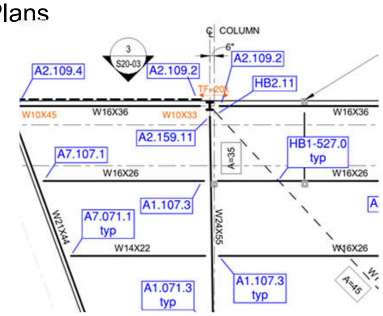
Connections – Vertical Bracing

- Coordinate with Plans



Floor Plan

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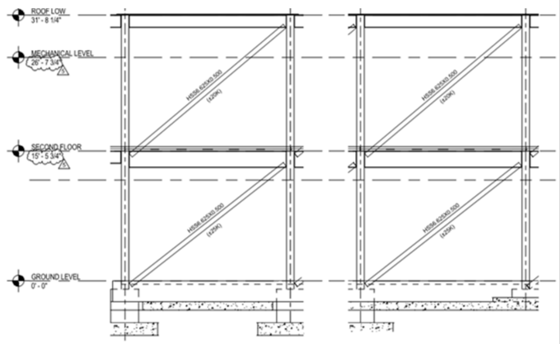
Vertical Bracing Elevations

- Typically shown
  - Elevations
  - Brace size
  - Brace force
  - Grid locations
- Helpful information
  - Beam size
  - Column size
  - Transfer forces
  - Bay length
  - Column orientation



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Connections – Vertical Bracing

Project Methodology

Design Criteria

Mapping

Design

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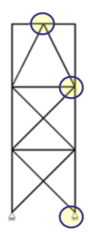
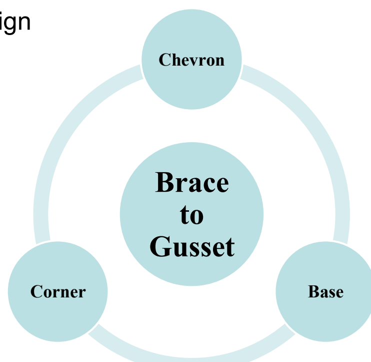
Connections – Vertical Bracing

- Implementing Design





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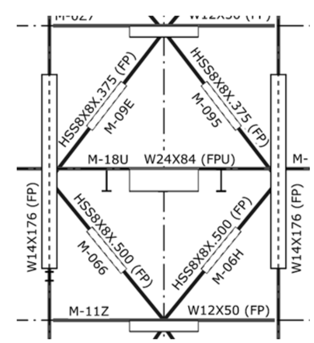
Connections – Vertical Bracing

Vertical Bracing

Starting with Brace-to-Gusset Controls:

- Matching gussets
- Consistent design at base, corner, and chevron



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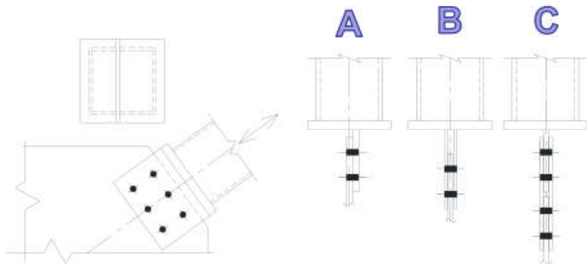
Connections – Vertical Bracing

- Brace to Gusset



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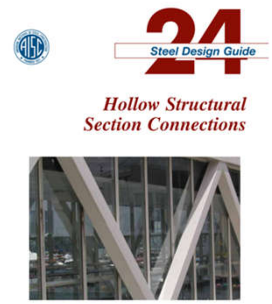
Connections – Vertical Bracing

- Brace to Gusset



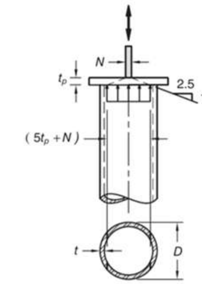


Fig. 7-3. Load dispersion through a cap-plate-to-round HSS connection.

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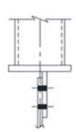
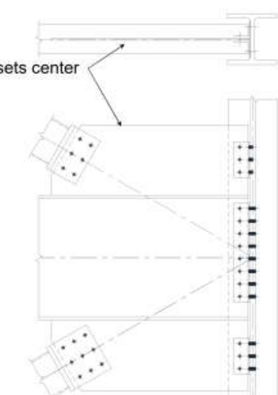
Connections – Vertical Bracing

- Brace to Gusset





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Connections – Vertical Bracing

- Brace to Gusset

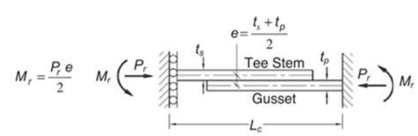

Fig. 5-5. Tee stem/gusset as an eccentrically loaded column.

$$P_r \le \frac{1}{\frac{1}{P_c} + \frac{4e}{9M_c}} \quad \text{for } \frac{P_r}{P_c} \ge 0.2 \qquad (5\text{-}3)$$

$$P_r \le \frac{2}{\frac{1}{P_c} + \frac{e}{M_c}} \quad \text{for } \frac{P_r}{P_c} < 0.2 \qquad (5\text{-}4)$$

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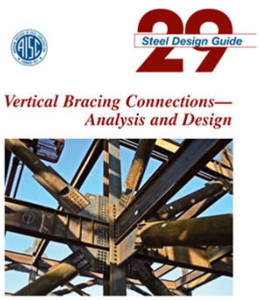
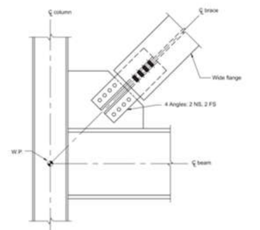
Connections – Vertical Bracing

- Brace to Gusset





orientation are typically connected to the gussets by WTs or double angles back-to-back on the near and far side of the gusset. Alternatively, single angles on each side of the brace could be employed. If the brace is subjected to compression as well as tension, plates should not be used in place of the WTs or angles. Figure 3-3 shows a wide-flange brace, flange to view in elevation. This brace is connected to the gusset with four angles, two on the near side and two on the far side of the gusset.

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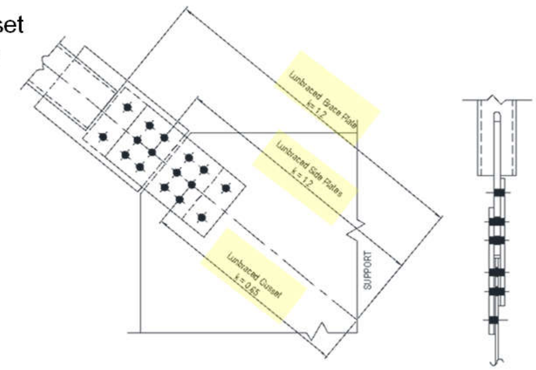
Connections – Vertical Bracing

- Brace to Gusset
  - Welded HSS



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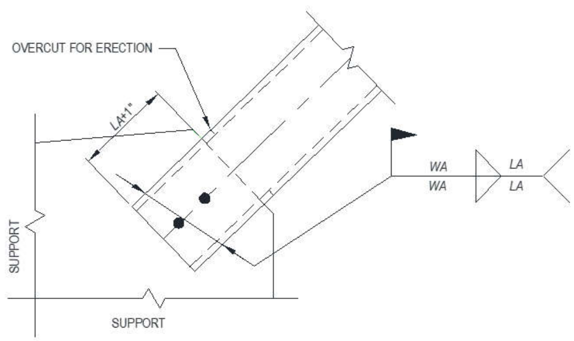
Connections – Vertical Bracing

- Brace to Gusset
  - Welded HSS



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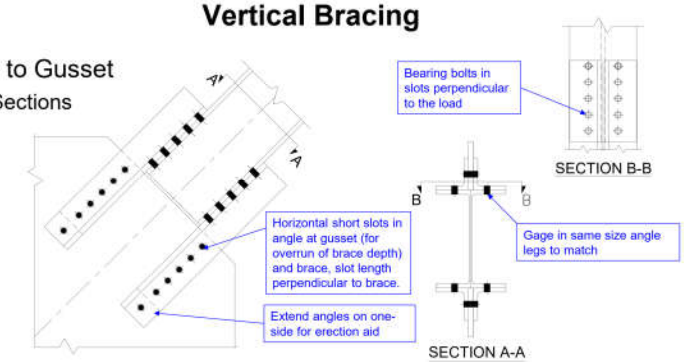
Vertical Bracing

- Brace to Gusset
  - W-Sections



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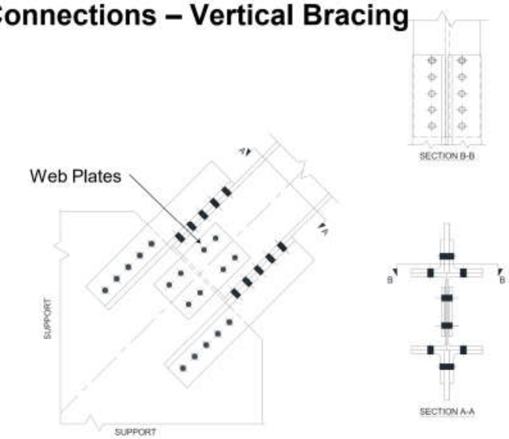
Connections – Vertical Bracing

- Brace to Gusset
  - W-Sections



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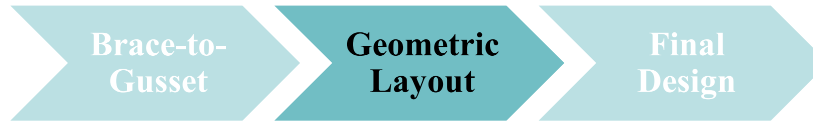
Connections – Vertical Bracing



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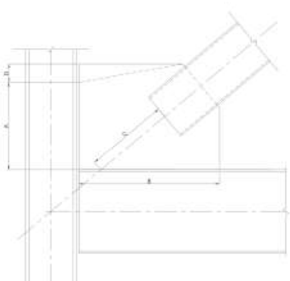
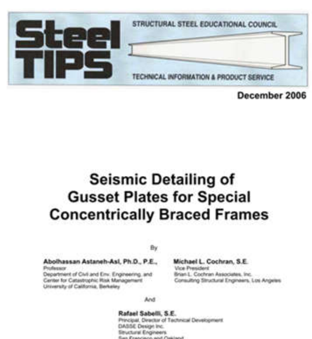
Connections – Vertical Bracing

- Geometric Layout
  - Reference Steel Tips 96




Steel TIPS
STRUCTURAL STEEL EDUCATIONAL COUNCIL
TECHNICAL INFORMATION & PRODUCT SERVICE
December 2006

Seismic Detailing of
Gusset Plates for Special
Concentrically Braced Frames

By

Abolhassan Astaneh-Asl, Ph.D., P.E.

Michael L. Cochran, S.E.

And

Rafael Sabelli, S.E.

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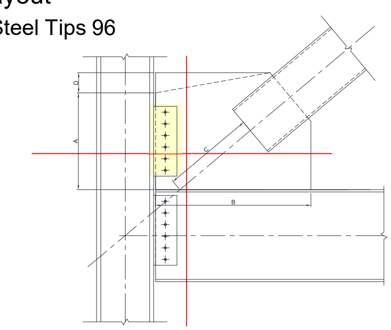
Connections – Vertical Bracing

- Geometric Layout
  - Reference Steel Tips 96



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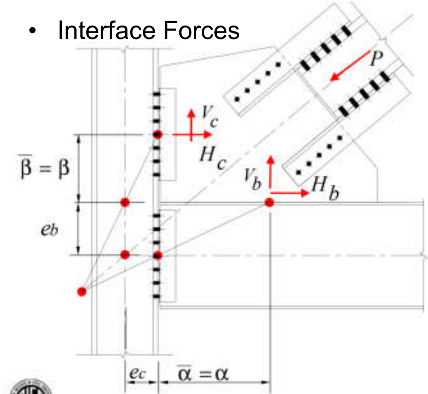
Connections – Vertical Bracing

Brace-to-Gusset → Geometric Layout → **Final Design**

Connections – Bracing UFM

*Reference AISC's Night School 28 and AISC's DG29

- Interface Forces



$$\alpha - \beta\tan(\theta) = e_b\tan(\theta) - e_c \quad \text{(eq. 13-1)}$$

Can set $\bar{\beta} = \beta$ and solve for α.
If $\bar{\alpha} = \alpha$, no moment

Can set $\bar{\alpha} = \alpha$ and solve for β.
If $\bar{\beta} = \beta$, no moment

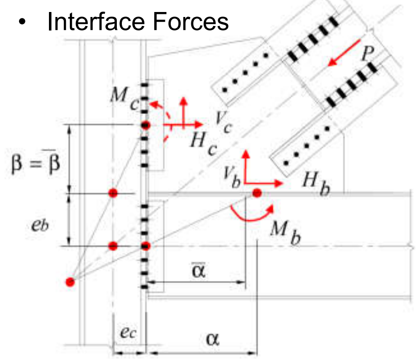
To column flange, set $\bar{\beta} = \beta$

To column web, set $\bar{\alpha} = \alpha$

Connections – Bracing UFM

*Reference AISC's Night School 28 and AISC's DG29

- Interface Forces



$$\alpha - \beta\tan(\theta) = e_b\tan(\theta) - e_c \quad \text{(eq. 13-1)}$$

$$V_b = \frac{e_b}{r}P \qquad V_c = \frac{\beta}{r}P$$

$$H_b = \frac{\alpha}{r}P \qquad H_c = \frac{e_c}{r}P$$

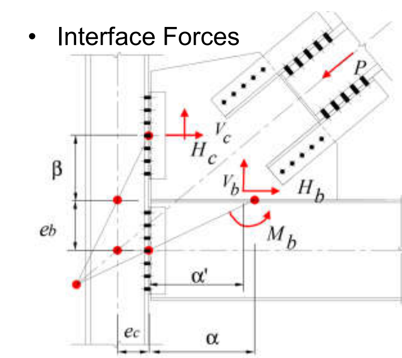
$$M_b = V_b(\alpha - \bar{\alpha}) \qquad M_c = H_c(\beta - \bar{\beta})$$

Note: If to column web, $e_c = 0$ in.

Connections – Bracing UFM

*Reference AISC's Night School 28 and AISC's DG29

- Interface Forces



$$V_b = \frac{e_b}{r}P - \Delta V_b$$

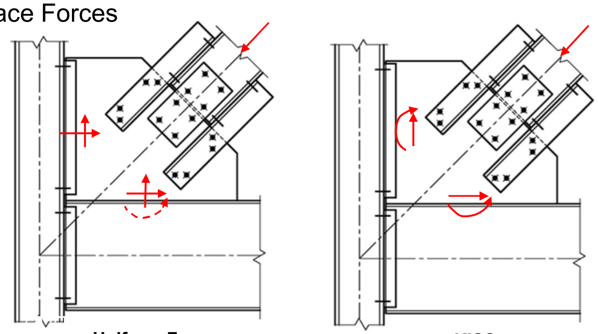
$$H_b = \frac{\alpha}{r}P$$

$$M_b = \frac{e_b}{r}P(\alpha - \bar{\alpha}) + \Delta V_b\bar{\alpha}$$

$$V_c = \frac{\beta}{r}P + \Delta V_b \qquad H_c = \frac{e_c}{r}P$$

Connections – Bracing

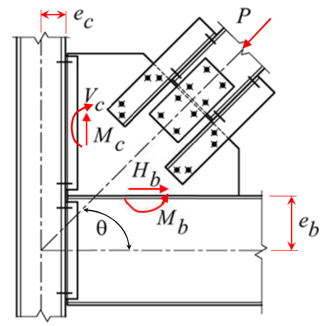
- Interface Forces



Uniform Force Method (UFM)   KISS

Connections – Bracing KISS

- Interface Forces



$$H_b = P\cos(\theta)$$

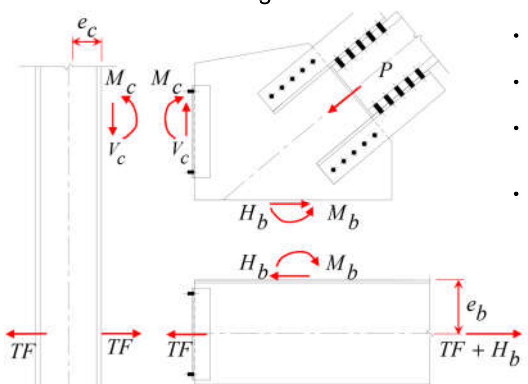
$$M_b = H_b(e_b)$$

$$V_c = P\sin(\theta)$$

$$M_c = V_c(e_c)$$

Connections – Bracing KISS

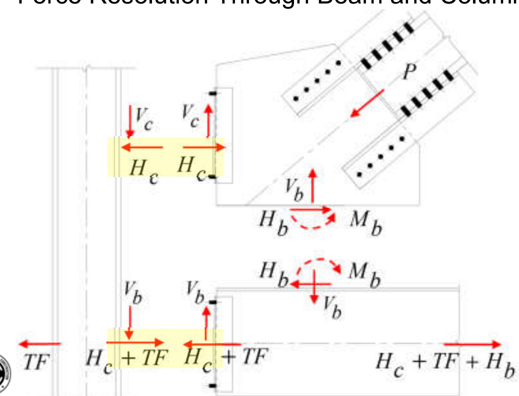
- Force Resolution Through Beam and Column



- No H_c
- No V_b
- Does not impact beam-to-column connection
- **Need to consider moment at beam and at column**

Connections – Bracing UFM

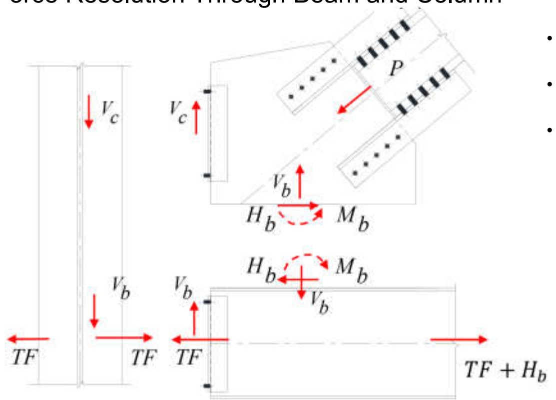
- Force Resolution Through Beam and Column



- Hc from gusset-to-column to column-to-beam
- Hb force is not resisted by column-to-beam connection
- Vb from gusset-to-beam to beam-to-column
- Add gravity to Vb
- Consider transfer forces and Hc
- Allows for force redistribution

Connections – Bracing UFM

- Force Resolution Through Beam and Column



- ec = 0”
- Hc = 0 kips
- Allows for force redistribution

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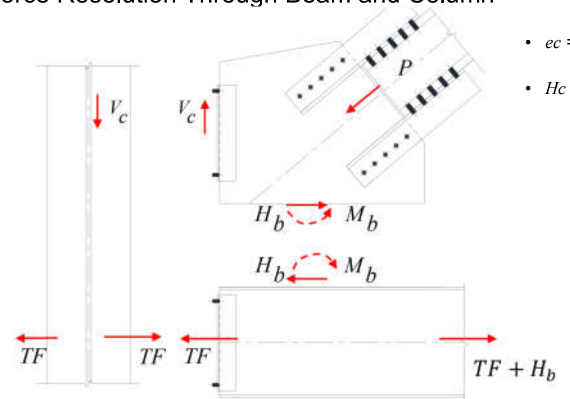
Connections – Bracing KISS

- Force Resolution Through Beam and Column



- ec = 0”
- Hc = 0 kips

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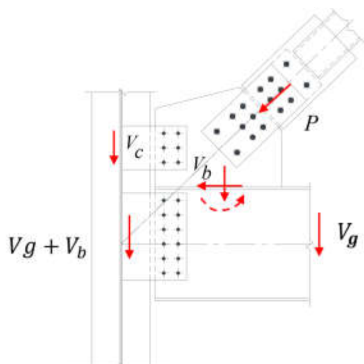
Connections – Bracing UFM

- Force Resolution Through Beam and Column



- Utilize reserve strength at the beam-to-column web connection

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KISS verses UFM

- Which type do you typically use/see

1. UFM
2. Kiss
3. N/A

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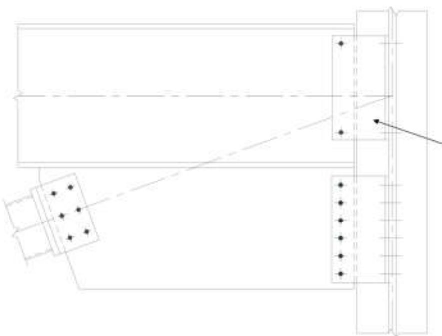
Connections – Bracing KISS

- Beam-to-Column Connection by Others



Mandated Connection

Vertical Bracing

Items to Note

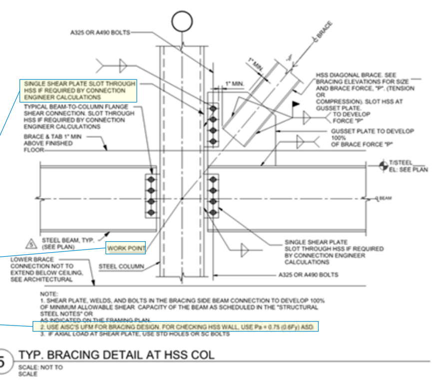
Vertical Bracing – Items for EOR

- Information needed for design to avoid RFIs, assumptions during connection design, or potential revisions in the field

SINGLE SHEAR PLATE SLOT THROUGH HSS IF REQUIRED BY CONNECTION ENGINEER CALCULATIONS

WORK POINT

FOR CHECKING HSS WALL, USE Pa = 0.75 (0.6Fy) ASD



Vertical Bracing – Items for EOR

- Architectural requirements

BRACE & TAB 1" MIN ABOVE FINISHED FLOOR

LOWER BRACE CONNECTION NOT TO EXTEND BELOW CEILING, SEE ARCHITECTURAL

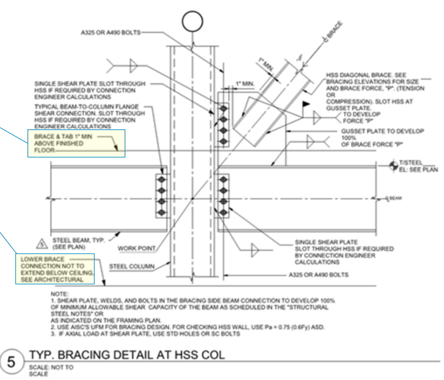


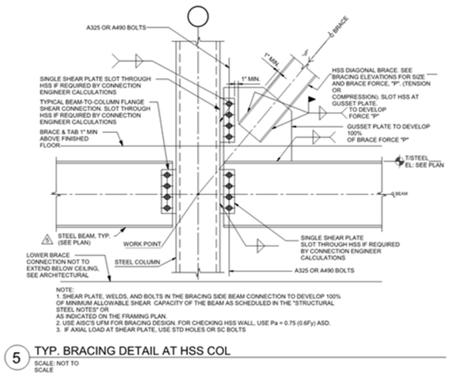
Photo by Jon Miller

Vertical Bracing – Items for EOR

Notes

All connections, unless specifically designated as being completely designed on the structural drawings, shall be designed and detailed by a structural engineer licensed in the state where the project is located

Schematic detail. Fabricator to design actual connection based on required loading



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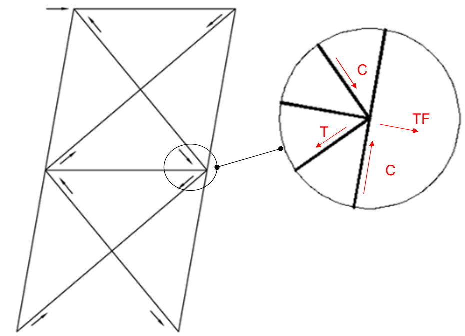
Vertical Bracing



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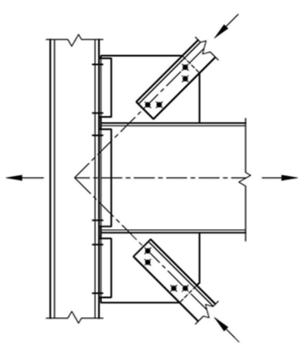
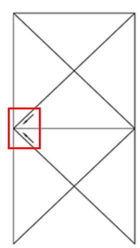
Vertical Bracing



- Indicate if both top and bottom braces in compression



Note: Do not use force from one brace to offset force from opposite brace

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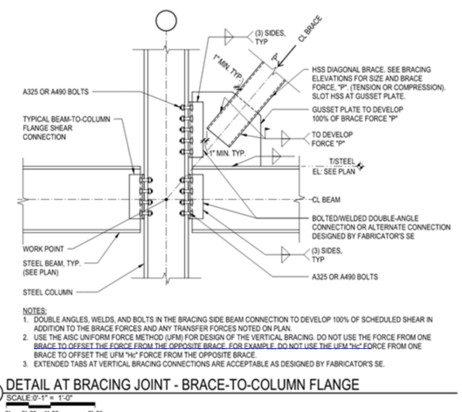
Vertical Bracing



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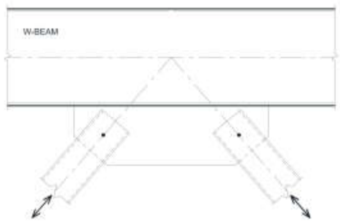
Vertical Bracing

- Indicate if both braces can be in compression
- Impact the effective length factor for whitmore compression



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Code of Standard Practice

– 2016 COSP (303-16) Section 3.1.1 and Section 3.1.2

» Option 3: in the structural *design documents* or *specifications*, the *connection* shall be designated to be designed by a licensed engineer working for the *fabricator*

» Options 3A and 3B: More applicable to moment connection design but could apply at vertical bracing (mainly at chevron connections)

» Option 3A: Member reinforcement at connections shall be designed by owners' designated representative for design and shown in the structural design documents

» Option 3B: Member reinforcement at connections is delegated design, but the quantities and conceptual configurations shall be provided and relied upon for bidding purposes. If no quantities or conceptual configurations are shown, member reinforcement at *connections* will not be included in the bid.

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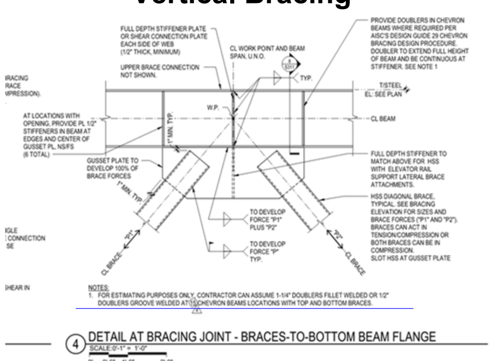
Vertical Bracing



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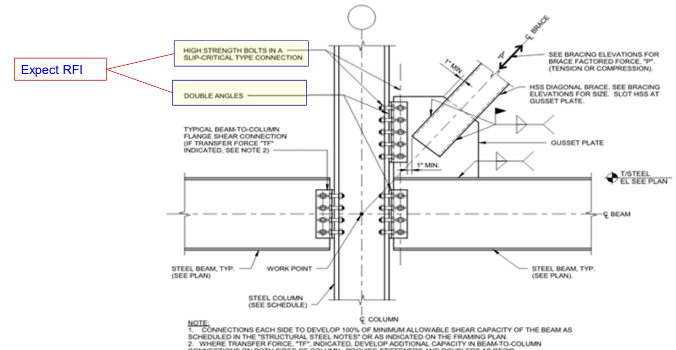
Vertical Bracing



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Vertical Bracing

- SC Bolt Requirements given in RCSC Specification

4.3. Slip-Critical Joints

Slip-critical joints are required in the following applications involving shear or combined shear and tension:

(1) *Joints* that are subject to fatigue load with reversal of the loading direction;
(2) *Joints* that utilize oversized holes;
(3) *Joints* that utilize slotted holes, except those with applied load approximately normal (within 80 to 100 degrees) to the direction of the long dimension of the slot; and,
(4) *Joints* in which slip at the *faying surfaces* would be detrimental to the performance of the structure.

Bolts in *slip-critical joints* shall be designed in accordance with the applicable provisions of Sections 5.1, 5.2, 5.3, 5.4 and 5.5, installed in accordance with Section 8.2 and inspected in accordance with Section 9.3.

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Bolts

- Which type of joint requirements do you typically specify/see?

1. Bearing bolts
2. Slip critical bolts
3. Pretensioned bolts

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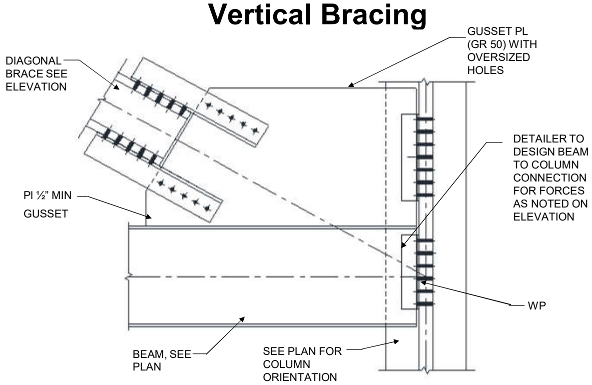
Vertical Bracing



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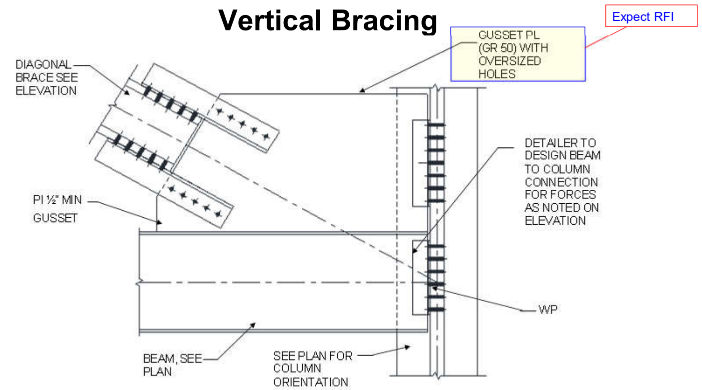
Vertical Bracing



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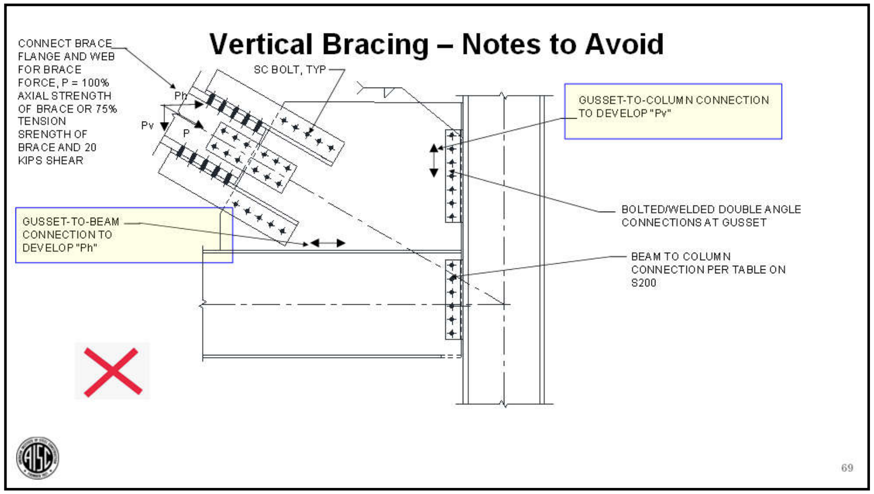
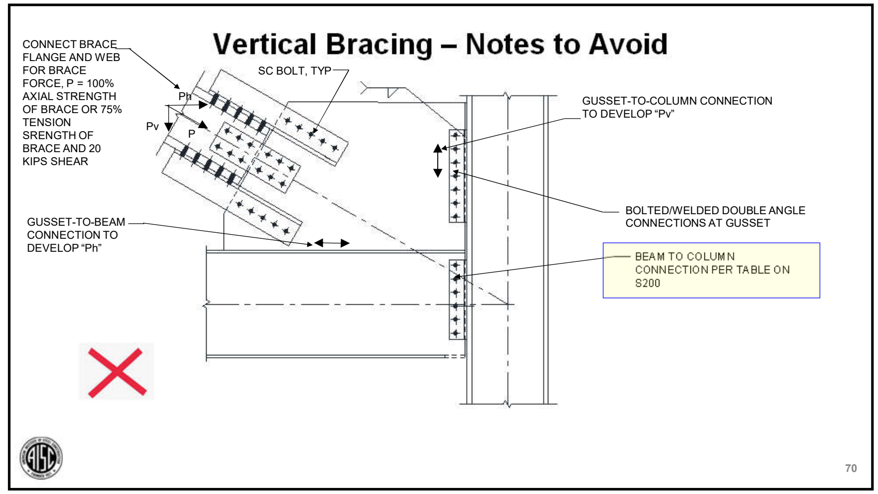
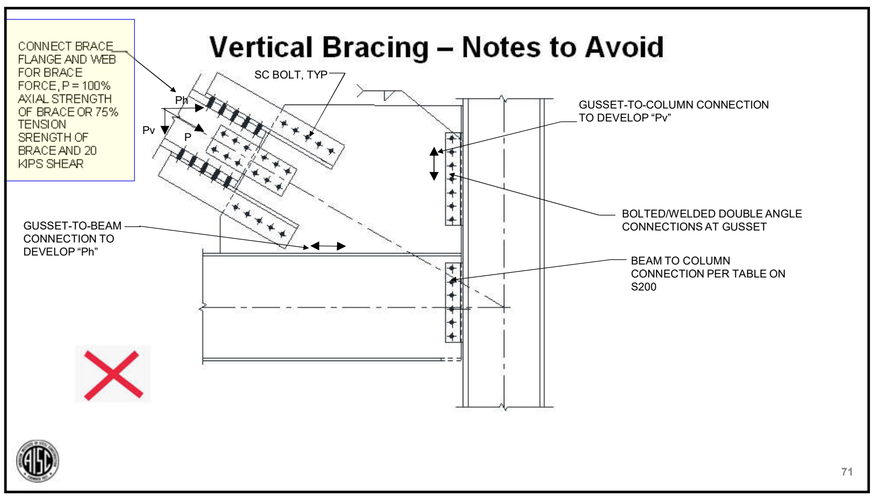

Vertical Bracing – Notes to Avoid
CONNECT BRACE FLANGE AND WEB FOR BRACE FORCE, P = 100% AXIAL STRENGTH OF BRACE OR 75% TENSION SRENGTH OF BRACE AND 20 KIPS SHEAR
SC BOLT, TYP
Ph
Pv
P
GUSSET-TO-COLUMN CONNECTION TO DEVELOP "Pv"
GUSSET-TO-BEAM CONNECTION TO DEVELOP "Ph"
BOLTED/WELDED DOUBLE ANGLE CONNECTIONS AT GUSSET
BEAM TO COLUMN CONNECTION PER TABLE ON S200
69


Vertical Bracing – Notes to Avoid
CONNECT BRACE FLANGE AND WEB FOR BRACE FORCE, P = 100% AXIAL STRENGTH OF BRACE OR 75% TENSION SRENGTH OF BRACE AND 20 KIPS SHEAR
SC BOLT, TYP
Ph
Pv
P
GUSSET-TO-COLUMN CONNECTION TO DEVELOP "Pv"
GUSSET-TO-BEAM CONNECTION TO DEVELOP "Ph"
BOLTED/WELDED DOUBLE ANGLE CONNECTIONS AT GUSSET
BEAM TO COLUMN CONNECTION PER TABLE ON S200
70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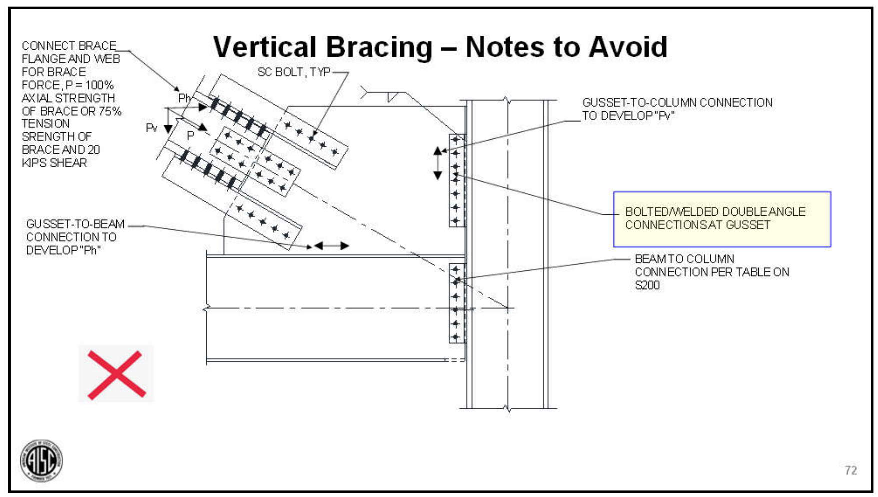
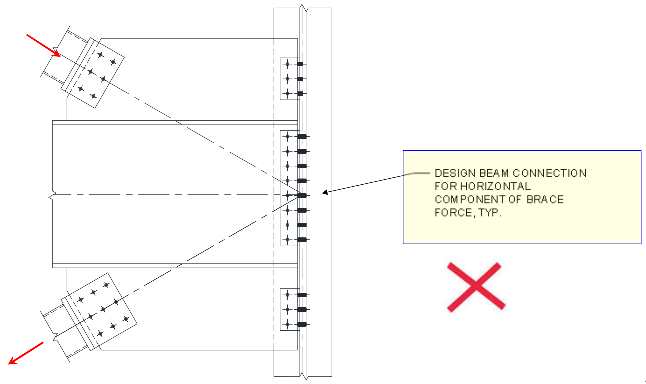
71


Vertical Bracing – Notes to Avoid
CONNECT BRACE FLANGE AND WEB FOR BRACE FORCE, P = 100% AXIAL STRENGTH OF BRACE OR 75% TENSION SRENGTH OF BRACE AND 20 KIPS SHEAR
SC BOLT, TYP
Ph
Pv
P
GUSSET-TO-COLUMN CONNECTION TO DEVELOP "Pv"
GUSSET-TO-BEAM CONNECTION TO DEVELOP "Ph"
BOLTED/WELDED DOUBLE ANGLE CONNECTIONS AT GUSSET
BEAM TO COLUMN CONNECTION PER TABLE ON S200
72

Vertical Bracing – Notes to Avoid



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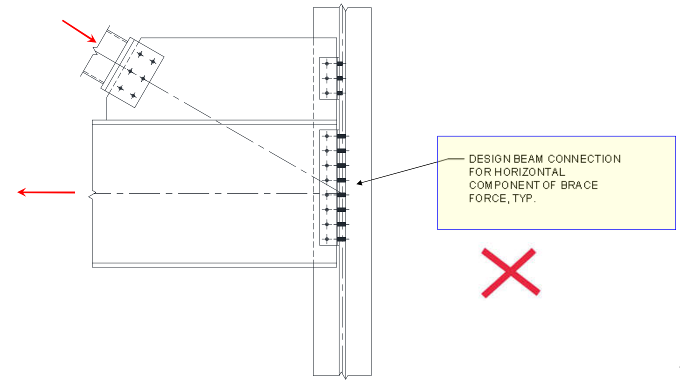
Vertical Bracing – Notes to Avoid



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General Notes

- Notes that could cause RFI
  - All plate and angles are A36
  - Hole type requirements
  - Specific bolt requirements
  - Spacing and edge distance requirements

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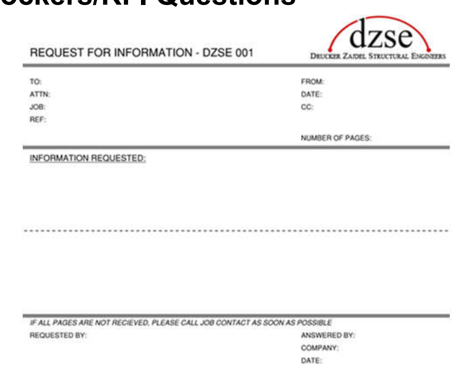
Most Common Blockers/RFI Questions

- ASD or LRFD
- Use of Slip Critical bolts
- Alternate Connections
- Full Strength
- HSS Beam Loading
- Transfer forces (TF)
- Column splice loading (Min. Axial)
- Material grade
- Restrictions
- Stitch Plates
- Shear load in beams (especially if a percentage of the Maximum Total Uniform Load, UDL, is used)
- Work Point


dzse
Drucker Zajdel Structural Engineers

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ANSWERED BY:
COMPANY:
DATE:

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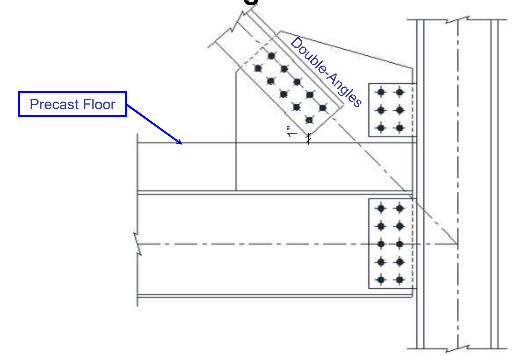
Vertical Bracing

Potential Issue

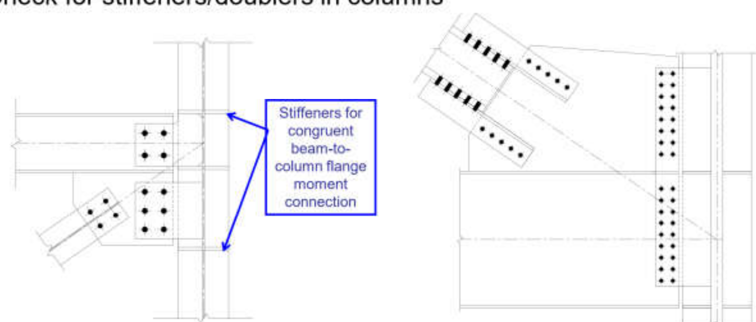
Getting Started with Design

- Flooring Type



Getting Started with Design

- Check for stiffeners/doublers in columns



Getting Started with Design

- Double-Angle Requirements
  - Stitch Plates
  - AISC Section E6
  - Table 4-8 to 4-10: Axial Compression Double Angles

$$\left(\frac{L_c}{r}\right)_m = \sqrt{\left(\frac{L_c}{r}\right)_o^2 + \left(\frac{a}{r_i}\right)^2} \quad \text{(E6-1)}$$

(1) When $\frac{a}{r_i} \le 40$

$$\left(\frac{L_c}{r}\right)_m = \left(\frac{L_c}{r}\right)_o \quad \text{(E6-2a)}$$

(2) When $\frac{a}{r_i} > 40$

$$\left(\frac{L_c}{r}\right)_m = \sqrt{\left(\frac{L_c}{r}\right)_o^2 + \left(\frac{K_i a}{r_i}\right)^2} \quad \text{(E6-2b)}$$

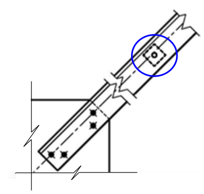
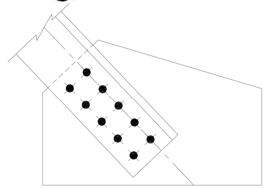


Table 4-9 (continued)
Available Strength in Axial Compression, kips
Double Angles—LLBB
F_y = 36 ksi
2L6 LLBB

Shape		2L6×4×								No. of connectors
		7/8		3/4		5/8		9/16		
lb/ft		54.4		47.2		40.0		36.2		
Design		P_n/Ω_c ASD	$\phi_c P_n$ LRFD	P_n/Ω_c ASD	$\phi_c P_n$ LRFD	P_n/Ω_c ASD	$\phi_c P_n$ LRFD	P_n/Ω_c ASD	$\phi_c P_n$ LRFD	
Effective length, KL (ft), with respect to indicated axis — X-X Axis	0	345	518	300	450	252	379	229	343	
	4	333	501	290	435	244	366	221	332	
	6	319	479	277	417	234	351	212	318	
	8	300	451	261	393	220	331	200	300	
	10	277	416	242	363	204	307	185	278	
	12	252	378	220	331	186	279	169	254	
	14	224	337	197	296	166	250	151	228	
	16	197	296	173	260	146	220	133	201	b
	18	170	255	150	225	127	191	116	174	
	20	144	216	127	191	108	162	98.6	148	
	22	119	179	106	159	90.1	135	82.5	124	
	24	100	151	89.0	134	75.7	114	69.3	104	
	26	85.5	128	75.9	114	64.5	97.0	59.1	88.8	
	28	73.7	111	65.4	98.3	55.6	83.6	50.9	76.6	
	30	64.2	96.5	57.0	85.6	48.5	72.9	44.4	66.7	
Y-Y Axis	0	345	518	300	450	252	379	229	343	
	4	319	480	273	410	224	336	199	298	
	6	304	456	259	390	213	320	189	284	
	8	283	425	241	363	198	298	176	265	
	10	251	378	214	322	176	264	156	235	
	12	222	334	189	284	155	233	138	208	
	14	192	289	163	244	133	200	119	179	2
	16	162	244	137	205	112	168	99.8	150	

Getting Started with Design



E6. BUILT-UP MEMBERS

1. Compressive Strength

This section applies to built-up members composed of two shapes either (a) interconnected by bolts or welds or (b) with at least one open side interconnected by perforated cover plates or lacing with tie plates. The end connection shall be welded or connected by means of pretensioned bolts with Class A or B faying surfaces.

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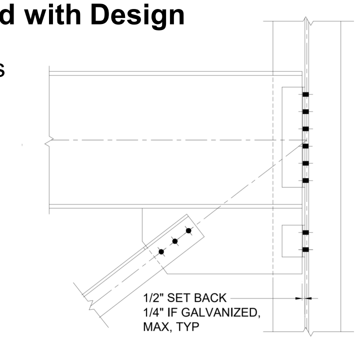
Getting Started with Design

- Surface Preparation Requirements
  - Class A Bolts
  - Class B Bolts
  - Galvanizing



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Getting Started with Design

- Seismic Design, $R > 3$ (AISC 341-16, Section D2.2(d))

(d) All bolts shall be installed as pretensioned high-strength bolts. Faying surfaces shall satisfy the requirements for slip-critical connections in accordance with *Specification* Section J3.8 with a faying surface with a Class A slip coefficient or higher.

Exceptions: Connection surfaces are permitted to have coatings with a slip coefficient less than that of a Class A faying surface for the following:

(1) End plate moment connections conforming to the requirements of Section E1, or ANSI/AISC 358

(2) Bolted joints where the seismic load effects are transferred either by tension in bolts or by compression bearing but not by shear in bolts

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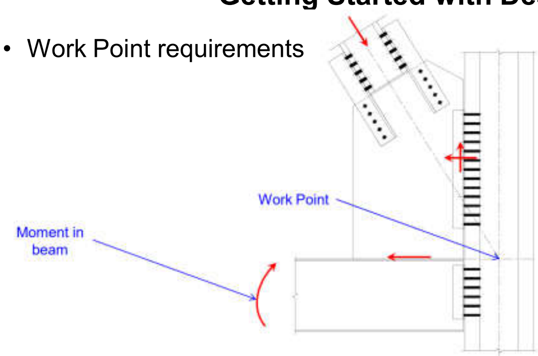
Getting Started with Design

- Work Point requirements



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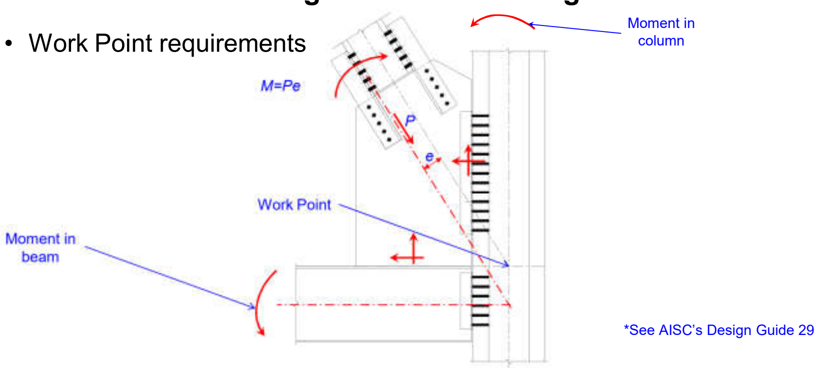
Getting Started with Design

- Work Point requirements



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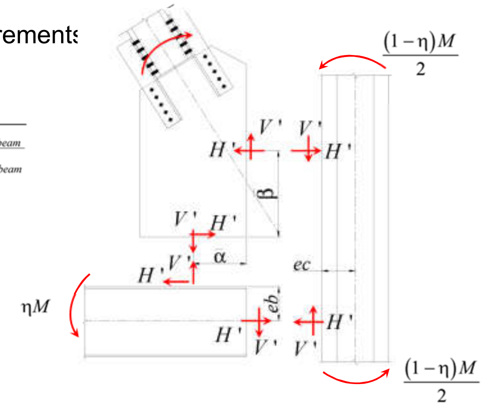
Getting Started with Design

- WP requirements

$$\eta = \frac{\frac{I_{beam}}{L_{beam}}}{\Sigma \frac{I_{col}}{L_{col}} + \frac{I_{beam}}{L_{beam}}}$$



$$H' = \frac{(1-\eta)M}{e_b + \bar{\beta}}$$

$$V' = \frac{M - H'\bar{\beta}}{\bar{\alpha}}$$

*Reference AISC's Night School 28 and AISC's DG29

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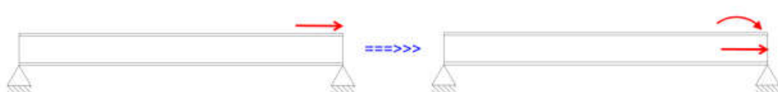
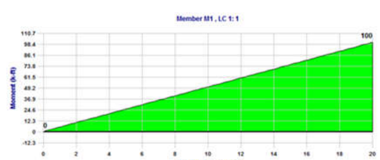
Getting Started with Design

- WP requirements



Work Point at Top of Beam



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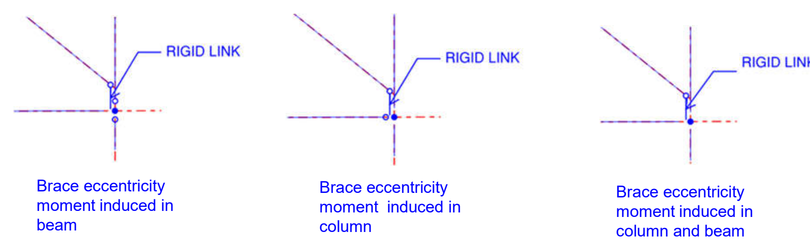
Frame Analysis

- WP requirements



Note: At least one member framing into joint needs to not be released to maintain numerical stability of the analysis

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Frame Analysis

- Which method do you commonly use/see for offset WP?

1. Brace eccentricity moment induced in beam
2. Brace eccentricity moment induced in beam and column
3. Not addressed

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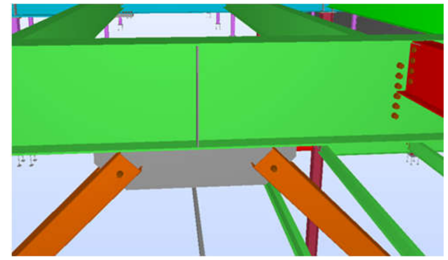
Chevron Connections

- Stability bracing
- Brace force directions



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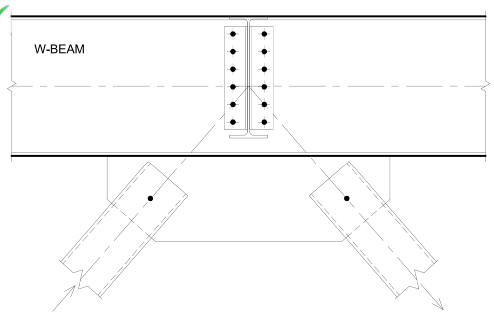
Chevron Connections

- Stability bracing
  - Beam framing into WP ✓
  - Tension brace
  - Stiffeners and studs on top



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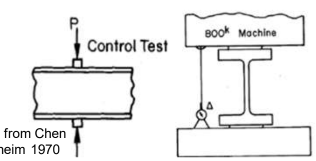
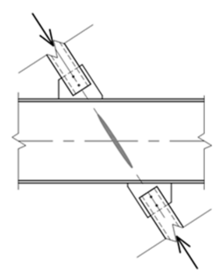
Single Brace Connections

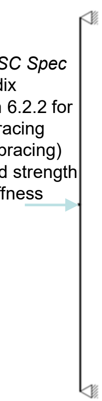
- Stability Concern
  - See *AISC Spec* Chapter C and Appendix 6 for Stability
  - Web compression buckling: *AISC Spec* Equation J10-8 developed from point loads and restrained flanges



Test Set-up from Chen and Oppenheim 1970



See *AISC Spec* Appendix Section 6.2.2 for point bracing (nodal bracing) required strength and stiffness



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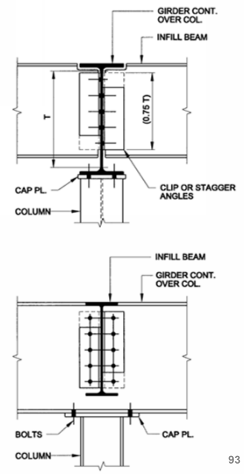
Chevron Connections

- Stability bracing
  - Beam framing into WP ✓
  - Tension brace
  - Stiffeners and studs

Reference AISC's 15 Ed. Manual, pp 2-16 and 2-17:

1. When an infill beam frames into the continuous beam at the column top, the required stability normally can be provided by using connection element(s) for the infill beam that cover three-quarters or more of the T-dimension of the continuous beam. Alternatively, connection elements that cover less than three-quarters of the T-dimension of the continuous beam can be used in conjunction with partial-depth stiffeners in the beam web along with a moment connection between the column top and beam bottom to maintain alignment of the beam/column assembly. A cap plate of reasonable proportions and four bolts will normally suffice.



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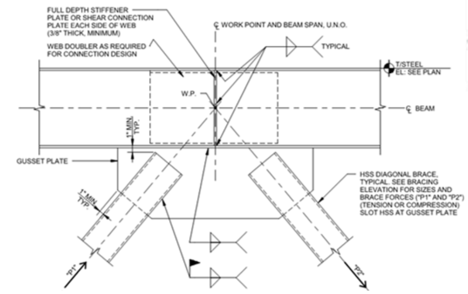
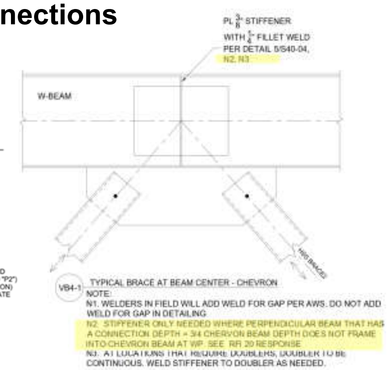
Chevron Connections

- Optimize connections





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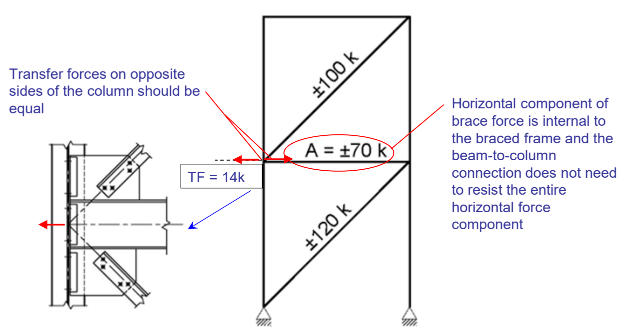
Transfer Forces



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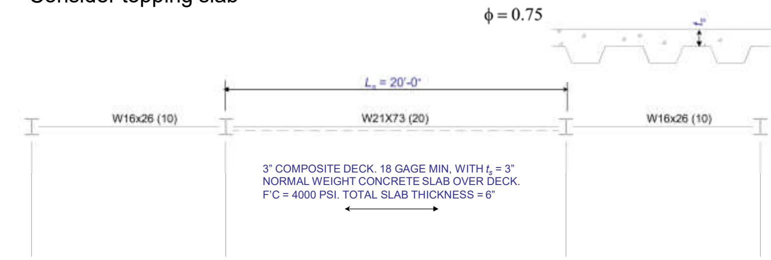
Diaphragm Strength

- Transfer Forces at Composite Deck
  - Consider topping slab

$$\phi V_n = \phi L_s t_s (2\lambda\sqrt{f'_c})$$ ACI 12.5.3.3

$$\phi = 0.75$$



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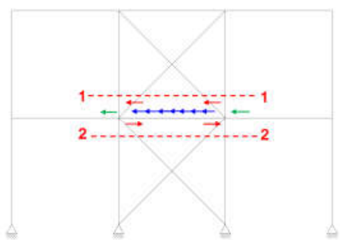
Diaphragm Strength

- Transfer Forces at Composite Deck

$$\phi V_n = \phi L_s t_s (2\lambda\sqrt{f'_c}) \qquad \text{ACI 12.5.3.3}$$
$$\phi = 0.75$$
$$\Sigma \text{TF} = \max(\text{abs}(\Sigma F_{x2} - \Sigma F_{x1}) - \phi V_n, 0 \text{ kips})$$



Red Arrow = F_x = Brace Horizontal Component

Blue Arrow = Diaphragm Strength

Green Arrow = Transfer Forces

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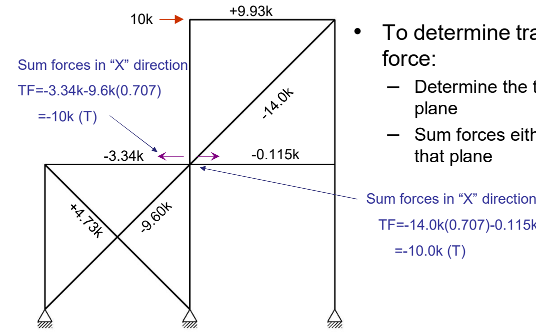
Transfer Forces - Discontinuous Braced Bays



- To determine transfer force:
  - Determine the transfer plane
  - Sum forces either side of that plane

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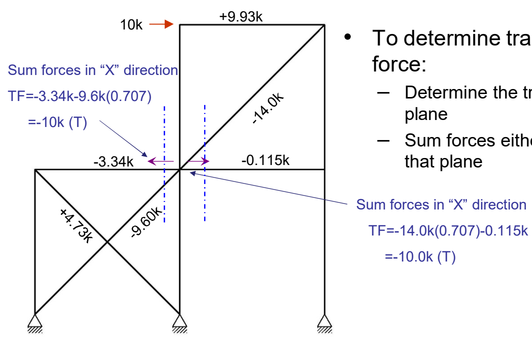
Transfer Forces - Discontinuous Braced Bays



- To determine transfer force:
  - Determine the transfer plane
  - Sum forces either side of that plane

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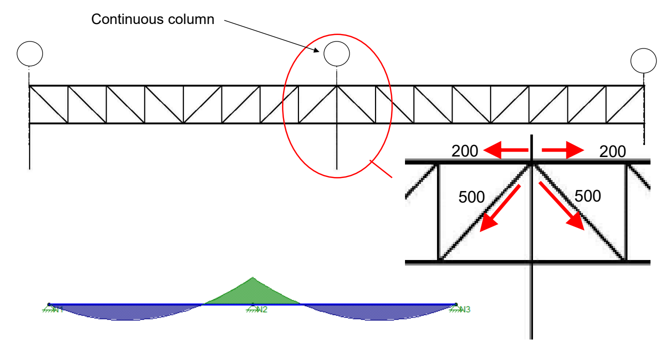
Transfer Forces



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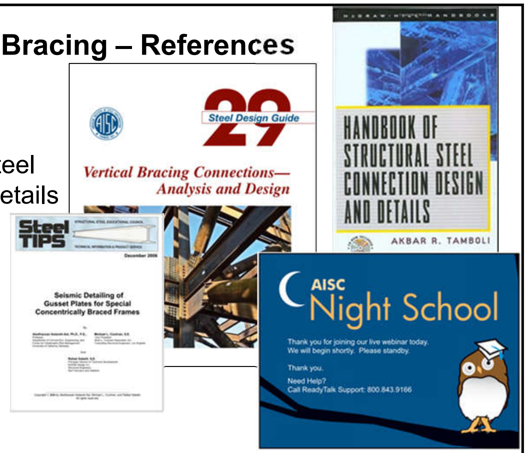
Vertical Bracing – References

- AISC's Design Guide 29 (DG29)
- Handbook of Structural Steel Connection Design and Details
- AISC's Night School 28
- Steel Tips
- 15th Ed. Manual, Part 13
- AISC's Design Examples



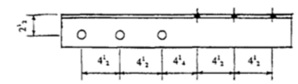
Vertical Bracing – Articles

- *Effective Length Factors for Gussets Plate Buckling*, EJ 2nd Qtr, 2006, Bo Dowswell
- *Effective Length Factors for Gussets Plates in Chevron Braced Frames*, EJ 3rd Qtr, 2012, Bo Dowswell
- *The Effect of Eccentricity on Brace-to-gusset Angles*, EJ 4th Qtr, 1996, W.A. Thornton

Table 3. Summary of Proposed Effective Length Factors[a]

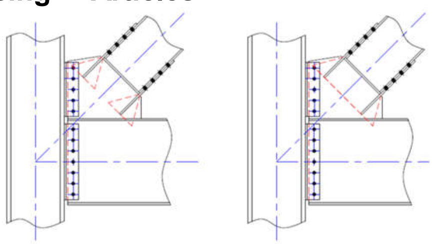
Gusset Configuration	Effective Length Factor	Buckling Length	$\frac{P_{exp}}{P_{calc}}$
Compact corner	—[b]	—[b]	1.36
Noncompact corner	1.0	l_{avg}	3.08
Extended corner	0.6	l_1	1.45
Single brace	0.7	l_1	1.45
Chevron	0.65	l_1	1.17

[a] Table 7 from Dowswell (2006) with revisions.
[b] Yielding is the applicable limit state for compact corner gusset plates; therefore, the effective length factor and the buckling length are not applicable.

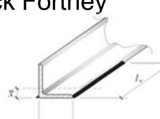


Vertical Bracing – Articles

- *The Whitmore Section,* MS, July 2011, WA Thornton and Carlo Lini
- *Recommendations for Shear Lag Factors for Longitudinally Welded Tension Members*, EJ 1st Qtr, 2012, Patrick Fortney and WA Thornton

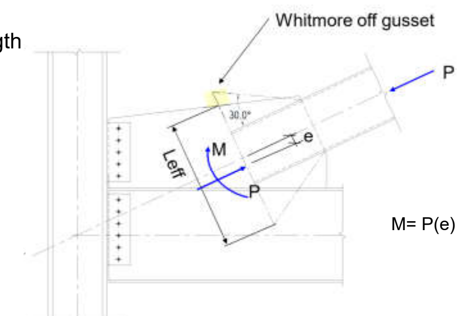


(a) Correct Whitmore length.
(b) Incorrect Whitmore length.



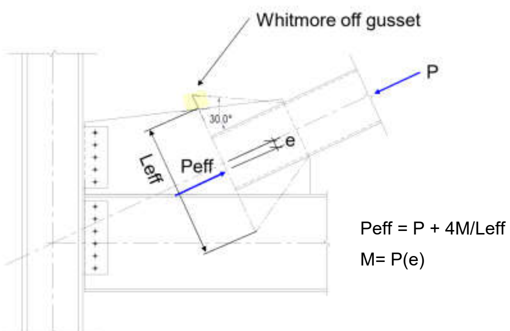
Connections – Vertical Bracing

- Whitmore Falls off Gusset
  - Consider Moment
  - Use Symmetric Length



Connections – Vertical Bracing

- Whitmore Falls off Gusset
  - Consider Moment
  - Use Symmetric Length



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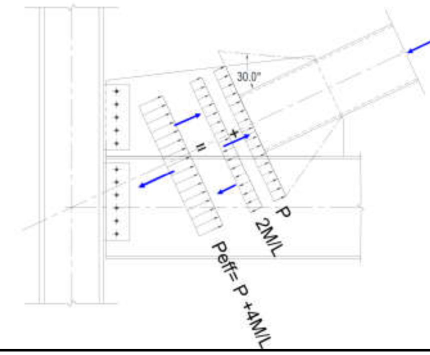
Connections – Vertical Bracing

- Whitmore Falls off Gusset
  - Consider Moment
  - Use Symmetric Length



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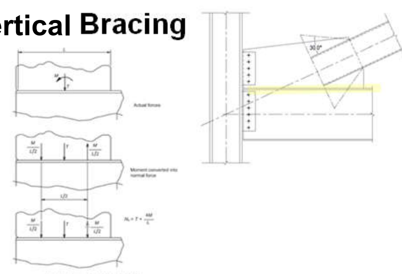
Connections – Vertical Bracing

- Equivalent Axial Force
  - Gusset-to-Beam Connection



The total equivalent normal force (including both the force and the moment resolved into a force couple) at the gusset-to-beam interface is:

LRFD	ASD
$N_{u\,equiv} = V_{ub} + \dfrac{2M_{ub}}{\left(\dfrac{L}{2}\right)}$ $= 167\text{ kips} + \dfrac{(4)(1{,}790\text{ kip-in.})}{31.5\text{ in.}}$ $= 394\text{ kips}$	$N_{a\,equiv} = V_{ab} + \dfrac{2M_{ab}}{\left(\dfrac{L}{2}\right)}$ $= 111\text{ kips} + \dfrac{(4)(1{,}190\text{ kip-in.})}{31.5\text{ in.}}$ $= 262\text{ kips}$

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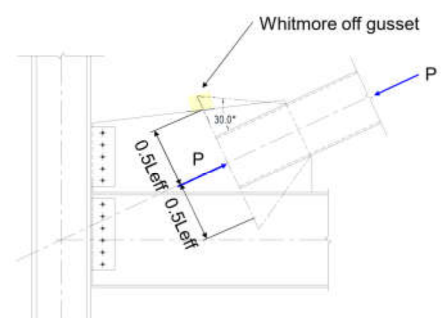
Connections – Vertical Bracing

- Whitmore Falls off Gusset
  - Consider Moment
  - Use Symmetric Length



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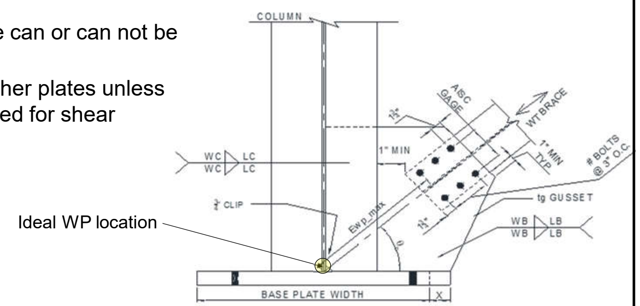
Vertical Bracing

Vertical Bracing
Base Connections

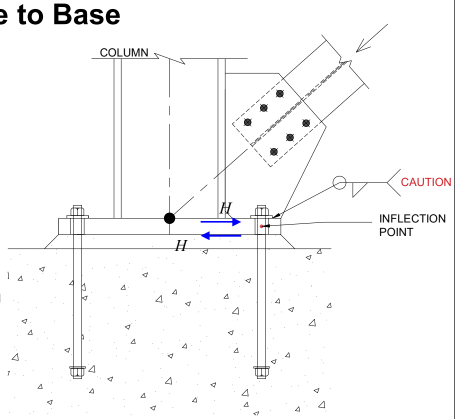
Brace to Base

- Work Point location: Typically top of plate or bottom of plate
- See DG29
- Indicate base plate can or can not be extended
- Avoid welding washer plates unless anchor rods checked for shear and bending



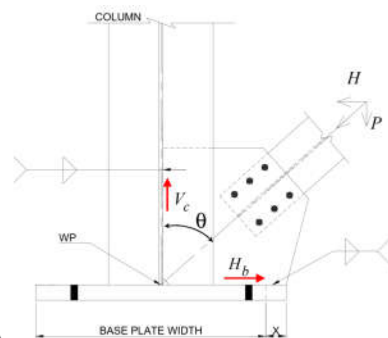
Brace to Base

- Check anchor rods for shear and bending if washer plate is welded to base plate
- Base plate hole size per 15[TH] Ed. Manual Table 14-2
- Washer plates per 15[TH] Ed. Manual Table 14-2
- Consider lugs if high shear load and column has insufficient compression to resist the shear in friction



Brace to Base

- Work Point location – Top of Plate



$$H = P \sin\theta$$

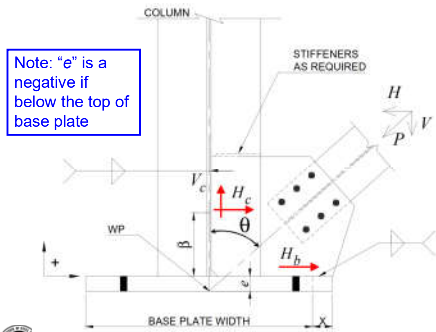
$$V = P \cos\theta$$

$$V_c = V$$

$$H_b = H$$

Brace to Base

- Work Point location – Bottom of Plate



$$H = P\sin\theta$$

$$V = P\cos\theta$$

$$V_c = V$$

Sum Moments about $\bar{\beta}$ to determine H_b

$$H_b = \frac{H(\bar{\beta}-e)}{\bar{\beta}}$$

$$H_c = H - H_b$$

*Reference DG29

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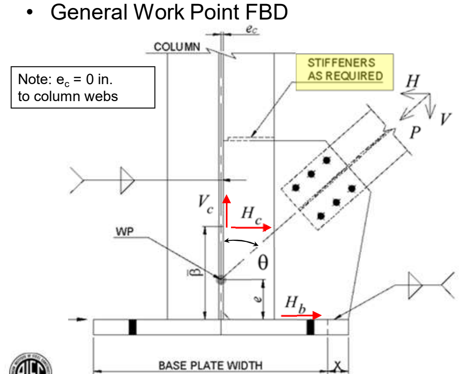
Brace to Base

- General Work Point FBD



$$H = P\sin\theta$$

$$V = P\cos\theta$$

$$V_c = V$$

$$H_b = \frac{H(\bar{\beta}-e)-Ve_c}{\bar{\beta}}$$

$$H_c = H - H_b$$

*Reference DG29

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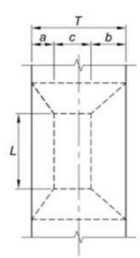
Brace to Base

- Transverse Loading at Column Web
  - **15th Ed Manual, Part 9**
  - Design Guide 29, Section 4.3

$$H_c = H - H_b$$



(a) Transverse load

For wide-flange sections, the edges of the column web are generally assumed to be pinned:

$$R_n = \frac{t_w^2F_y}{4}\left[\frac{4\sqrt{2Tab(a+b)}+L(a+b)}{ab}\right] \quad (9\text{-}31)$$

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Brace to Base

- Transverse Loading at Column Web
  - 15th Ed Manual, Part 9
  - Design Guide 29, Section 4.3

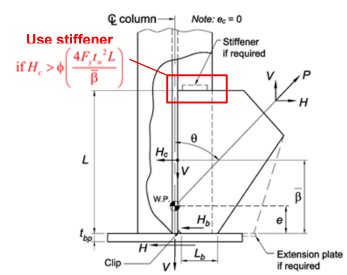
Admissible Force Field for Column Base – Weak Axis (cont.):
Using $k = 16$

$M_n = 16(¼)F_yt_w^2L$
$= 4\,F_yt_w^2L$

For an applied moment of

$$H_c\bar{\beta} \le \phi M_n = \phi\left(4F_yt_w^2L\right)$$

$$\text{or } H_c \le \phi\left(\frac{4F_yt_w^2L}{\bar{\beta}}\right)$$



Note: For HSS columns, a *k*-value for fixed flanges would be appropriate.

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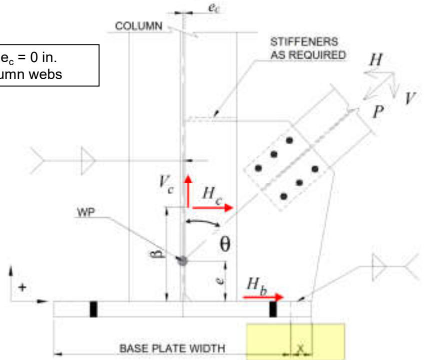
Brace to Base

- General Work Point FBD

Note: e_c = 0 in. to column webs



$$H = P\sin\theta$$

$$V = P\cos\theta$$

$$V_c = V$$

$$H_b = \frac{H(\bar{\beta} - e) - Ve_c}{\beta}$$

$$H_c = H - H_b$$

*Reference DG29

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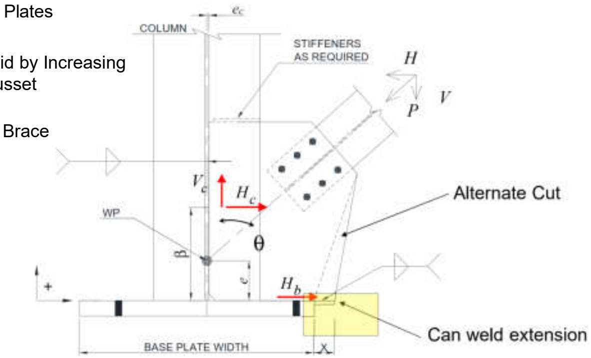
Brace to Base

- Base Plate Extensions
  - Can Extend Base Plates
  - Can Weld Plate
  - Can Possibly Avoid by Increasing Weld Size and Gusset Thickness
  - More Common at Brace to Column Flange Connections



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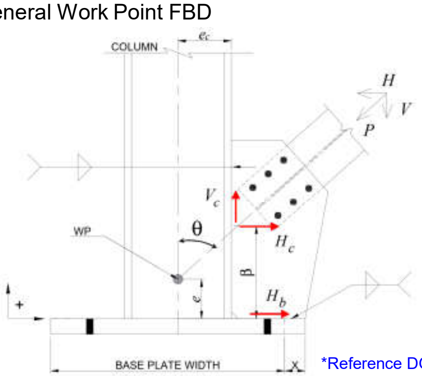
Brace to Base

- General Work Point FBD



*Reference DG29

$$H = P\sin\theta$$

$$V = P\cos\theta$$

$$V_c = V$$

$$H_b = \frac{H(\beta - e) - Ve_c}{\beta}$$

$$H_c = H - H_b$$

Can also determine Hc by summing moments about face of column flange at base plate:

$$H_c = \frac{H(e) + V(e_c)}{\beta}$$

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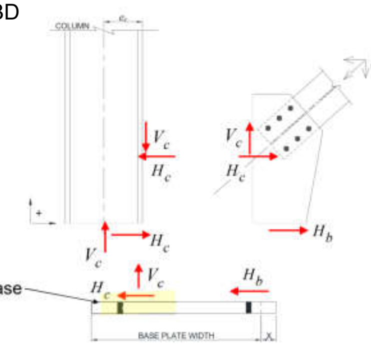
Brace to Base

- General Work Point FBD



Hc resisted by column web. Coordinate column web-to-base plate weld. Add weld as needed.

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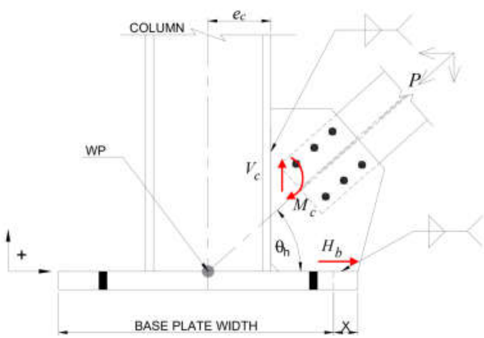
Brace to Base

- Work Point location – Top of Plate



$$V_c = P \sin \theta_h$$

$$M_c = V_c(e_c)$$

$$H_b = P \cos \theta_h$$

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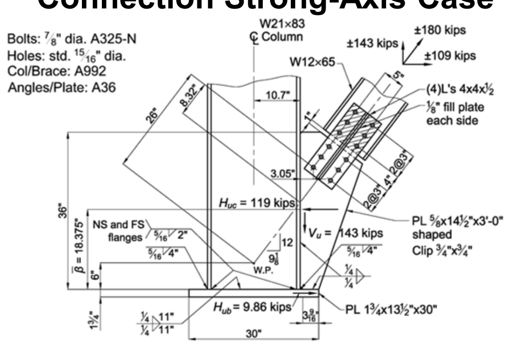
Example of Brace-to-Column Base Plate Strong-Axis Case: Distribution of Forces

Example of Brace-to-Column Base Plate Connection Strong-Axis Case



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Example of Brace-to-Column Base Plate Connection Strong-Axis Case

Given:

1. AISC 15th Edition *Manual*, LRFD
2. Brace Force: P_u = ±180 kips
3. Brace Slope: 12:9⅛ (rise:run)
4. W Shape: ASTM A992, F_y = 50 ksi, F_u = 65 ksi
5. Angles/Plate: ASTM A36, F_y = 36 ksi, F_u = 58 ksi
6. Bolts: ⅞-in. dia. A325-N in STD. 15/16" dia. Holes

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Example of Brace-to-Column Base Plate Connection Strong-Axis Case

Distribution of Forces:

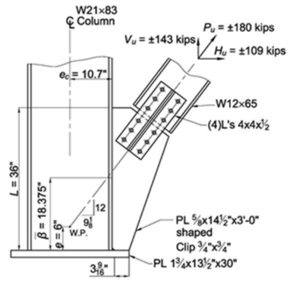
$$\bar{\beta} = \frac{(L - \text{clip})}{2} + clip$$

$$= \frac{(36\text{ in.} - 0.75\text{ in.})}{2} + 0.75\text{ in.}$$

$$= 18.375\text{ in.}$$

$$e = 6\text{ in.}$$

$$e_c = d_{col}/2 = (21.4\text{ in.})/2 = 10.7\text{ in.}$$



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Example of Brace-to-Column Base Plate Connection Strong-Axis Case

Distribution of Forces (cont.):

Horizontal component of brace force:

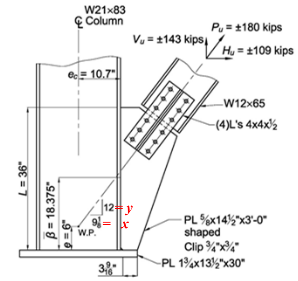
$$H_u = \frac{xP_u}{\sqrt{x^2 + y^2}} = \frac{(9.125)(180\text{ kips})}{\sqrt{(9.125)^2 + (12)^2}}$$

$$= 109\text{ kips}$$

Vertical component of brace force:

$$V_u = \frac{yP_u}{\sqrt{x^2 + y^2}} = \frac{(12)(180\text{ kips})}{\sqrt{(9.125)^2 + (12)^2}}$$

$$= 143\text{ kips}$$



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Example of Brace-to-Column Base Plate Connection Strong-Axis Case

Distribution of Forces (cont.):

Sum moments about CF:

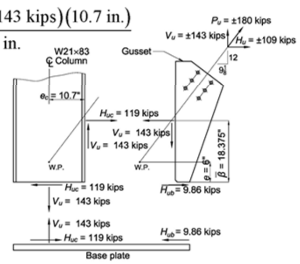
$$H_{ub} = \frac{H_u(\bar{\beta} - e) - V_u e_c}{\bar{\beta}} = \frac{(109\text{ kips})(18.375\text{ in.} - 6.0\text{ in.}) - (143\text{ kips})(10.7\text{ in.})}{18.375\text{ in.}}$$

$$= -9.86\text{ kips}$$

Sum moments about base plate at column face.

$$H_{uc} = \frac{H_u e + V_u e_c}{\bar{\beta}} = \frac{(109\text{ kips})(6.0\text{ in.}) + (143\text{ kips})(10.7\text{ in.})}{18.375\text{ in.}}$$

$$= 119\text{ kips}$$



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Example of Brace-to-Column Base Plate Strong-Axis Case: Gusset-to-Column Connection

Example of Brace-to-Column Base Plate Connection Strong-Axis Case (cont.)

Gusset-to-Column – Shear and Tension Yielding of Gusset Plate Along Column Flange:

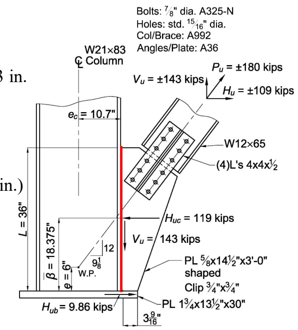
$l_w = L - \text{clip} = 36.0 \text{ in.} - 0.75 \text{ in.} = 35.3 \text{ in.}$

From AISC *Specification* Eq. J4-3,
Shear Yielding:

$$\phi R_n = \phi 0.60 F_y A_{gv}$$
$$= 1.0(0.60)(36 \text{ ksi})(0.625 \text{ in.})(35.3 \text{ in.})$$
$$= 477 \text{ kips} > V_u = 143 \text{ kips} \quad \textbf{o.k.}$$

From AISC Specification Eq. J4-1

$$\phi R_n = \phi F_y A_g$$
$$= 0.9(36 \text{ ksi})(0.625 \text{ in.})(35.3 \text{ in.})$$
$$= 715 \text{ kips} > H_{uc} = 119 \text{ kips} \quad \textbf{o.k.}$$



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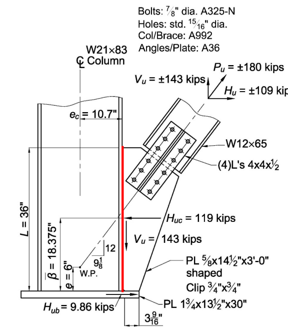
Example of Brace-to-Column Base Plate Connection Strong-Axis Case (cont.)

Gusset-to-Column – Design Weld for Combined Forces:

From AISC *Manual* Part 13, the connection should be designed for the larger of the peak stress and **1.25** times the average stress. The weld, however, need not be larger than that required to develop the strength of the gusset. The **25% increase** is recommended to provide ductility to allow adequate force redistribution in the weld group. (Hewitt and Thornton, 2004).



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Example of Brace-to-Column Base Plate Connection Strong-Axis Case (cont.)

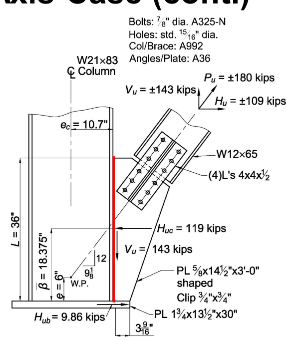
Gusset-to-Column – Design Weld for Combined Forces (cont.):

Resultant load is:

$$R_u = \sqrt{H_{uc}^{\,2} + V_u^{\,2}}$$
$$= \sqrt{(119 \text{ kips})^2 + (143 \text{ kips})^2}$$
$$= 186 \text{ kips}$$

Resultant load angle is:

$$\theta = \tan^{-1}\left(\frac{H_{uc}}{V_u}\right) = \tan^{-1}\left(\frac{119 \text{ kips}}{143 \text{ kips}}\right)$$
$$= 39.8°$$



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Example of Brace-to-Column Base Plate Connection Strong-Axis Case (cont.)

Gusset-to-Column – Design Weld for Combined Forces (cont.):

From AISC *Manual* Eq. 8-2 and strength increase from Eq. J2-5,

$$D_{req'd} = \frac{1.25 R_u}{1.392 l_w \left(1.0 + 0.50 \sin^{1.5}\theta\right)(2 \text{ sides})}$$
$$= \frac{(1.25)(186 \text{ kips})}{1.392(35.3 \text{ in.})\left[1.0 + 0.50 \sin^{1.5}(39.8°)\right](2)}$$
$$= 1.88 \text{ sixteenths}$$

From AISC *Specification* Table J2.4, minimum fillet weld size of ¼ in.

TABLE J2.4
Minimum Size of Fillet Welds

Material Thickness of Thinner Part Joined, in. (mm)	Minimum Size of Fillet Weld,[a] in. (mm)
To 1/4 (6) inclusive	1/8 (3)
Over 1/4 (6) to 1/2 (13)	3/16 (5)
Over 1/2 (13) to 3/4 (19)	1/4 (6)
Over 3/4 (19)	5/16 (8)

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Example of Brace-to-Column Base Plate Connection Strong-Axis Case (cont.)

LRFD Weld Strength:

$1.392D$ = D/16 (0.707) (ϕ)0.6F_{exx}
1.392 = (1/16) (0.707) (0.75)(0.6)(70 ksi)
1.392 = 1.392

Where
D = # of 16th of an inch. For 5/16" fillet weld, D = 5.

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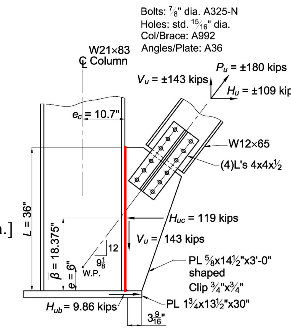
Example of Brace-to-Column Base Plate Connection Strong-Axis Case (cont.)

Gusset-to-Column – Local Yielding on Column Web:
H_{uc} is applied at

$$\bar{\beta} = 18.375 \text{ in.} < d_{col} = 21.4 \text{ in.}$$

From AISC *Specification* Eq. J10-3,

$$\begin{aligned} \phi R_n &= \phi F_y t_w (2.5k + l_b) \\ &= 1.0(50 \text{ ksi})(0.515 \text{ in.}) \\ &\quad \times [2.5(1.34 \text{ in.}) + 35.25 \text{ in.}] \\ &= 995 \text{ kips} > 119 \text{ kips} \quad \textbf{o.k.} \end{aligned}$$



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Example of Brace-to-Column Base Plate Connection Strong-Axis Case (cont.)

Gusset-to-Column – Local Crippling on Column Web:
H_{uc} is applied at

$$\bar{\beta} = 18.375 \text{ in.} > \frac{d_{col}}{2} = \frac{21.4 \text{ in.}}{2} = 10.7 \text{ in.}$$

From AISC *Specification* Eq. J10-4,

$$\phi R_n = \phi 0.80 t_w^2 \left[1 + 3\left(\frac{l_b}{d}\right)\left(\frac{t_w}{t_f}\right)^{1.5}\right]\sqrt{\frac{EF_{yw}t_f}{t_w}}$$

$$= 0.75(0.80)(0.515 \text{ in.})^2 \left[1 + 3\left(\frac{35.25 \text{ in.}}{21.4 \text{ in.}}\right)\left(\frac{0.515 \text{ in.}}{0.835 \text{ in.}}\right)^{1.5}\right]$$

$$\times \sqrt{\frac{(29{,}000 \text{ ksi})(50 \text{ ksi})(0.835 \text{ in.})}{0.515 \text{ in.}}}$$

$$= 829 \text{ kips} > H_{uc} = 119 \text{ kips}$$

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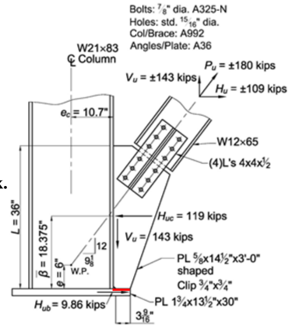
Example of Brace-to-Column Base Plate Strong-Axis Case: Gusset-to-Base Plate Connection

Example of Brace-to-Column Base Plate Connection Strong-Axis Case

Gusset-to-Base Plate – Shear Yielding on Gusset Plate:
From AISC *Specification* Eq. J4-3,

$$\phi R_n = \phi 0.60 F_y A_{gv}$$
$$= 1.0(0.60)(36\text{ ksi})(0.625\text{ in.})$$
$$\times (3^9/_{16}\text{ in.})$$
$$= 48.1\text{ kips} > H_{ub} = 9.86\text{ kips } \textbf{o.k.}$$



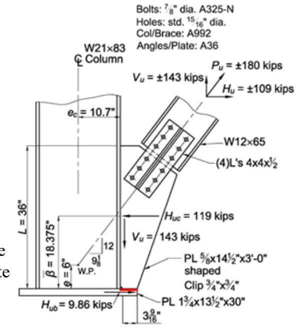
Example of Brace-to-Column Base Plate Connection Strong-Axis Case

Gusset-to-Base Plate – Design Weld:
From AISC *Manual* Eq. 8-2a,

$$D_{req'd} = \frac{R_u}{1.392 l_w (2\text{ sides})}$$
$$= \frac{9.86\text{ kips}}{1.392(3^9/_{16}\text{ in.})(2)}$$
$$= 0.99\text{ sixteenths}$$

From AISC *Specification* Table J2.4, minimum fillet weld size of ¼ in.

Note: An extension plate could be used if the gusset stress and gusset weld to the base plate are excessive. Or the base plate could be extended to accommodate the gusset.

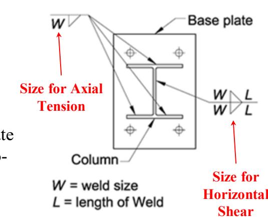


Example of Brace-to-Column Base Plate Strong-Axis Case: Column-to-Base Plate Connection

Example of Brace-to-Column Base Plate Connection Strong-Axis Case

Column-to-Base Plate:
The figure on the right shows a common weld arrangement. For this example, the welds need to be designed for the axial tension and shear loads that are present.

For gussets to the column strong axis, the most effective force distribution is to take the horizontal shear to the web-to-base plate weld, and the axial tension to the flange-to-base plate welds.



This force distribution assumes that the anchor bolts are placed close to the flanges to avoid excessive base plate bending due to the axial tension.

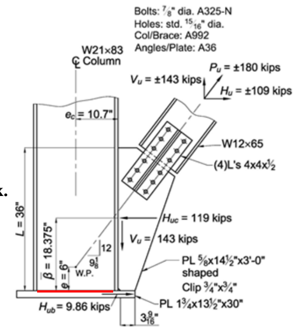
Note: For high uplift, 2-sided fillet welds can be used.

Example of Brace-to-Column Base Plate Connection Strong-Axis Case

Column-to-Base Plate – Shear Yielding on Column Web:

From AISC *Specification* Eq. J4-3,

$$\phi R_n = \phi 0.60 F_y A_{gv}$$
$$= 1.0(0.60)(50\text{ ksi})(21.4\text{ in.}) \times (0.515\text{ in.})$$
$$= 331\text{ kips} > H_{uc} = 119\text{ kips} \quad \textbf{o.k.}$$

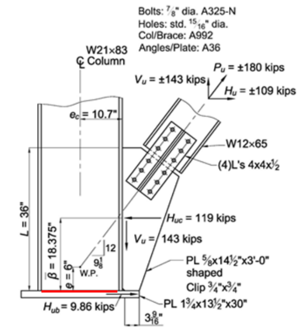


Example of Brace-to-Column Base Plate Connection Strong-Axis Case

Column-to-Base Plate – Design Column Web-to-Base Plate Welds:

Using the minimum ¼-in. fillet weld requirement per AISC *Specification* Table J2.4, determine required weld length from AISC *Manual* Eq. 8-2a,

$$l_{w\_req'd} = \frac{H_{uc}}{1.392D(2\text{ sides})}$$
$$= \frac{119\text{ kips}}{1.392(4\text{ sixteenths})(2)}$$
$$= 10.7\text{ in.}$$

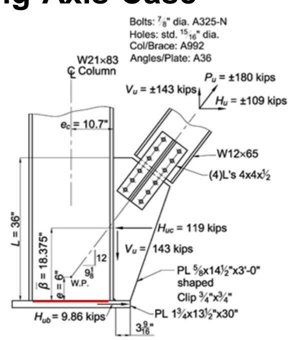


Example of Brace-to-Column Base Plate Connection Strong-Axis Case

Column-to-Base Plate – Design Column Web-to-Base Plate Welds (cont.):

From AISC Manual Eq. 9-3 and using l_w = 11.0 in. long ¼-in. fillet welds on each side of web, check column web shear rupture along the weld.

$$t_{min} = \frac{6.19D}{F_u} = \frac{6.19(4\text{ sixteenths})}{65\text{ ksi}}$$
$$= 0.381\text{ in.} < t_w = 0.515\text{ in.} \quad \textbf{o.k.}$$



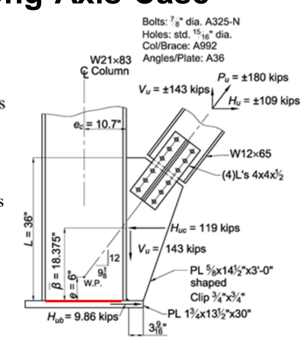
Example of Brace-to-Column Base Plate Connection Strong-Axis Case

Column-to-Base Plate – Design Column Flange-to-Base Plate Welds:

Axial load per flange is:

$$\text{flange force} = \frac{V_u}{2} = \frac{143\text{ kips}}{2} = 71.5\text{ kips}$$

From AISC *Specification* Table J2.4, minimum fillet weld size for thickness of thinner part joined > ¾ in. (t_f = 0.835 in.) is $^5/_{16}$ in.



Example of Brace-to-Column Base Plate Connection Strong-Axis Case

Column-to-Base Plate – Design Column Flange-to-Base Plate Welds (cont.):

From AISC *Manual* Eq. 8-2a and strength increase from Eq. J2-5 from the 90° tension loading,

$$l_{w\_req'd} = \frac{\text{flange force}}{1.392D\left(1.0+0.50\sin^{1.5}\theta\right)(2\text{ sides})}$$

$$= \frac{71.5\text{ kips}}{1.392(5\text{ sixteenths})\left[1.0+0.50\sin^{1.5}(90°)\right](2)} = 3.42\text{ in.}$$

On the outside of each flange, use 4-in. long $^{5}/_{16}$-in. fillet weld and (2) 2-in. long welds on the inside of each flange.

From AISC *Manual* Eq. 9-3, check column flange shear rupture

$$t_{min} = \frac{6.19D}{F_u} = \frac{6.19(5\text{ sixteenths})}{65\text{ ksi}}$$

$$= 0.476\text{ in.} < t_f = 0.835\text{ in.}\quad \textbf{o.k.}$$

Note: At column base plate connections, there may be additional loads that need to be considered. This information would need to be provided by the EOR.

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Conclusion

- Give actual forces on contract documents
- Avoid specifying unnecessary requirements that could penalize the contractor.
- Coordinate with other team members for most efficient design.
- Provide all information needed to properly complete connection design.

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AISC | Thank you

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AISC | Questions?

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Individual Session Registrants

PDH Certificates

- All WFH individuals associated with a group registration will be issued a certificate.
- All individuals attending at your connection: you will receive an email on how to report their attendance from: registration@aisc.org.
  - Be on the lookout: Check your spam filter! Check your junk folder!
  - Completely fill out online form. Don't forget to check the boxes next to each attendee's name!

8-Session Registrants

PDH Certificates

One certificate will be issued at the conclusion of all 8 sessions.

8-Session Registrants

Access to the quiz

Information for accessing the quiz will be emailed to you by Wednesday. It will contain a link to access the quiz. EMAIL COMES FROM NIGHTSCHOOL@AISC.ORG.

Quiz and attendance records

Posted Friday mornings. www.aisc.org/nightschool -- Click on Current Course Details.

Reasons for quiz

- EEU – You must take all quizzes and the final exam to receive EEU.
- PDHs – If you watch a recorded session, you must pass quiz for PDHs.
- REINFORCEMENT – Reinforce what you learn tonight. Get more out of the course.

Note: If you attend the live presentation, you do not have to take the quizzes to receive PDHs

8-Session Registrants

Access to the recording

Information for accessing the recording will be emailed to you by Wednesday. The recording will be available for four weeks. (For 8-session registrants only.) EMAIL COMES FROM NIGHTSCHOOL@AISC.ORG.

PDHs via recording

If you watch a recorded session, you must take *and pass* the quiz for PDHs.

8-Session Registrants

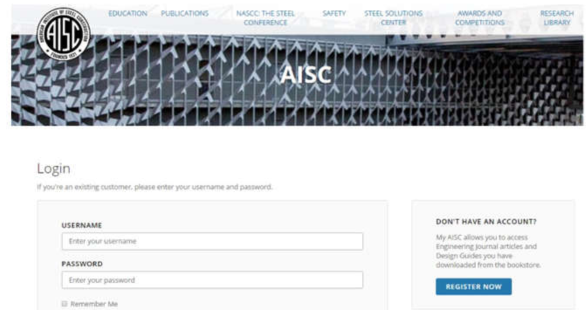
Night School Resources

Find all your handouts, quizzes and quiz scores, recording access, and attendance information all in one place!

8-Session Registrants

Night School Resources

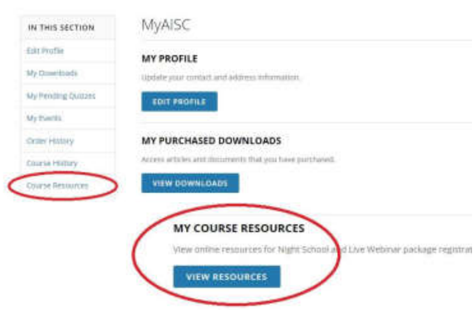
Go to www.aisc.org and sign in.



8-Session Registrants

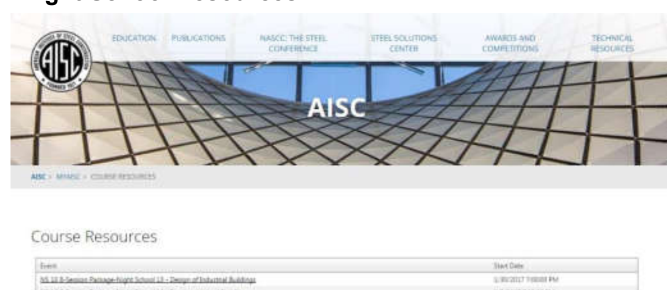
Night School Resources

Go to www.aisc.org and sign in.



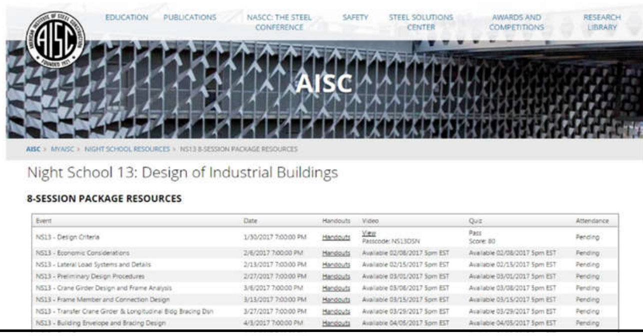
8-Session Registrants

Night School Resources



8-Session Registrants

Night School Resources


EDUCATION PUBLICATIONS NASCC: THE STEEL CONFERENCE SAFETY STEEL SOLUTIONS CENTER AWARDS AND COMPETITIONS RESEARCH LIBRARY

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AISC > MYAISC > NIGHT SCHOOL RESOURCES > NS13 8-SESSION PACKAGE RESOURCES

Night School 13: Design of Industrial Buildings

8-SESSION PACKAGE RESOURCES

Event	Date	Handouts	Video	Quiz	Attendance
NS13 - Design Criteria	1/30/2017 7:00:00 PM	Handouts	View Passcode: NS13DSN	Pass Score: 80	Pending
NS13 - Economic Considerations	2/6/2017 7:00:00 PM	Handouts	Available 02/08/2017 5pm EST	Available 02/08/2017 5pm EST	Pending
NS13 - Lateral Load Systems and Details	2/13/2017 7:00:00 PM	Handouts	Available 02/15/2017 5pm EST	Available 02/15/2017 5pm EST	Pending
NS13 - Preliminary Design Procedures	2/27/2017 7:00:00 PM	Handouts	Available 03/01/2017 5pm EST	Available 03/01/2017 5pm EST	Pending
NS13 - Crane Girder Design and Frame Analysis	3/6/2017 7:00:00 PM	Handouts	Available 03/08/2017 5pm EST	Available 03/08/2017 5pm EST	Pending
NS13 - Frame Member and Connection Design	3/13/2017 7:00:00 PM	Handouts	Available 03/15/2017 5pm EST	Available 03/15/2017 5pm EST	Pending
NS13 - Transfer Crane Girder & Longitudinal Bldg Bracing Dsn	3/27/2017 7:00:00 PM	Handouts	Available 03/29/2017 5pm EST	Available 03/29/2017 5pm EST	Pending
NS13 - Building Envelope and Bracing Design	4/3/2017 7:00:00 PM	Handouts	Available 04/05/2017 5pm EST	Available 04/05/2017 5pm EST	Pending

8-Session Registrants

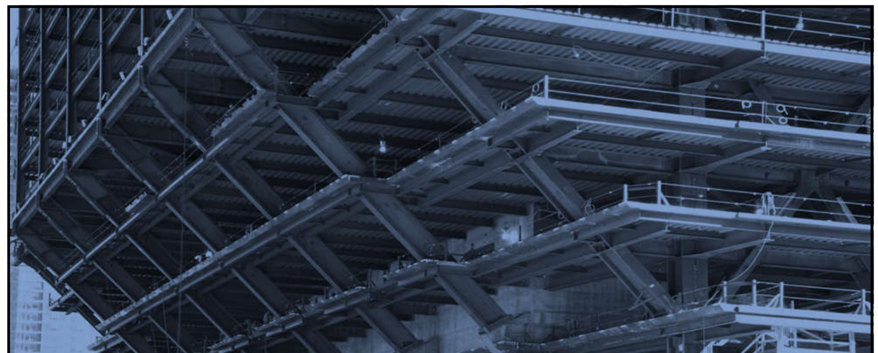
Night School Resources

- Weekly "quiz and recording" email.
- Weekly updates of the master quiz and attendance record, found at www.aisc.org/nightschool28. Scroll down to Quiz and Attendance records.
    - Updated on Friday mornings.

8-Session Registrants

Night School Resources

- Webinar connection information
    - Reminder email sent out Monday mornings
- Links to handouts also found here



AISC | Thank you

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