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Course Description

What an Engineer Needs to Know about Steel Erection January 19, 2017

With some early planning and interaction with the steel erector during the design phase, engineers may find that projects run more smoothly during construction. For the steel erector, certain details and specifications can be considered advantageous while others can be considered problematic. Knowing this information, the engineer can integrate better constructability into the drawings which can lead to a better outcome for the project. In this webinar, participants will learn what an engineer needs to know about steel erection. Topics will include:

- Erector (and fabricator) friendly connections
- Field welding guidelines
- Construction stability issues to consider
- Items in the specifications for the erector that may need clarification
- Examples of the use of Building Information Modeling (BIM) in erection planning

Learning Objectives

- Identify construction stability issues that can be addressed during the design phase
- Select erector and fabricator friendly connections when available
- Identify areas in the specifications for the erector that may need clarification
- Identify appropriate situations for field welding

What An Engineer Needs to Know About Steel Erection

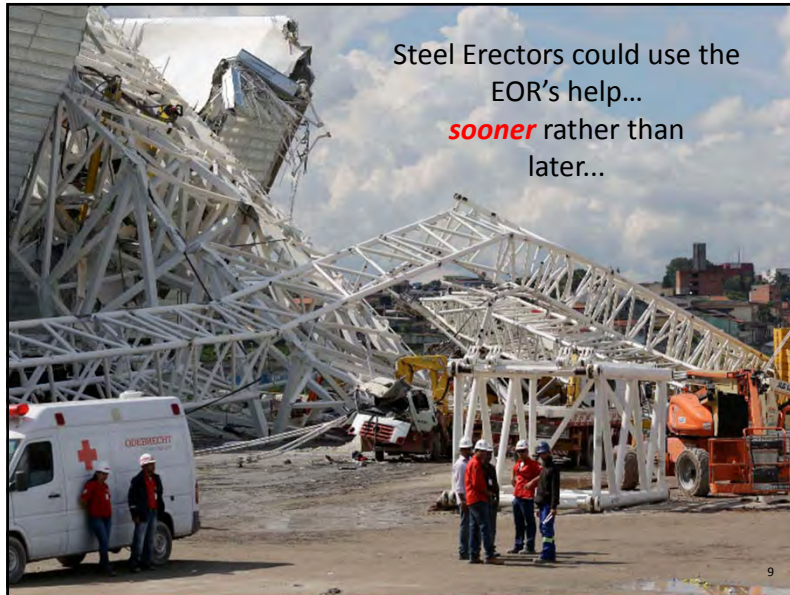


Presented by
Curtis Mayes, P.E.

LPR
CONSTRUCTION
Loveland, CO




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We will cover some of each of the following... For Steel Erection


- Specifications
- Safety
- Connections
- Lateral Force-Resisting Systems
- Using and Sharing BIM



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Specifications for Steel Erection



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What do you need to specify for the steel erector?


Rely on the **AISC Code of Standard Practice (COSP)** where you can.

Clarify your building behavior expectations.

COSP 7.10.1 – Temporary Support of Structural Steel Frames

- (a) The lateral force-resisting system...
- (b) Any special erection conditions...

How do you expect your structure to behave? Is it obvious? If not, clarify if you need anything loaded or constructed in a particular manner to assure the structure behaves the way you intended. If you don't do this, you are at risk to end up with a structure that does not perform as you would like. You should not assume the erector will understand the intended behavior of your structure.



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What do you need to specify?

COSP 7.12 – Structural Steel Frame Tolerances

The accumulation of the mill tolerances and fabrication tolerances shall not cause the erection tolerances to be exceeded.

A stark example of where accumulated tolerances can quickly overcome the expected field tolerances is in rolled tubes. In some cases when a HSS rectangle is rolled, the dimensions of the cross section changes, **dramatically**.

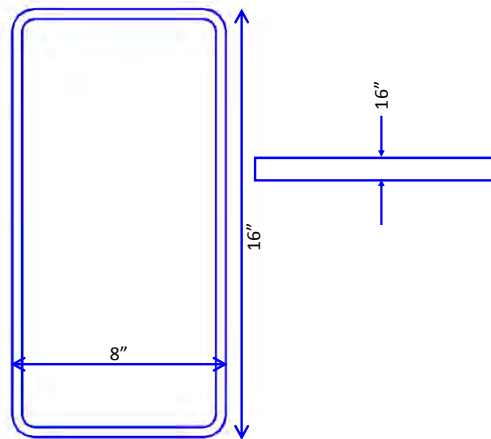


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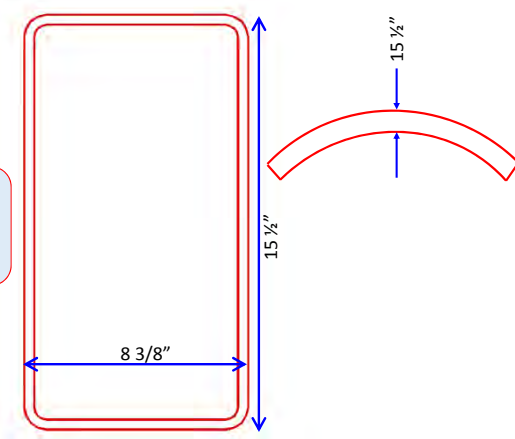
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HSS 16 x 8 x 3/8 as received from the mill

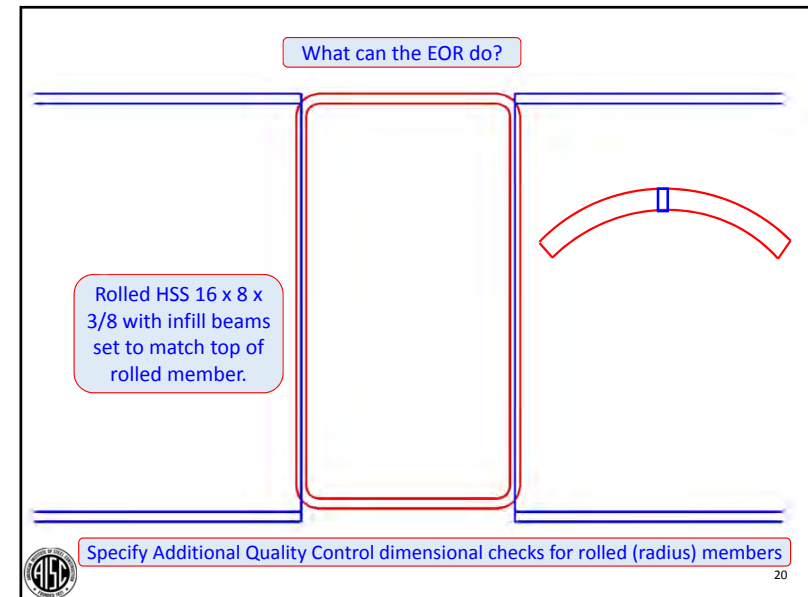
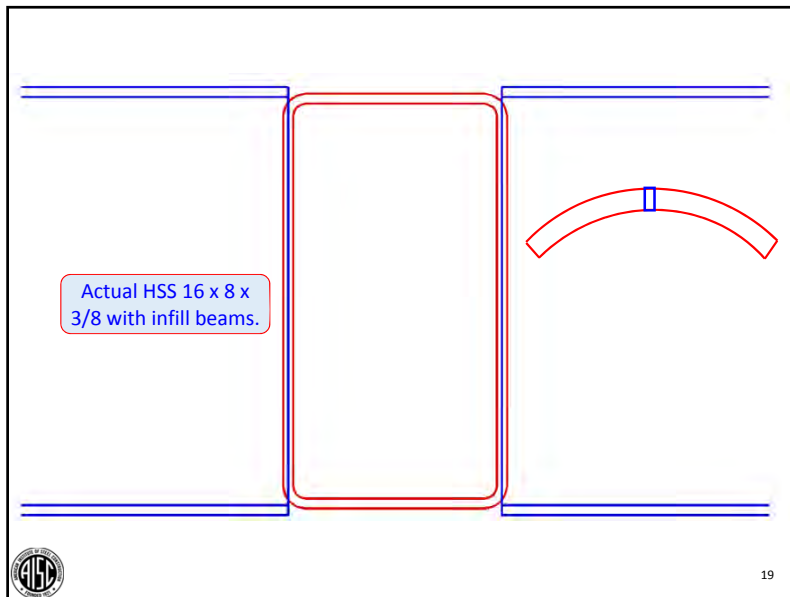
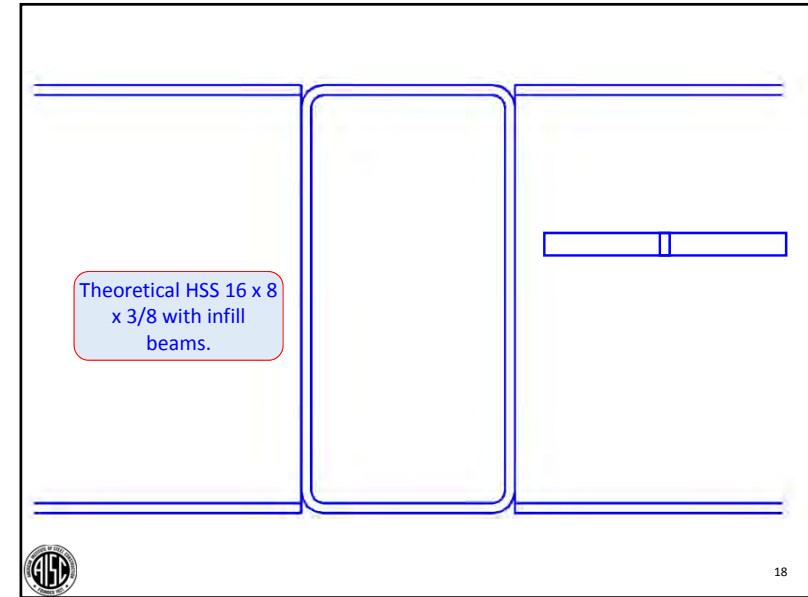
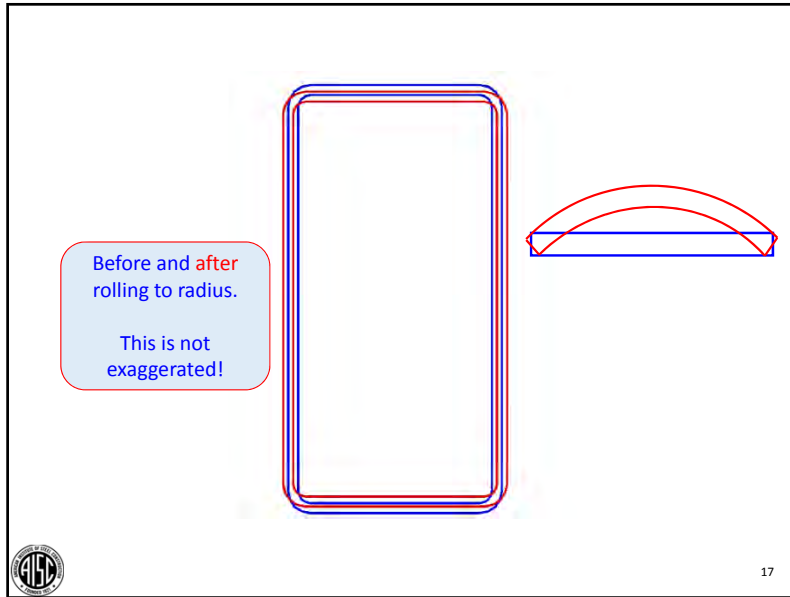


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HSS 16 x 8 x 3/8 rolling into arch shape resulting in 15 1/2 x 8 3/8



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What do you need to specify?

Clarify your building behavior expectations.

Case Study 1.

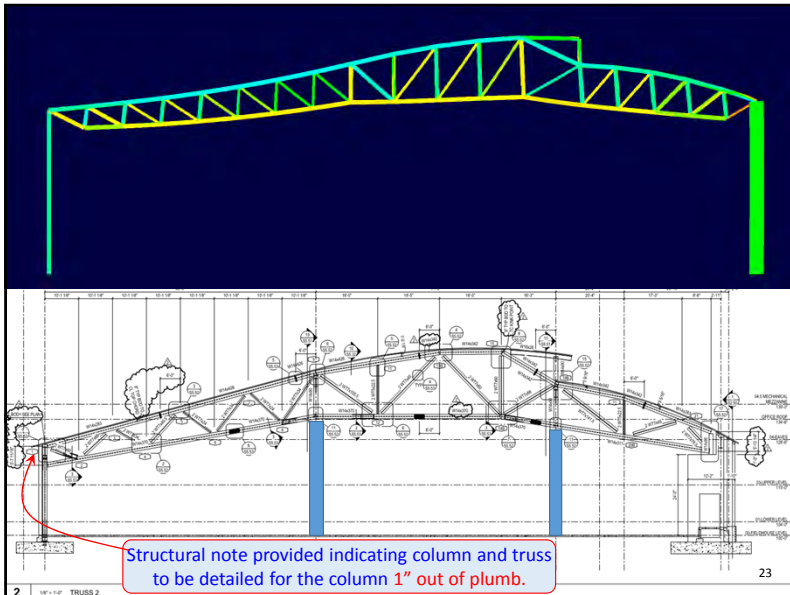
A **good** example of a specified intended structural behavior.



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What do you need to specify?

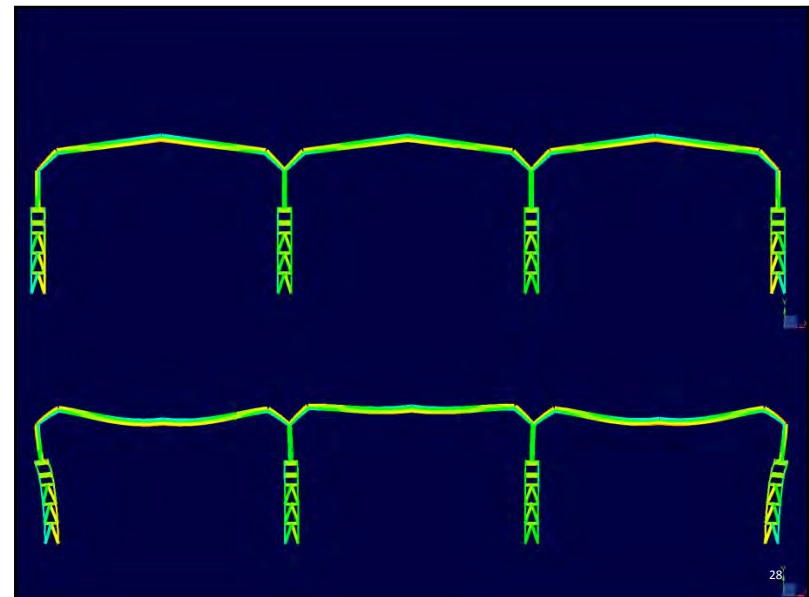
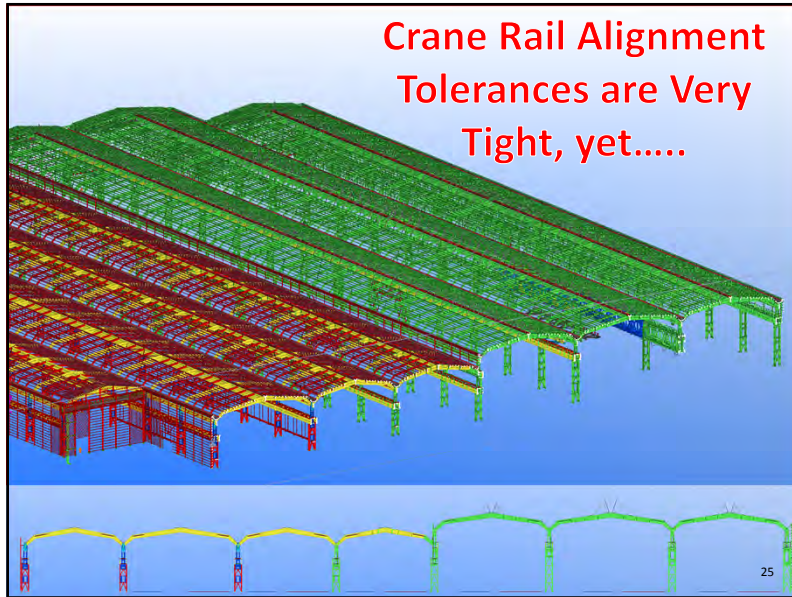
Clarify your building behavior expectations.

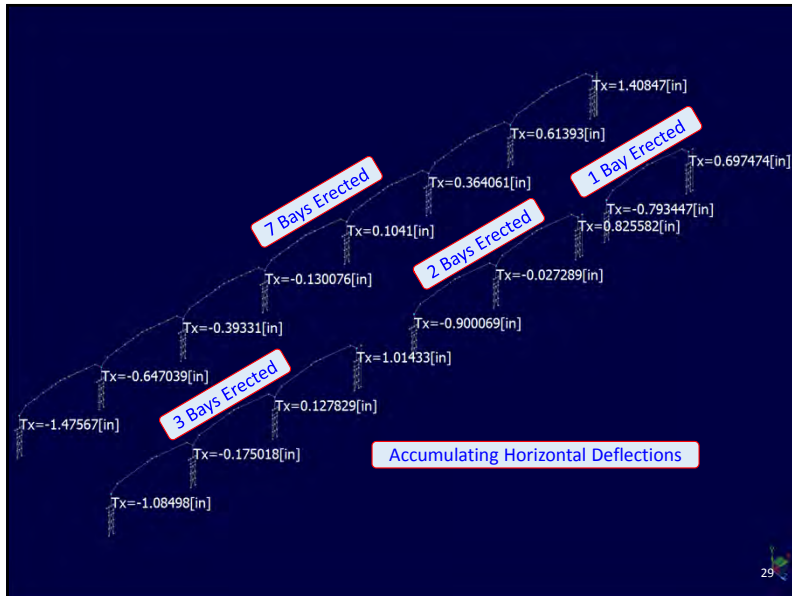
Case Study 2.

An example of an **unspecified** intended structural behavior with potential negative consequences.



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What do you need to specify?

Just consider construction safety.

The EOR knows the most about the structure and how it behaves, especially at the time that the specifications are released. Flag potential hazards.

Construction means and methods are not your responsibility.



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Hurricane Contingency Plans for Construction?

1. AISC Code of Standard Practice 7.10.3 clearly indicates that the erector shall not consider loads due to hurricane, tornado, earthquake, explosion or collision.
2. ASCE 37 does address provisions for hurricane load planning.

LPR believes hurricane load planning is an extraordinary measure and should be clearly addressed in your specifications.

First Choice: Builder Risk – No hurricane readiness plan per AISC Code of Standard Practice

Last Choice: Clearly indicate in specs that hurricane readiness plan is required and ask for separate pricing to evaluate the cost vs. risk.



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Safety for Steel Erection



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OSHA Subpart R

1926.755(a) General requirements for erection stability.


1926.755(a)(1) All columns shall be anchored by a minimum of 4 anchor rods (anchor bolts).

1926.755(a)(2) Each column anchor rod (anchor bolt) assembly, including the column-to-base plate weld and the column foundation, shall be designed to resist a minimum eccentric gravity load of 300 pounds (136.2 kg) located 18 inches (.46m) from the extreme outer face of the column in each direction at the top of the column shaft.

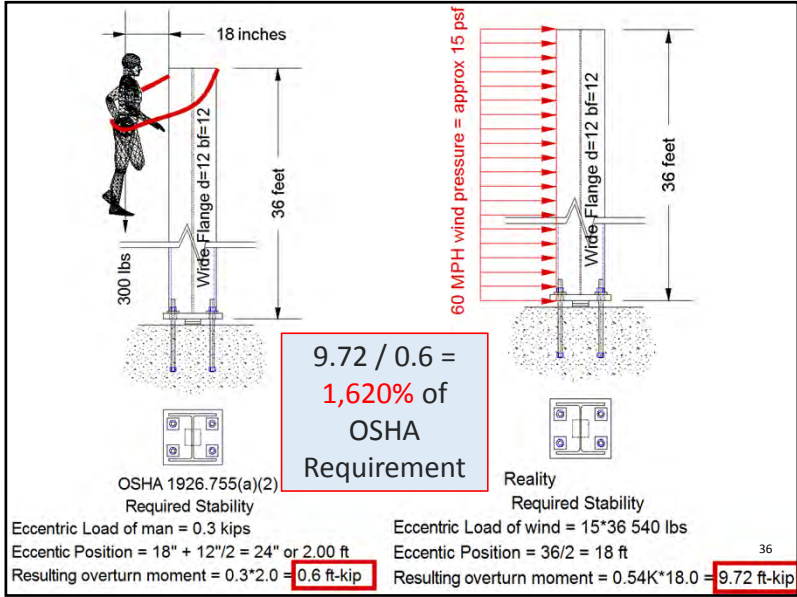
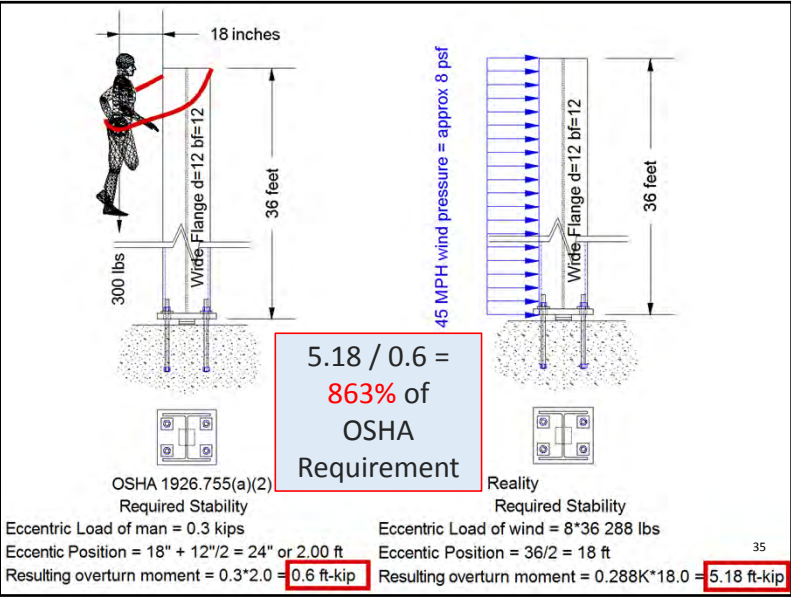
1926.755(a)(3) Columns shall be set on level finished floors, pre-grouted leveling plates, leveling nuts, or shim packs which are adequate to transfer the construction loads.

1926.755(a)(4) All columns shall be evaluated by a competent person to determine whether guying or bracing is needed; if guying or bracing is needed, it shall be installed.

1926.756(d) Column splices. Each column splice shall be designed to resist a minimum eccentric gravity load of 300 pounds (136.2 kg) located 18 inches (.46 m) from the extreme outer face of the column in each direction at the top of the column shaft.



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Brace Connections

OSHA

1926.756(b) **Diagonal bracing.** Solid web structural members used as diagonal bracing shall be secured by **at least one bolt per connection** drawn up wrench-tight or the equivalent as specified by the project structural engineer of record.

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Connections for Steel Erection

structural STEEL

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Notice:

The details shown in this presentation reflect some of the thoughts and preferences of LPR Construction. Each fabricator and erector has their own opinions and preferences that may vary from this presentation.

structural STEEL

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Just some basics

This is a much easier beam to column web connection for erection, but it comes with a significant fabrication cost. Certainly do this if you need continuity plates through the column.

Access to insert beams into column webs can present difficulties if this occurs on both ends of the beam.

An added plus here for infill is that short slots can be provided for infill, and is more forgiving for accumulated tolerances.

Double angle clip connections for infill beams are OK, but dealing with erecting the second side can be tricky and slow the erection.

Single shear tabs are faster in the field and economical for the shop. Some shops would prefer single sided clip angles if the design will allow as there could be no shop and no field welding.

Simply think about ease of access in your design and you can really help the erector with just a little effort.

Leave additional room for slotting if required

shop 5/16"

Anchor rod with 2 nuts

tack nut at bottom of rod or use double nut (very tight)

shim pack and anchor rod size depends on column size, height and load

Use 1" diameter minimum anchor rods

- normal structural dimensions as required + 1/2" added for slotting

Wide Flange or HSS Column oversized holes in base plates per AISC Manual 13th Edition Table 14-2

Design Anchor Rods for overturn resulting from 15 psf applied to face of freestanding column

Detail A Preferred Arrangement

nut plus plate washer

add 1"

Anchor rod with 3 nuts and 2 plate washers

see Detail A for notes and dimensions not shown

Wide Flange or HSS Column

Logistical Pre-requisites

- proper access to leveling nuts required after column is erected
- rods are fully threaded
- protect exposed threads prior to erection

Design Anchor Rods for overturn resulting from 15 psf applied to face of freestanding column

Detail B Arrangement if single shim pack will not work for anchor rod load

nut plus plate washer

add 1"

Anchor rod with 3 nuts

see Detail A for notes and dimensions not shown

Wide Flange or HSS Column

Logistical Pre-requisites

- proper access to leveling nuts required after column is erected
- rods are fully threaded
- protect exposed threads prior to erection

Design Anchor Rods for overturn resulting from 15 psf applied to face of freestanding column

Detail C Best Arrangement for large Shear Key



see Detail A for notes and dimensions not shown

maximize

maximize

Wide Flange Column

Design Anchor Rods for overturn resulting from 15 psf applied to face of freestanding column

Detail E
Preferred arrangement
If anchor rods
must be inside flanges

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see Detail A for notes and dimensions not shown

nut plus plate washer

add 1"

maximize

maximize

Wide Flange Column

Logistical Pre-requisites

- proper access to leveling nuts required after column is erected
- rods are fully threaded
- protect exposed threads prior to erection

Design Anchor Rods for overturn resulting from 15 psf applied to face of freestanding column

Detail F
Arrangement if anchor rods must be inside flanges and single shim pack will not work for anchor rod load

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Column splices are just as "safety critical" as anchor rods

SEAA and NIST are both still promoting "300 lbs at 18 inches" as ... "safe" design criteria.

DETAILING GUIDE FOR THE ENHANCEMENT OF ERECTION SAFETY

LPR requires erection connection to resist the greater of the 2 following conditions:
1) 15 psf horizontal wind load applied in any direction on freestanding column;
2) 300 lb eccentric load located 18" from the column face in any direction at the top of the column.

Each column assembly shall be designed to resist a 300 pounds eccentric load located 18" from the column face in any direction at the top of the column.

Upper column

Lower column

B-U4e Typ.

17 Rot holes

Temp. erection splice plate not shown for clarity

Wide Flange Col.

NOTES:
Web splice plates might be sufficient at partial penetration welds where there is no root opening required. Always check with E.O.R. or design engineer for requirements.

TITLE: Welded Column Splice (Suggested) 1926-756(d)

ERECTOR/FABRICATOR NAME

JOB NAME

DATE

REV#

DATE

SKETCH No. M75

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Or, if channel bending actually can handle the wind load.

W14 x 61 or larger

13/16 dia. holes in column

15/16 dia. holes in channel with 3/4 dia A325 bolts

2 washers each

Partial Pen.

2 1/8" lift hole

C9x15

Shim as required

(Note: Use 2 channels for column shafts over 30' 0" long or over 100 lbs. per foot)

Web only splice OK if you know you will get significant flange bearing

Note: Minimum land for this detail is 1/4" if land is < 1/4" use 4 corner brackets

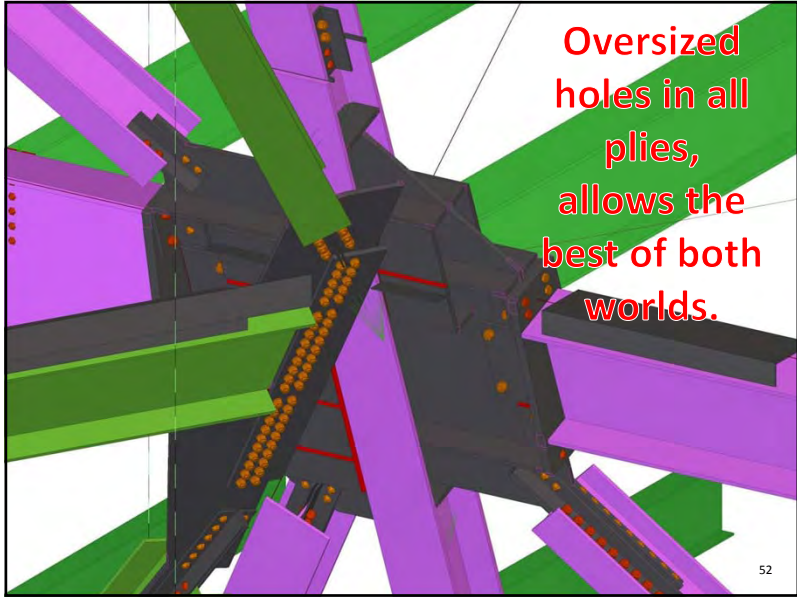
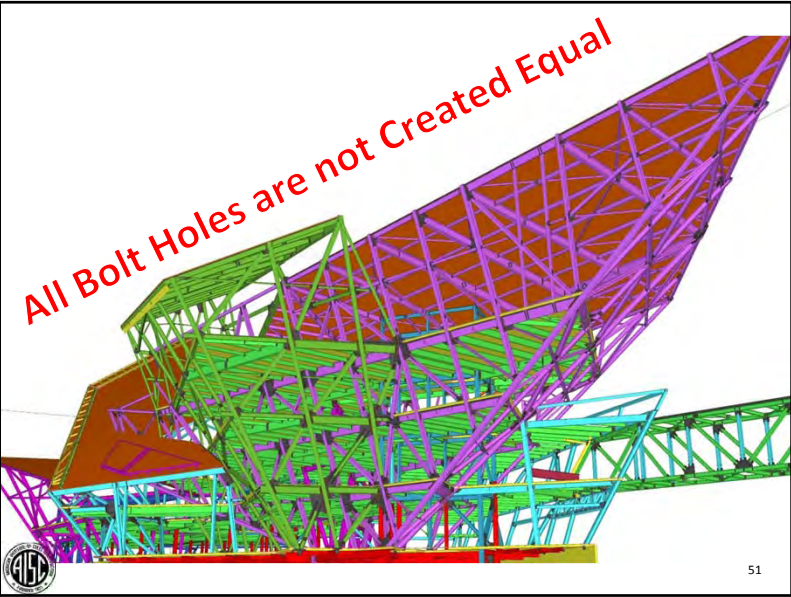
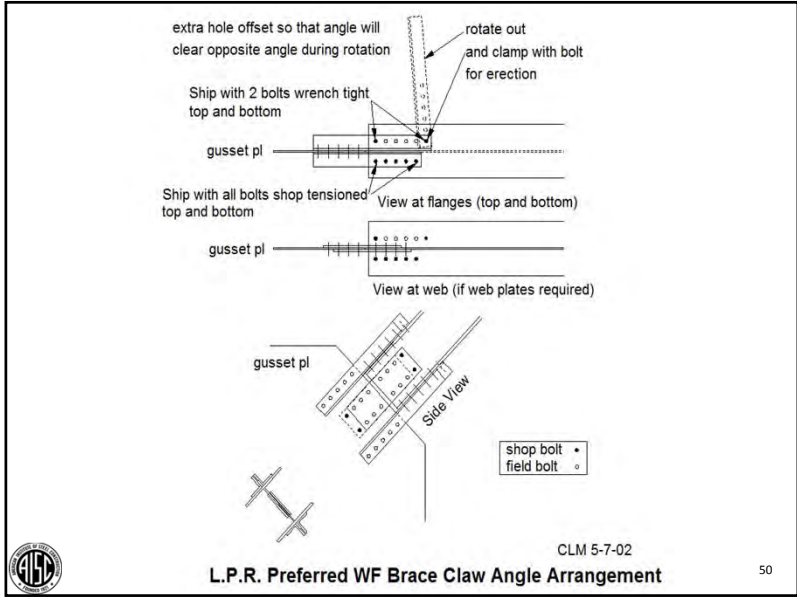
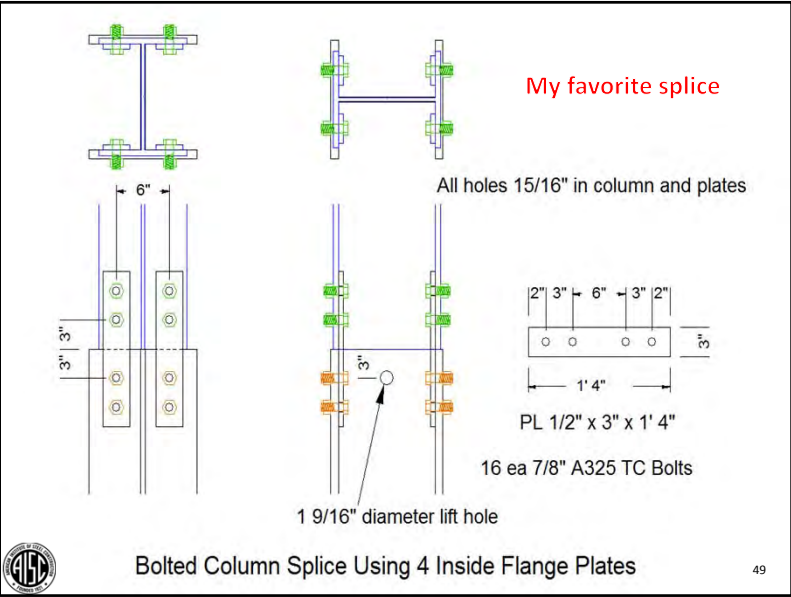
Return 5/16 2"

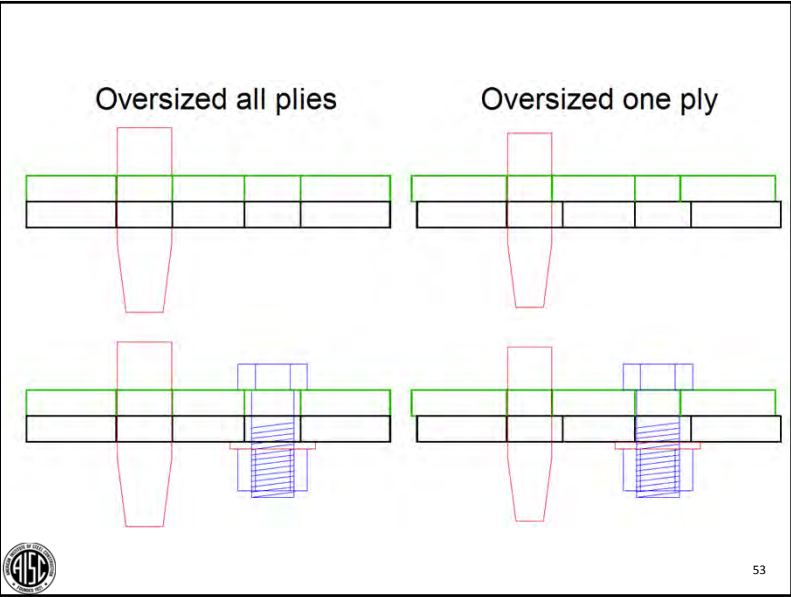
5/16 6"

Erection Connection for Partial Penetration Column Splice

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Slots everywhere adds cost and reduces quality

accumulation of mill tolerance is more dramatic for beam to column flange connections
 therefore use more short slotted connections (example every 5 bays)

Infill beams, however can have short slots both ends which can be quite beneficial

accumulation of mill tolerance error much less dramatic for beam to column web connections
 therefore use less short slotted connections (example every 10 bays)

Beam Legend
— regular beam with no slots requiring column spacing
— occasional adjustment beam with slots available on one end to bring column spacing back into tolerance

Please use this guideline to avoid unnecessary work in the field to space every column.

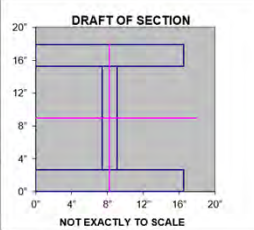
Use of Short Slots at Beam to Column Connections



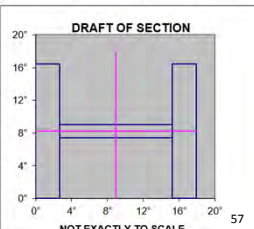
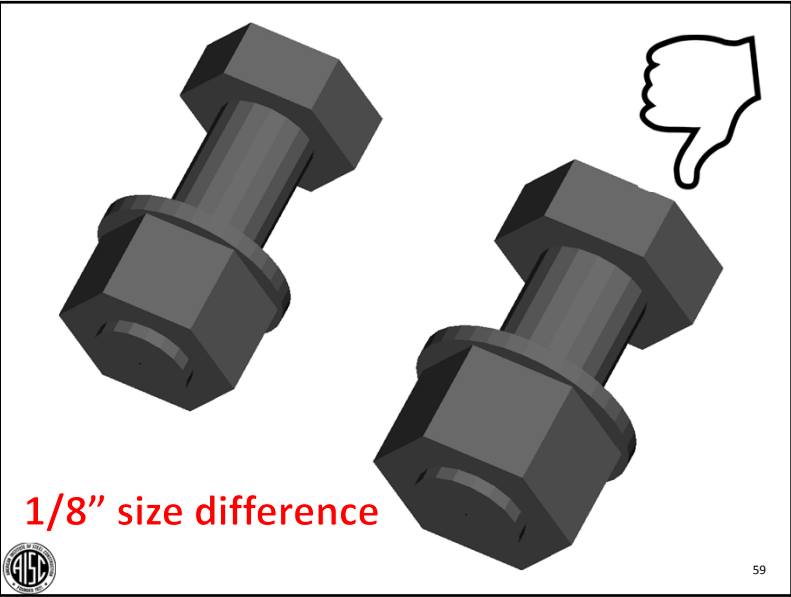
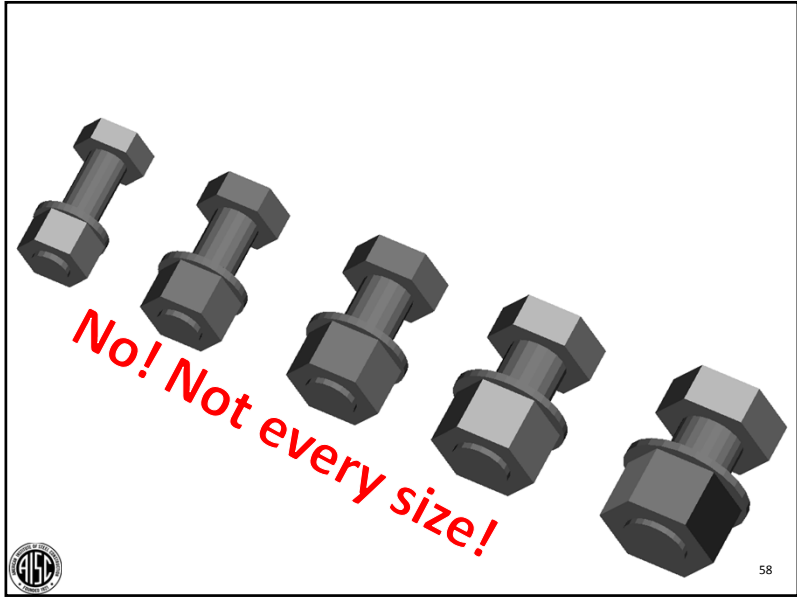
Some things require only a small design effort to help with constructability.

How you orient your truss chords is very significant to the erector.

Truss Top Chord Stability - Shore and Guy Check	
W 14 x 370	
Total Length	145.00'
Input - Total Truss Weight	160.95 kips
Select Top Chord Web Orientation	vertical
Input - Truss Depth	12.00'
Input Material Strength - Fy (KSI)	50 ksi
Input - Number of shores	0
Input - Guys per span	0
Number of spans	1
Span Length	145.00'
total Guys not including shores	0 guys/truss
243.102 kips Top Chord Compr Load	98.025 kips Top Chord Capacity
	248.0% OF REQ'D CAPACITY
	NOT STABLE



Truss Top Chord Stability - Shore and Guy Check	
W 14 x 370	
Total Length	145.00'
Input - Total Truss Weight	160.95 kips
Select Top Chord Web Orientation	horizontal
Input - Truss Depth	12.00'
Input Material Strength - Fy (KSI)	50 ksi
Input - Number of shores	0
Input - Guys per span	0
Number of spans	1
Span Length	145.00'
total Guys not including shores	0 guys/truss
243.102 kips Top Chord Compr Load	268.731 kips Top Chord Capacity
	90.5% OF REQ'D CAPACITY
	STABLE

Designing Field Welds

Be
"empathetic"
of the welder



Imagine yourself wearing the Ironworker's Boots.




As well as wearing the face shield.




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Position of the weld:



Initially, We Ironworkers learn how to weld on the ground...

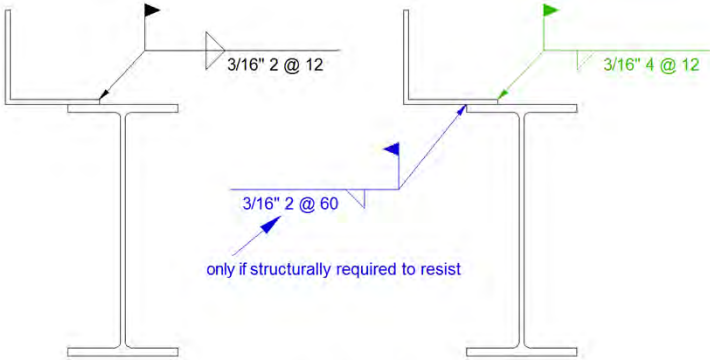


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Then, the real world sets in.



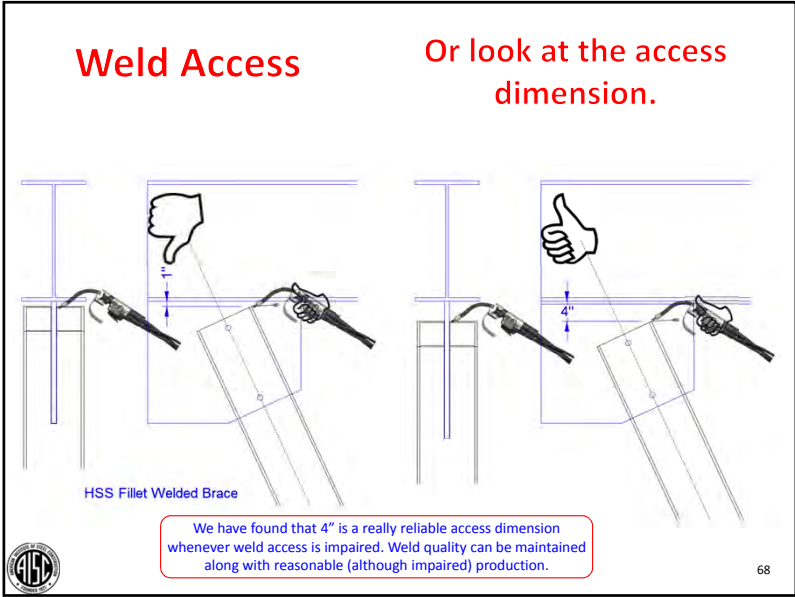
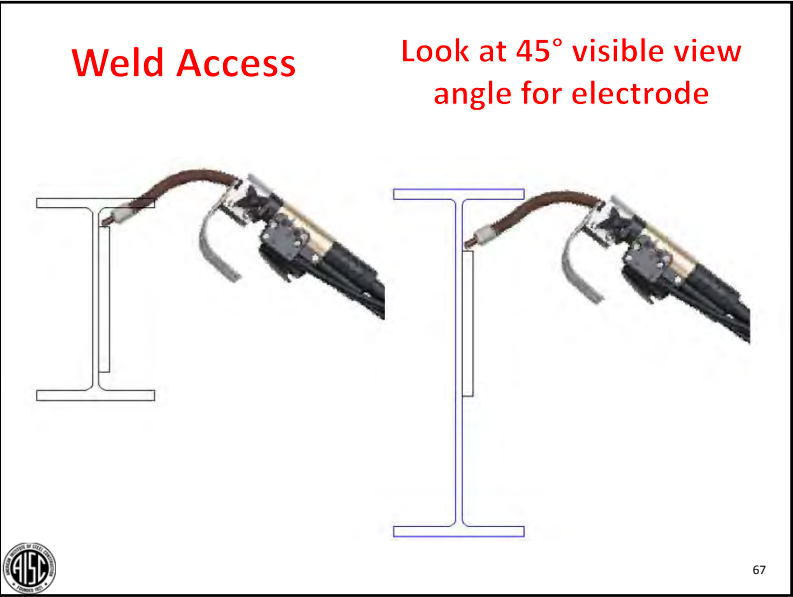
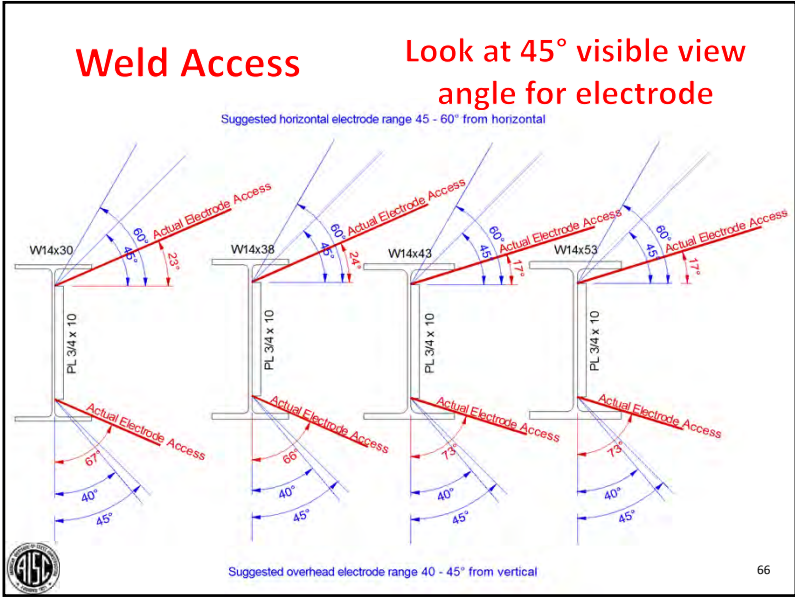
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Avoid Overhead Weld As Much As Possible



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Priority #5: Quantity of the weld: Fillet Weld Size Matters:

Fillet Welds: Production = passes
5/16" is typical maximum field weld fillet size and optimum weld size.
Bump a 5/16" weld up to 3/8" and it takes almost twice as long to install.

Fillet Weld Cost Comparison												
Load to Resist	Fillet Weld Size	Strength of Weld	Linear Inches of Weld Required	Number of Passes Required	Total Inches to weld	Production Inches per hour	Hours to weld	Cost Per Hour	Cost to weld	\$ per kip		Relative Cost
100.0 kips	1/8"	1.9 k/in	53.9"	1	53.9"	60.0"/hr	0.898hrs	\$ 55.00	\$ 49.38	\$ 0.49	150%	increase over 5/16" size
100.0 kips	3/16"	2.8 k/in	35.9"	1	35.9"	60.0"/hr	0.599hrs	\$ 55.00	\$ 32.92	\$ 0.33	67%	increase over 5/16" size
100.0 kips	1/4"	3.7 k/in	26.9"	1	26.9"	60.0"/hr	0.449hrs	\$ 55.00	\$ 24.69	\$ 0.25	25%	increase over 5/16" size
100.0 kips	5/16"	4.6 k/in	21.5"	1	21.5"	60.0"/hr	0.359hrs	\$ 55.00	\$ 19.75	\$ 0.20	0%	increase over 5/16" size
100.0 kips	3/8"	5.6 k/in	18.0"	2	35.9"	60.0"/hr	0.599hrs	\$ 55.00	\$ 32.92	\$ 0.33	67%	increase over 5/16" size
100.0 kips	7/16"	6.5 k/in	15.4"	2	30.8"	60.0"/hr	0.513hrs	\$ 55.00	\$ 28.22	\$ 0.28	43%	increase over 5/16" size
100.0 kips	1/2"	7.4 k/in	13.5"	3	40.4"	60.0"/hr	0.673hrs	\$ 55.00	\$ 37.04	\$ 0.37	88%	increase over 5/16" size
100.0 kips	9/16"	8.4 k/in	12.0"	4	47.9"	60.0"/hr	0.798hrs	\$ 55.00	\$ 43.90	\$ 0.44	122%	increase over 5/16" size
100.0 kips	5/8"	9.3 k/in	10.8"	5	53.9"	60.0"/hr	0.898hrs	\$ 55.00	\$ 49.38	\$ 0.49	150%	increase over 5/16" size
100.0 kips	11/16"	10.2 k/in	9.8"	5	49.0"	60.0"/hr	0.816hrs	\$ 55.00	\$ 44.89	\$ 0.45	127%	increase over 5/16" size
100.0 kips	3/4"	11.1 k/in	9.0"	6	53.9"	60.0"/hr	0.898hrs	\$ 55.00	\$ 49.38	\$ 0.49	150%	increase over 5/16" size
100.0 kips	13/16"	12.1 k/in	8.3"	7	58.0"	60.0"/hr	0.967hrs	\$ 55.00	\$ 53.18	\$ 0.53	169%	increase over 5/16" size
100.0 kips	7/8"	13.0 k/in	7.7"	8	61.6"	60.0"/hr	1.026hrs	\$ 55.00	\$ 56.44	\$ 0.56	186%	increase over 5/16" size
100.0 kips	15/16"	13.9 k/in	7.2"	10	71.8"	60.0"/hr	1.197hrs	\$ 55.00	\$ 65.84	\$ 0.66	233%	increase over 5/16" size
100.0 kips	1"	14.9 k/in	6.7"	11	74.1"	60.0"/hr	1.235hrs	\$ 55.00	\$ 67.90	\$ 0.68	244%	increase over 5/16" size

There's always a solution in steel.

Lateral Force-Resisting Systems for Steel Erection



AISC Code of Standard Practice 7.10. Temporary Support of Structural Steel Frames

7.10.1. The owner's designated representative for design shall identify the following in the contract documents:

- The **lateral force-resisting system** and connecting diaphragm elements that provide for lateral strength and stability in the completed structure.
- Any **special erection conditions** or other considerations that are required by the design concept, such as the use of shores, jacks or loads that must be adjusted as erection progresses to set or maintain camber, position within specified tolerances or prestress.



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Lateral force resisting system?

- Roof deck diaphragm?
- Concrete on deck diaphragm?
- Formed and poured in place concrete decks?
- Moment frame?
- Braced frame?
- Horizontal bracing?
- Vertical bracing?
- Rigid or fixed column bases?
- Shear walls?
- Sheet rock? ;)


Simply clarify your intended permanent lateral load path on your drawings. The more unusual the lateral stability system, warrants more effort to describe the system in your contract documents. Do not assume the erector will know what you have in mind.



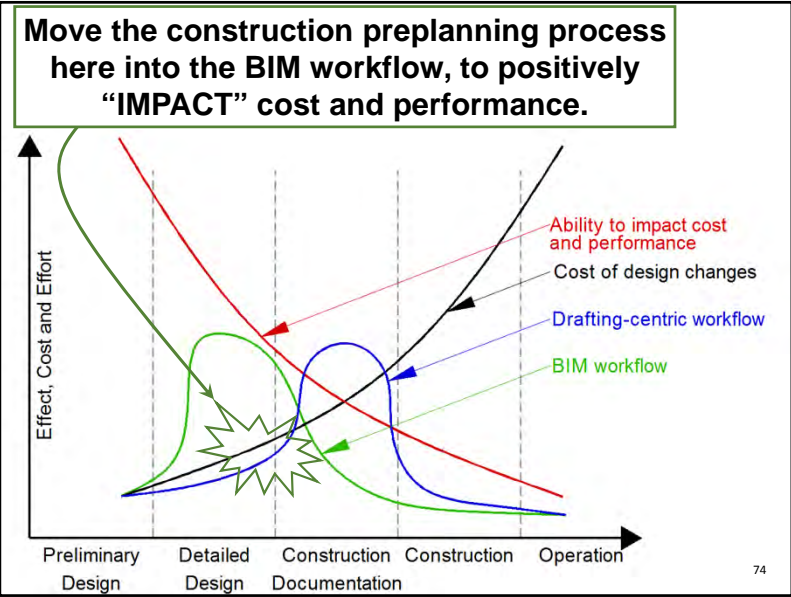
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Using and Sharing BIM for Steel Erection



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EOR Benefits of Sharing BIM Information Early

1. Improved and streamlined collaboration with the Fabricator and Erector
2. Construction team can help identify clashes much earlier.
3. Visual aid dramatically increases understanding of the contract documents, resulting in EOR spending less time attending to construction changes and rework design.

How Erectors can use BIM

1. Enhanced view of the construction conditions, including crane access, work access and, construction load paths.
2. Quick and accurate lift weight information, resulting in better lift planning.
3. Reduced chances of the erector missing or misunderstanding an important detail.
4. A valuable tool for developing and illustrating construction plans that are easily understood by field workers, construction team members, owners and design team.



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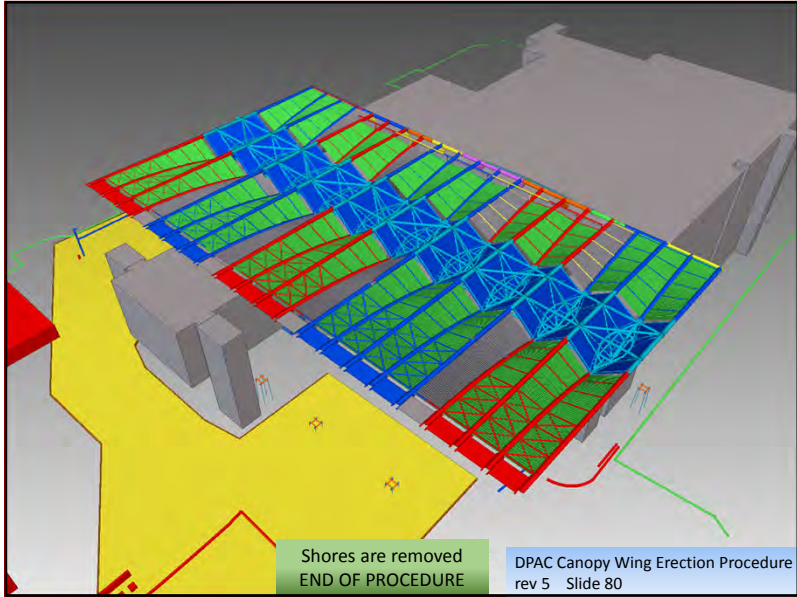
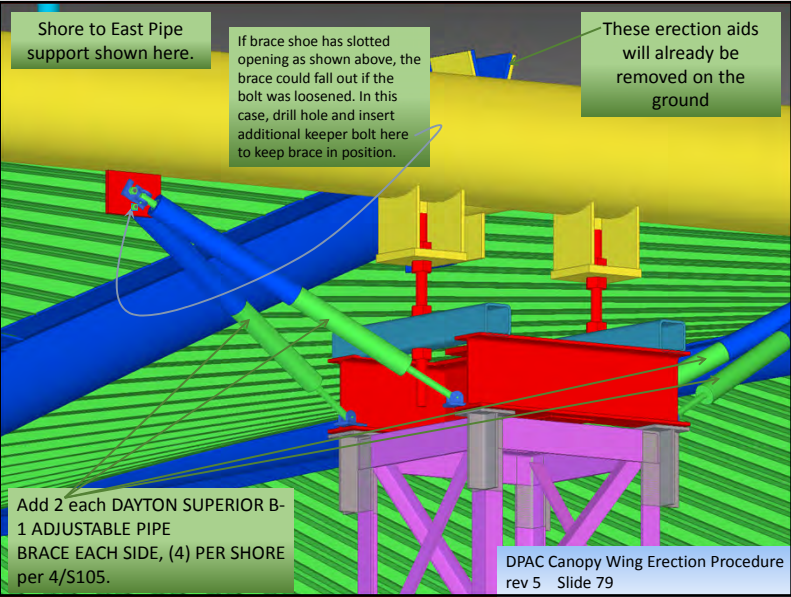
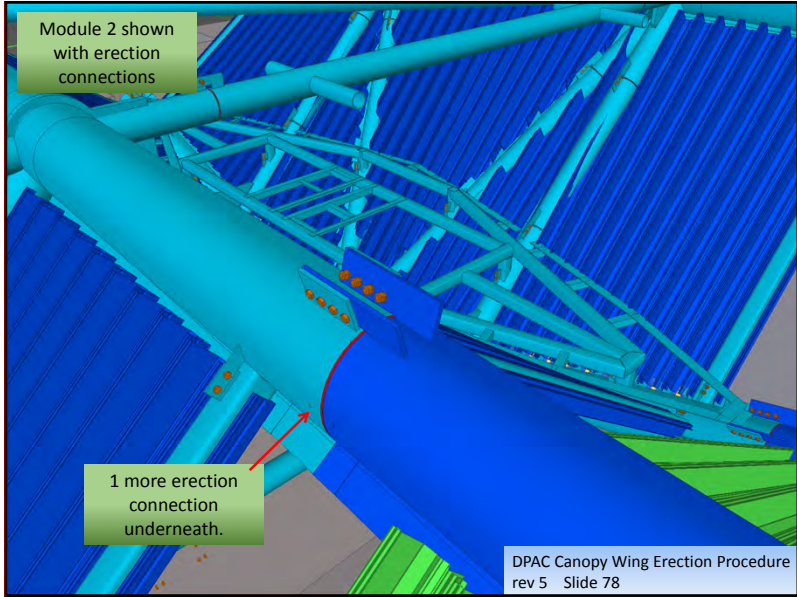
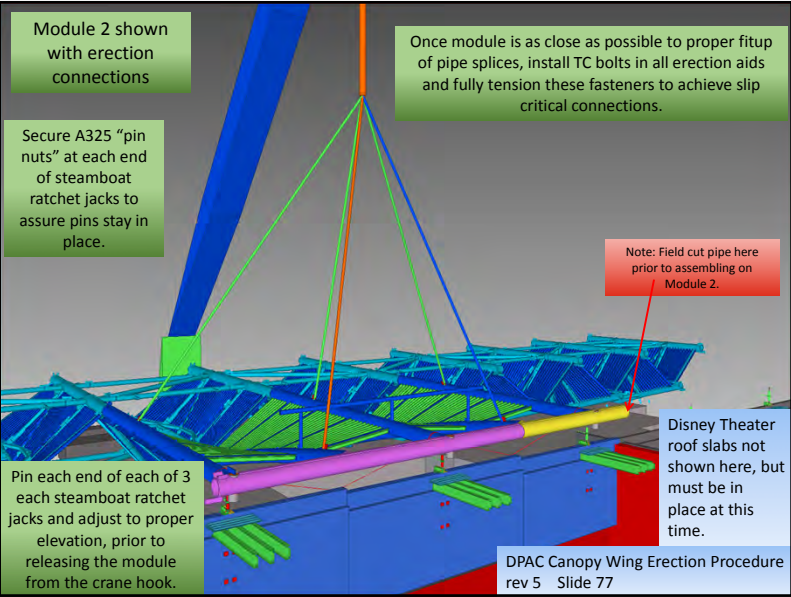
Lift and Set Module 2

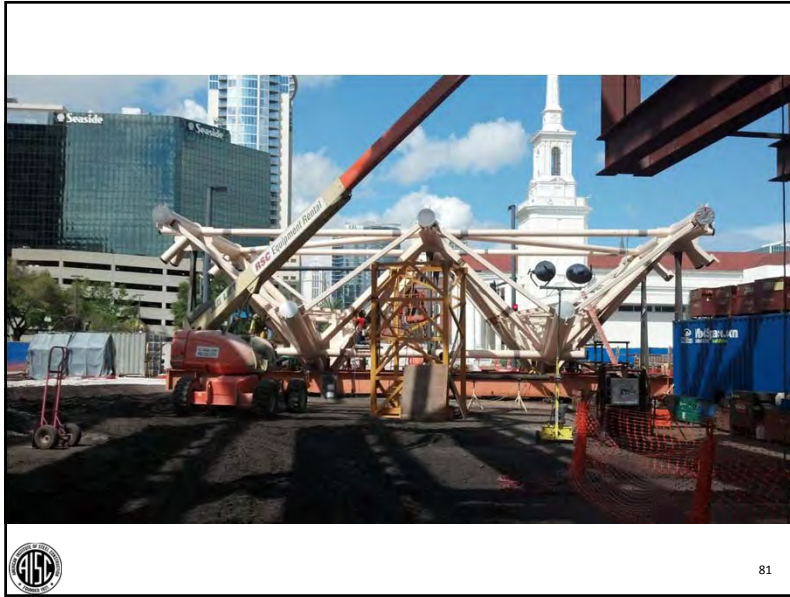
DPAC Canopy Wing rev 5 with East Pipes	Lift Wing Module 2	Set Wing Module 2
Weight of Lift	77,574 lbs	77,574 lbs
Crane Designation	130010508	13010503
Boom Length	125 ft	125 ft
	Liebherr LR1300 105ft main 125ft Heavy luffing Chart 350 deg 86 deg bn angle 2316-2 load fall point	Liebherr LR1300 105ft main 125ft Heavy luffing Chart 350 deg 83 deg bn angle 2316-2 load fall point
Long Crane Description	Luffing Jib	Luffing Jib
Using Jib, Luffing jib or Boom?	71.000'	71.000'
Crane Position (X)	128.373'	128.373'
Crane Position (Y)	49.200'	171.276'
Load Position (X)	46.510'	126.973'
Load Position (Y)	83.2233'	100.2760'
Radius of Lift	122,290 lbs	109,169 lbs
Raw Crane Capacity	54,750' bn ang	50,171' bn ang
Crane Boom Angle	272.7541 hrz	0.0000' hrz
Using Crane Angle	205.79'	205.79'
Number of parts in hoist line	6 parts	6 parts
Load Line only capacity	193,500 lbs	193,500 lbs
Lead line	2.3 pfl	2.3 pfl
Main Boom Lock Weight	5,837 lbs	5,837 lbs
Other Rigging Weight	1,849 lbs	1,849 lbs
Weight of hoist line	2,334 lbs	2,340 lbs
Total rigging weight	10,620 lbs	10,526 lbs
Add for Wind Sill Effect (EGL)	5,527 lbs	4,587 lbs
Total Suspended Load	93,721 lbs	92,687 lbs
Total Load Under Subject Sheave	82,357 lbs	82,263 lbs
Percent of rated chart capacity	76.6%	86.8%
Percent of rated L line capacity	42.6%	42.5%
Wind Speed	25 mph	25 mph
Avg Height of lift above ground	115'	115'
Projected area of lift	1,600 sq ft	1,600 sq ft
Wind Pressure for associated	2.5 psf	2.5 psf
horizontal Load due to wind	4,000 lbs	4,000 lbs
EGL = Equiv Gravity Load (wind)	5,527 lbs	4,587 lbs
Limiting Wind 2% Side Load	19.5 MPH	18.5 MPH

NOTE: LR1300 Configured with 105' main boom and 125' luffing jib.

DPAC Canopy Wing Erection Procedure rev 5 Slide 76










There's always a solution in steel.

Questions?



Presented by
Curtis L. Mayes, P.E.

LPR
CONSTRUCTION
Loveland, CO




structural
STEEL

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Polling Question

Slots in beam to column connections should be used:

- Always and everywhere possible
- Never
- Sparsely to manage accumulating tolerances



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PDH Certificates

Within 2 business days...

- You will receive an email on how to report 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!

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There's always a solution in steel.

Thank You

Please give us your feedback!
Survey at conclusion of webinar.

A large, light gray watermark of the AISC logo is positioned in the bottom right corner of the slide. The logo consists of a circular emblem with the letters 'AISC' in the center, surrounded by the text 'AMERICAN INSTITUTE OF STEEL CONSTRUCTION' and 'FOUNDED 1921'. Below the emblem, the words 'structural STEEL' are written in a sans-serif font.