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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

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## What An Engineer Needs to Know About Steel Erection

**Presented by**
**Curtis Mayes, P.E.**

LPR CONSTRUCTION

**Loveland, CO**

AISC ASSOCIATE | AISC CERTIFIED ERECTOR

structural STEEL


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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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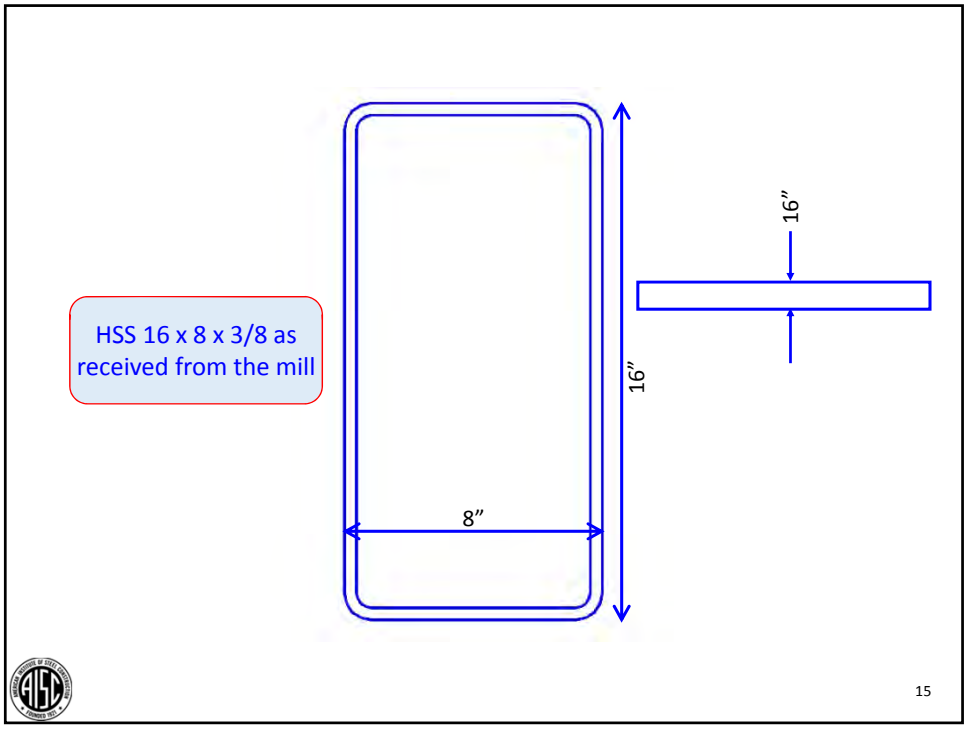


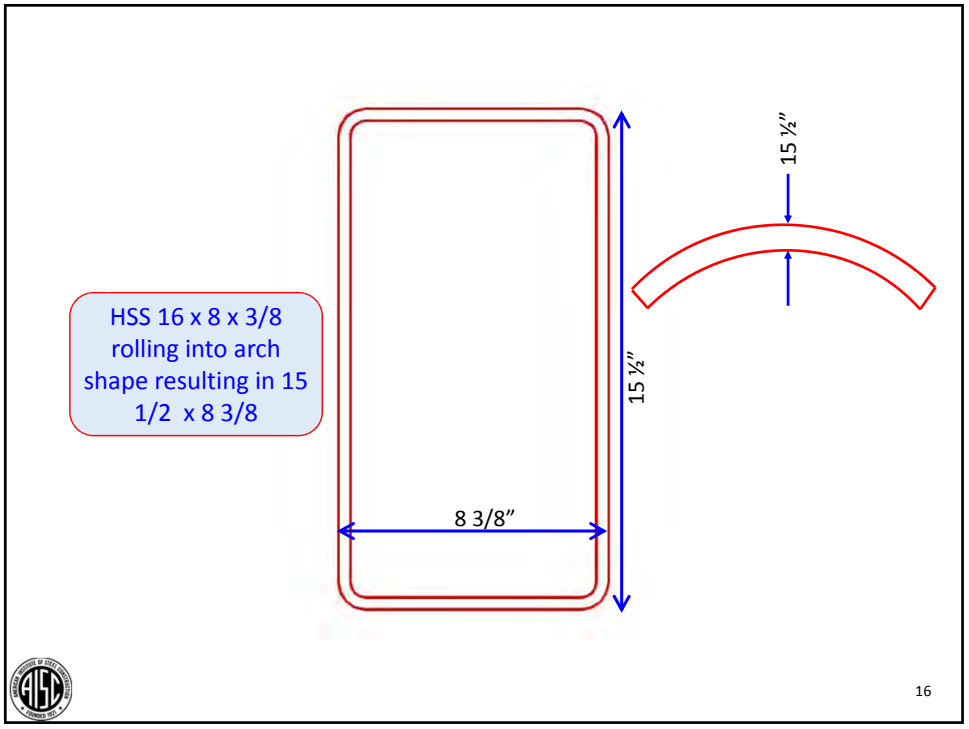

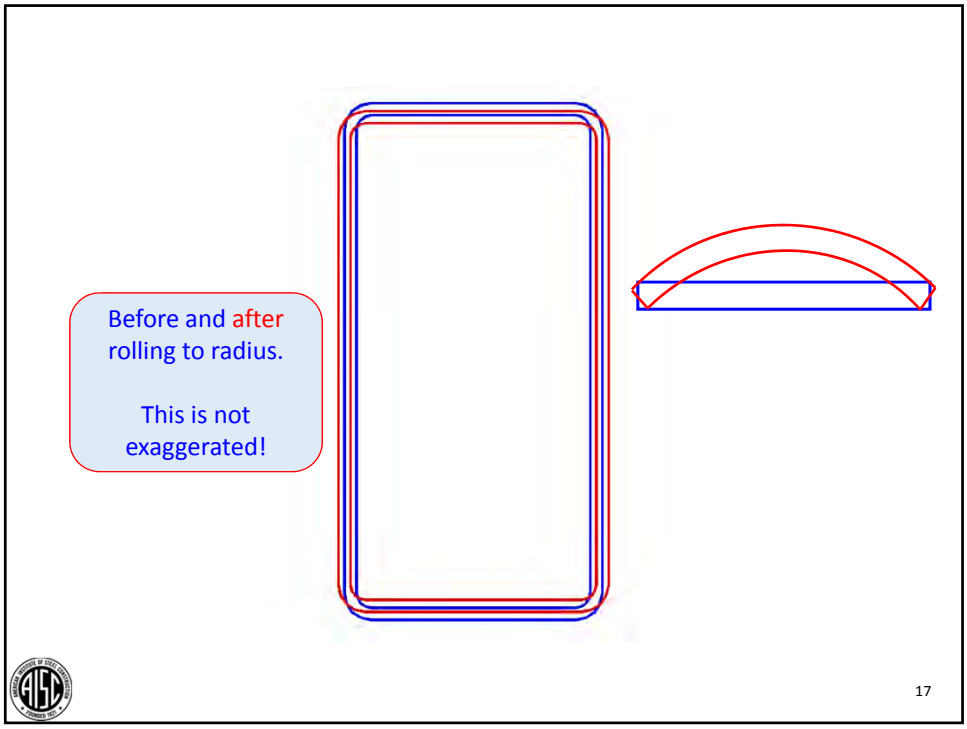


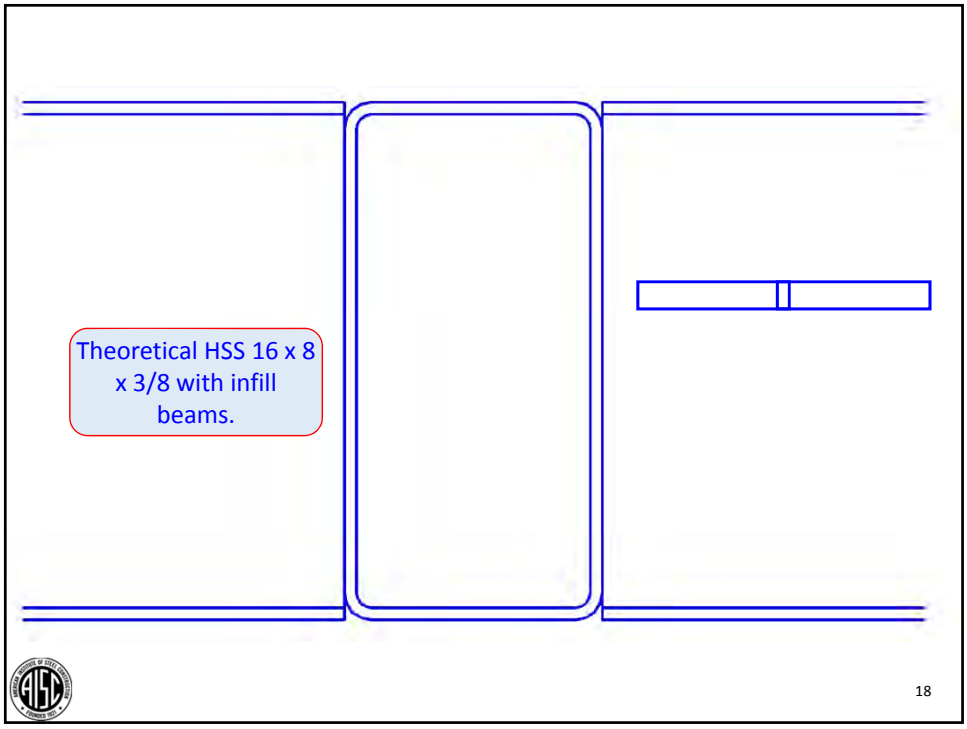

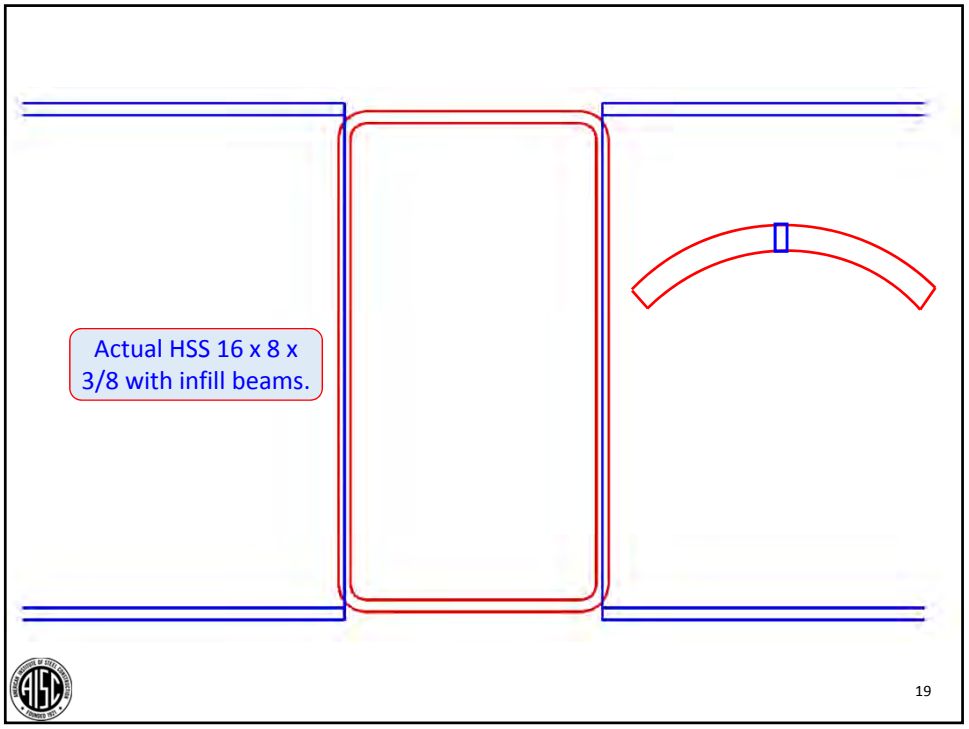


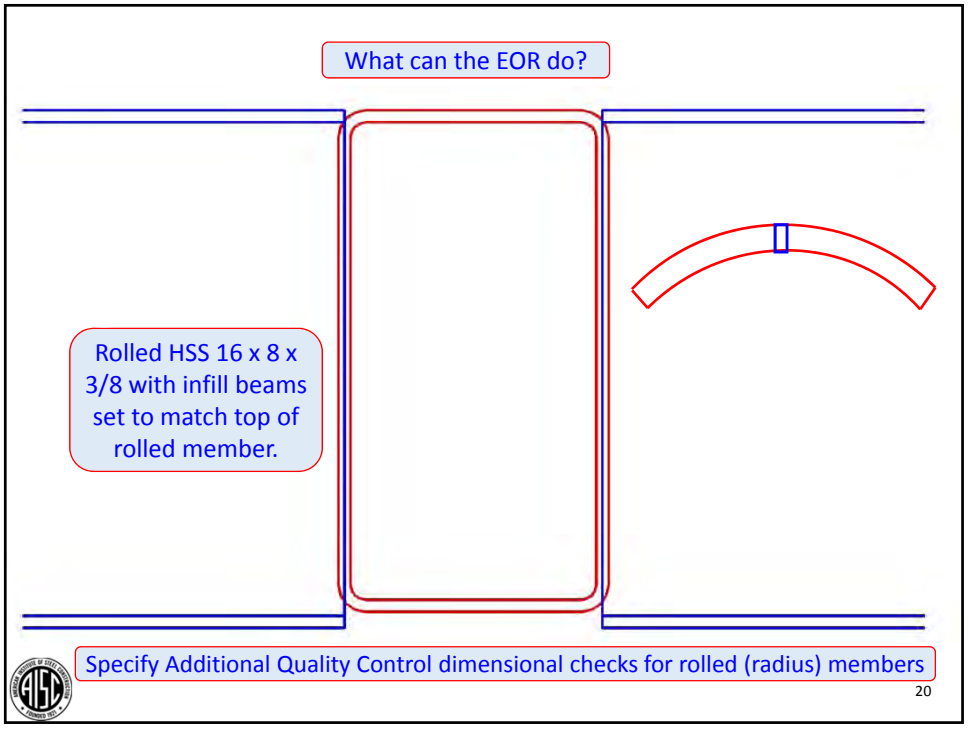

What do you need to specify?

Clarify your building behavior expectations.

Case Study 1.

A good example of a specified intended structural behavior.

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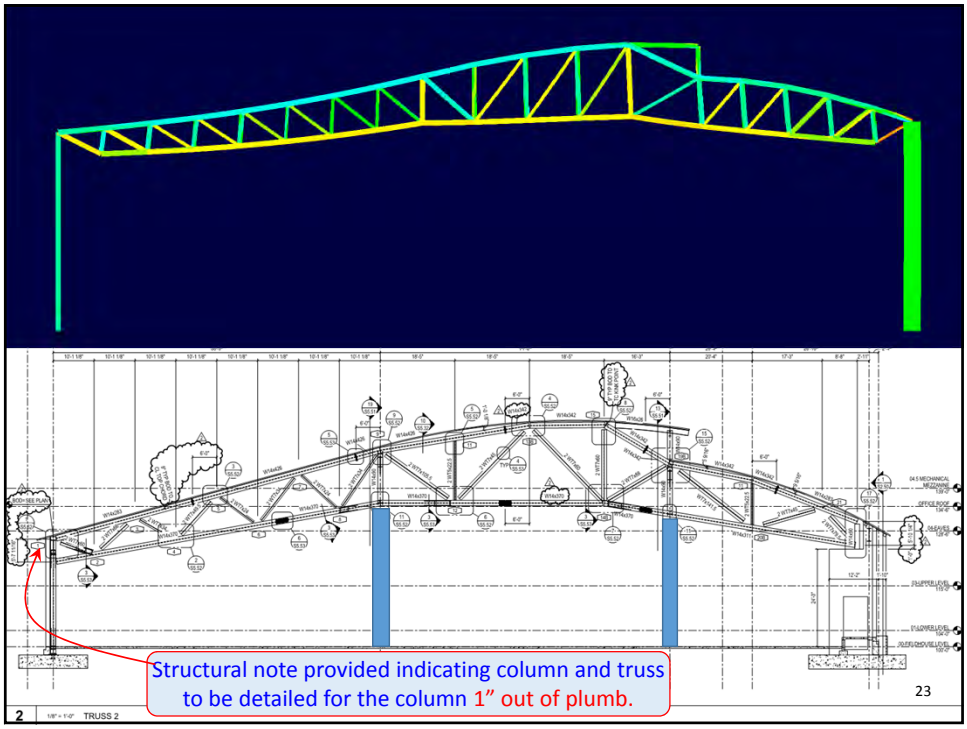


What do you need to specify?

Clarify your building behavior expectations.

Case Study 2.

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

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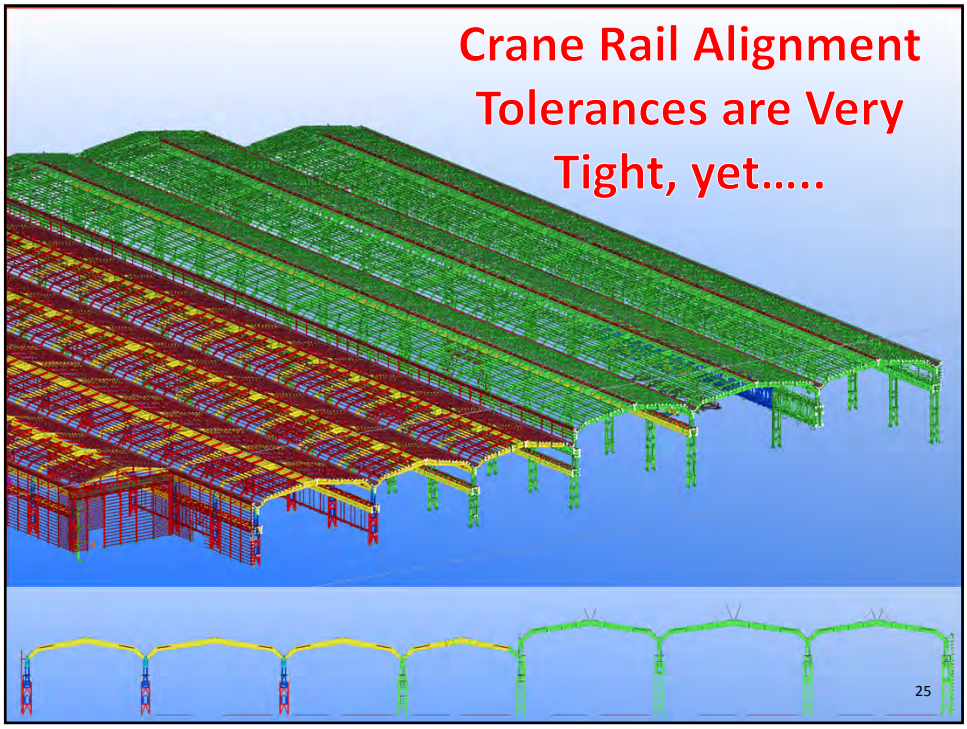



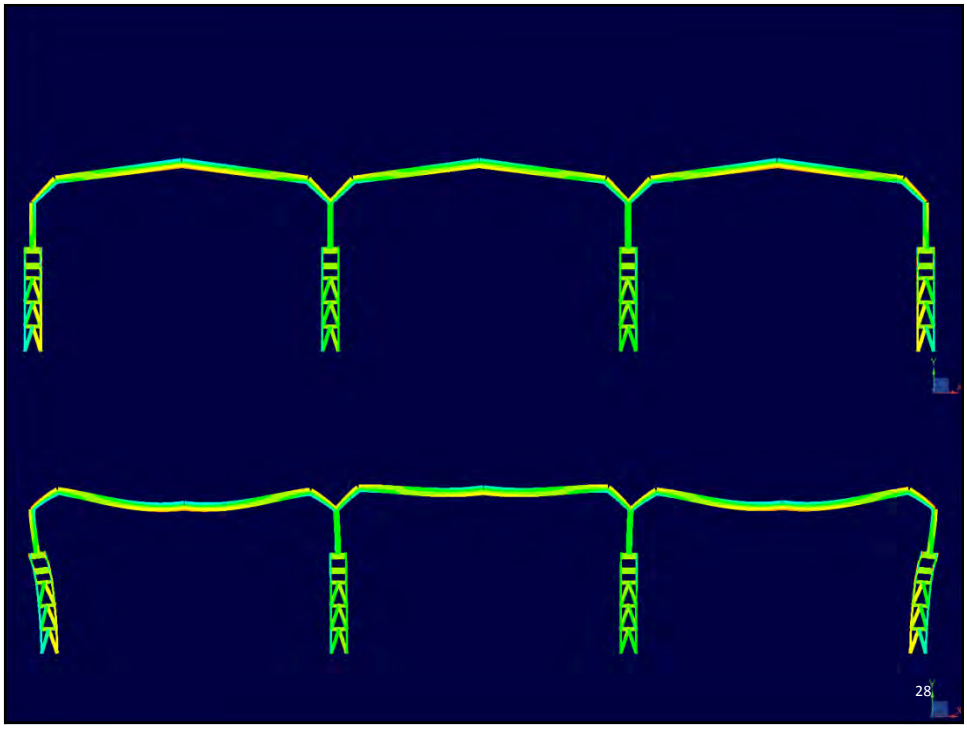

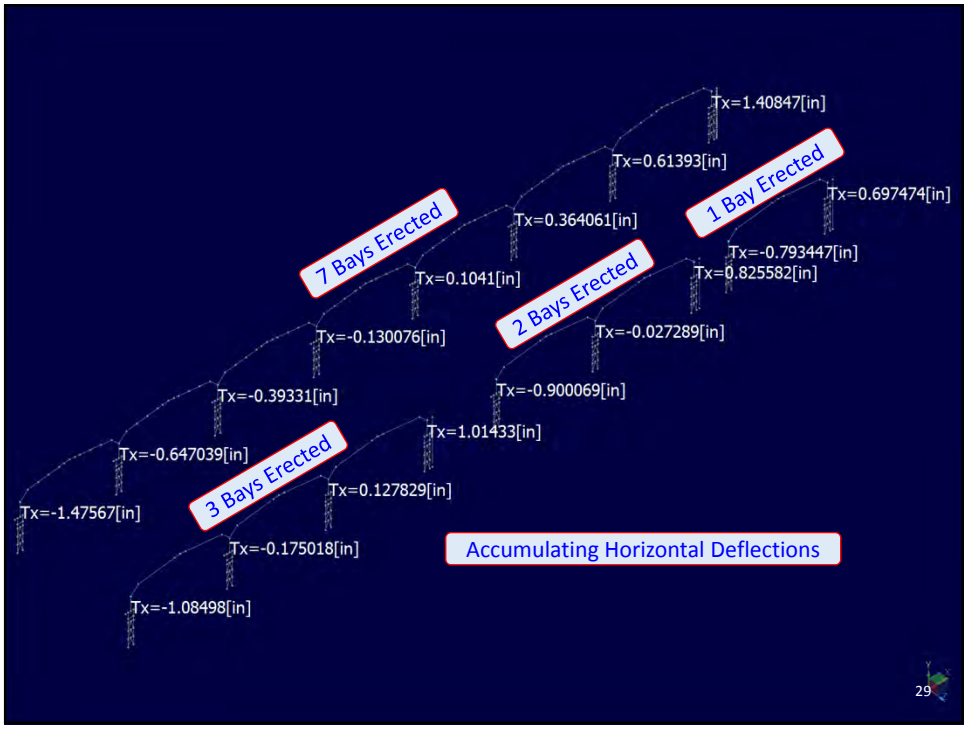


What do you need to specify?

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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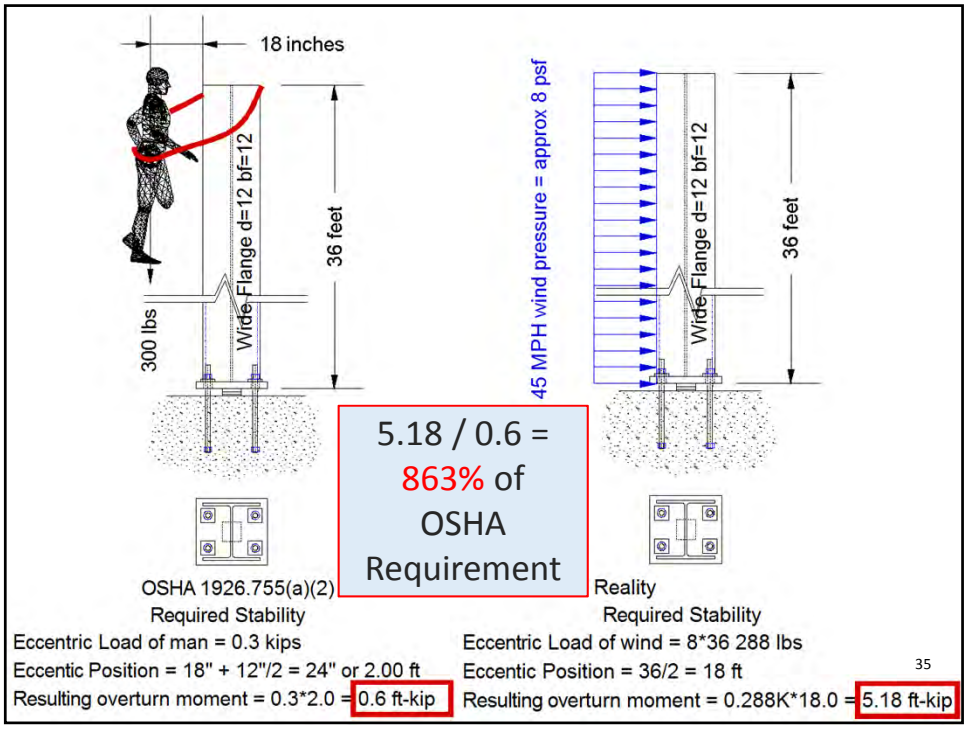
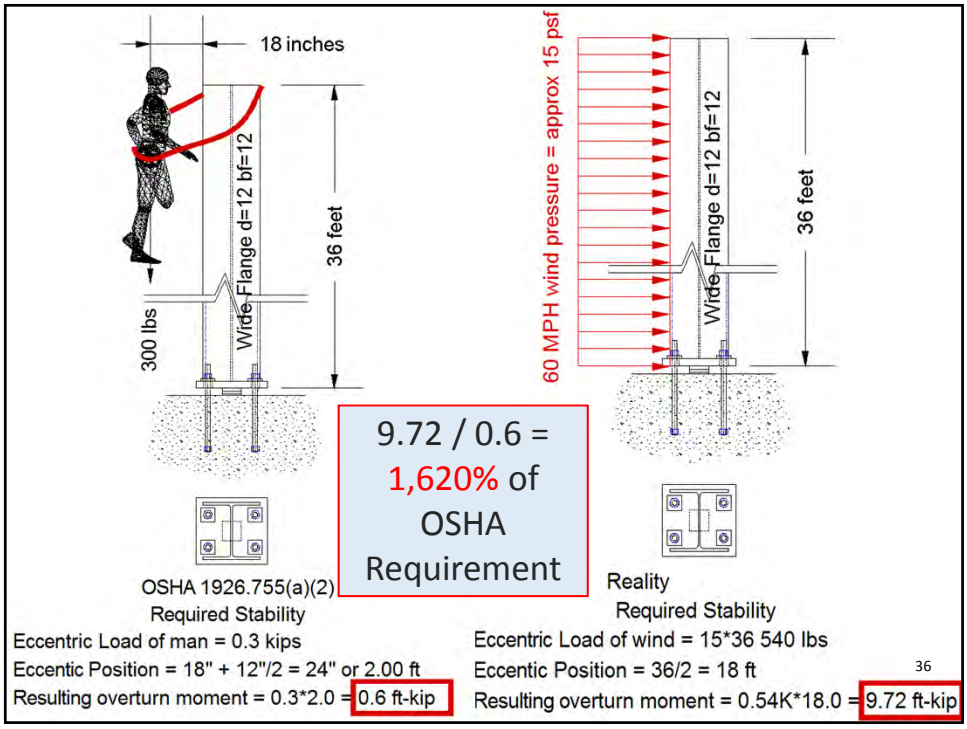
## Certainly think about the "High Functioning" Ironworkers!

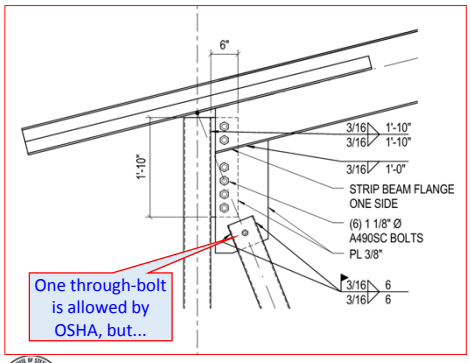


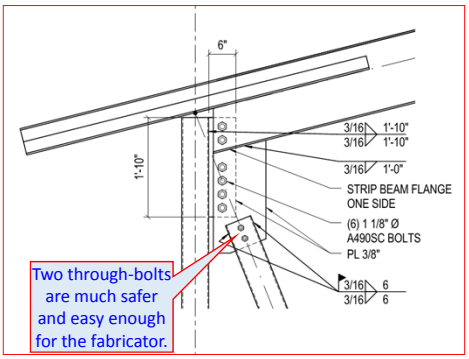




## Brace Connections

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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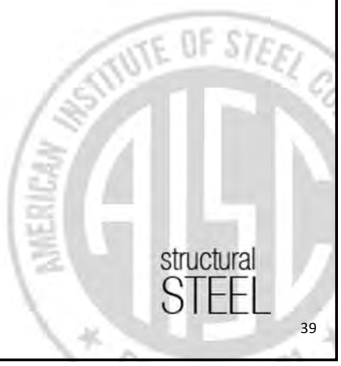
## Connections for Steel Erection

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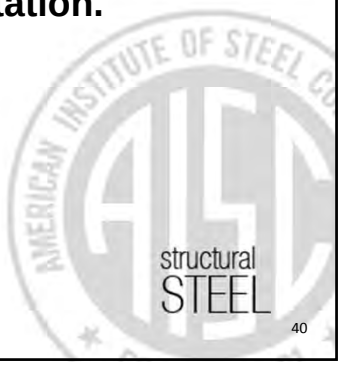
**Notice:**
**The details shown in this presentation reflect some of the thoughts and preferences of LPR Construction. Each fabricator and erector has their own opinions and preferences that may vary from this presentation.**

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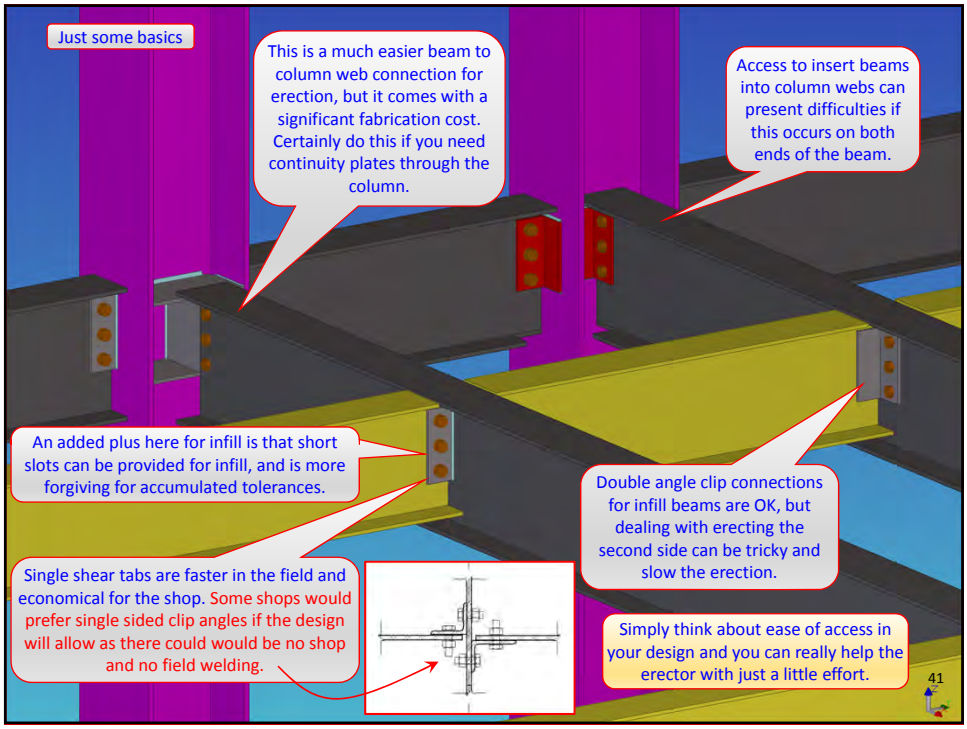
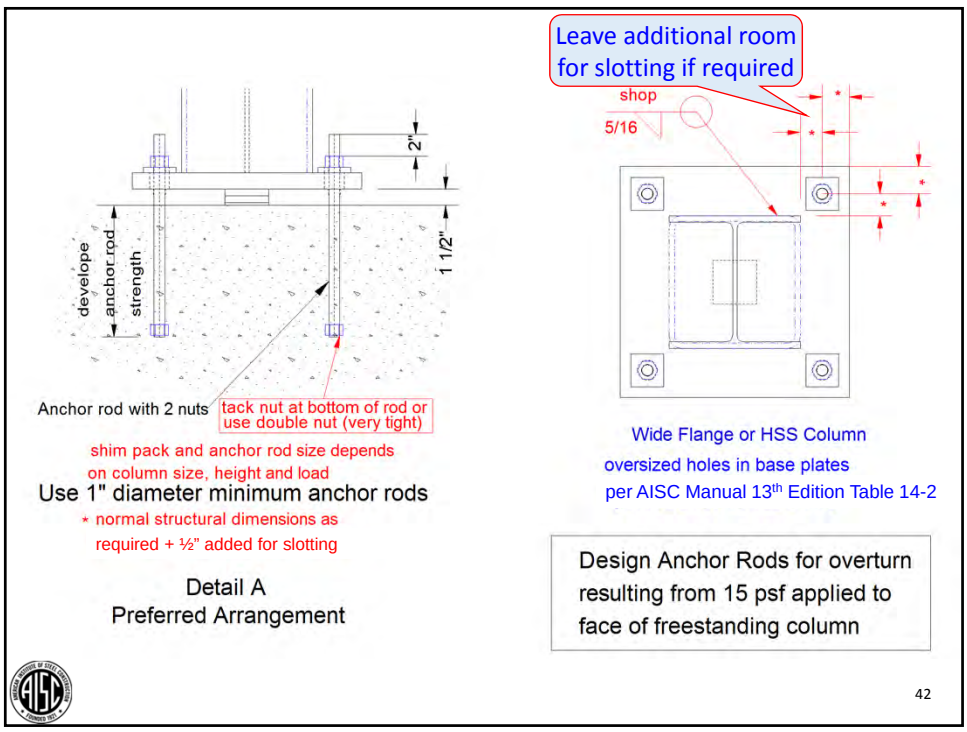
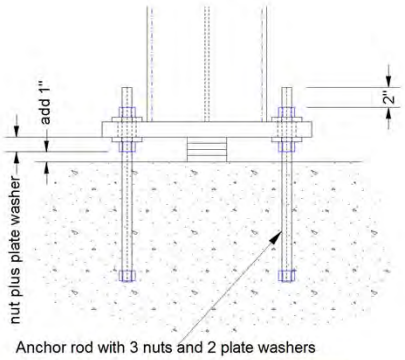


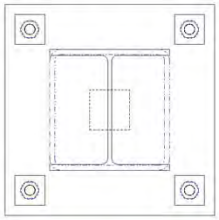






Logistical Pre-requisites
- proper access to leveling nuts required after column is erected
- rods are fully threaded
- protect exposed threads prior to erection

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

see Detail A for notes and dimensions not shown



Wide Flange or HSS Column

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

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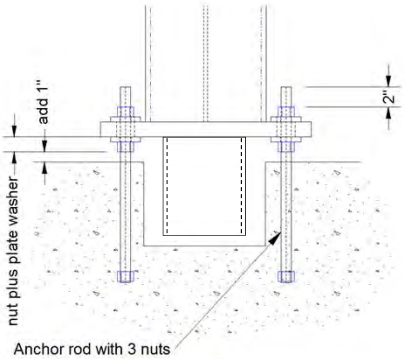
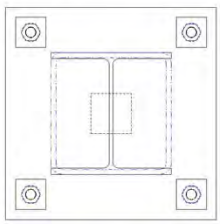



Logistical Pre-requisites
- proper access to leveling nuts required after column is erected
- rods are fully threaded
- protect exposed threads prior to erection

Detail C
Best Arrangement for large Shear Key

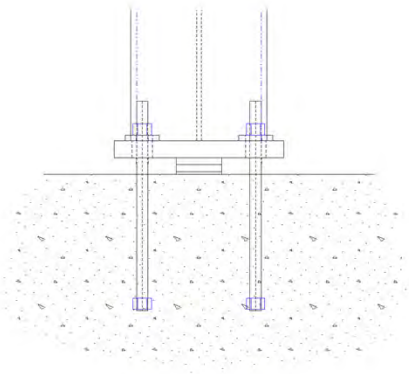
see Detail A for notes and dimensions not shown



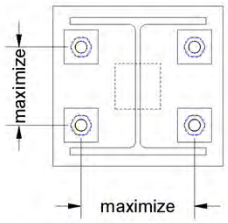
Wide Flange or HSS Column

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

44



see Detail A for notes
and dimensions not shown

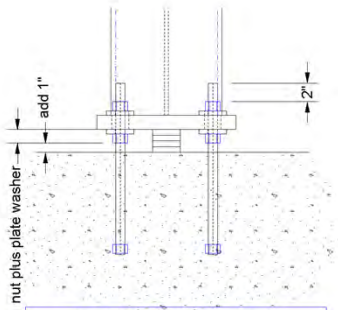



Wide Flange Column

Detail E
Preferred arrangement
If anchor rods
must be inside flanges

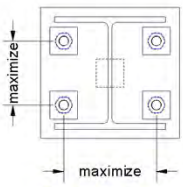
Design Anchor Rods for overturn resulting from 15 psf applied to face of freestanding column

45




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

see Detail A for notes
and dimensions not shown




Wide Flange Column

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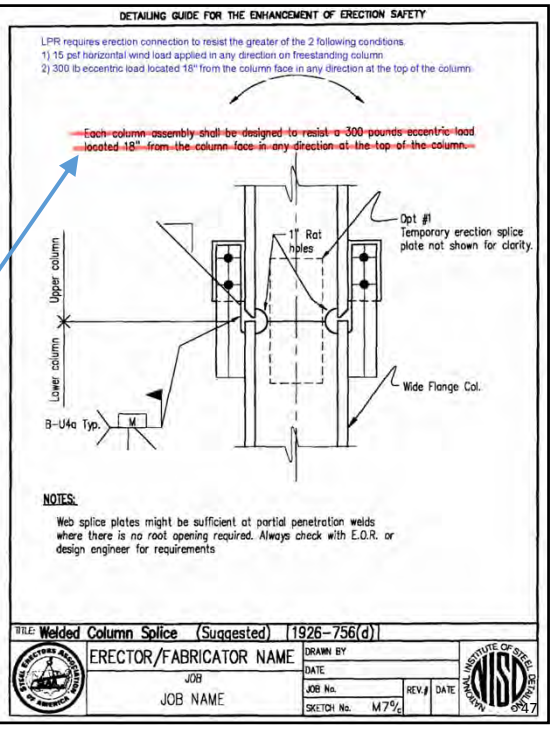
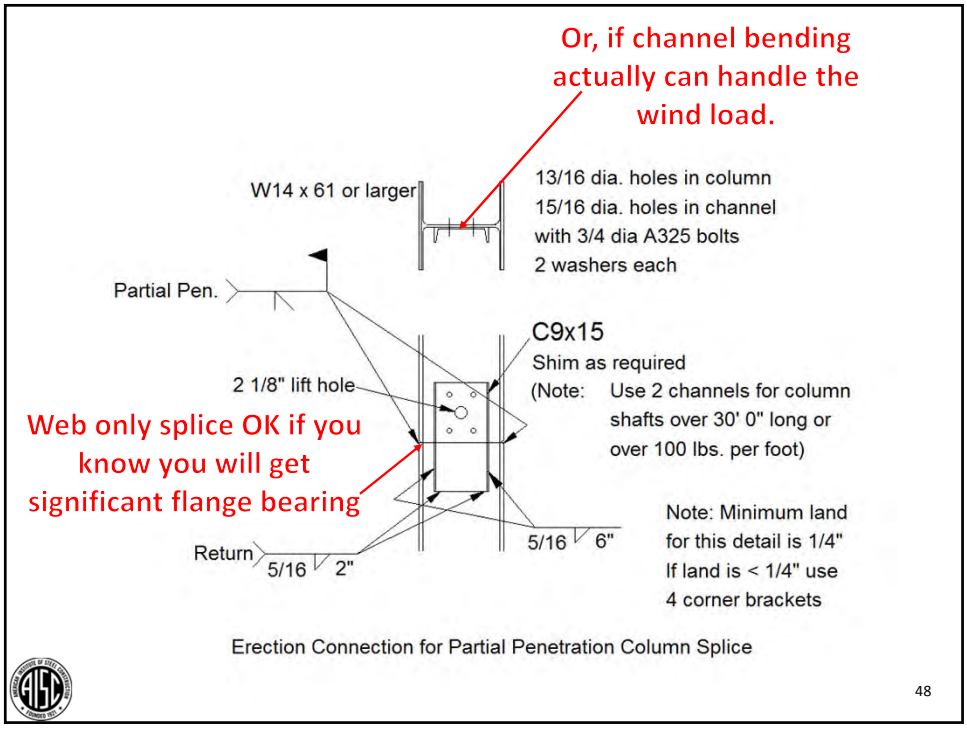
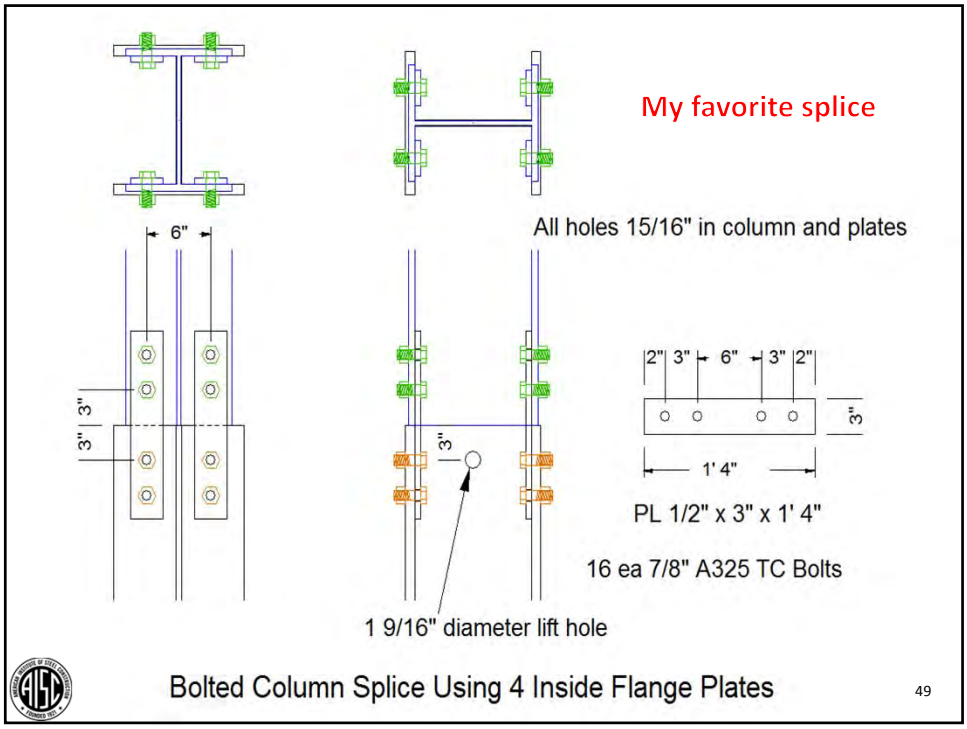
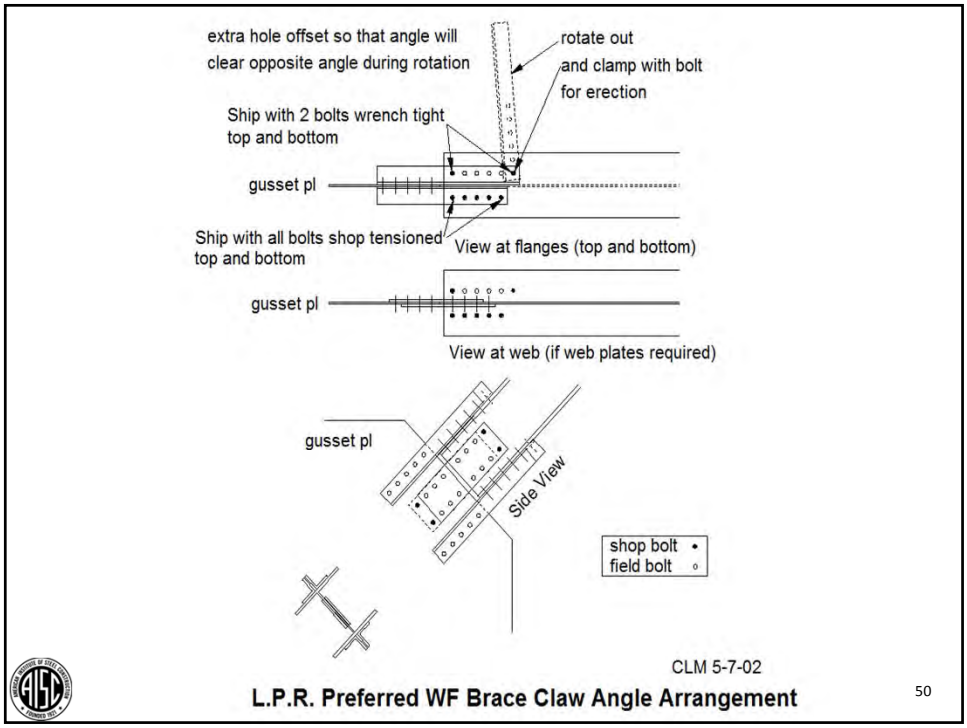
Column splices are just as "safety critical" as anchor rods

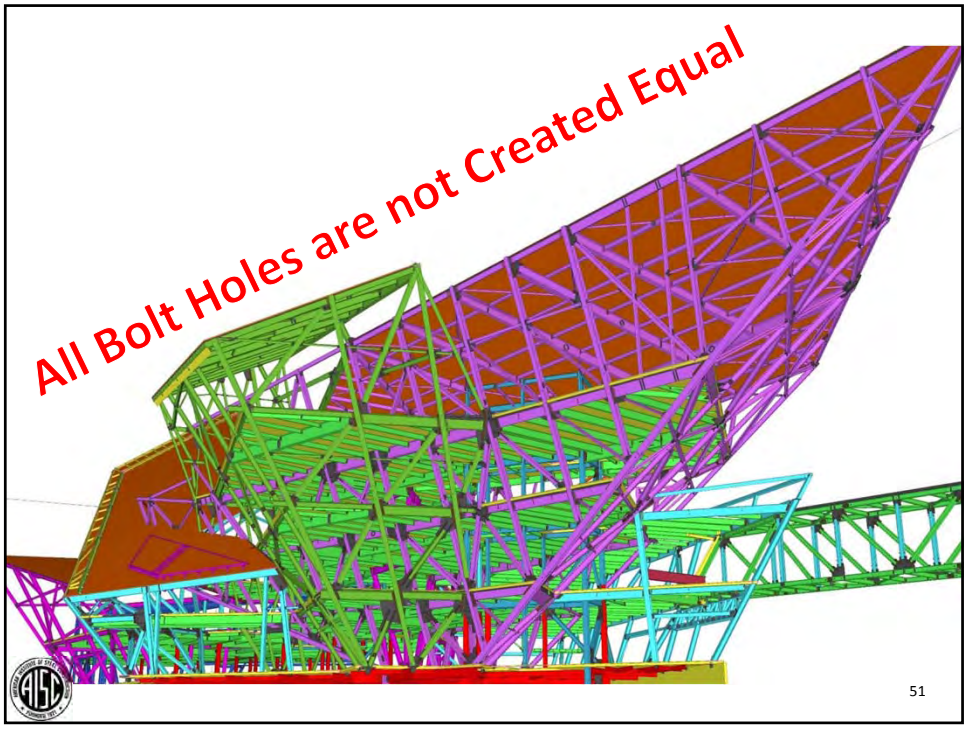
SEAA and NIST are both still promoting "300 lbs at 18 inches" as ... "safe" design criteria.

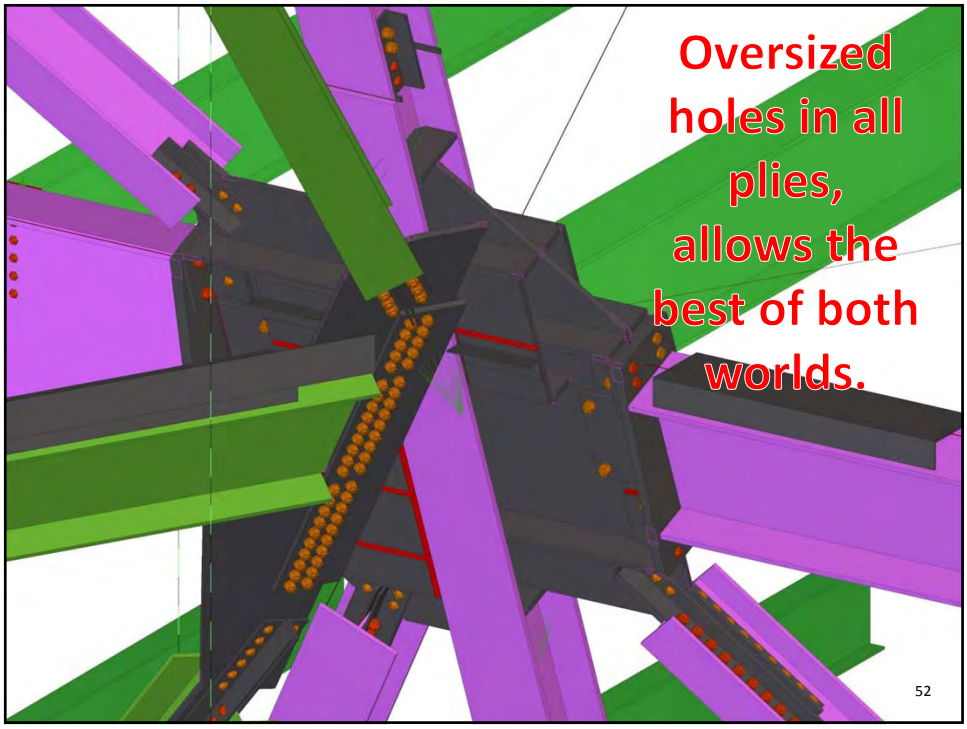


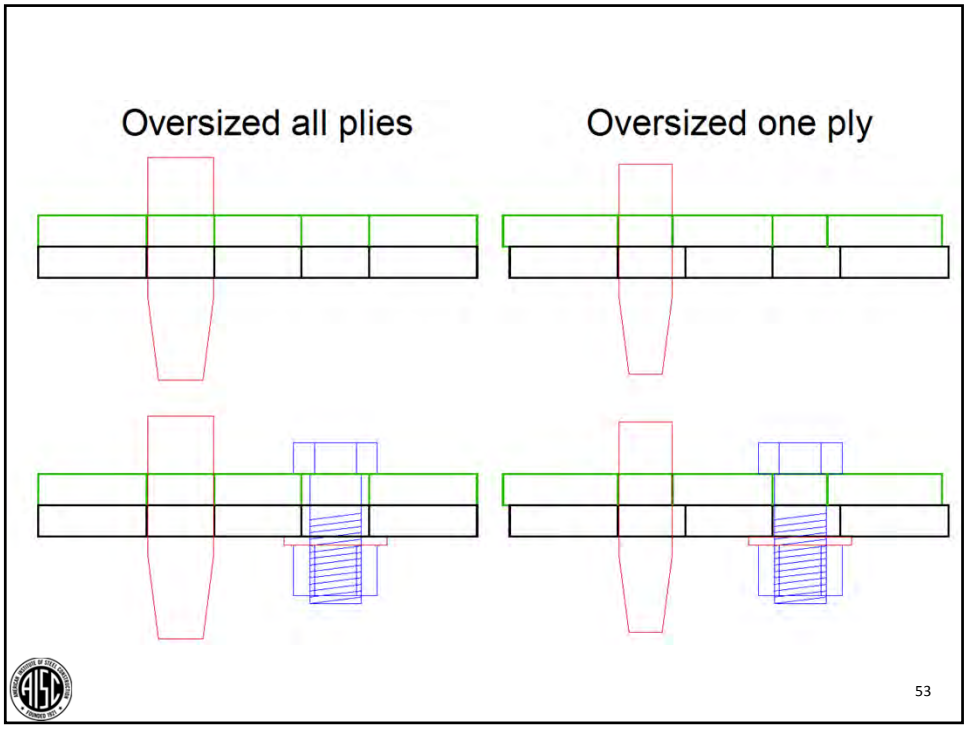





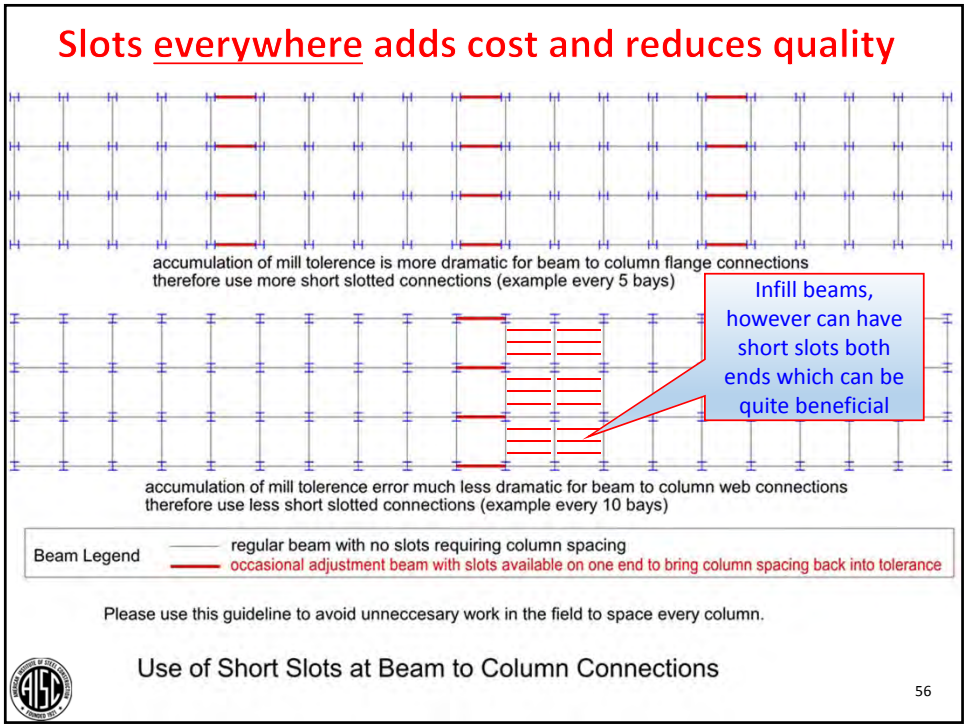











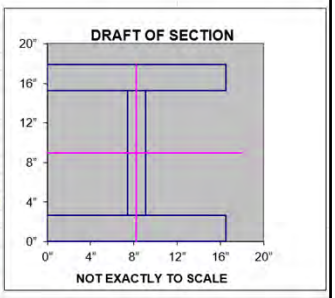
Some things require only a small design effort to help with constructability.

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 |

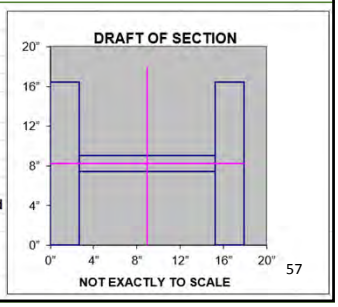
243.102 kips Top Chord Compr Load
98.025 kips Top Chord Capacity
248.0% OF REQ'D CAPACITY
NOT STABLE




**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

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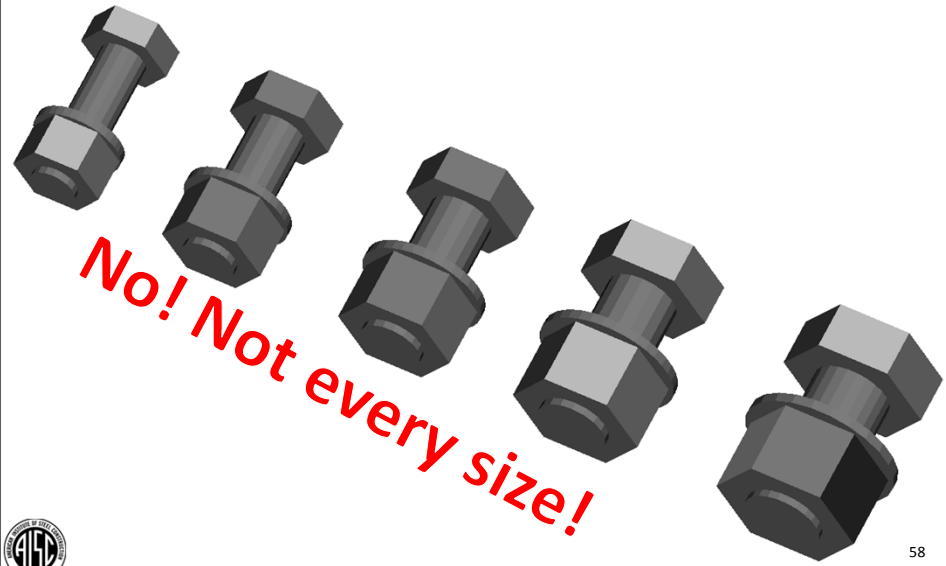


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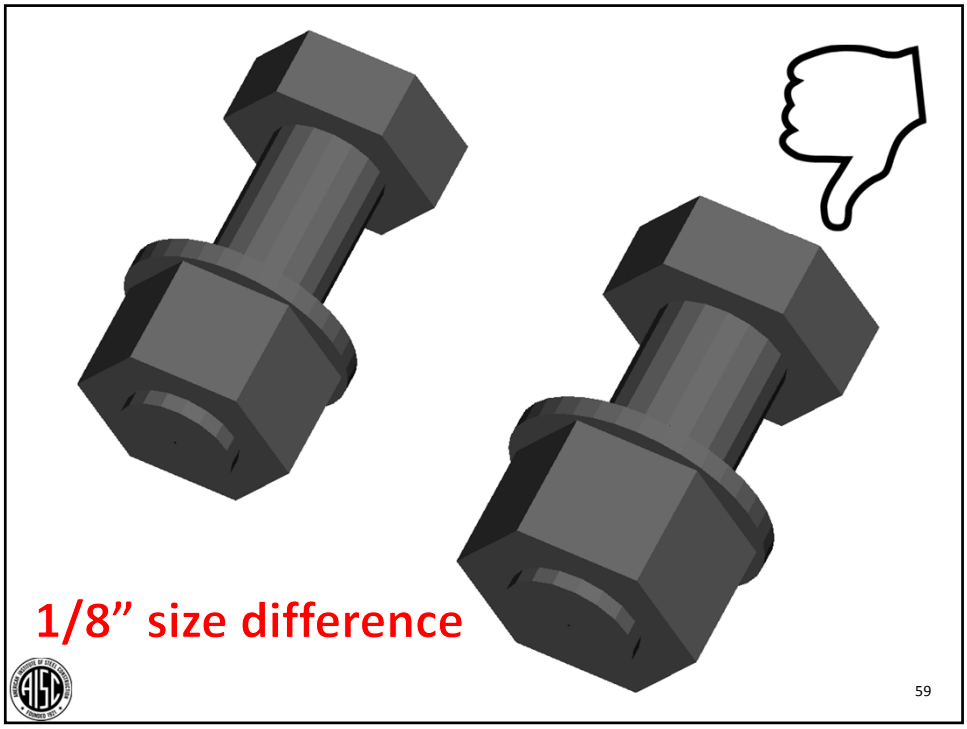


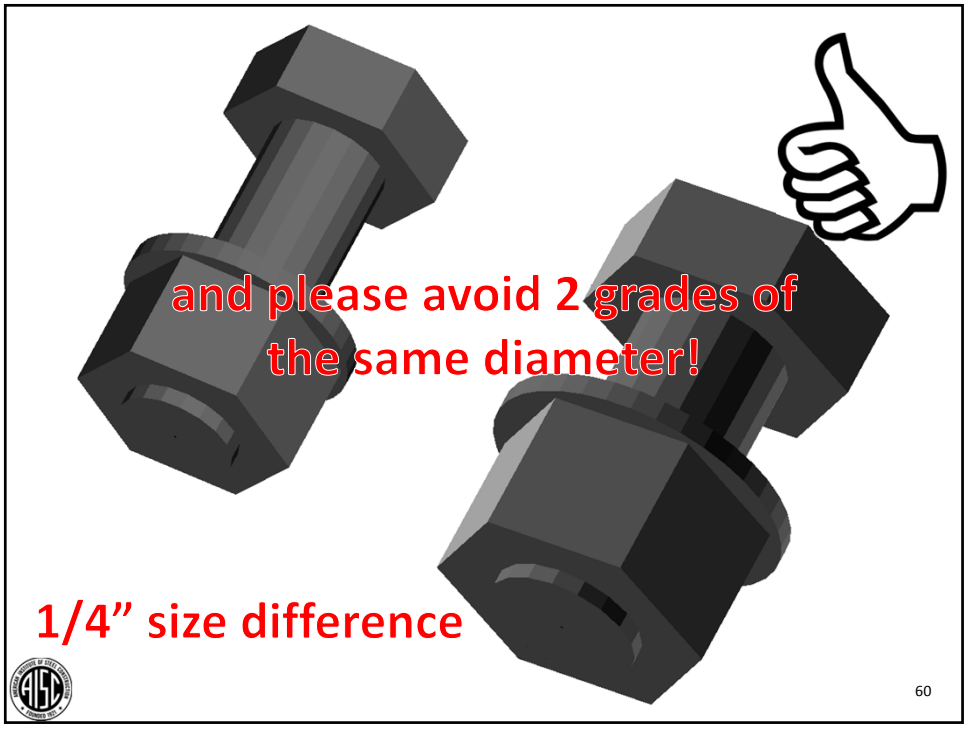

## Designing Field Welds

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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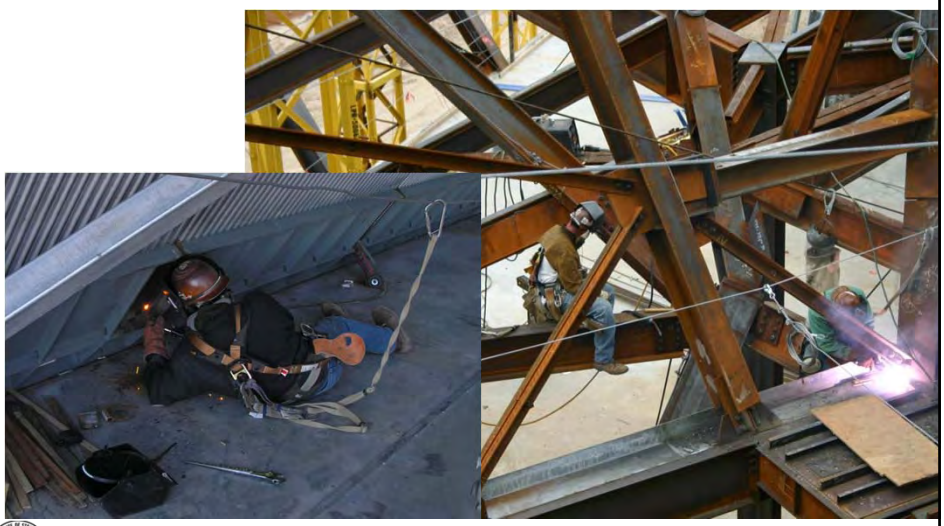
## Then, the real world sets in.



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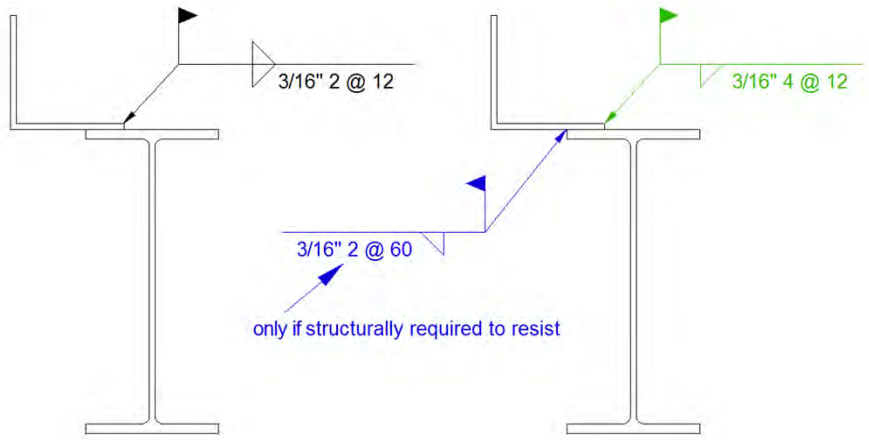


Avoid Overhead Weld As Much As Possible

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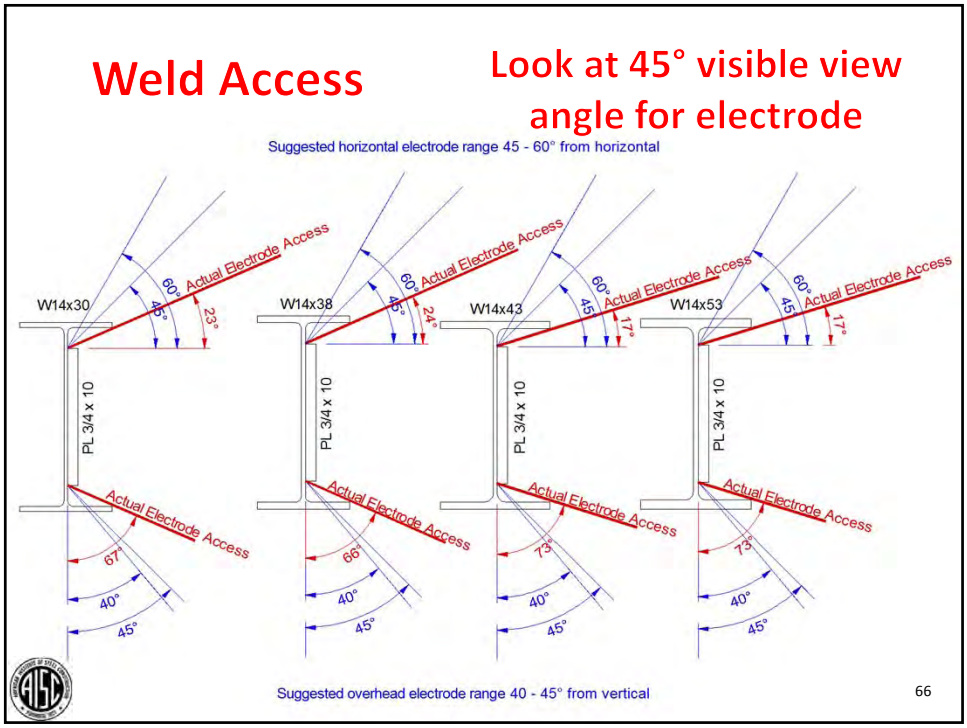

## Weld Access

Look at 45° visible view angle for electrode

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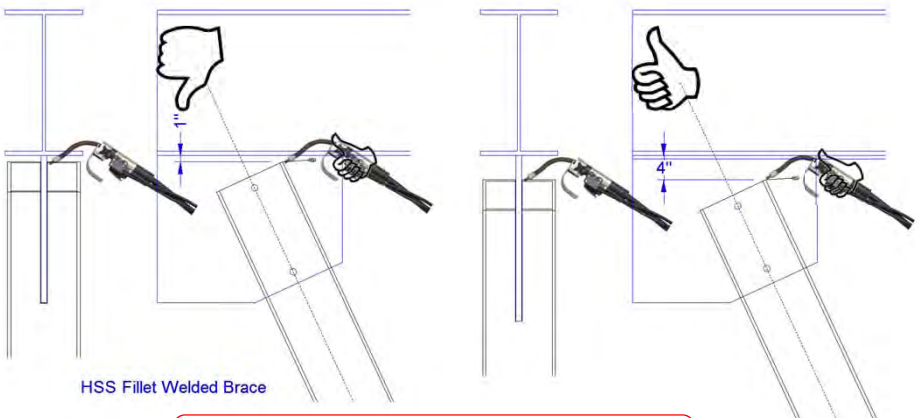
## Weld Access

Or look at the access dimension.




We have found that 4" is a really reliable access dimension whenever weld access is impaired. Weld quality can be maintained along with reasonable (although impaired) production.

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# Priority #5:
# Quantity of the weld:

## Fillet Weld Size Matters:

Fillets 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 along 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 | Prodiction 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 |

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There's always a solution in steel.

**Lateral Force-Resisting Systems for Steel Erection**

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## 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:

(a) The **lateral force-resisting system** and connecting diaphragm elements that provide for lateral strength and stability in the completed structure.

(b) 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

structural STEEL

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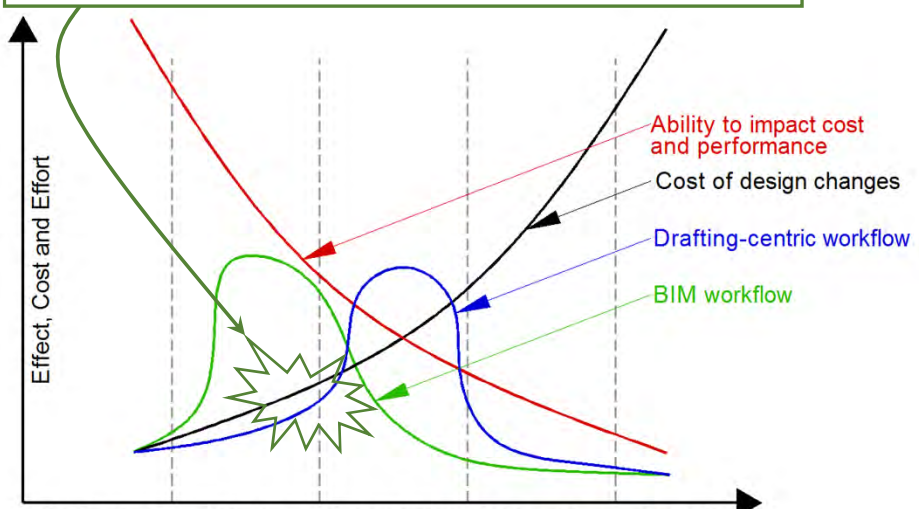
**Move the construction preplanning process here into the BIM workflow, to positively "IMPACT" cost and performance.**

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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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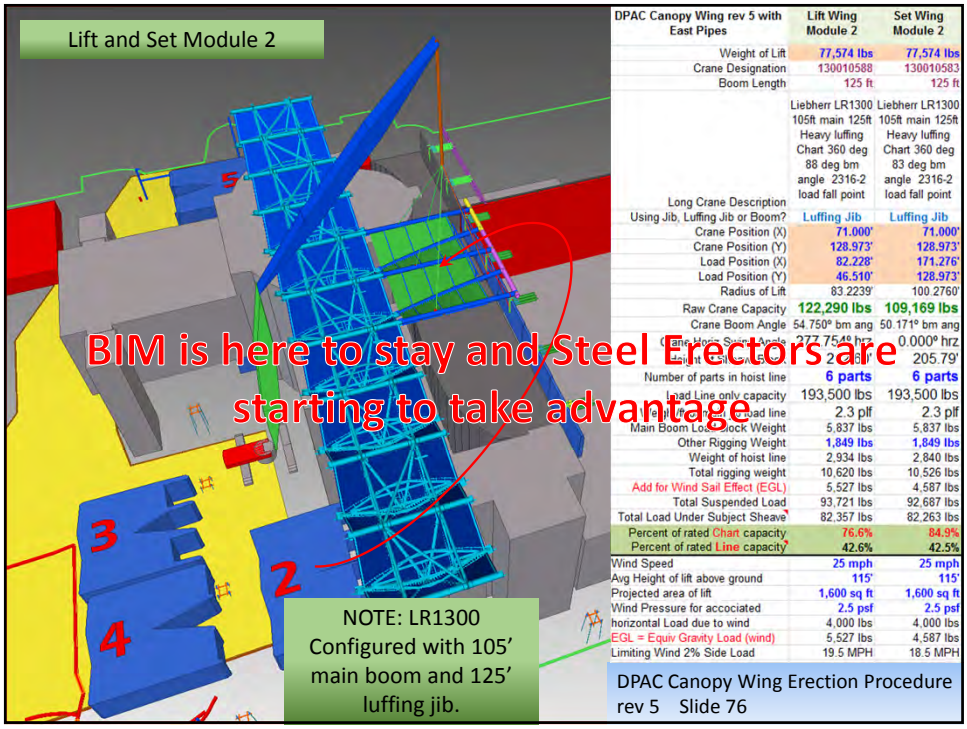
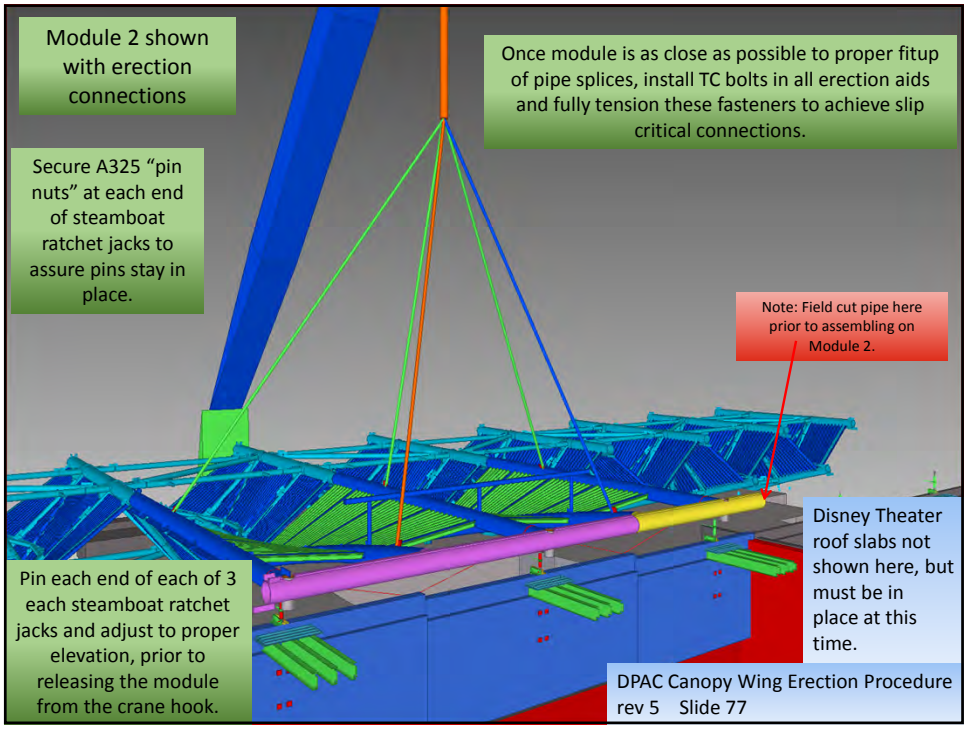
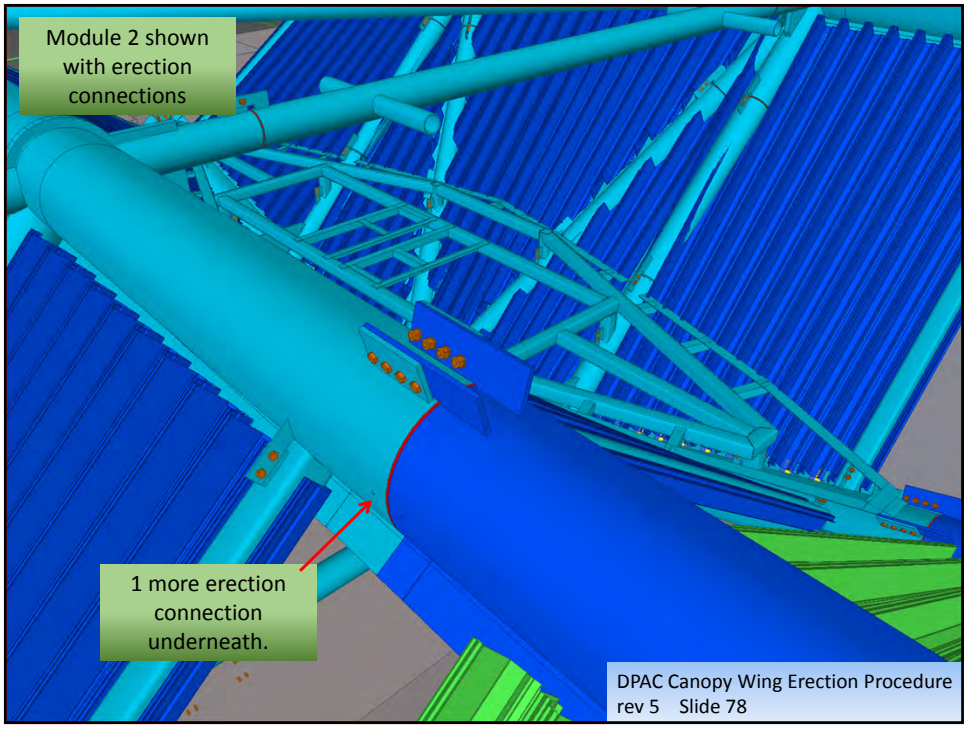
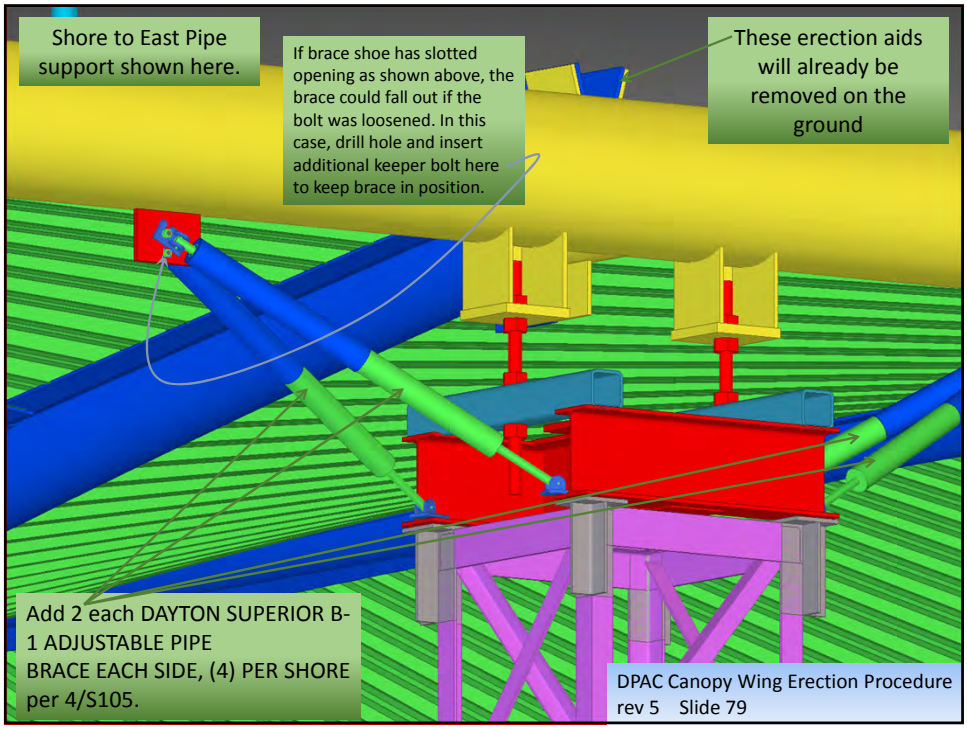
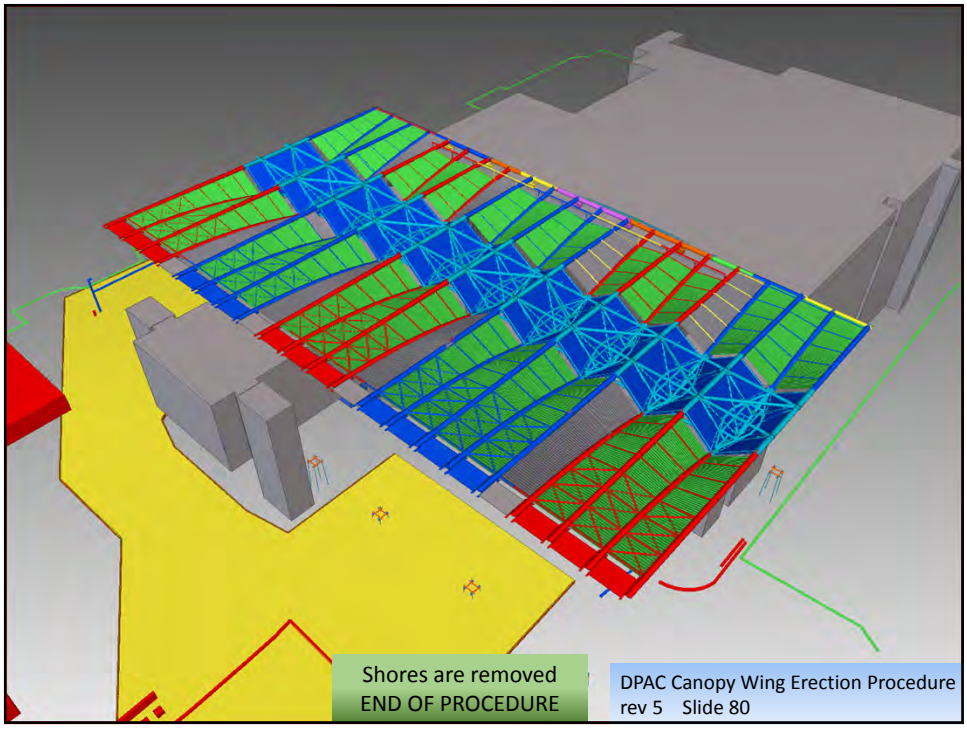


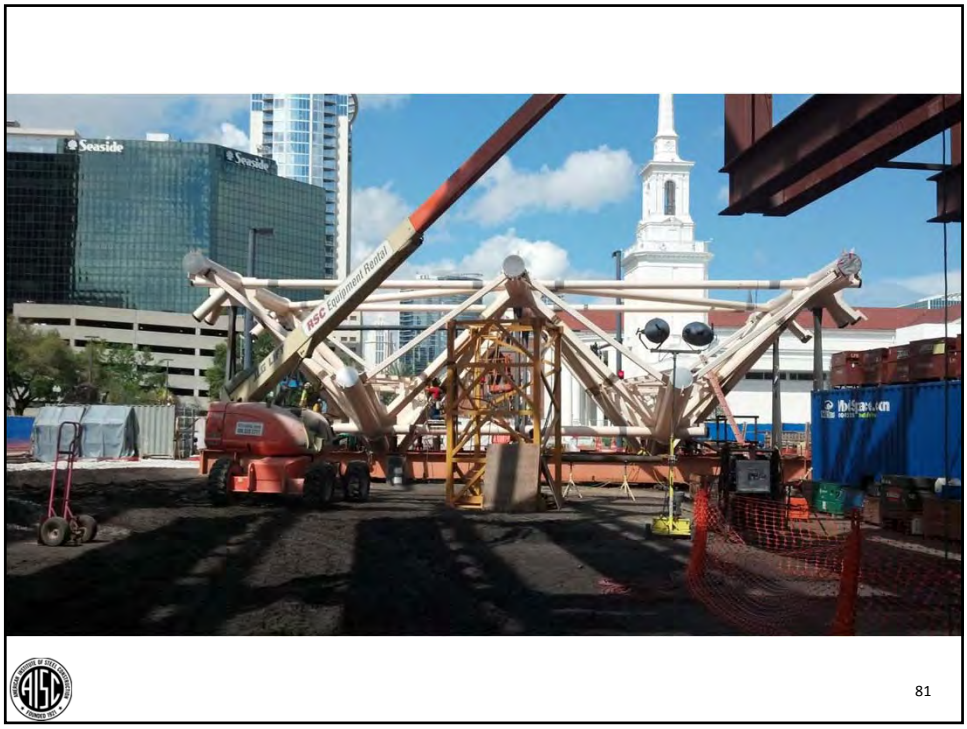

| DPAC Canopy Wing rev 5 with East Pipes | Lift Wing Module 2 | Set Wing Module 2 |
|---|---|---|
| Weight of Lift | 77,574 lbs | 77,574 lbs |
| Crane Designation | 130010588 | 130010583 |
| Boom Length | 125 ft | 125 ft |
| Long Crane Description | Liebherr LR1300 105ft main 125ft Heavy luffing Chart 360 deg 88 deg bm angle 2316-2 load fall point | Liebherr LR1300 105ft main 125ft Heavy luffing Chart 360 deg 83 deg bm angle 2316-2 load fall point |
| Using Jib, Luffing Jib or Boom? | Luffing Jib | Luffing Jib |
| Crane Position (X) | 71.000' | 71.000' |
| Crane Position (Y) | 128.973' | 128.973' |
| Load Position (X) | 82.228' | 171.276' |
| Load Position (Y) | 46.510' | 128.973' |
| Radius of Lift | 83.2239' | 100.2760' |
| Raw Crane Capacity | 122,290 lbs | 109,169 lbs |
| Crane Boom Angle | 54.750° bm ang | 50.171° bm ang |
| Crane Horiz Swing Angle | 277.754° hrz | 0.000° hrz |
| Height of Hook | 205.79' | 205.79' |
| Number of parts in hoist line | 6 parts | 6 parts |
| Load Line only capacity | 193,500 lbs | 193,500 lbs |
| Hoist Rigging Load line | 2.3 plf | 2.3 plf |
| Main Boom Lower Block Weight | 5,837 lbs | 5,837 lbs |
| Other Rigging Weight | 1,849 lbs | 1,849 lbs |
| Weight of hoist line | 2,934 lbs | 2,840 lbs |
| Total rigging weight | 10,620 lbs | 10,526 lbs |
| Add for Wind Sail 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% | 84.9% |
| Percent of rated 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 accociated | 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 |





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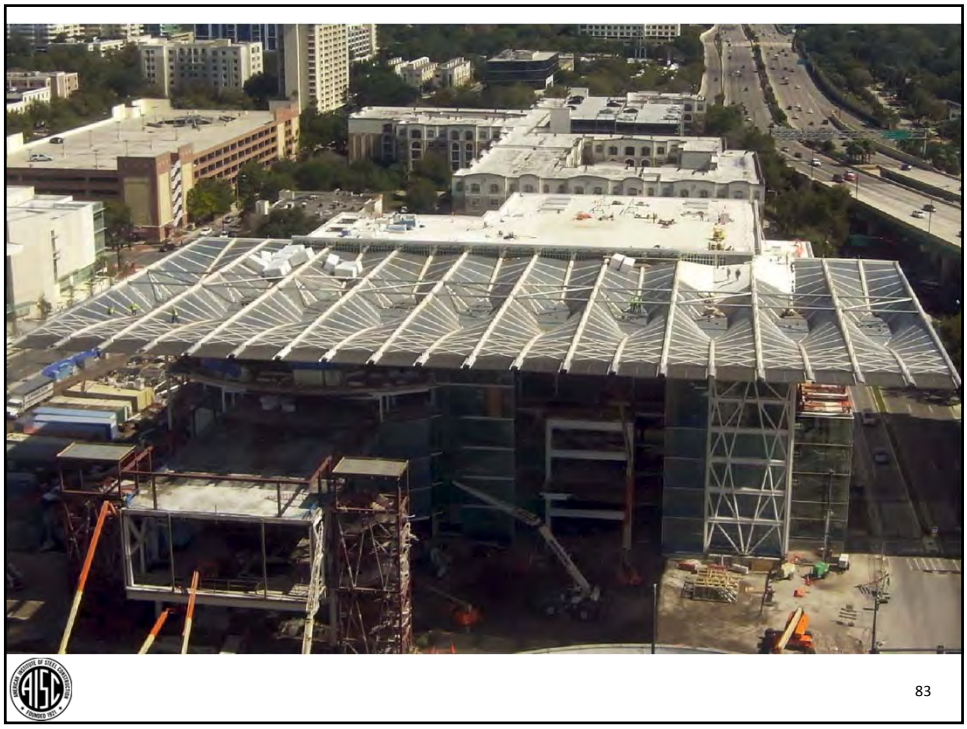


There's always a solution in steel.

## Questions?

**Presented by**
**Curtis L. Mayes, P.E.**

**LPR CONSTRUCTION**
**Loveland, CO**

AISC ASSOCIATE | AISC CERTIFIED ERECTOR

structural STEEL

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# Polling Question

Slots in beam to column connections should be used:

a. Always and everywhere possible
b. Never
c. 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!

## PDH Certificates

Within 2 business days…

- Reporting site (URL will be provided in the forthcoming email).
- Username: Same as AISC website username.
- Password: Same as AISC website password.