

There's always a solution in steel.

AISC Live Webinars

Thank you for joining our live webinar today.
We will begin shortly. Please stand by.

Thank you.

Need Help?

Call ReadyTalk Support: 800.843.9166



AISC Live Webinars

Today's audio will be broadcast through the internet.

Alternatively, to hear the audio through the phone, dial:

(888) 378-4398

Passcode: 624925



AISC Live Webinars

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

As a reminder, all lines have been muted. Please type any questions or comments through the Chat feature on the left portion of your screen.

Today's audio will be broadcast through the internet.
Alternatively, to hear the audio through the phone, dial:

(888) 378-4398

Passcode: 624925



AISC Live Webinars

AISC is a Registered Provider with The American Institute of Architects Continuing Education Systems (AIA/CES). Credit(s) earned on completion of this program will be reported to AIA/CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

This program is registered with AIA/CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.



AISC Live Webinars

Copyright Materials

This presentation is protected by US and International Copyright laws. Reproduction, distribution, display and use of the presentation without written permission of AISC is prohibited.

© The American Institute of Steel Construction 2018

The information presented herein is based on recognized engineering principles and is for general information only. While it is believed to be accurate, this information should not be applied to any specific application without competent professional examination and verification by a licensed professional engineer. Anyone making use of this information assumes all liability arising from such use.



Course Description

Truss Design and Construction

August 9, 2018

Steel truss design and construction involves more than simply resisting the imposed loads. This webinar will provide insights into the design and construction of floor and roof trusses, covering unique load considerations like rigging, operable partitions and maintenance vehicles that are often required in facilities with long-span framing. Truss deflection and vibration considerations will also be discussed.



Learning Objectives

- List the criteria to consider when establishing deflection limits for trusses.
- Name the resources that can be useful in assessing vibration performance of long-span floor systems.
- Describe the relative advantages and disadvantages of bolted vs. welded truss connections.
- Identify the types of structural shapes commonly used in trusses. Explain how member type selection affects the design.



Truss Design and Construction



Presented by
Thomas R. Meyer, P.E., S.E.
Magnusson Klemencic Associates
Seattle, Washington

There's always a solution in steel.



Design Criteria: Loading

Dead Loads and Superimposed Dead Loads

- Steel Self Weight is Significant
- Connection Material Weight

Code-Based Uniform Live Loads

Unique / Facility-Specific Uniform Live Loads

- Exhibit Halls: 350 psf (example)

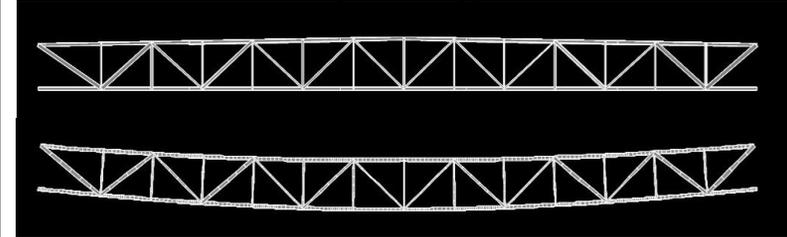
Concentrated Loads

- Vehicles / Operational Equipment
- Operable Partitions
- Rigging



13

Serviceability Design: Deflections



Standard L/240 and L/360 Not Relevant

120' Span: L/240 = 6" and L/360 = 4"

Too much deflection!



14

Serviceability Design: Deflections

- Consider Standard Architectural Systems
 - Compensation channels at interior wall heads
 - Joint dimensions in cladding systems
- Consider Specialized Architectural Systems
 - Operable partitions
- Consider Roof Drainage and Ponding



15

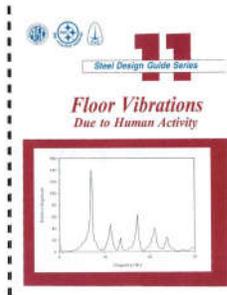
Serviceability Design: Deflections

- Camber
 - AISC Code of Standard Practice
 - Tolerance is $\pm L/800$
 - L = Distance from closest support to point where camber is specified
- Camber Tolerance for 120-ft span = $\pm 0.9"$



16

Serviceability Design: Floor Vibrations



17

Serviceability Design: Floor Vibrations

- Airport Concourses
 - Shopping Malls
- 1.5% g



18

Serviceability Design: Floor Vibrations

- Pedestrian Bridges
- 1.5% g (Indoor)
– 5.0% g (Outdoor)



19

Serviceability Design: Floor Vibrations

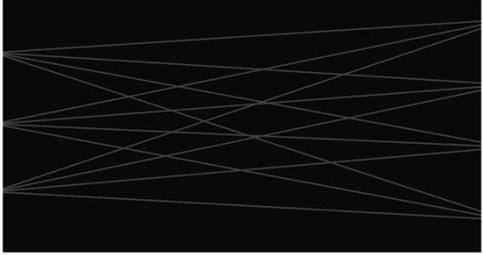
- Dining and Dancing
- 2.0% g



20

There's always a solution in steel.

Geometry Considerations



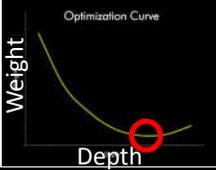
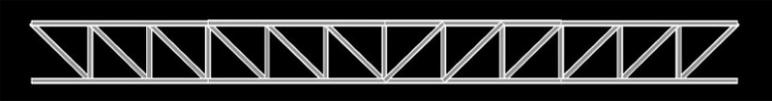
Geometry Considerations: Depth

Rule of Thumb Depth: $\text{Depth in Inches} = \text{Span in Ft} / 2$



22

Geometry Considerations: Depth



23

Geometry Considerations: Depth

- Span-to-Depth Ratio
- Roof Truss
 - **Relatively flat between 12 and 15**
 - Significant increases above 15
- Floor Truss (Strength-Controlled)
 - **Relatively flat between 8 and 10**
 - Significant increases above 10
- Floor Truss (Vibration-Controlled)
 - **Modest increases between 6 and 8**
 - Significant increases above 8



24

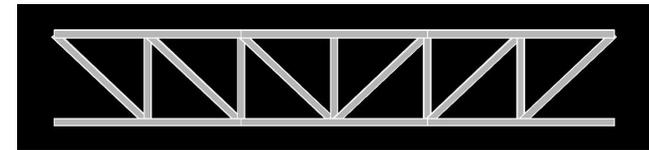
Geometry Considerations: Layout

- Architectural Considerations
- Tension / Compression Member Efficiency
- Load Flow
- M/E/P Routing



25

Geometry Considerations: Layout

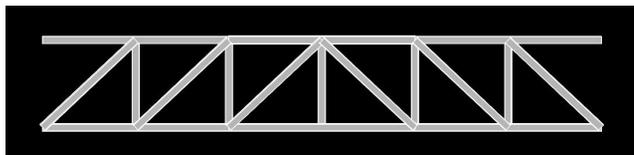


Pratt Truss



26

Geometry Considerations: Layout

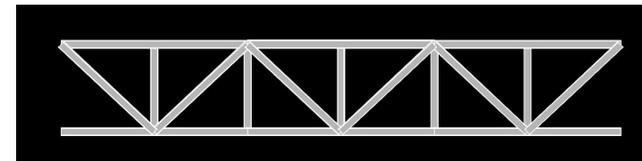


Howe Truss



27

Geometry Considerations: Layout



Warren Truss



28

Geometry Considerations: Panels

Beams Aligned With Panel Points

Beams Not Aligned With Panel Points



29

Geometry Considerations: Panels

Beams Aligned With Panel Points Truss Weight = 11.5 T

Beams Not Aligned With Panel Points Truss Weight = 11.6 T



30

Geometry Considerations: Shipping



31

Geometry Considerations: Shipping

- Pre-Fabricated Truss Dimensions:
 - 50'-0" Length x 8'-6" Depth
- Pre-Fabricated Truss Dimensions:
 - 50'-0" Length x 12'-6" Depth
- Dimensions can be increased with special permits



Lay Flat
On Trailer Bed



Lay At Angle
On Trailer Bed



32

Geometry Considerations: Shipping



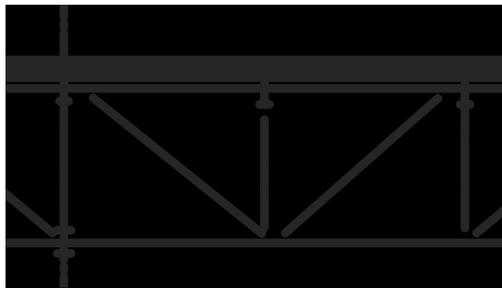
33

Geometry Considerations: Shipping



34

Member Shapes



There's always a solution in steel.

Member Shapes



36

Member Shapes: Web Members

- Tension Web Members



37

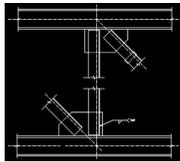
Member Shapes: Web Members

- Compression Web Members

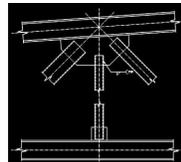


38

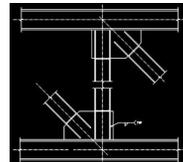
Member Shapes: Web Members



Double Angles



Hollow Structural Sections



Wide Flanges

- Architectural Considerations
- Truss Connection Considerations
- Compression Efficiency Considerations
- Shape Cost Considerations



39

Member Shapes: Chord Members

- Tension Chord



40

Member Shapes: Chord Members

- Compression Chord



41

Member Shapes: Chord Members



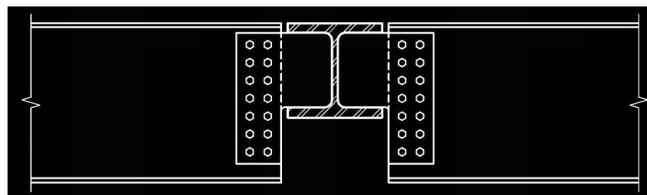
- Architectural Considerations
- Truss Connection Considerations
- Shape Cost Considerations
- Incoming Member Connection Considerations
- Alignment Considerations



42

Member Shapes: Chord Members

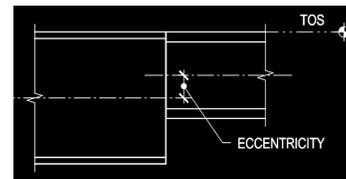
- Incoming Members



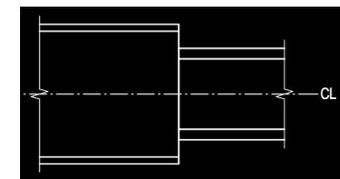
43

Member Shapes: Chord Members

- Alignment



Top of Steel Aligned



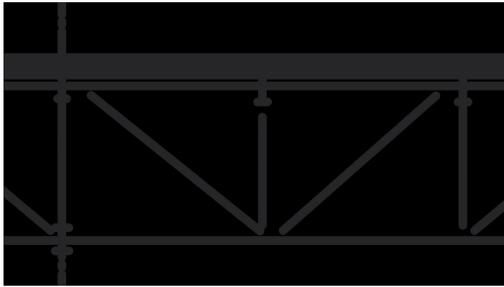
Centerline Aligned



44

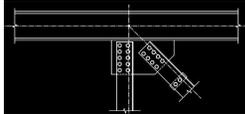
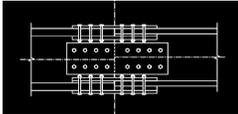
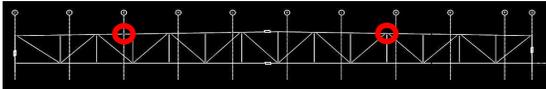
There's always a solution in steel.

Truss Analysis



Truss Analysis: Member Fixity

- Pinned Vs. Fixed



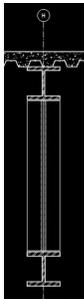
Chord Splices – Pinned or Fixed?

Web Connections – Pinned or Fixed?



46

Truss Analysis: Composite Action

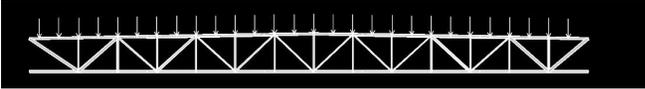


Floor Trusses – Composite or Non-Composite?



47

Truss Analysis: Applied Loads



Top Chord Loads

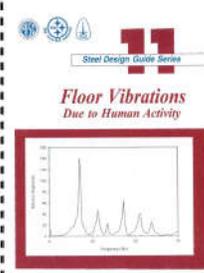


Bottom Chord Loads



48

Truss Analysis: Floor Vibrations



49

Truss Analysis: Floor Vibrations

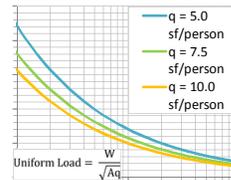
- ISO 10137



50

Truss Analysis: Floor Vibrations

- Uncoordinated Group Walking
– Uniform Loading



51

Truss Analysis: Floor Vibrations

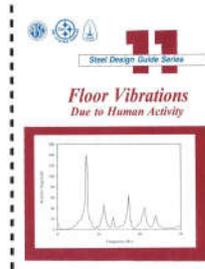
- Rhythmic Excitation



52

Truss Analysis: Floor Vibrations

- Rhythmic Excitation



Basic Hand Calculation



Truss Analysis: Floor Vibrations

- Rhythmic Excitation

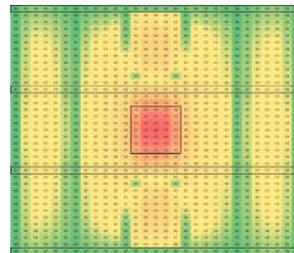
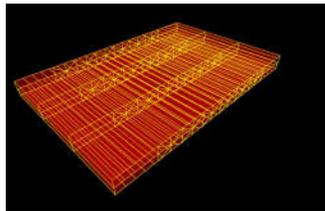


Modified Hand Calculation



Truss Analysis: Floor Vibrations

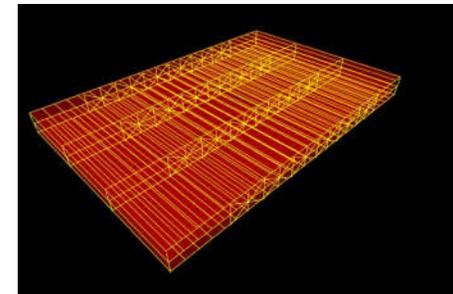
- Rhythmic Excitation



Dynamic Analysis Modeling



Truss Analysis: Floor Vibrations



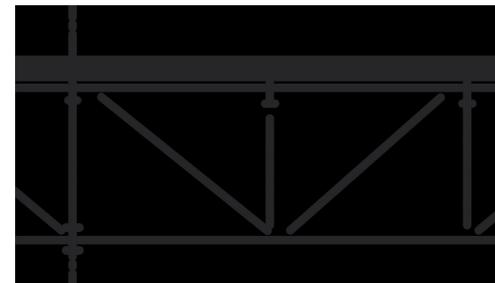
Truss Analysis: Floor Vibrations

- Basic Hand Calculation:
 - Predicted Floor Acceleration = 10.6% g
- Modified Hand Calculation:
 - Predicted Floor Acceleration = 4.0% g
- Dynamic Analysis Model:
 - Predicted Floor Acceleration = 2.0% g



57

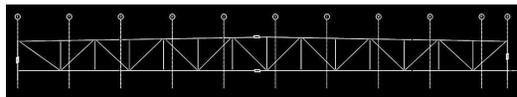
Member Design



There's always a solution in steel.



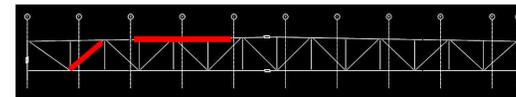
Member Design



59

Member Design

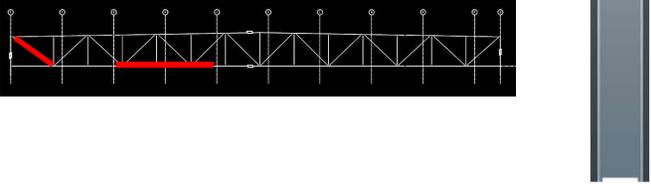
- Compression Members



60

Member Design

- Tension Members



The diagram shows a truss structure with a red member highlighted. To the right is a vertical cross-section of a steel member.



61

Member Design



Compression Members Tension Members

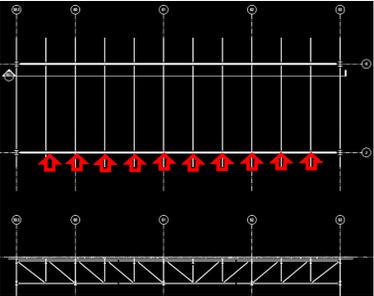
- Determine member forces and design members per AISC 360 criteria



62

Member Design

- Brace Points?



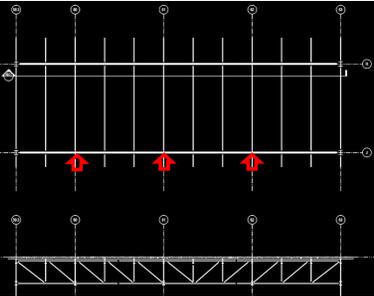
The diagram shows a truss structure with red arrows indicating brace points.



63

Member Design

- Brace Points?



The diagram shows a truss structure with red arrows indicating brace points.



64

There's always a solution in steel.

Truss Connections



AMERICAN INSTITUTE OF STEEL CONSTRUCTION
structural STEEL

Truss Connections



Bolted Connection Welded Connection



66

Truss Connections: Bolted

- Standard Holes vs. Slotted or Oversize Holes?
- F3125 Grade A325 vs. A490 Bolts?
- Bolt Diameter?
- Consistent vs. Variable Bolt Sizes?
- Slip-Critical vs. Bearing Bolts?
- N-Bolts vs. X-Bolts?



67

Truss Connections: Bolted

- Consider Net Section and Block Shear
 - Limit DCR During Design?
 - Stagger Bolts?
 - Doubler Plates Required?
- Consider Weld Access if Bolts Don't Fit



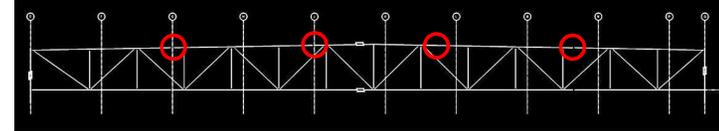
68

Truss Connections: Bolted



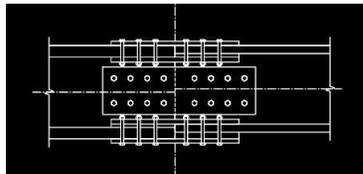
69

Truss Connections: Chord Splices

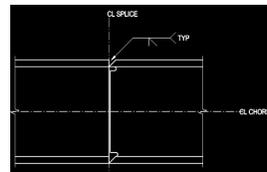


70

Truss Connections: Chord Splices



Bolted Splice

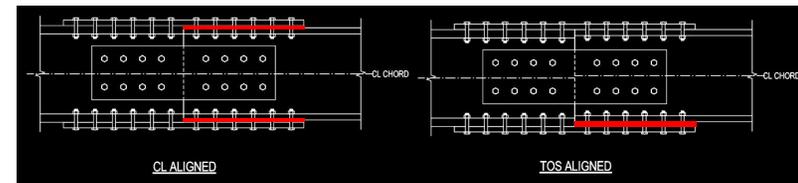


Welded Splice



71

Truss Connections: Chord Splices



72

Truss Connections: Chord Splices

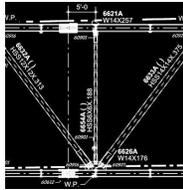
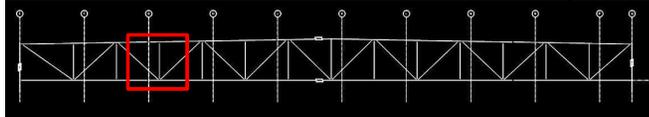


A photograph showing a close-up of a steel truss chord splice. The splice is a long, narrow steel plate with several bolts along its length, connecting two sections of the truss chord. The background shows a construction site with other steel members.



73

Truss Connections: Chord Splices

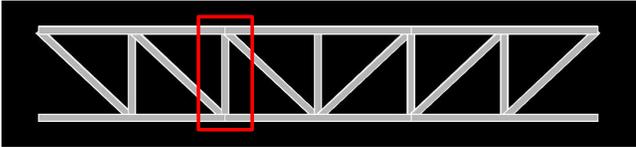


- Considerations
 - Splice Length
 - Conflict with Truss Web Connections
 - Conflict with Incoming Beam Connections
 - Conflict with M/E/P System Routing



74

Truss Connections: Web-to-Chord



A diagram showing a truss web-to-chord connection. A vertical web member is connected to a horizontal chord member. A red box highlights the connection point, which is a gusset plate connection.



75

Truss Connection: Web-to-Chord

*To Gusset Plate or Not To Gusset Plate...
That Is The Question*



76

Truss Connections: Web-to-Chord

- No Gusset Plate
- Pros
 - Often Architecturally Preferred
 - Reduces M/E/P Routing Conflicts
- Cons
 - No Bolted Options
 - Extensive CJP / PJP Welding Typically Required
 - Slower Site Assembly
 - Not Appropriate for All Shapes



77

Truss Connections: Web-to-Chord

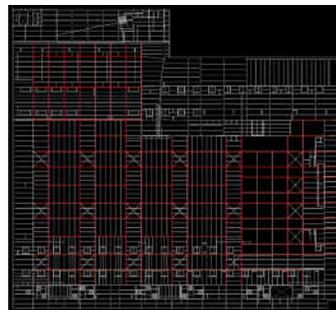
- Gussets
- Pros
 - Bolted or Fillet Welded Connections
 - Faster Site Assembly
- Cons
 - Can Create M/E/P Routing Challenges



78

Truss Connections: Web-to-Chord

- Gusset Plates Connections

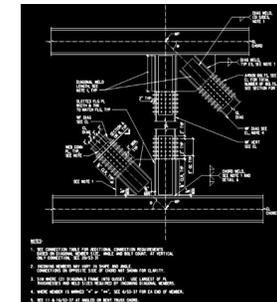


79

Truss Connections: Web-to-Chord

- Gusset Plate Connections

MEMBER NUMBER	ANGLE OR PLATE	CONNECTION TABLE					
		TABLE IS	NUMBER OF	WELD ALL	DESIGNED	DESIGNED	DESIGNED
		TABLE	PLATES	TABLE	TABLE	TABLE	TABLE
1	3/16" x 4"	A	1	A			
2	3/16" x 4"	A	1	A			
3	3/16" x 4"	A	1	A			
4	3/16" x 4"	A	1	A			
5	3/16" x 4"	A	1	A			
6	3/16" x 4"	A	1	A			
7	3/16" x 4"	A	1	A			
8	3/16" x 4"	A	1	A			
9	3/16" x 4"	A	1	A			
10	3/16" x 4"	A	1	A			
11	3/16" x 4"	A	1	A			
12	3/16" x 4"	A	1	A			
13	3/16" x 4"	A	1	A			
14	3/16" x 4"	A	1	A			
15	3/16" x 4"	A	1	A			
16	3/16" x 4"	A	1	A			
17	3/16" x 4"	A	1	A			
18	3/16" x 4"	A	1	A			
19	3/16" x 4"	A	1	A			
20	3/16" x 4"	A	1	A			



80

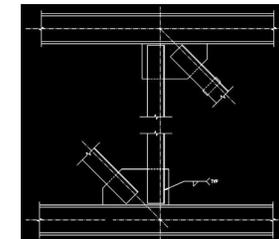
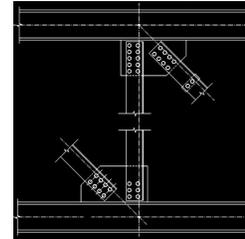
Truss Connections: Web-to-Chord



81

Truss Connections: Web-to-Chord

- Double Angles



82

Truss Connections: Web-to-Chord

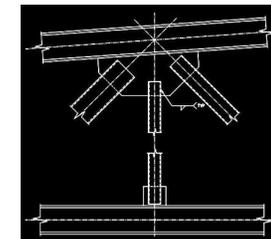
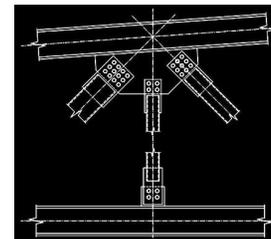
- Minimum Leg Length for Bolted Connections
 - < 6" – 1 Row
 - 6" – 2 Rows (Staggered)
 - 8" – 2 Rows (In Line)
- Bolt Groups Can Be Long
- Easy Field Bolt Installation / Fillet Welding
- Don't Forget about Shear Lag Effects
- Don't Forget about Stitch Plates



83

Truss Connections: Web-to-Chord

- HSS



84

Truss Connections: Web-to-Chord

- Weld HSS Directly to Gusset Plate
 - Over-Size Slot for Tolerance?
 - Patch Plates Required?
 - Field Welding



85

Truss Connections: Web-to-Chord

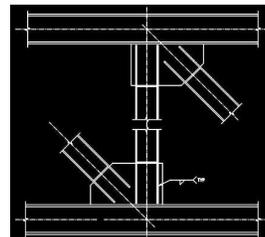
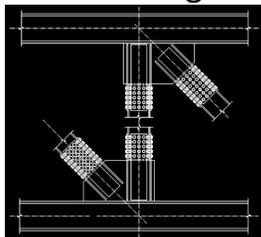
- Connection Plate Bolted to Gusset Plate
 - Shop Welding / Field Bolting
 - Eccentricity Somewhere



86

Truss Connections: Web-to-Chord

- Wide Flange



87

Truss Connections: Web-to-Chord

- Wide Flange



88

Truss Connections: Web-to-Chord

- Wide Flange
- Large Number of Bolts per Row
 - Compact Connections
 - Net Section Issues
 - Doubler Plates



89

Truss Connections: Web-to-Chord

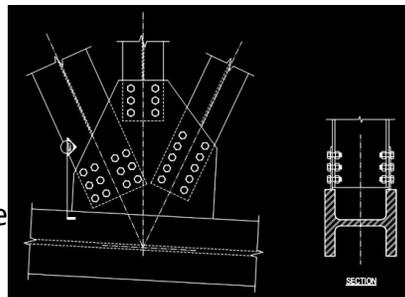
- Webs Horizontal
- **Works Great If All Members Same Size**
- **If Not...**
 - Filler Plates Required for External Gusset Plates



90

Truss Connections: Web-to-Chord

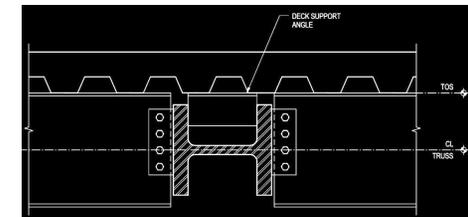
- Webs Horizontal
- **Works Great If All Members Same Size**
- **If Not...**
 - Co-Planar Gusset Plate to Chord Flange Weld Can Be Challenging



91

Truss Connections: Web-to-Chord

- Web Horizontal



Floor or Roof Deck Support



92

Truss Connections: End Connections

- Similar to Vertical Bracing Connections

93

Truss Connections: End Connections

- Bottom Chord – Slotted vs. Locked

94

Truss Connections: Material Weight

Bid Design

Final Design

95

Truss Connections: Material Weight

Well-Proportioned Truss: ~ 15% Connection Factor

Poorly-Proportioned Truss: Connection Factors Increase Rapidly

96

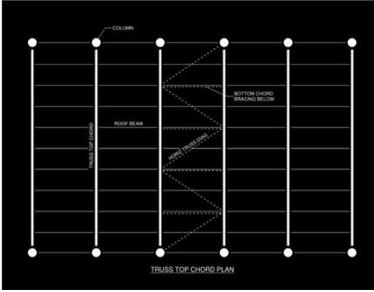
There's always a solution in steel.

Stability Considerations



Stability Considerations

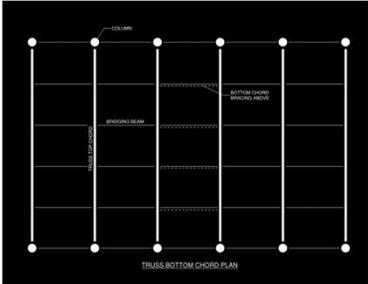
- Top Chord Plan



98

Stability Considerations

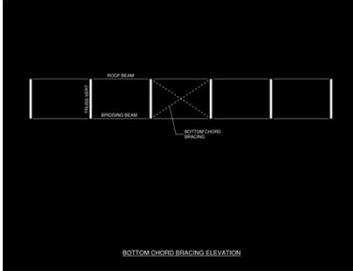
- Bottom Chord Plan



99

Stability Considerations

- Bracing Elevation



100

Stability Considerations

- AISC Appendix 6.3 (Beams & Trusses)
 - Limit the twist of the truss
 - Provide lateral bracing at compression chord
 - Provide torsional bracing to connect the tension and compression chords
 - Provide tension chord bracing to stabilize compression web members



101

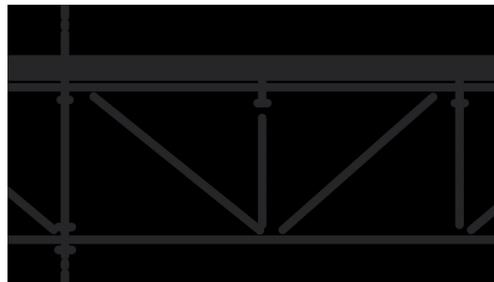
Stability Considerations

- Items to Consider
 - Consider all trusses buckling in the same mode
 - Consider both strength *and* stiffness of stability load path
 - Don't forget bracing at the tips of cantilever trusses
 - Watch for chord axial load reversal
 - Add bracing forces to all dead load cases
 - Consider the type of bracing appropriately
 - Panel Bracing
 - Point Bracing



102

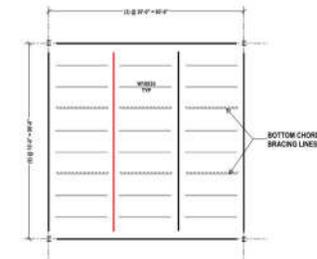
Examples



There's always a solution in steel.

Example 1: Geometry

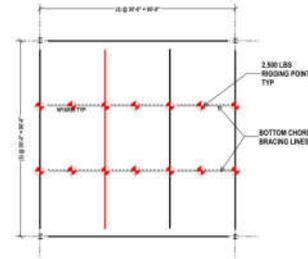
- Top Chord Framing Plan
 - 90'-0" x 90'-0" bay
 - Trusses at 30'-0" o.c.
 - 4 1/2" slab on 3" steel deck (7 1/2" total)
 - W18x35 beams 10'-0" o.c.



104

Example 1: Geometry

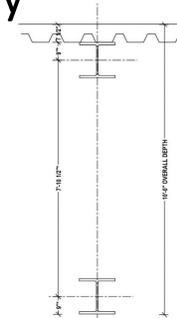
- Bottom Chord Framing Plan
 - 2,500 lbs. Rigging Loads
 - W18x50 Rigging Beams
 - Bottom Chord Bracing @ 30'-0"



105

Example 1: Geometry

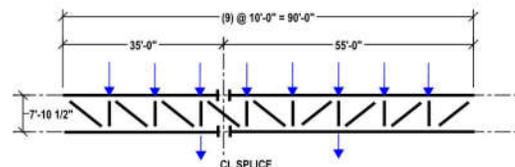
- Truss Section
 - 10'-0" overall structural depth
 - Span-to-depth = 9
 - 7'-10 1/2" effective truss depth



106

Example 1: Geometry

- Truss Elevation
 - (1) splice



107

Example 1: Geometry

- Members
 - W14 chords (A992, $F_y = 50$ ksi)
 - HSS webs (A500, Grade C, $F_y = 50$ ksi)



108

Example 1: Loading Criteria

- Dead Loads
 - Slab on Steel Deck (75 psf)
 - Steel Framing
 - Ceiling/MEP/Miscellaneous SDL (10 psf)
 - Truss Self-weight
- Live Loads
 - 250 psf Uniform Live Load
 - Rigging (per diagram)



109

Example 1: Serviceability Criteria

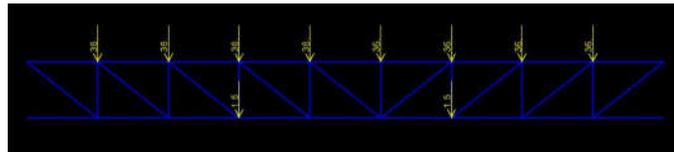
- Live Load Deflection < 2.0 inches
- Not Sensitive to Floor Vibrations



110

Example 1: Analysis

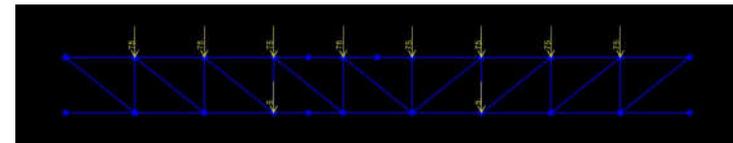
- Applied Loads – Dead Loads



111

Example 1: Analysis

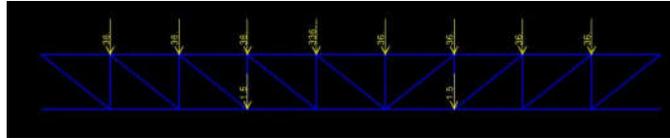
- Applied Loads – Live Loads



112

Example 2: Analysis

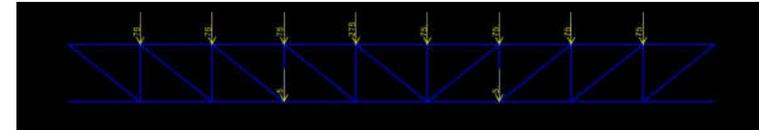
- Applied Loads – Dead Loads



121

Example 2: Analysis

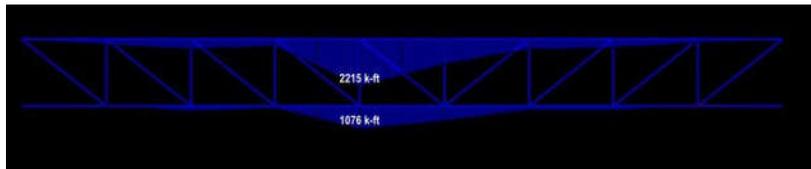
- Applied Loads – Live Loads



122

Example 2: Analysis

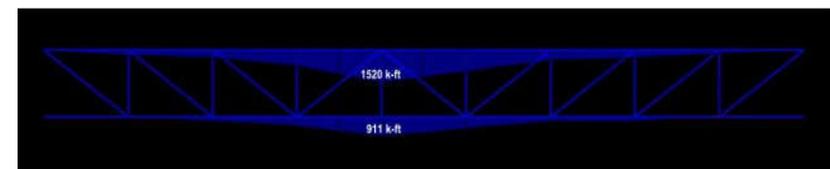
- Member Forces – Moments (1.2D+1.6L)



123

Example 2: Analysis

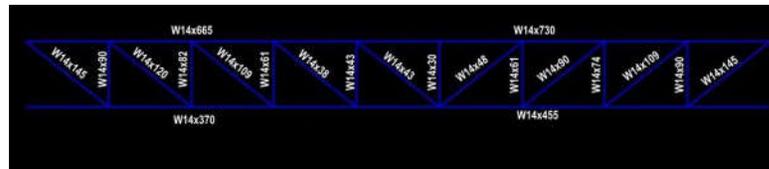
- Member Forces – Moments (1.2D+1.6L)



124

Example 2: Design

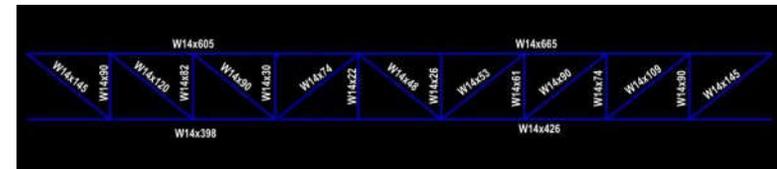
- Design Results
 - Self-weight: 58.1 tons (1,291 plf)



125

Example 2: Design

- Design Results
 - Self-weight: 55.0 tons (1,222 plf)



126

Questions?



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.



There's always a solution in steel.

Thank You

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

