



**UNIVERSITY  
PROGRAMS**

## A New Convention Center Rises in Steelville

### INSTRUCTIONS

Business owners in Steelville, Ill., are excited about the new convention center that will bring new customers to the area--but the architect needs your help!

The convention center will have large open spaces for exhibit areas on the first and second floors. The second floor framing is designed to carry a uniform floor load from above as well as hanging loads from below. To keep the spaces open and column-free, the floor framing system uses very large trusses spanning 90 ft. As the design team's structural engineer, you must review the preliminary design for the truss in preparation of the design package for the client.

#### Drawings

Preliminary framing plan [[Appendix A](#)]

Truss loading diagram [[Appendix B](#)]

#### References

Questions refer to the *Specification for Structural Steel Buildings* (ANSI/AISC 360-22) and the 16th Edition *Steel Construction Manual*.

## ROUND 1

In this first round, you will try your hand at some steel-themed trivia!

### Questions

- 1) In what year was AISC founded?
  - a) 1873
  - b) 1898
  - c) 1901
  - d) 1921
  
- 2) In structural steel design, what does the acronym HSS stand for?
  - a) Hollow Structural Steel
  - b) High-Speed Steel
  - c) Hollow Structural Section
  - d) High Strength Steel
  
- 3) True or False: The AISC *Steel Construction Manual* is the same thing as the AISC *Specification for Structural Steel Buildings*.
  - a) True
  - b) False
  
- 4) On average in the U.S., a new structural steel member contains what percentage of recycled material?
  - a) 10%
  - b) 25%
  - c) 75%
  - d) 93%

## ROUND 2

Before you can dive into the design of the truss itself, you will need to take a look at the framing plan and become familiar with the load path. A partial framing plan showing the area of interest is provided, along with the preliminary design loads for the floor framing. The gravity framing consists of a concrete slab on metal deck spanning between wide-flange beams that frame into the 90-ft-long steel trusses.

In this round, you'll need to follow the load path and calculate select demands on the typical beam and truss.

If you want a refresher on general concepts for floor framing and tributary area, take a moment to use [this interactive applet](#).

### Questions

- 1) What is the tributary width for the typical W18x35 beam that frames into the truss?
  - a) 5 ft
  - b) 10 ft
  - c) 20 ft
  - d) 30 ft
  
- 2) What is the total distributed dead load (lb/ft) on the typical W18x35 beam? Do not include any load factors.
  - a) 35 lb/ft
  - b) 85 lb/ft
  - c) 850 lb/ft
  - d) 885 lb/ft
  
- 3) For LRFD load combination  $1.2D + 1.6L$ , what is the factored distributed load (k/ft) on the typical W18x35 beam?
  - a) 1.42 kip/ft
  - b) 4.02 kip/ft
  - c) 5.06 kip/ft
  - d) 10.1 kip/ft
  
- 4) What is the factored vertical reaction (for  $1.2D + 1.6L$  load combo) at the end of the W18 at the truss?
  - a) 25.3 kips
  - b) 63.3 kips
  - c) 75.9 kips
  - d) 151.8 kips

## ROUND 3

In addition to the uniform floor loads that you considered in the previous round, the floor framing is also designed to carry hanging loads from below. With this being a convention center, there are a variety of uses for these spaces. For the purposes of this preliminary analysis, you've been asked to consider two equally spaced point loads positioned at joints in the bottom chord.

In this round, you'll consider the 90-ft. long truss and use the provided loads to determine the forces in select members. Refer to the truss elevation drawing for the truss geometry and the applied loads. Note that these provided loads have already been factored using LRFD load combinations.

Use the following assumptions in your calculations:

- All members are pin connected (i.e. no moment in the members)
- The truss loads are point loads applied at the truss joints.
- The weight of each truss member is small compared to joint loads and internal axial force that can be carried by that member. For the purposes of this preliminary analysis, an assumed self-weight for the truss members has been incorporated into the applied point loads for simplicity.

### Questions

- 1.) What is the determinacy of the truss?
  - a.) Statically determinate
  - b.) Statically indeterminate
  - c.) Unstable
- 2.) Assuming a truss effective depth =  $7'-10\frac{1}{2}''$ , what is the vertical angle of the diagonal,  $\theta$ ?
  - a.) 38.2 degrees
  - b.) 41.2 degrees
  - c.) 45 degrees
  - d.) 51.8 degrees
- 3.) What is the vertical reaction at joint A?
  - a.) 0 kip
  - b.) 440 kip
  - c.) 652 kip
  - d.) 660 kip

- 4.) What is the member force in the bottom chord (member OP)?
- a.) 660 kip
  - b.) 1654 kip
  - c.) 2100 kip
  - d.) 2113 kip
- 5.) What is the member force in the outermost diagonal (member AL)?
- a.) 0 kip
  - b.) 408 kip
  - c.) 840 kip
  - d.) 1067 kip

## ROUND 4

Now that you have the member forces, you want to get an initial sense for how large some of the individual members in the truss may need to be. With the long span and heavy loads, both you and the architect are curious about the potential member sizes. In this round, you'll run some hand calculations on a preliminary design and check limit states for some of the tension members: first, the bottom chord and then, the outermost diagonal members.

Assume:

- Top and bottom chords are wide-flange shapes (ASTM A992/A992M)
- Diagonal members are hollow structural sections (ASTM A500/A500M Gr. C)
- Member sizes as shown in the drawing
- Use LRFD
- The diagonal member will be connected to a gusset plate using a slotted connection. (Curious what that looks like? Check out this model: <https://aisc-org.github.io/aisc-model-viewer/slotted-hss/#3D-mode!>)
- The top and bottom chords can be considered continuous for the purposes of these preliminary calculations. The splices will be designed later.

Note: The following questions refer to the 2022 *Specification* and the 16th Edition *Steel Construction Manual*. The 2022 *Specification* is available for [free download](#).

### Questions

- 1.) What is the gross cross-sectional area of the bottom chord?
  - a.)  $62.0 \text{ in}^2$
  - b.)  $68.5 \text{ in}^2$
  - c.)  $75.6 \text{ in}^2$
  - d.)  $109 \text{ in}^2$
  
- 2.) What is the design strength for tensile yielding of the W14x233 bottom chord?
  - a.) 3083 kip
  - b.) 3339 kip
  - c.) 3425 kip
  - d.) 4007 kip

- 3.) What is the design strength for tensile rupture of the W14x233 bottom chord? (For these preliminary calculations, assume the bottom chord is continuous. The splices will be designed later.)
- a.) 2569 kip
  - b.) 3339 kip
  - c.) 4007 kip
  - d.) 4453 kip
- 4.) The required tensile strength for the W14x233 bottom chord is 2100 kip (calculated in round 3). Is the assumed W14x233 member adequate?
- a.) Yes
  - b.) No
- 5.) What is the yield stress ( $F_y$ ) and tensile stress ( $F_u$ ) for the HSS diagonal members?
- a.)  $F_y = 50$  ksi,  $F_u = 65$  ksi
  - b.)  $F_y = 50$  ksi,  $F_u = 62$  ksi
  - c.)  $F_y = 36$  ksi,  $F_u = 58$  ksi
  - d.)  $F_y = 46$  ksi,  $F_u = 58$  ksi
- 6.) Moving on to diagonal member AL, what is the gross cross-sectional area of the HSS member?
- a.)  $11.3 \text{ in}^2$
  - b.)  $18.5 \text{ in}^2$
  - c.)  $21.0 \text{ in}^2$
  - d.)  $24.7 \text{ in}^2$
- 7.) Referring to the preliminary connection detail for member AL, what is the net cross-sectional area of the HSS member at the location of the slot?
- a.)  $15.3 \text{ in}^2$
  - b.)  $23.3 \text{ in}^2$
  - c.)  $23.4 \text{ in}^2$
  - d.)  $24.0 \text{ in}^2$

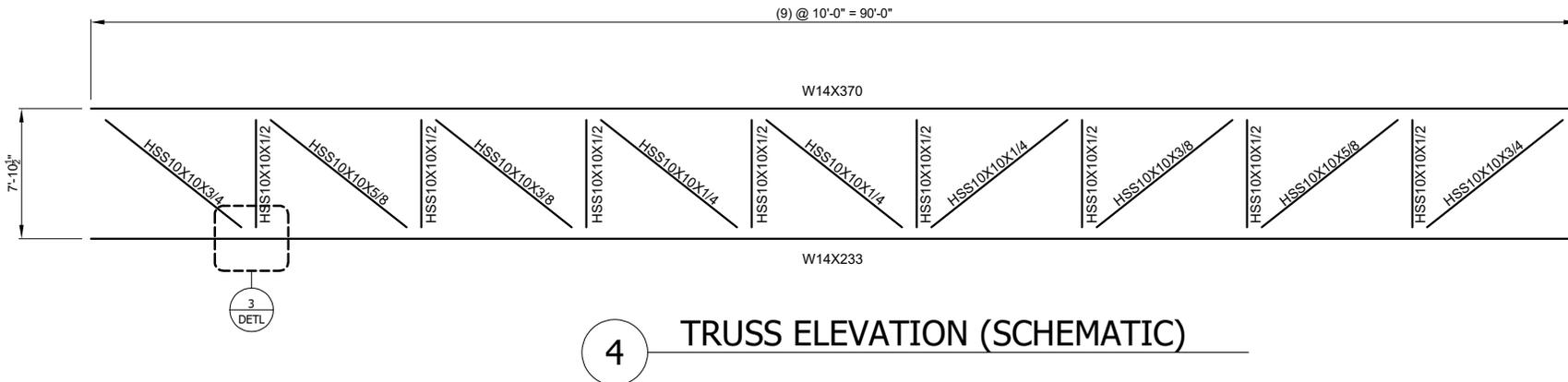
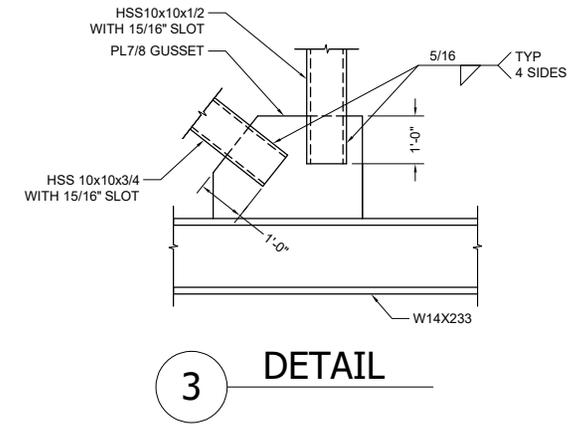
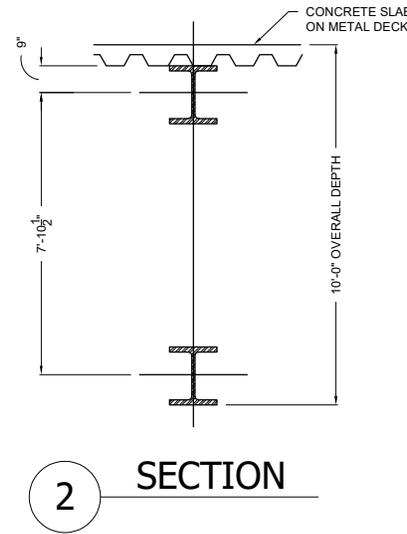
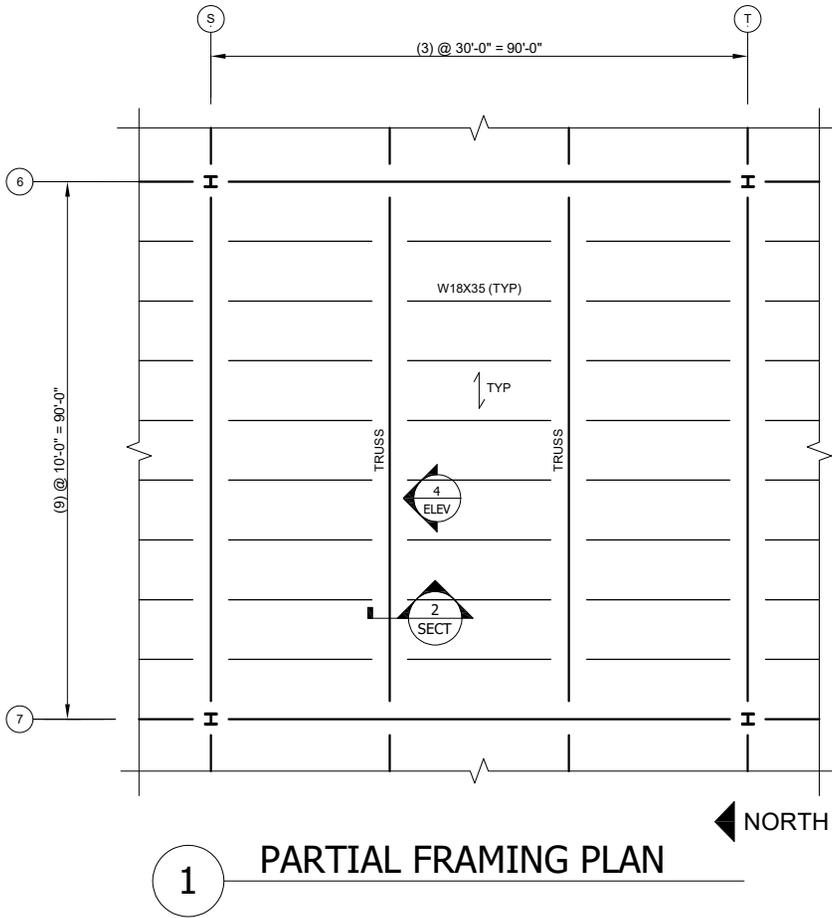
- 8.) Referring to the preliminary connection detail for member AL, what is the shear lag factor for calculating the effective net area at the location of the slot?
- a.) 0.688
  - b.) 0.732
  - c.) 0.942
  - d.) 1.00
- 9.) What is the design strength for tensile yielding of the HSS member (member AL)?
- a.) 1053 kip
  - b.) 1112 kip
  - c.) 1235 kip
  - d.) 1378 kip
- 10.) What is the design strength for tensile rupture of the HSS member (member AL)?
- a.) 796 kip
  - b.) 834 kip
  - c.) 955 kip
  - d.) 1088 kip
- 11.) The required strength for the HSS diagonal is 1067 kip (calculated in round 3). Is the preliminary design using the HSS10x10x3/4 and the slotted plate adequate?
- a.) Yes
  - b.) No

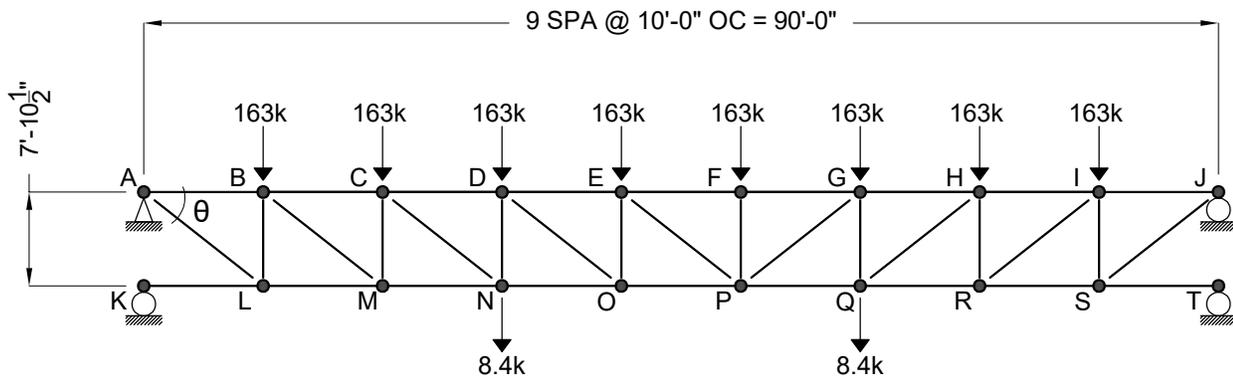
**GENERAL NOTES**

**LOADS**

For the purposes of preliminary design, assume the following gravity loads for the floor framing.

DEAD LOADS	
Concrete slab on metal deck	75 PSF
Ceiling + MEP	10 PSF
Steel framing	Self-weight (refer to drawings)
Hanging loads at truss bottom chord	7,000 LB (EACH)
LIVE LOADS	
Heavy storage	250 PSF





**LOADING DIAGRAM FOR TRUSS**

LRFD COMBO: 1.2D + 1.6L

NOTE:

1. POINT LOADS AT THE TOP CHORD INCLUDE AN ASSUMED TRUSS SELF-WEIGHT FOR THE PURPOSE OF PRELIMINARY ANALYSIS.