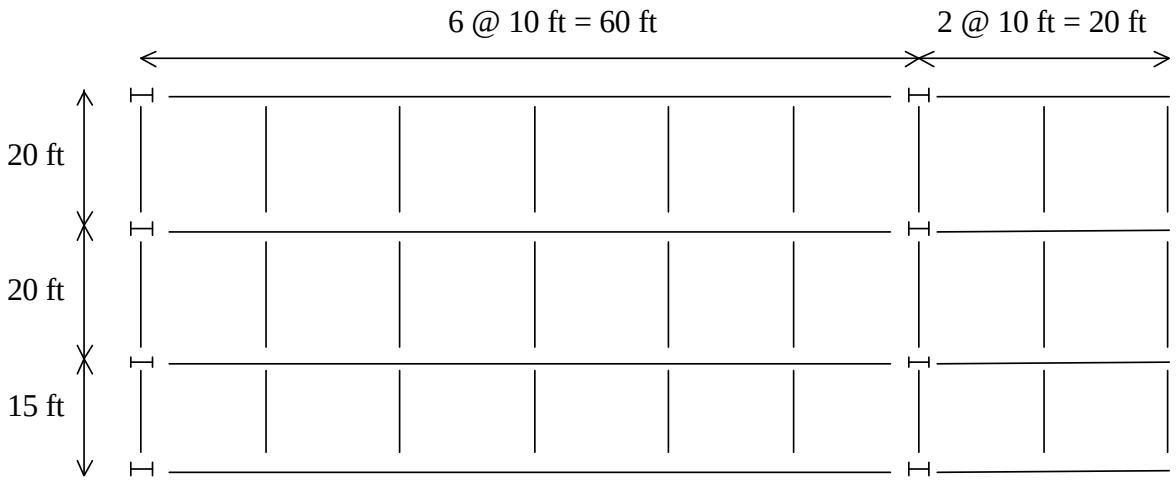
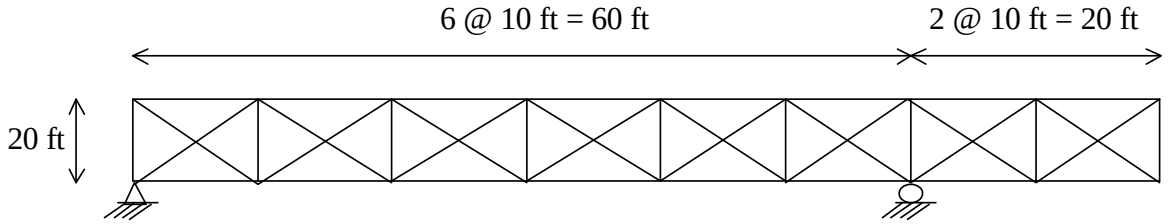
Design a typical steel truss girder to support the roof of the office building shown below.



Plan View



Front Elevation

Fy = 36 ksi

Purlins are Z 7 x 2.5 light gage steel, weighing 2.7 lb/ft

Use WT sections for the chords, double angles (LL) for the verticals, and single angels (L) for the diagonals.

Roof:

- Composition 4-ply felt & gravel
- 18 ga metal deck
- fiberglass insulation
- gravel and bitumen waterproofing membrane

Ceiling:

- acoustic tile
- suspended steel channel

Calculate Dead Loads

Composition 4-ply felt and gravel	5.5 psf
18 ga metal deck	3.0 psf
Fiberglass insulation	1.1 psf
Gravel Bitumin Waterproofing	5.5 psf
Acoustic Tile	1.0 psf
Suspended Steel Channel	2.0 psf
Total	**18.1 psf**

P^{DL}_int = 18.1 psf x 10 ft x 20 ft + 2.7 lb/ft x 20 ft = 3.67 k

P^{DL}_ext = 18.1 psf x 5 ft x 20 ft + 2.7 lb/ft x 20 ft = 1.86 k

Find chord with the max. bar force (assume compression controls)

Model truss on RISA:

1. Open new file in RISA

Setup

2. Select 1st item on "Data Entry" menu, "Global", and select "2" for "Number of Sections"
3. Select 2nd item on "Data Entry" menu, "Materials" and select correct yield stress, "Fy" (default = 36 ksi which is what is specified for this homework).
4. Select 4th item on "Data Entry" menu, "Sections", and specify three sections, labeled "Chords", "Verticals", and "Diagonals". Do not specify shapes at this time.

Draw Members

5. Select "Modify the drawing grid" from graphic editing tool bar and create grid (8@10 for the X-axis and 1@6 for the Y-axis).
6. Select "Draw new members" from the graphic editing tool bar, select "Chords" under "Section Set" and select "Bending Moments Released (torsion fixed)" under both "I-end Release Codes" and "J-end Release Codes".
7. Draw chords.
8. Repeat steps 6 and 7 for the verticals and the diagonals.
9. Select "Save As" under the "File" menu and save your model.

Modify Boundary Conditions

10. Select "Modify Boundary Conditions" from the graphic editing toolbar.
11. Specify "Fixed" and click the "Use" box for the last for boundary conditions (Z-Translation, X Rotation, Y Rotation and Z Rotation) , select the "Apply entries to all selected items" button and click "Apply".
12. Specify "Reaction" and click the "Use" box for the first two boundary conditions (X-Translation and Y-Translation), select the "Apply Entries by Clicking them Individually" button, click "Apply" and click on the node at the pinned support.
13. Specify "Free" for the first boundary condition (X-Translation), click "Apply" and click on the node at the pinned support.

Apply Dead Load and Solve

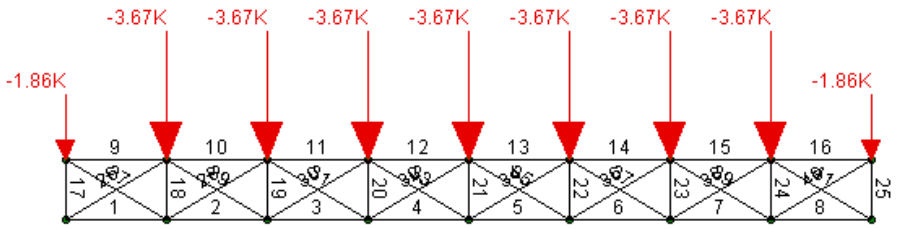
14. Select the Basic Load Case button on the top tool bar and type "Dead Loads" on the first line under "BLC Description"
15. Select the "Apply joint loads" button on the graphic editing tool bar and select"
    - "Y" for Direction
    - "-1.86" for Magnitude
    - "1: Dead Loads" for Basic Load Case
    - "Apply Entry by Clicking Items Individually", and
    - the "Apply" button
16. Select the nodes that have the external point loads applied
17. Repeat steps 15 and 16 for the internal point loads
18. Select the "Load Combinations" button on the top tool bar and type "DL Only" under "Description", "1" under "BLC" and "1" under "Factor".
19. Select the solve button ("=") on the top tool bar, select "Single Combination" and "1: DL Only" and select the "Solve" button.
20. Check to make sure that the Total Y reaction (29.41 k) equals the sum of the loads

    2 x 1.86 k + 7 x 3.67 k = 29.41 k, OK

Find Max. Bar Force and Document Results

21. Find the max. compressive chord force (+'ve in RISA) by
    - Selecting just the chords (first "unselect" the entire truss, then select just the chords by drawing a box around first the top and then the bottom chords). Use the selection tools on the toolbar along the left edge of the screen.
    - Click the "Exclude" button in the bottom-left corner of the screen
    - Select "Member Forces" on the "Results" toolbar (only the members representing chords should be shown), click on the column marked "Axis [K]", and select "sort" from the menu which appears by right-clicking. At the top of the list should be the member corresponding to your top chord in the 3rd panel with a bar force of "20.645 k".
22. Document your results.

RISA model of truss showing dead loads and member numbers



Chord Forces due to Dead Load (max = 20.645 k in member 11)

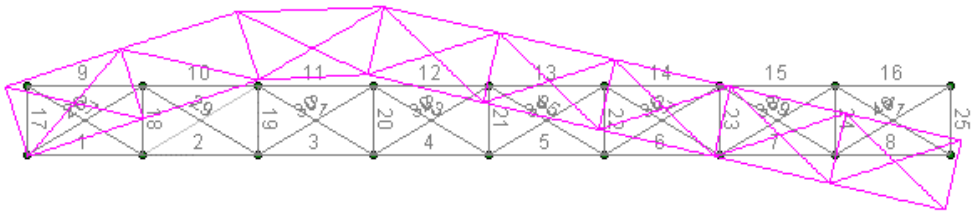
Member Label	Sec	Axial, K
M1	1	-7.104
	2	-7.104
M2	1	-17.009
	2	-17.009
M3	1	-21.083
	2	-21.083
M4	1	-19.031
	2	-19.031
M5	1	-10.837
	2	-10.837
M6	1	2.818
	2	2.818
M7	1	6.88
	2	6.88
M8	1	1.404
	2	1.404
M9	1	6.135
	2	6.135
M10	1	16.591
	2	16.591
M11	1	20.645
	2	20.645
M12	1	18.591
	2	18.591
M13	1	10.446
	2	10.446
M14	1	-4.471
	2	-4.471
M15	1	-8.536
	2	-8.536
M16	1	-1.696
	2	-1.696

Determine Live-Load Span Loading to cause Max. force in Member 11

(Member 11 is the top chord of panel 3 in this RISA model)

23. Construct influence diagram for member 11 by applying distributed temperature load to member 11 of 1"/(6.5 E-6 x 10 ft x 12 in/ft) = 1282 ^{o}F.
24. Click on "Dist. Patterns" in the "Data Entry" menu and on the second line (the line below "Uniform") type "Temperature", "T", "1", and "1" in the first four columns.
25. Create a basic load case for the influence diagram by typing "Influence for mem 11" on the second line of the "Basic Load Case" menu.
26. Bring up the "Member Distributed Loads" menu by clicking on the cell under "Dist" ***in the second line*** of the Basic Load Case menu and select or type "M11", "Temperature" and "1282" in the first three columns. A "1" should appear in the cell you selected of the "Basic Load Case" menu.
27. Create a load combination for the influence diagram by opening the "Load Combinations" sheet and typing "Influence for 11", "2" and "1" in the 1st, 7th and 8th columns, respectively.
28. Compute the influence diagram by clicking on the "=" button and selecting "Single Combination" and "2: Influence for 11" and then "Solve".
29. Display the influence diagram by opening the plot options menu (press "F2" or click the "blue box" button in the upper left (two buttons below the "File" menu)). Select the "Load Combination" button and the "Include Undeflected Shadow" button.
30. Printout the influence diagram for member 11 and label appropriately (in pencil, write: Influence Diagram for Member 11).

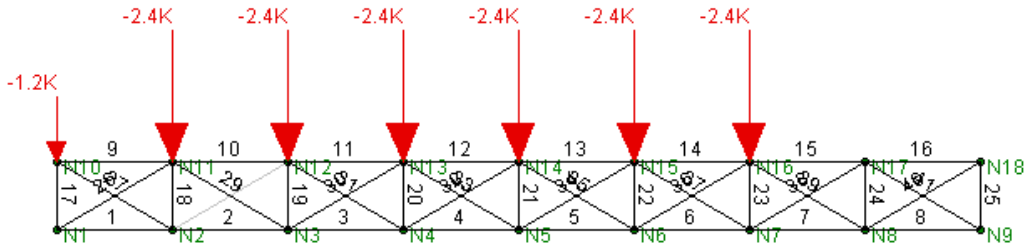
Influence Diagram for Member 11



Compute Bar Forces due to Live Load

31. Create a Basic Load Case for the Live Load on Span 1 by opening the BLC sheet and typing "LL on Span 1 only" on the 3rd line.
32. Repeat steps 15 through 17 to place the external and internal concentrated loads on the left-most 7 joints. (The loads over the support will have no effect on the bar force in member 11, but they will affect the bar forces in the verticals and diagonals near the supports). Show the live loading to cause max. force in member 11.

Live Loads to Cause Max. Force in Member 11



Calculate Chord Forces due to Dead + Live Loads

33. Create a Load Combination for DL + LL by typing "DL + LL on span 1", "1", "1", "3", "1" on the third line of the "Load Combination" sheet in columns 1 and 7 through 10, respectively.
34. Select the solve button ("=") on the top tool bar, select "Single Combination" and "3 : DL + LL on Span 1" and select the "Solve" button.
35. Check to make sure that the Total Y reaction (45.01 k) equals the sum of the loads

    DL: 2 x 1.86 k + 7 x 3.67 k = 29.41 k

    LL: 1.20 k + 6 x 2.40 k = 15.60 k

    Total: 45.01 k, **OK**
36. Document your results (see step 21)

Chord Forces due to Dead plus Live Load (max. compressive = 37.5 k in member 11)

Member Label	Sec	Axial, K
M1	1	-12.446
	2	-12.446
M2	1	-30.144
	2	-30.144
M3	1	-38.227
	2	-38.227
M4	1	-36.174
	2	-36.174
M5	1	-23.97
	2	-23.97
M6	1	-2.588
	2	-2.588
M7	1	6.549
	2	6.549
M8	1	1.417
	2	1.417
M9	1	10.793
	2	10.793
M10	1	29.456
	2	29.456
M11	1	37.501
	2	37.501
M12	1	35.448
	2	35.448
M13	1	23.313
	2	23.313
M14	1	0.123
	2	0.123
M15	1	-8.868
	2	-8.868

Determine Section Sizes

37. Make sure "Redesign" has been specified for your members (step 4a).
38. Select "Sections" from the "Data Entry" menu and select the heaviest (default) WT section for the chords, "Double Angle" section for the verticals, and "Single Angle" section for the diagonals.
39. Analyze ("=" button) for Load Combination 3 (DL + LL on Span 1).
40. Select "Alternate Shapes" from the "Results" menu, right click and select "Replace and Resolve" until asterisks appear in front of all 3 shapes.
41. Check to make sure that none of the sections are "off the chart" for RISA (this happens for very slender members) and is indicated by the message "compressive stress fa exceeds F'e (Euler stress)". If this happens, select a heavier section from the "Sections" menu for this type of member and repeat steps 40 and 41.
42. Document your results (unity check values, section sizes and truss weight).

Steel Code Checks (for DL + LL on Span 1)

Member	Unity Check
M1	0.189
M2	0.434
M3	0.551
M4	0.521
M5	0.346
M6	0.053
M7	0.12
M8	0.03
M9	0.218
M10	0.637
M11	0.811
M12	0.766
M13	0.504
M14	0.014
M15	0.142
M16	0.025
M17	0.588
M18	0.11
M19	0.147
M20	0.144
M21	0.149
M22	0.084
M23	0.929
M24	0.025
M25	0.053
M26	0.677
M27	0.178
M28	0.366
M29	0.106
M30	0.111
M31	0.015
M32	0.051
M33	0.217
M34	0.144
M35	0.468
M36	0.202
M37	0.819
M38	0.349
M39	0.043
M40	0.089
M41	0.024

Final Member Sizes

Section	Controlling Member	Shape
CHORDS	M11	*WT5X11
VERTICALS	M23	*LL2X2X3X6
DIAGONALS	M37	*L5X5X5

Truss Weight

Section	Shape	Length (ft)	Weight (k)
CHORDS	WT5X11	160	1.764
VERTICALS	LL2X2X3X6	54	0.263
DIAGONALS	L5X5X5	186.59	1.924
		Total Wt:	**3.951**