AE 308
Examination #1
1 October 2009

This examination is open book and open notes. The exam will be conducted under an honor system, where you are responsible for your own conduct, and for the conduct of your classmates. The following rules apply

No talking

No sharing of books

No sharing of notes

No passing or displaying of paper of any kind

No sharing of calculators

Cell phones turned off and put out of sight. Please use some other means of keeping time.

Time limit of 120 minutes.

No more than one student at a time on bathroom break, except in emergency.

If you suspect a violation of these rules, you are obligated to report to a member of the class Honor Council. Failure to report a suspected violation is also considered a breach of academic integrity principles.

Honor Council: Rebecca Dick
Pat Laninger
Mike Tellep
Nicole Trujillo
Josh Wentz

If you finish early, please drop off your paper at the front of the room, and leave the general area. Please do not congregate outside the classroom door.

By my signature below, I agree to comply with these rules, with University Faculty Senate Policy 49-20, and with the principles of academic integrity.

Justin Kovach

Signature

Justin Kovach

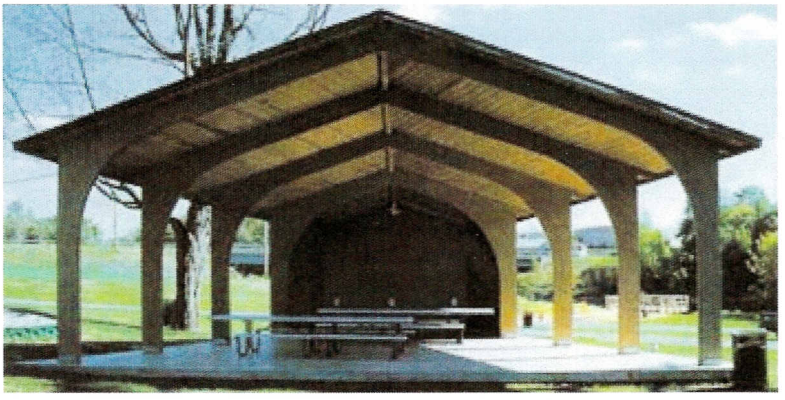
Print Name (**5 points**)

99

AE 421
Examination 1
1 October 2008

Problem I Carefully consider the three similar picnic shelter structures shown below.

Shelter Structure A



Shelter Structure B

Shelter Structure C

For convenience we will fix the dimensions of all three of the shelters

- The frame of each structure spans 48 feet,
- The eave height of each shelter is 12 feet
- The frames supporting the roof of each shelter are spaced 10 feet apart.
- The roof pitch of each shelter is 4:12.

The roof of each shelter consists of asphalt shingles (3 lbs/ft^2) supported on 2 1/2" plank deck. Add a 5 psf allowance for additional miscellaneous framing.

The snow load is 20 psf.

A sketch of the outline of each shelter is provided on the three following sheets.

For each of these structures, complete the following tasks (5 points each, for each shelter)

1. Draw a structural diagram of each frame on the next pages.

2. Identify the support conditions, and draw an appropriate symbol.

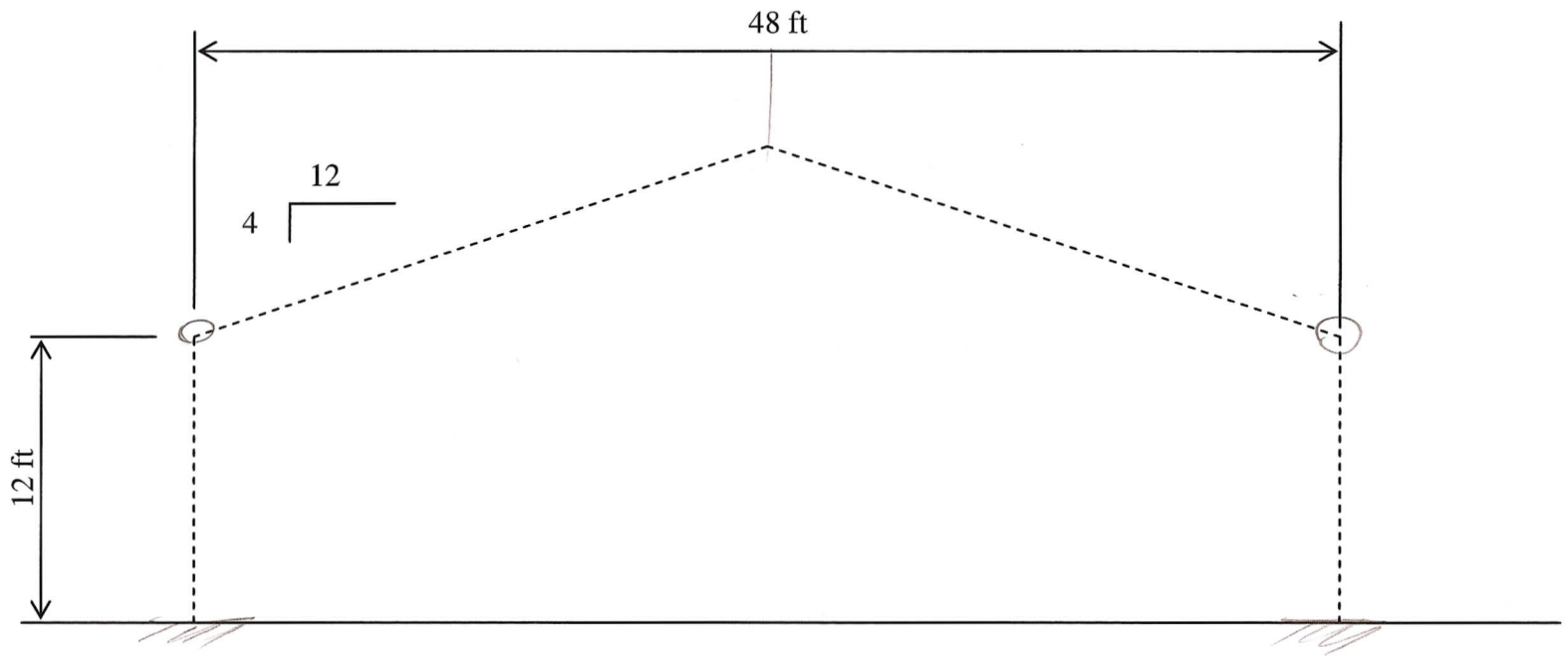
3. Locate any internal hinges.

4. Find the uniformly distributed dead + snow load on the frames for the shelters. **(10 points total)**

5. Using the estimated dimensions on the next pages, and the loads and support conditions from 2-4 above, determine the support reactions.

Further instructions are given on the following pages

Shelter A

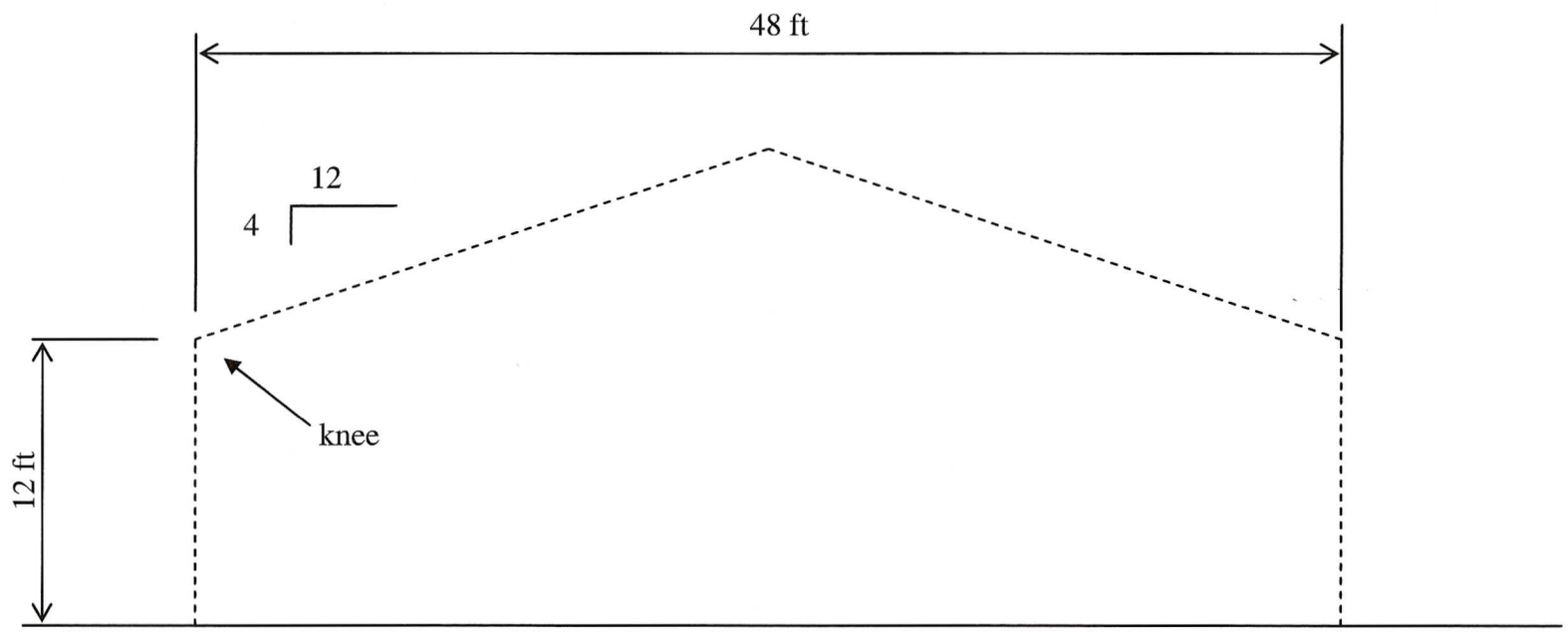


Additional tasks for Shelter A (5 points each)

Find bending moment at midspan under dead + snow loading.

Suppose beam is 6 3/4" × 24" at midspan. Find the bending stress under dead + snow loading. and determine the adequacy of the beam for dead + snow loading. Maximum bending stress in beam is 1800 psi.

Shelter B

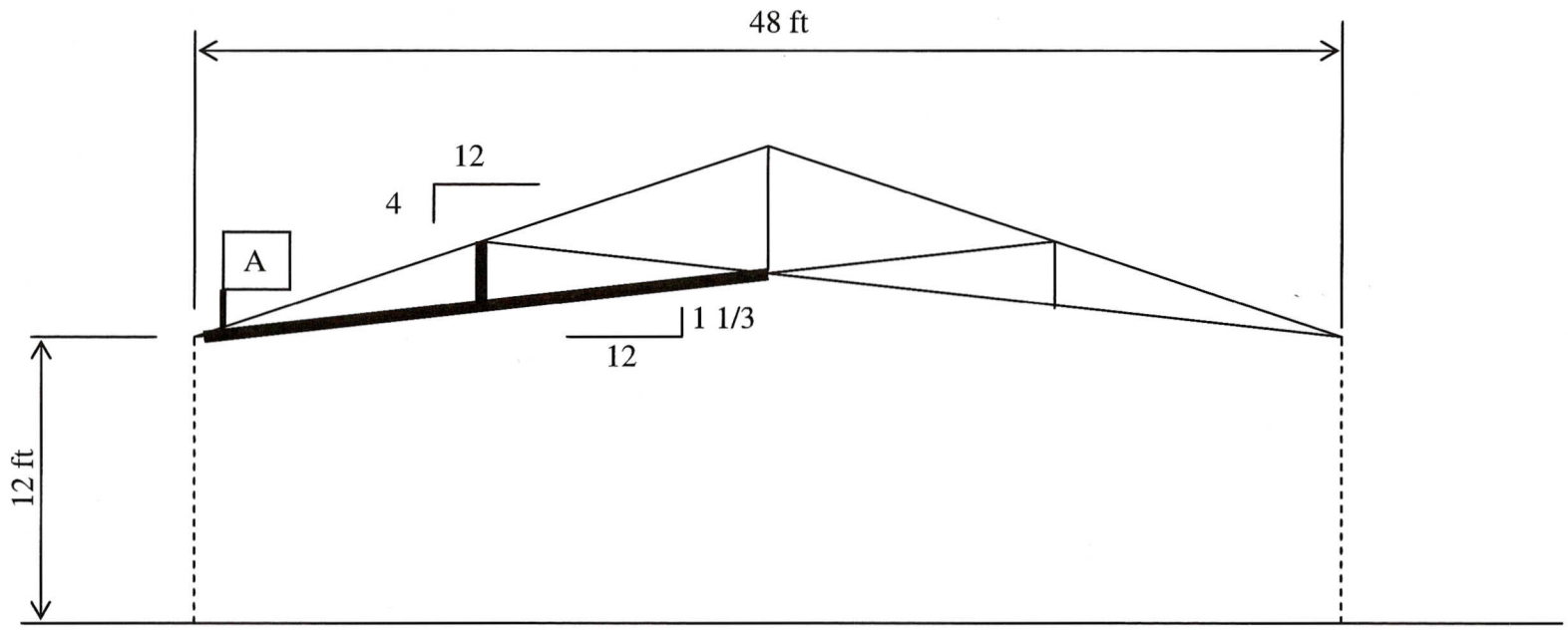


Additional Tasks for Shelter B (5 points each)

Find the bending moment at the knee under dead + snow loading (location indicated on outline above)

Sketch the bending moment diagram for the remainder of the frame.

Shelter C



Additional tasks for Shelter C (5 points each)

Find the bar force under dead + snow load in the three bars drawn boldface. Include whether bar is in tension or compression

Find the shear in the top chord at the support (section A). Assume all joints pinned.

Note: This configuration is known as a scissors truss.

All Shelters

Loads

20 psf = Snow Load
3 psf = Shingles
7.083 psf = 2½" Plank Deck
5 psf = additional allowance

Assumptions

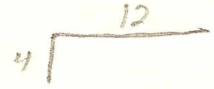
1) Douglas Fir was the wood chosen to be used for the Plank Deck ($34\ lb/ft^3$)

Plank Deck

$$34\ lb/ft^3 \times \left(\frac{2.5}{12}\right)' = 7.083\ lb/ft^2$$

Frame Information

Span = 48'
Eave Height = 12'
Dist between frames = 10'



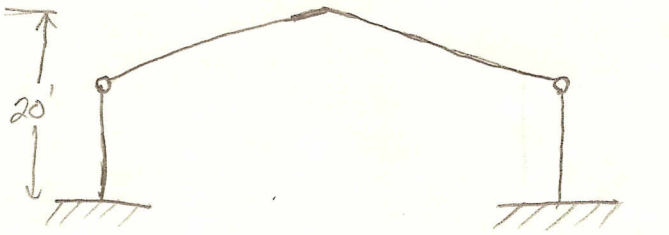
Total Loads per sq ft

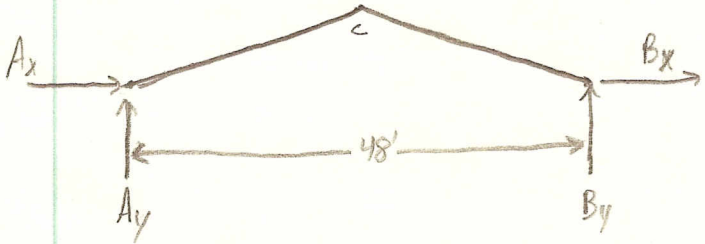
$$(20 + 3 + 7.083 + 5)\ psf = 35.083\ psf$$

Total Distributed Load per Frame

4) $35.083\ lb/ft^2 \times 10\ ft = \boxed{350.83\ lb/ft}$

Shelter A





$$\frac{24}{x} = \frac{12}{4} \Rightarrow x = 8$$

Assumptions

1) Fixed at the base of the columns because the columns appear to be penetrating into the concrete

2) Hinged at the top of the columns because the columns appear to not be able to support a moment reaction with the Frame

$$+\circlearrowleft \Sigma M_A = 0 = 24(-350.83(48)) + 48\,B_y$$

$$\boxed{B_y = 8.4199 \text{ kips}}$$

$$\Sigma F_y = 0 = A_y + B_y + (-350.83(48))$$

$$\boxed{A_y = 8.4199 \text{ kips}}$$

$$\Sigma F_x = 0 = A_x + B_x$$

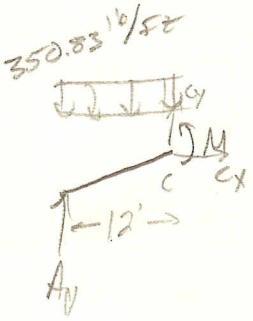
$$A_x = -B_x$$

All the reactions for Shelter A cannot be determined because Shelter A is statically indeterminate

30

Shelter A

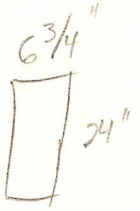
Additional Tasks



$\curvearrowleft \Sigma M_c = 0 = M + 350.83(6) + 12(-A_y)$

$\therefore M = 98.934 \text{ kip-ft}$

$M = 98934.06 \text{ lb-ft} \times \frac{12 \text{ in}}{1 \text{ ft}} = 1,187,208.72 \text{ lb-in}$



$A = 162 \text{ in}^2 \times 12' = 1944 \text{ in}^3$

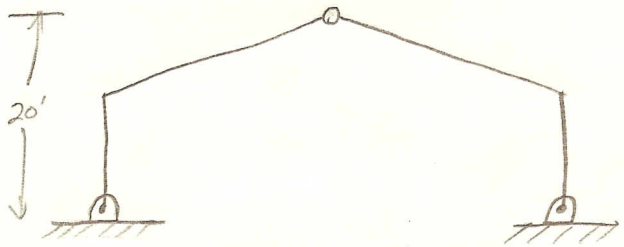
$F_S = \frac{M}{S}$

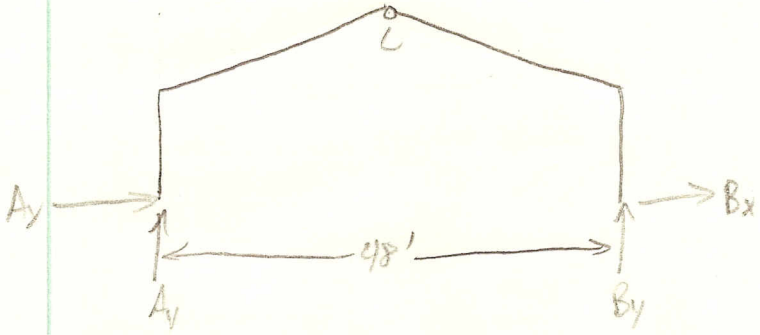
$F_S = 610.7 \text{ psi}$

Good to Withstand

7

Shelter B





Assumptions

1) The connection with the concrete pad appears to be a pinned reaction on both sides of the frame. This is because their appears to be nothing to resist a moment reaction at this point

2) A hinge occurs at the peak of roof because their appears to be a thin board in the picture and a board connecting 2 sides of a truss at the peak cannot resist a moment and is therefore a hinge

$+\circlearrowleft \sum M_A = 0 = (-350.83(48))(24) + 48\,B_y$

$\therefore -B_y = 8.4199$ kips

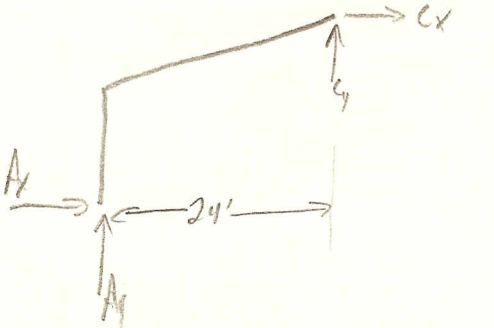
$\sum F_y = 0 = A_y + B_y + (-350.83(48))$

$\therefore A_y = 8.4199$ kips

$\sum F_x = 0 = A_x + B_x$

$A_x = -B_x \longrightarrow A_x = -B_x$

$\therefore B_x = -9.8934$ kips



28

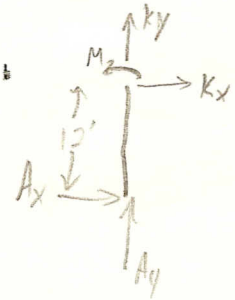
$+\circlearrowleft \sum M_C = 0 = (-350.83(-12) + A_y(-24) + A_x(-0)$

$\therefore A_x = 9.8934$ kips

Shelter B

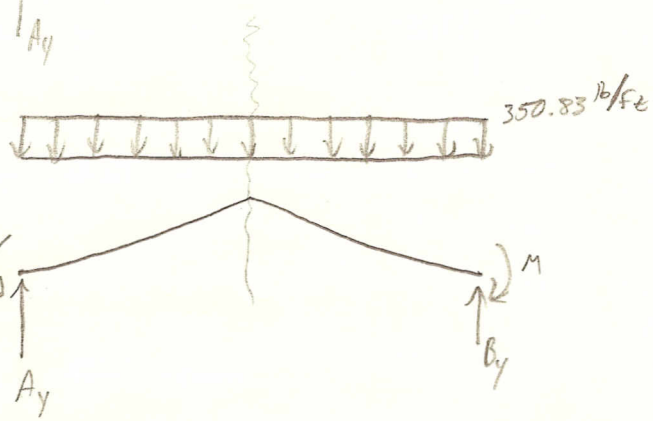
Additional Tasks

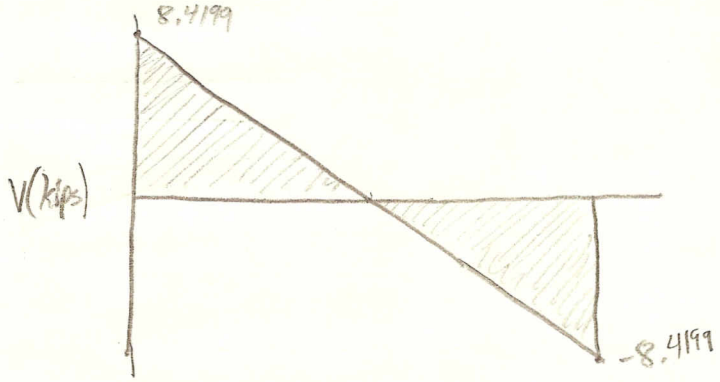
Bending Moment at the knee

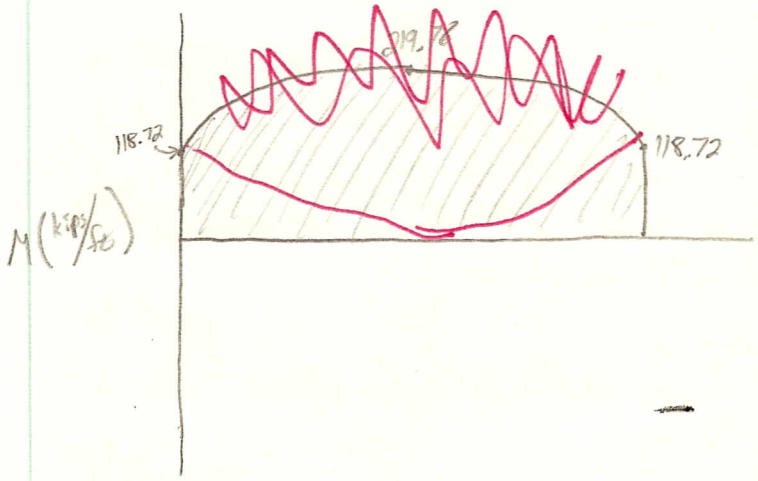


$$+\circlearrowleft \Sigma M_k = 0 = M + 12A_x$$

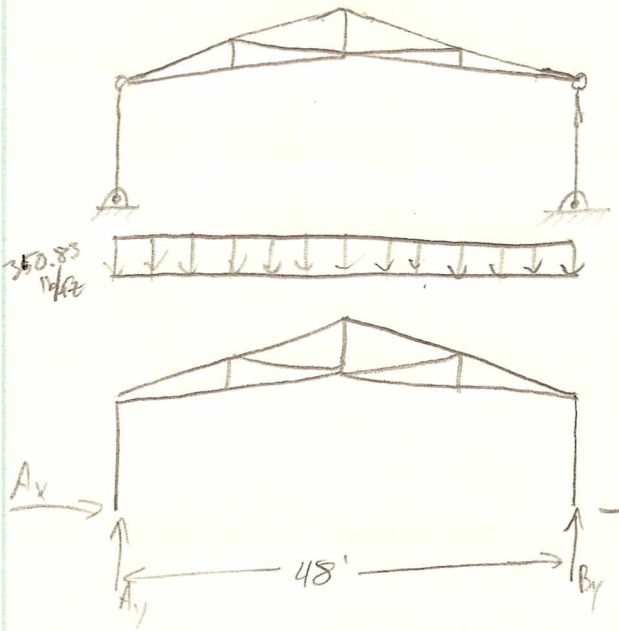
$$\therefore M = 118.72 \text{ kips/ft}$$







Shelter C



$\tan\theta = \frac{2\frac{2}{3}}{24}$

$\theta = 6.34°$

$\frac{24}{x} = \frac{12}{1\frac{1}{3}} \Rightarrow x = 2\frac{2}{3}'$

Assumptions

1) Pinned at the base of the columns because the brackets there can support no moment reaction

2) A Hinge is located at the top of each column- This is because the support at the top of the column cannot support a moment reaction

$+\circlearrowleft \Sigma M_A = 0 = 24(-350.83(48)) + 48\,B_y$

$\therefore B_y = 8.4199$ kips

$\Sigma F_y = 0 = A_y + B_y + (-350.83(48))$

$\therefore A_y = 8.4199$ kips

$\Sigma F_x = 0 = A_x + B_x$

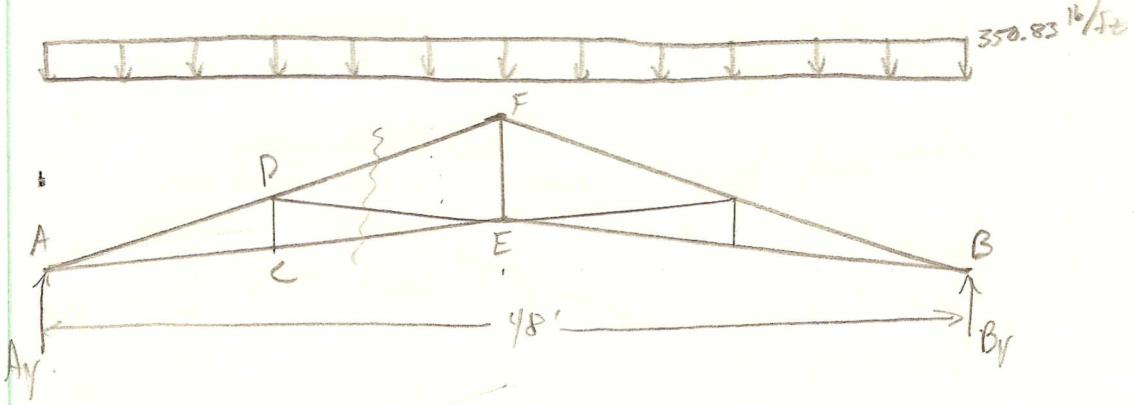
$A_x = -B_x$

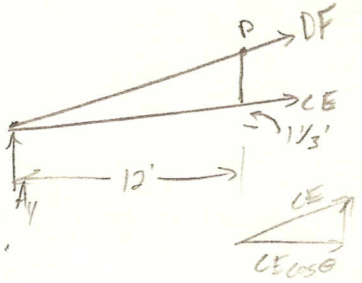
28

Shelter C

Additional Tasks

$A_y = B_y = 8.4199$ kips

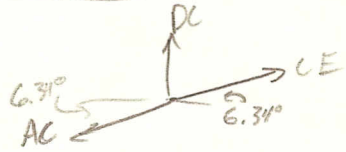




$+\circlearrowleft \Sigma M_D = 0 = -12A_y + CE\cos\theta\,(4 - 1\tfrac{1}{3})$

$\therefore CE = 27.726$ kips (T)

Joint C



$\Sigma F_x = 0 = CE\cos\theta - AC\cos\theta$

$\therefore AC = CE = 27.726$ kips (T)

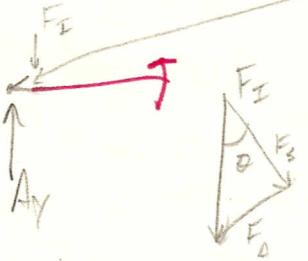
$\Sigma F_y = 0 = DC + CE\sin\theta - AC\sin\theta$

$\therefore DC = 0$

Joint A

$\tan\theta = \frac{8}{24}$

$\theta = 18.4349°$



$F_S = F_I\cos\theta$

$F_S = 7.9878$ kips

$\Sigma F_y = 0 = A_y - F_I$

$F_I = A_y = 8.4199$ kips