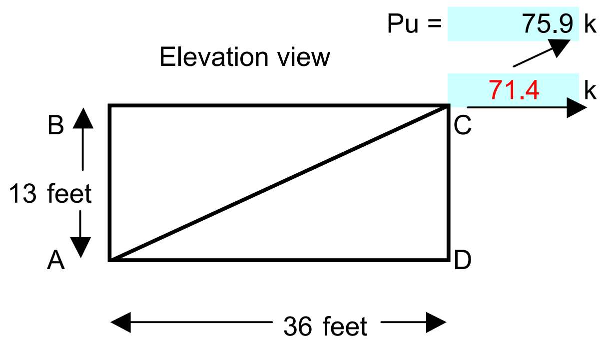
SELECT ANGLE FOR CROSS-BRACING ON 1st FLOOR
Use LLBB double angles.

Notation:

Ae - effective net area, in^2
Ag - gross area of member, in^2
Fu - specified minimum tensile strength, ksi
Fy - specified minimum yield stress, ksi
Pn - nominal axial strength, kips
Pu - factored load
ϕt - yielding/fracture factor



ANALYSIS:

Loads: Pu = 75.9 k

Use A992 Steel [a]

Corresponds to lateral load flow calculations
for 2nd floor, brace line B3.

Fu = 58 ksi
Fy = 36 ksi

Brace carries either tension or compression, depending on direction of applied lateral load.
Compression will control member size.

Compression member design:

$\lambda c = (K * L/\pi * r) * (Fy / E)^{0.5}$
ϕc = 0.85
K = 1

ϕt Pn = ϕc* Fcr * Ag
Fcr = $(.658^{\lambda c^2}) * Fy$ when $\lambda c \leq 1.5$
Fcr = $(0.877 / \lambda c^2) * Fy$ when $\lambda c > 1.5$
λr = 0.45 * (E/Fy)^(1/2)
If b/t > λr section is a slender-element cross-section

for a slender-element cross-section:
Fcr = $Q*(.658^{Q*\lambda c^2}) * Fy$ when $\lambda c*Q \leq 1.5$
Fcr = $(0.877 / \lambda c^2) * Fy$ when $\lambda c*Q > 1.5$
$\lambda c = (K * L/\pi * r) * (Fy / E)^{0.5}$

If : 12.77 < b/t < 25.83
Q = 1.34 - 0.76 *(b/t) * (Fy/E)^(1/2)
If : b/t $\geq$ 25.83
Q = 0.53 * E / (Fy*(b/t)^2)

ϕt Pn > Pu
ϕc* Fcr * Ag > 75.9 k
Ag required > Pu / (ϕc* Fcr)

Try Fcr = 8 ksi
Ag required = 11.16 in^2

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Try: **2L8x4x1/2LLBB**

Ag =	11.6	in^2	>	11.2	in^2	OK!
r =	2.58	in				
b =	4	in				
t =	0.5	in				

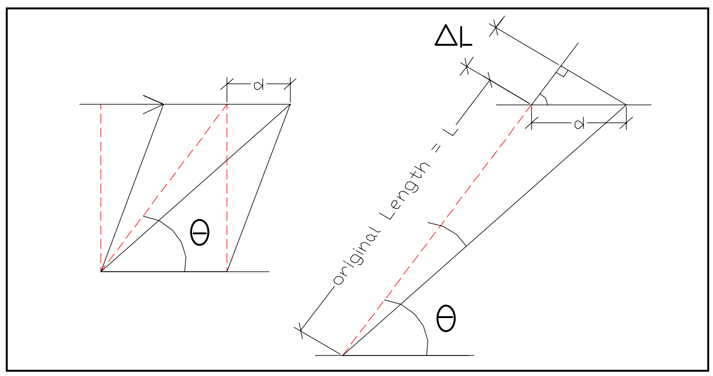
b/t =	8	
λc =	1.997	
λr =	12.77	section is not slender
Q =	1.000	
Fcr =	7.92	ksi

ϕt Pn = 78.1 kips > 75.9 kips **Angle OK!**

Use 2L8x4x1/2LLBB

Check using LRFD table 4-11:
for a 2L8x4x1/2LLBB (from table 4-11)
ϕt Pn = 78.05 kips > 75.9 kips **Angle OK!**

Deflection check:
Deflection, or drift, of a singe story braced frame is usually caused primarily by tension elongation of the diagonal member. The elongation of one diagonal moves the rectangular-framed bay into a parallelogram form.
Assuming the change in the angle of the diagonal, $\Delta\theta$, to be small, the change in the is to be used to approximate the hypotenuse of the triangle, which is d.



d = ΔL / COSθ and ΔL = Pu*L/(A*E)

θ = 19.86

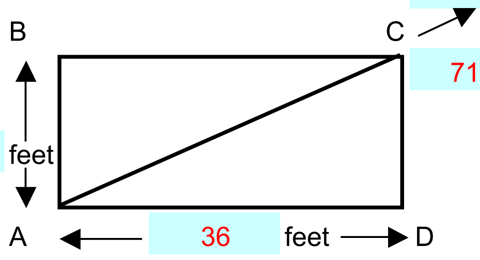
d = Pu * L / (A*E*COSθ) = 0.009241 ft

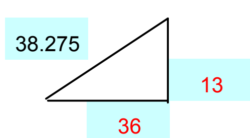
deflection = 0.111 in

Elevation view

Pu = 75.9 k

71.4 k





Limit - Δ = h/250

h =	13	ft
Δ =	0.052	ft
Δ =	0.624	in
E =	29000	ksi

drift = 0.111 in < Δ = 0.624 in OK!
Deflection doesn't control member size

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If deflection doesn't control member size use LRFD table 4-10 to size braces on other floors.
If deflection controls member size, find the section gross area required adequate for deflection limit .

h/250 = 0.0520 ft
drift limit = 0.6240 ft
L = 38.28 ft
E = 29000 ksi

Ag required > Pu*L/(drift limit *E*COS(θ))

Deflection doesn't control member size

Floor	Lateral load (k)	Brace force (k)	KL (ft)	if deflection controls member size ΔL (ft)	L (ft)	Ag req.	Use Table 4-10
4	10.3	11.0	38.28	0.6240	38.28	-	**2 L 8x4x7/16**
3	35.7	38.0	38.28	0.6240	38.28	-	**2 L 8x4x7/16**
2	57.5	61.1	38.28	0.6240	38.28	-	**2 L 8x4x7/16**
1	71.4	75.9	38.28	0.6240	38.28	-	**2 L 8x4x1/2**

Lab Note: Shear studs along the beams that are part of the lateral load-resisting truss are necessary to transfer the lateral loads from the floor diaphragms to the lateral load resisting truss members.

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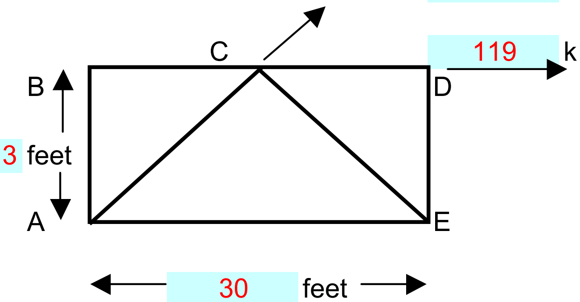
SELECT ANGLE FOR CROSS-BRACING ON 1st FLOOR
Use LLBB double angles.

Elevation view

Pu = 157.5 k



Notation:
Ae - effective net area, in^2
Ag - gross area of member, in^2
Fu - specified minimum tensile strength, ksi
Fy - specified minimum yield stress, ksi
Pn - nominal axial strength, kips
Pu - factored load
ϕt - yielding/fracture factor

ANALYSIS:

Loads: Pu = 157.5 k

Corresponds to lateral load flow calculations for 2nd floor, brace line B3.

Use A992 Steel [a]

Fu = 58 ksi
Fy = 36 ksi

Brace carries either tension or compression, depending on direction of applied lateral load.
Compression will control member size.

Compression member design:

$\lambda c = (K * L/\pi * r) * (Fy / E)^{0.5}$
ϕc = 0.85
K = 1

$\phi t\ Pn = \phi c * Fcr * Ag$
$Fcr = (.658^{\lambda c^2}) * Fy$ when $\lambda c \leq 1.5$
$Fcr = (0.877 / \lambda c^2) * Fy$ when $\lambda c > 1.5$
$\lambda r = 0.45 * (E/Fy)^{(1/2)}$
If $b/t > \lambda r$ section is a slender-element cross-section

for a slender-element cross-section:
$Fcr = Q*(.658^{Q*\lambda c^2}) * Fy$ when $\lambda c*Q \leq 1.5$
$Fcr = (0.877 / \lambda c^2) * Fy$ when $\lambda c*Q > 1.5$
$\lambda c = (K * L/\pi * r) * (Fy / E)^{0.5}$

If : 12.77 < b/t < 25.83
$Q = 1.34 - 0.76 *(b/t) * (Fy/E)^{(1/2)}$
If : $b/t \geq 25.83$
$Q = 0.53 * E / (Fy*(b/t)^2)$

$\phi t\ Pn > Pu$
$\phi c * Fcr * Ag >$ 157.5 k
Ag required > $Pu / (\phi c * Fcr)$

Try Fcr = 14 ksi
Ag required = 13.23 in^2

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Try:	**2L6x4x3/4**	Ag =	13.9	in^2	>	13.2 in^2	OK!
		r =	1.88	in			
		b =	6	in			
		t =	3/4	in			

b/t =	8	
λc =	1.421	
λr =	12.77	section is not slender
Q =	1.000	
Fcr =	15.46	ksi

ϕt Pn = 182.7 kips > 157.5 kips **Angle OK!**

Use 2L6x4x3/4

Check using LRFD table 4-11:

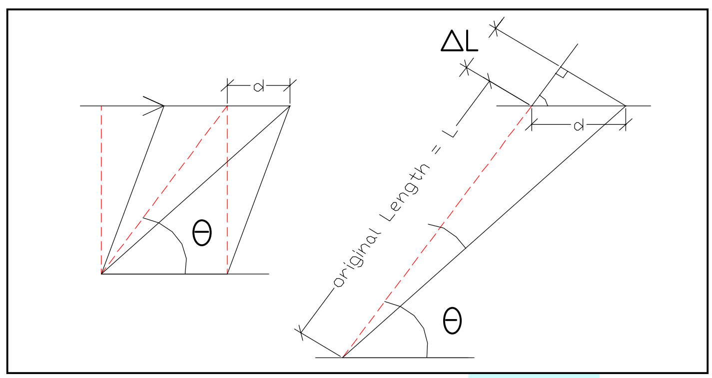
for a 2L6x4x3/4 (from table 4-11)

ϕt Pn = 180 kips > 157.5 kips **Angle OK!**

Deflection check:

Deflection, or drift, of a singe story braced frame is usually caused primarily by tension elongation of the diagonal member. The elongation of one diagonal moves the rectangular-framed bay into a parallelogram form.

Assuming the change in the angle of the diagonal, $\Delta\theta$, to be small, the change in the is to be used to approximate the hypotenuse of the triangle, which is d.



Elevation view

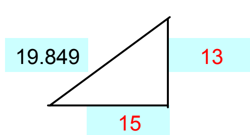
$d = \Delta L / \cos\theta$ and $\Delta L = Pu*L/(A*E)$

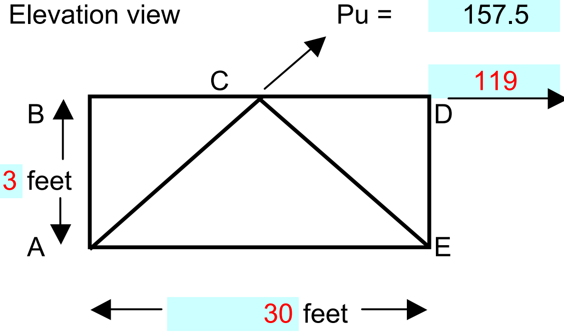
Pu = 157.5 k

θ = 40.91

$d = Pu * L / (A*E*\cos\theta)$ = 0.009353 ft

deflection = 0.112 in





Limit - *Δ = h/250*

drift = 0.112 in < Δ = 0.624 in OK!

Deflection doesn't control member size

h =	13	ft
Δ =	0.052	ft
Δ =	0.624	in
E =	29000	ksi

Red font indicates user input

If deflection doesn't control member size use LRFD table 4-10 to size braces on other floors.
If deflection controls member size, find the section gross area required adequate for deflection limit .

h/250 =	0.0520	ft
drift limit =	0.6240	ft
L =	19.85	ft
E =	29000	ksi

Ag required > Pu*L/(drift limit *E*COS(θ))

Deflection doesn't control member size

Floor	Lateral load (k)	Brace force (k)	KL (ft)	if deflection controls member size			Use
				ΔL (ft)	L (ft)	Ag req.	Table 4-10
4	17.2	22.8	0.00	0.6240	19.85	-	**2 L 4x 3 1/2 x5/16**
3	59.5	78.7	38.28	0.6240	19.85	-	**2 L 6x4x5/16**
2	95.6	126.5	38.28	0.6240	19.85	-	**2 L 6x4x1/2**
1	119	157.5	38.28	0.6240	19.85	-	**2 L 6x4x3/4**

Lab Note: Bracing fill beam is necessary to laterally brace the W24x68 (W14x26) framing beam. The beam is part of the North/South lateral load-resisting truss. A plate is added to brace the bottom flange against buckling out-of plane.

Lab Note: Shear studs along the beams that are part of the lateral load-resisting truss are necessary to transfer the lateral loads from the floor diaphragms to the lateral load resisting truss members. (This design however is beyond the scope of this class.)

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