PROBLEM 21

GIVEN: Service tensile loads: PD= 35k, PL=115 k, and Ps=65 k. The connection is through the flange with two lines of three 3/4-in diameter bolts 4 in on center. Use A572 Grade 50 steel. Neglect block shear.

Load Info:												
D =	35	kips	L =	115	kips	R=	0	kips	S=	65	kips
I=	0	kips	Lr=	0	kips	W=	0	kips	E=	0	kips
Pu=	0	kips	Pa=	0	kips						

					REFERENCE:	
Structural	Yield stress	Fy=	50	ksi	table 2-4	page 2-48
A572 Gr50	Ultimate stress	Fu=	65	ksi	table 2-4	page 2-48
Shape	Shape:					page 1-72
Values:	Gross area	Ag=		in^2	table 1-	page 1-72
	xbar	x-=		in	table 1-	p 1-42
	bolt diameter	=	0.75	in	Statement	
	nominal hole dia	=	0.813	in	table J3.3	p 16.1-121
	effective hole dia	h=	0.875	in	B4.3b	p 16.1-18
	length	l=	6	in		
	thickness	tf=	0.285	in	Statement	
	Member Length	L=	20	ft	Statement	
	Number of bolts in A,	N=			Statement	
	Gage	g=	1	in		
	Pitch	s=		in		
	Number of sections,	Ns=				
	Diagonal Factor=	df=	0			

Figure

FIND: *Select an ST shape to be used as a 20ft long tension member that will safely support the service tensile loads.*

METHOD: 1. Find loads according to AISC p2-10

2. Determine min Ag

2.1) YIELDING STRENGTH

1	Pn=Fy*Ag			D2-1	page 16.1-26
2	LRFD yield strength=Φ*Pn	Φ=	0.9		
3	ASD yield strength= Pn/Ω	Ω=	1.67		

2.2) RUPTURE STRENGTH:

1 Pn=Fu*Ae D2-1 page 16.1-26
2 LRFD rupture strength=Φ*Pn Φ= 0.75
3 ASD rupture strength= Pn/Ω Ω= 2.00

WHERE: Effective net area: Ae=An*U D3-1 p 16.1-27
An= net area determined B4.3
U=shear lag factor Table D3.1

3. Determine min r
4. Check limit states

SOLUTION: **1. Finding loads:**

1.1) LRFD:

		Uniform Load Cases							
	Load Combinations	**D**	**L+I**	**Lr**	**S**	**R**	**W**	**E**	**Sum**
1	1.4D	35							35
2	1.2D+1.6L+0.5(Lr or S or R)	42	184	0	32.5	0			259
3	1.2D+1.6(Lr or S or R)+(L* or 0.5W)	42	57.5	0	104	0	0		204
4	1.2D+1.0W+L*+0.5(Lr or S or R)	42	57.5	0	32.5	0	0		132
5	1.2D+1.0E+L* + 0.2S	42	57.5		13			0	113
6	0.9D+1.0W	31.5					0		32
7	0.9D+1.0E	31.5						0	32

***Note:** *Change Load Factor for 1 for public assembly, live loads in excess of 100 psf and for parking*

The governing factored load for design is equal to: **258.5** kips

1.2.) ASD:

		Uniform Load Cases							
	Load Combinations	**D**	**L+I**	**Lr**	**S**	**R**	**W**	**E**	**Sum**
1	D	35							35
2	D+L	35	115						150
3	D+(Lr or S or R)	35		0	65	0			100
4	D+0.75L + 0.75(Lr or S or R)	35	86.25	0	48.75	0			170
5	D+(0.6W OR 0.7E)	35					0	0	35
6 (a)	D+0.75L+0.75(0.6W)+0.75(Lr/S/R)	35	86.25	0	48.75	0	0		170
6 (b)	D+0.75L+0.75(0.7E)+0.75S	35	86.25		48.75			0	170
7	0.6D+0.6W	21					96		117
8	0.6D+0.7E	21						0	21

The governing factored load for design is equal to: **170** kips

Pu= 258.5 kips	Pa= 170 kips

2. Determine min Ag

2.1) YIELDING STRENGTH

LRFD:
Ag >= Pu/ϕ*Fy = 5.744 in2

ASD:
Ag >= Pa*Ω/Fy = 5.678 in2

2.2) RUPTURE STRENGTH:

Assuming U = 0.85 *This assumption should start with smaller number for a larger value of area.
We have that, Pu= Fu*Ae = or Ag >= Pu/f*Fu*U + 0.15Ag

LRFD:
Ag >= Pu/ϕ*Fu*U*0.85 = 7.339 in2

ASD:
Ag >= Pa*Ω/Fu*U*0.85 = 5.68 in2

	LRFD:	ASD:	
Thus the governing minimum Ag >=	7.339	5.678	in^2

3. Determining Slenderness Ratio Limitation

r >= L / 300 in > = 0.8 in

r >= 0.8 in

*Make other used cases sheet.

4. Trials

TRIAL SHAPE			Ag>	r>	SHEAR LAG: CASE 2		SHEAR LAG: CASE 7 (a)			Ag,r	Sat*	Umax
TYPE		WGT	7.339	0.8	x-	U	bf	d	U			
ST	7.5	25	7.34	2.35	2.25	0.625	5.64	7.5	0.9	8.1547	0	0.9
ST	9	27.35	8.02	2.79	2.51	0.582	6	9	0.9	8.1547	0	0.9
ST	10	33	9.7	3.1	2.81	0.532	6.26	10	0.85	8.6343	1	0.9
						1		0	0.9	7.3392	0	1
						1		0	0.9	7.3392	0	1
						1		0	0.9	7.3392	0	1
						1		0	0.9	7.3392	0	1
						1		0	0.9	7.3392	0	1

Sat*: 1- Mean if the area gross used given the shape used still satisfy the possibly new maximum minimum area.
0- New area does not satisfied whichever new maximum minimum area.

Min Area that satisfy	Smallest section to start check=

5. Checking Limit States SECTION STRENGTH

5.1. YIELD

TRIAL SHAPE				LRFD		ASD	
				Pn*ϕ= Fy*Ag*ϕ		Pn/Ω= Fy*Ag*Ω	
TYPE		WGT	Ag> 0	Pn*ϕ	Pn*ϕ> Pu	Pn/Ω	Pn/Ω> Pa
ST	7.5	25	7.34	330.3	1	219.8	1
ST	9	27.35	8.02	360.9	1	240.1	1
ST	10	33	9.7	436.5	1	290.4	1
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

<- Given the sort this is the best option. The are organized accordingly till the last row.

5.1. RUPTURE

**An= Ag - N*h*tf .+ Ns*(s^2/4g)

IF STAGGERED (use diagonal factor):

Ae=An*U

TRIAL SHAPE								LRFD		ASD		
								Pn*ϕ= Fu*Ae*ϕ		Pn/Ω= Fu*Ae/Ω		
TYPE		WGT	Ag> 0	An**	U	Ae	Pn	Pn*ϕ	Pn*ϕ >Pu	Pn/Ω	Pn/Ω >Pa	
ST	7.5	25	7.34	7.34	0.9	6.606	429.4	322.04	1	214.7	1	<-
ST	9	27.35	8.02	8.02	0.9	7.218	469.2	351.88	1	234.59	1	
ST	10	33	9.7	9.7	0.85	8.245	535.9	401.94	1	267.96	1	
0	0	0	0	0	1	0	0	0	0	0	0	
0	0	0	0	0	1	0	0	0	0	0	0	
0	0	0	0	0	1	0	0	0	0	0	0	
0	0	0	0	0	1	0	0	0	0	0	0	
0	0	0	0	0	1	0	0	0	0	0	0	

Sat*: 1- Mean if the area gross used given the shape used still satisfy the possibly new maximum minimum area.
0- New area does not satisfied whichever new maximum minimum area.

<- Given the sort filter applied the top rows represents the best options

Given these two values the choice of section is:	ST	10X	33