Alan Williams

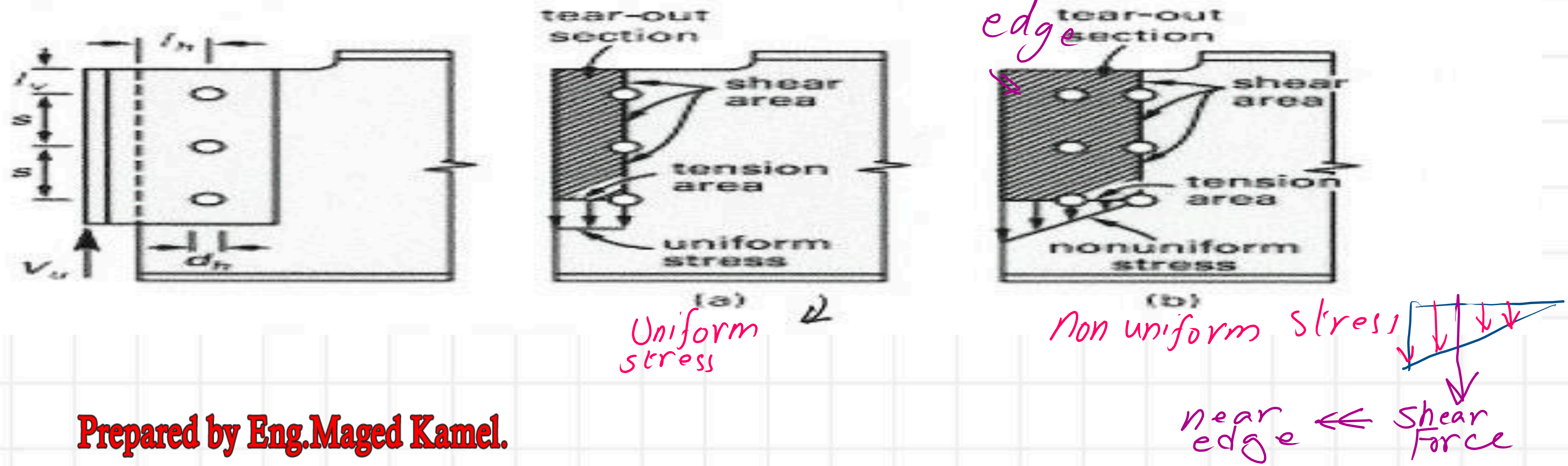
Example 5.13

Alan Williams

Block shear for Coped beams.

Determine the resistance to block shear of the coped W16 × 40 grade A36 beam shown in Fig. 5.7(a). The relevant dimensions are $l_h = l_v = 1.5$ in and $s = 3$ in. The bolt diameter is ¾ in.

Figure 5.7 *Block Shear in a Coped Beam*



Uniform stress

Non uniform stress

near edge ⇐ Shear Force

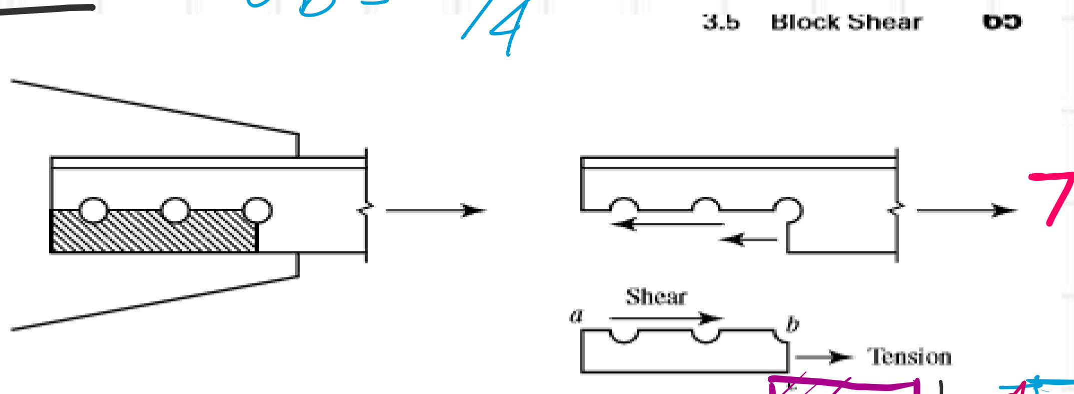
Prepared by Eng.Maged Kamel.

Given data : $d_b = 3/4"$

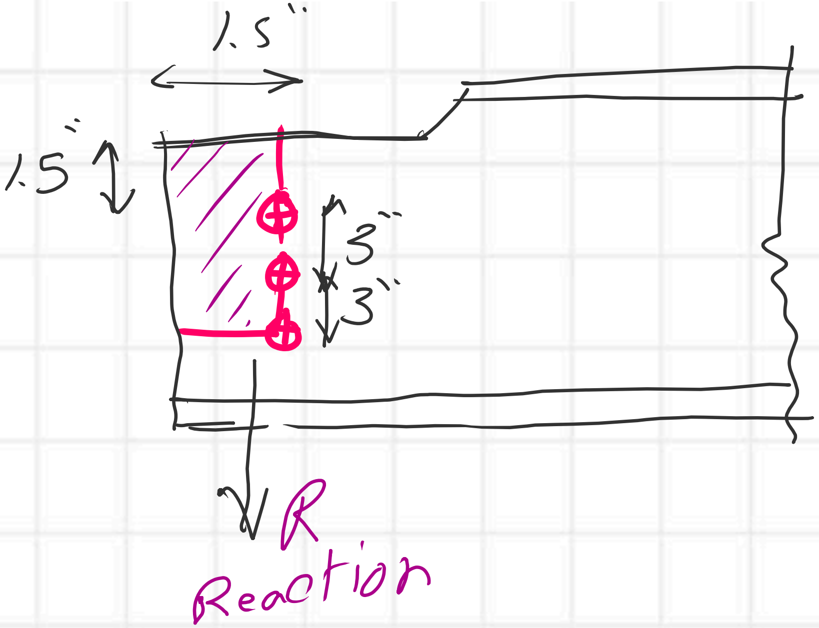
A36 $F_y = 36$ ksi

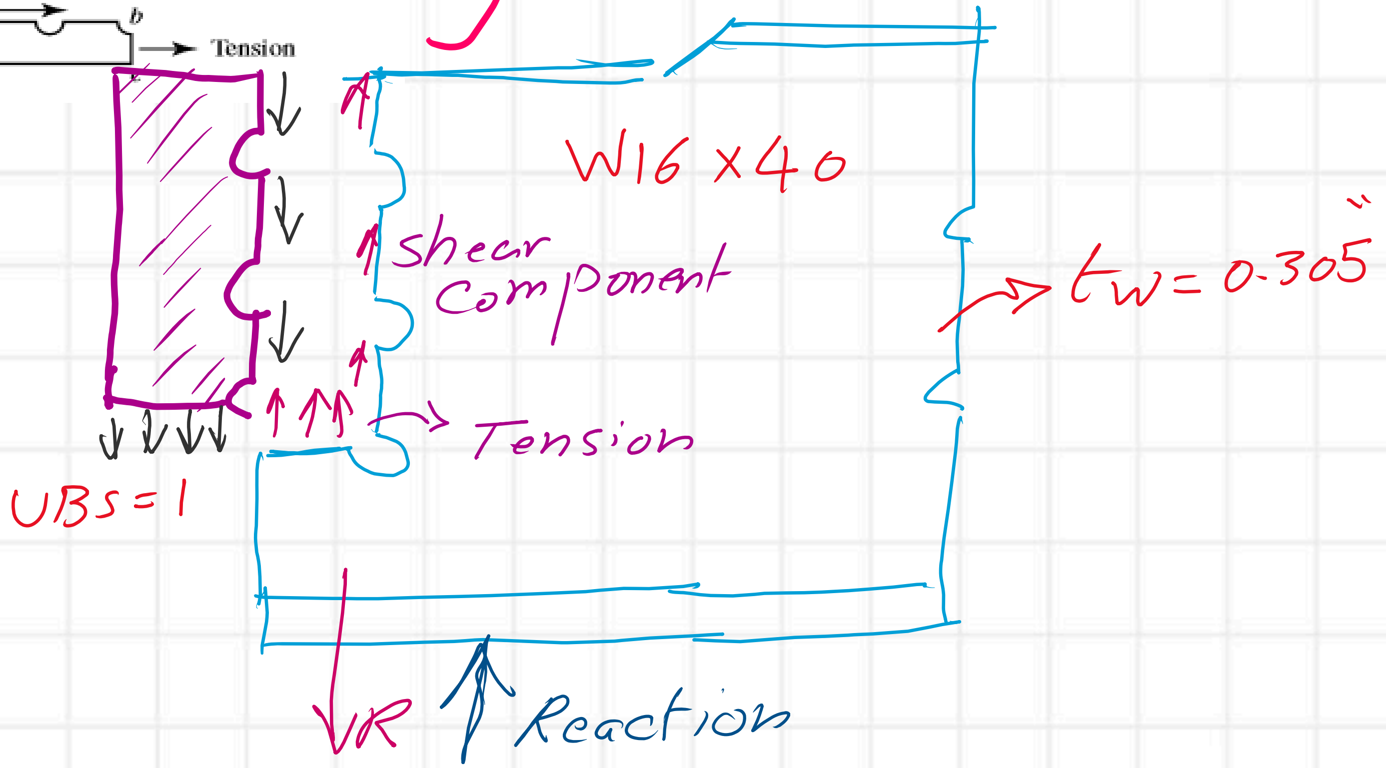
$F_u = 58$ ksi

FIGURE 3.21



To remind us of Force directions





Serves as Tension Force

$d_h = d_b + 1/8" = \frac{7}{8}"$

Prepared by Eng.Maged Kamel.

LRFD = 46.20 $\frac{\text{kips}}{\text{inch}}$, ASD value = 30.80 kips/inch

our data

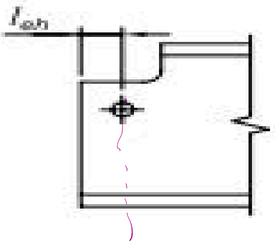
$d_b = 3/4"$, $l_{eh} = 1.50"$ ⟷ $F_{ult} = 58$ ksi

Case # 1

$\boxed{U_{bs} = 1.0}$

$d_b = 3/4"$

Table 9-3a
Block Shear
Tension Rupture
Component
per inch of thickness, kip/in.



$l_{eh} = 1.50"$

F_u	58 ksi					
	Bolt diameter, d, in.[a]					
l_{eh}, in.	3/4		7/8		1	
	$\frac{F_uA_{nt}}{\Omega t}$	$\frac{\phi F_uA_{nt}}{t}$	$\frac{F_uA_{nt}}{\Omega t}$	$\frac{\phi F_uA_{nt}}{t}$	$\frac{F_uA_{nt}}{\Omega t}$	$\frac{\phi F_uA_{nt}}{t}$
	ASD	LRFD	ASD	LRFD	ASD	LRFD
1	16.3	24.5	14.5	21.8	11.8	17.7
1⅛	19.9	29.9	18.1	27.2	15.4	23.1
1¼	23.6	35.3	21.8	32.6	19.0	28.5
1⅜	27.2	40.8	25.4	38.1	22.7	34.0
1½	30.8	46.2	29.0	43.5	26.3	39.4
1⅝	34.4	51.7	32.6	48.9	29.9	44.9
1¾	38.1	57.1	36.3	54.4	33.5	50.3
1⅞	41.7	62.5	39.9	59.8	37.2	55.7
2	45.3	68.0	43.5	65.3	40.8	61.2
2¼	52.6	78.8	50.7	76.1	48.0	72.0
2½	59.8	89.7	58.0	87.0	55.3	82.9
2¾	67.1	101	65.3	97.9	62.5	93.8
3	74.3	111	72.5	109	69.8	105

For

$\left(\frac{A_{nt}}{t_w}\right)\phi U_{bs} F_u$

LRFD

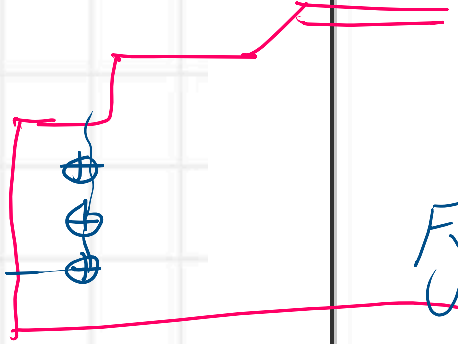
↕

$\left(\frac{A_{nt}}{t_w}\right)\frac{1}{\Omega} U_{bs} F_u$

ASD

Prepared by Eng.Maged Kamel.

Our solved problem No bolt diameter $n=3$ $d_b = 3/4"$ $l_{ev} = 1.5"$

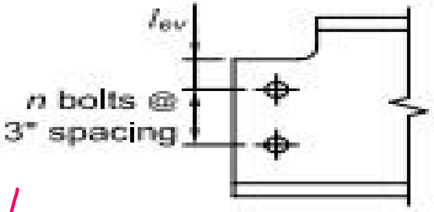


This is a gross area

$F_y = 36$ ksi

$n=3$

Table 9-3b (continued)
Block Shear
Shear Yielding Component
per inch of thickness, kip/in.



l_{ev}, in.	n	F_y, ksi 36 $\frac{0.6F_yA_{gv}}{\Omega t}$ ASD	36 $\frac{\phi 0.6F_yA_{gv}}{t}$ LRFD	50 $\frac{0.6F_yA_{gv}}{\Omega t}$ ASD	50 $\frac{\phi 0.6F_yA_{gv}}{t}$ LRFD	n	F_y, ksi 36 $\frac{0.6F_yA_{gv}}{\Omega t}$ ASD	36 $\frac{\phi 0.6F_yA_{gv}}{t}$ LRFD	50 $\frac{0.6F_yA_{gv}}{\Omega t}$ ASD	50 $\frac{\phi 0.6F_yA_{gv}}{t}$ LRFD
1¼	6	175	263	244	366	3	78.3	117	109	163
1⅜		177	265	246	368		79.6	119	111	166
1½		178	267	248	371		81.0	121	113	169
1⅝		180	269	249	374		82.3	124	114	172
1¾		181	271	251	377		83.7	126	116	174
1⅞		182	273	253	380		85.0	128	118	177
2		184	275	255	383		86.4	130	120	180
2¼		186	279	259	388		89.1	134	124	186
2½		189	283	263	394		91.8	138	128	191
2¾		192	288	266	399		94.5	142	131	197
3		194	292	270	405		97.2	146	135	203

LRFD = 121 kip/inch

ASD = 81.10 kip/Ft

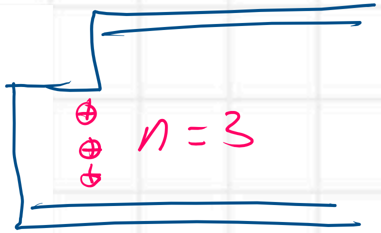
Prepared by Eng.Maged Kamel.

$n = 3$ 3ree bolts

$d_b = 3/4"$

$t_w = 0.305"$

our case



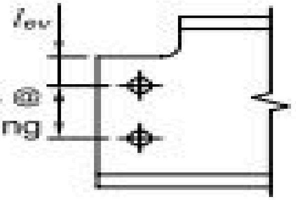
$L_{ev} = 1.5"$

$S = 3"$

$F_u = 58$ ksi

d_b

Table 9-3c (continued)
Block Shear
Shear Rupture
Component
per inch of thickness, kip/in.



ASD

92.40 kips/inch

F_u, ksi		58						65					
		Bolt diameter, *d*, in.[a]											
		3/4		7/8		1		3/4		7/8		1	
n	l_{ev}, in.	$\frac{0.6F_uA_{nv}}{\Omega t}$	$\frac{\phi 0.6F_uA_{nv}}{t}$	$\frac{0.6F_uA_{nv}}{\Omega t}$	$\frac{\phi 0.6F_uA_{nv}}{t}$	$\frac{0.6F_uA_{nv}}{\Omega t}$	$\frac{\phi 0.6F_uA_{nv}}{t}$	$\frac{0.6F_uA_{nv}}{\Omega t}$	$\frac{\phi 0.6F_uA_{nv}}{t}$	$\frac{0.6F_uA_{nv}}{\Omega t}$	$\frac{\phi 0.6F_uA_{nv}}{t}$	$\frac{0.6F_uA_{nv}}{\Omega t}$	$\frac{\phi 0.6F_uA_{nv}}{t}$
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
3	1¼	88.1	132	82.6	124	74.5	112	98.7	148	92.6	139	83.5	125
	1⅜	90.3	135	84.8	127	76.7	115	101	152	95.1	143	85.9	129
	1½	$\boxed{92.4}$	139	87.0	131	78.8	118	104	155	97.5	146	88.4	133
	1⅝	94.6	142	89.2	134	81.0	122	106	159	99.9	150	90.8	136
	1¾	96.8	145	91.4	137	83.2	125	108	163	102	154	93.2	140
	1⅞	99.0	148	93.5	140	85.4	128	111	166	105	157	95.7	144
	2	101	152	95.7	144	87.5	131	113	170	107	161	98.1	147
	2¼	105	158	100	150	91.9	138	118	177	112	168	103	154
	2½	110	165	104	157	96.2	144	123	185	117	176	108	162
	2¾	114	171	109	163	101	151	128	192	122	183	113	169
	3	119	178	113	170	105	157	133	199	127	190	118	176
	1¼	51.1	76.7	47.8	71.8	43.0	64.4	57.3	85.9	53.6	80.4	48.1	72.2

139 $\frac{\text{kips}}{\text{inch}}$ LRFD

Prepared by Eng.Maged Kamel.

From table 9.3a For tension rupture, $t_w = 0.305''$
$F_u = 58$ ksi

LRFD $\Rightarrow \phi\left(\frac{A_{nt}}{t_w}\right)(U_{bs})(F_u) = 46.20$ kips/inch
t_w

↳ multiply by $t_w \Rightarrow (0.305)(46.20) = 14.09$ kips

From table 9.3b Shear yielding, $t_w = 0.305''$, $F_y = 36$ ksi

LRFD $\Rightarrow \phi\left(\frac{A_{gv}}{t_w}\right)(0.60)(F_y) \Rightarrow 121$ kips/inch

↳ multiply by $t_w \rightarrow (0.305)(121) = 36.91$ kips

From table 9.3C Shear rupture $\rightarrow t_w = 0.305''$, $F_u = 58$ ksi

LRFD $\Rightarrow \phi\left(\frac{A_{gt}}{t_w}\right)(0.60)(F_u) \Rightarrow 139$ kips

↳ multiply by $t_w \Rightarrow (0.305)(139) = 42.40$ kips

$\phi R_1 = \phi(\text{shear yielding} + \text{Tension rupture})$

$\phi\,(0.6 F_y A_{gv} + U_{BS} \cdot A_{nt} \cdot F_{ult})$

table 9.3a

from $= (36.91 + 14.09)$

Table 9.3b $= 50.99 \Rightarrow 51.00$ kips

$\phi R_2 = \phi(\text{shear rupture} + \text{Tension rupture})$

$\phi\,(0.60 F_u \cdot A_{nv} + U_{BS} \cdot A_{nt}\, F_{ult})$

table 9.3C

table 9.3a

$= [42.40 + 14.09) = 56.49$ kips

Select $\min(51, 56.49) \rightarrow 51.00$ kips

Shear yielding = 49.42 kips

Shear rupture = 56.411 kips

Tension rupture =

$U_{BS}\, A_{nt} \cdot F_U = (1)\, 0.324(58) = 18.798$ kips

Tension rupture = 18.798 kips

Failure is Controlled by shear yielding + Tension rupture

Total : $0.60 F_y A_{gv} + U_{BS} \cdot A_{nt} \cdot F_U$

$R_{n_1} = 49.42 + 18.798 = 68.218$

$0.60 F_U A_{nv} + U_{BS} A_{nt} \cdot F_{Ult}$

$R_{n2} = 56.411 + 18.798 = 75.208$ kips

$\phi R_1 = [0.75(49.42 + 18.798)]$

$\phi = 0.75$

$= [37.065 + 14.099]$

$\phi R_1 = 51.16$ kips

$\phi R_2 = 0.75[56.411 + 18.798]$

$\phi R_2 = [42.31 + 14.099]$

$\phi R_2 = 56.41$ kips

$\phi R = \min(51.16, 56.41) = 51.16$ kips

51.20 kips

From table 9.3a For tension rupture, $t_w = 0.305''$
$F_U = 58$ ksi

$\boxed{ASD}$

$\Rightarrow \frac{1}{\Omega}\left(\frac{A_{nt}}{t_w}\right)(U_{BS})(F_U) = \frac{30.80}{t_w}$ kips/inch

↳ multiply by $t_w \Rightarrow (0.305)(30.80) = 9.394$ kips

From table 9.3b Shear yielding, $t_w = 0.305''$, $F_y = 36$ ksi

$\frac{1}{\Omega}\left(\frac{A_{gv}}{t_w}\right)(0.60)(F_y) \Rightarrow 81.1$ kips/inch

↳ multiply by $t_w \rightarrow (0.305)(81.10) = 24.74$ kips

From table 9.3C Shear rupture → $t_w = 0.305''$, $F_U = 58$ ksi

$\frac{1}{\Omega}\left(\frac{A_{gt}}{t_w}\right)(0.60)(F_U) \Rightarrow 92.40$ kips/ft

↳ multiply by $t_w \Rightarrow (0.305)(92.4) = 28.18$ kips

$\frac{1}{\Omega} R_1 = \frac{1}{\Omega}$ (shear yielding + Tension rupture)

ASD

$(0.6 F_y A_{gv} + U_{BS} \cdot A_{nt} \cdot F_{ult})$

table 9.3a

$= (24.74 + 9.394)$

table 9.3b

$= 34.14$ kips

$\frac{1}{\Omega} R_2 = \frac{1}{\Omega}$ (shear rupture + Tension rupture)

$(0.60 F_u \cdot A_{nv} + U_{BS} \cdot A_{nt} \, F_{ult})$

table 9.3C

table 9.3a

$= [28.18 + 9.394) = 37.57$ kips

Select $\min(34.14, 37.57) = 34.14$ kips

Shear yielding = 49.42 kips

Tension rupture =

$U_{BS} \, A_{nt} \cdot F_U = (1) \, 0.324 (58) = 18.798$ kips

Total : $0.60 F_y A_{gv} + U_{BS} \cdot A_{nt} \cdot F_U$

$R_{n_1} = 49.42 + 18.798 = 68.218$ kips

R_1 ASD $= \frac{1}{\Omega} R_1$

$= \frac{1}{2} (49.42 + 18.798) = 24.71 + 9.399$

$= 34.109$ kips

Shear rupture = 56.411 kips

Tension rupture = 18.798 kips

Failure is controlled by shear yielding + Tension rupture

$0.60 F_U A_{nv} + U_{BS} \, A_{nt} \cdot F_{Ult}$

$R_{n_2} = 56.411 + 18.798 = 75.208$ kips

ASD value for R_2

$= \frac{1}{2} (56.411 + 18.798)$

$= 28.205 + 9.399$

$= 37.604$ kips

Select min(34.109, 37.604)

$= 34.109 \approx 34$ kips