Problem 5-13 Allan - Williams

Determine the resistance to Block Shear

For a given beam W16x40

Grade A36 → $F_y = 36$ ksi $d_b = 3/4"$

$F_u = 58$ ksi

- Spacing between bolts = 3", Edge distance

$L_h = 1.50"$
$L_v = 3$

ⓐ Find A_{gv}, A_{gt} } Shear yielding + Tensile Rupture

A_{nv}, A_{nt} } Shear rupture + Tensile Rupture

Select Lower Case value → LRFD $\phi_{bs} = 0.75$

ASD $\Omega_{bs} = 2.0$

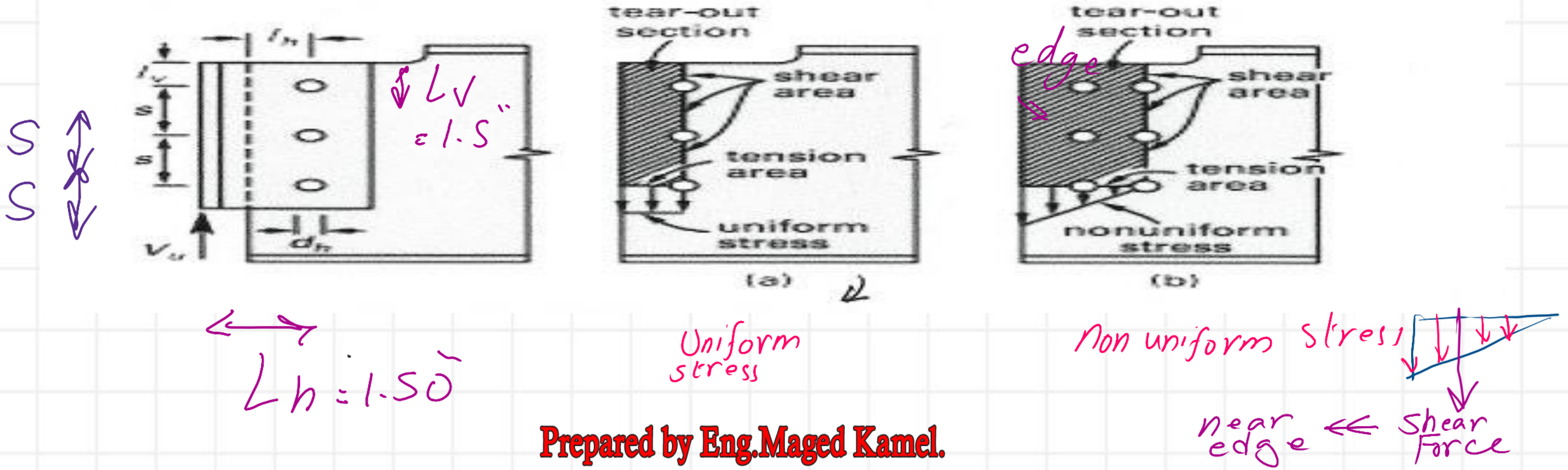
Example 5.13

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*



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Solution Case-1 A36

$L_h = L_v = 1.50''$

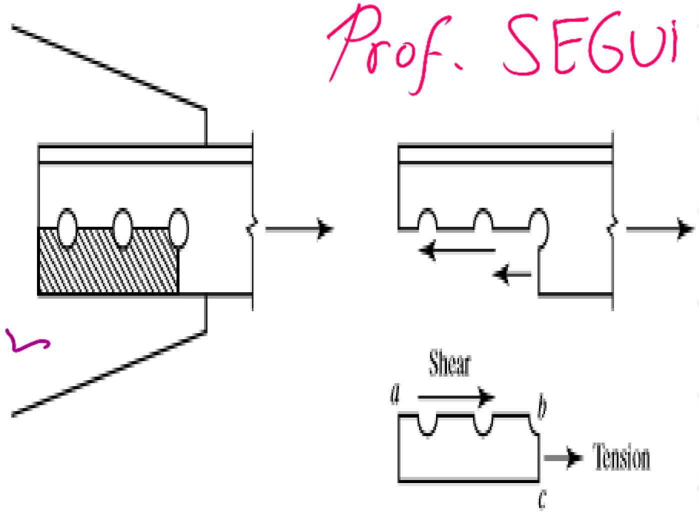
UBS = 1

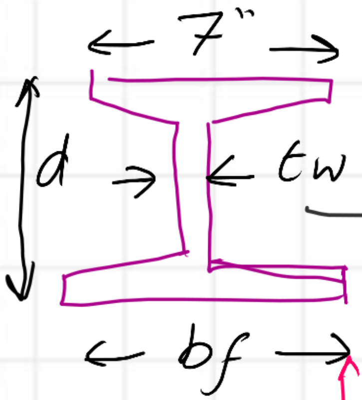
$d_b = 3/4''$ For $d_h = d_b + 1/8'' = 7/8''$

S = 3" VL spacing between bolts

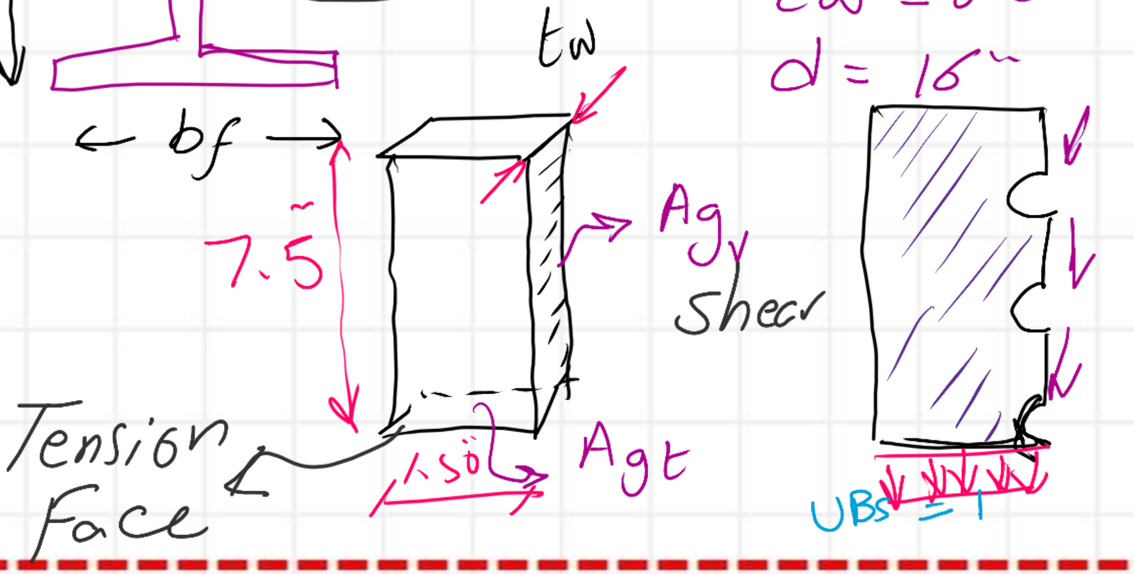
quoted from Prof. SEGUI's hand-book

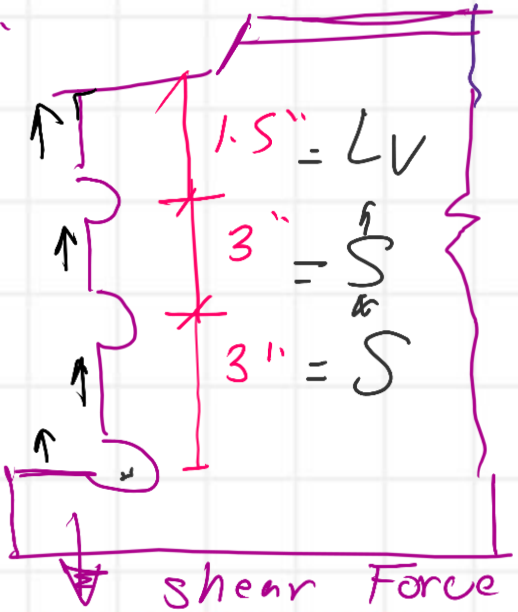
FIGURE 3.21

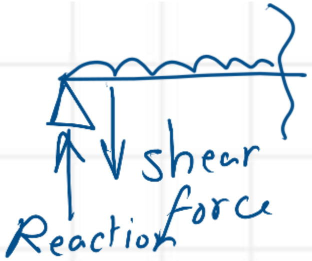




W16x40 → $F_y = 36\,ksi$
$F_u = 58\,ksi$
$t_w = 0.305''$
$d = 16''$







$$A_{gv} = t_w(2S + L_v)$$
$$= 0.305(7.5)$$
$$= 2.288\ inch^2$$

Solution Case-1 A36

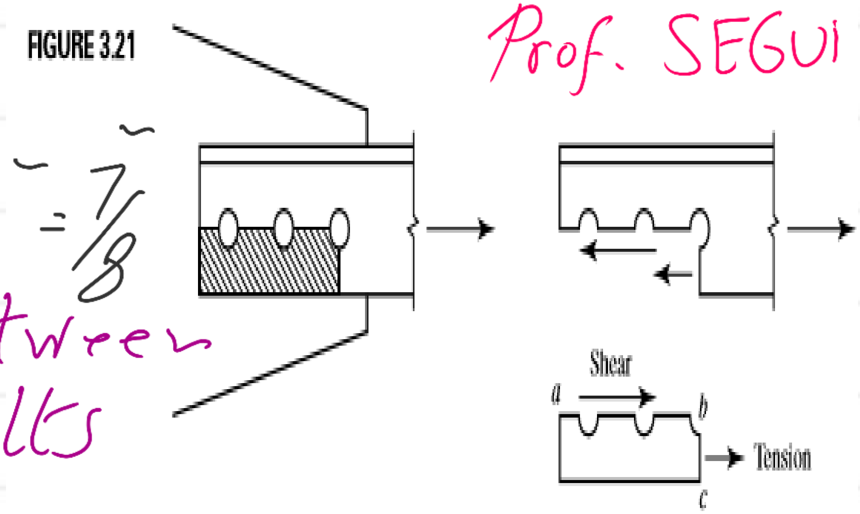
$L_h = L_v = 1.50''$ $\quad$ UBS = 1

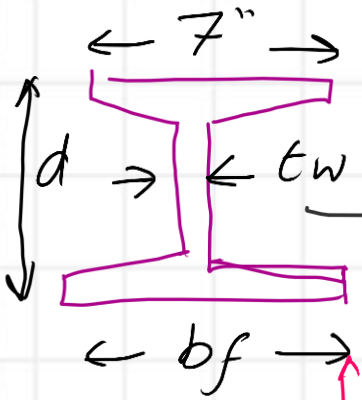
$d_b = 3/4''$ For $d_h = d_b + 1/8'' = 7/8''$

$S = 3''$ VL spacing between bolts

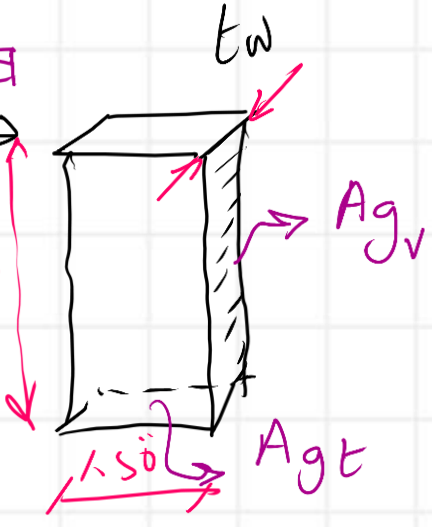
quoted from Prof. SEGUI's handbook

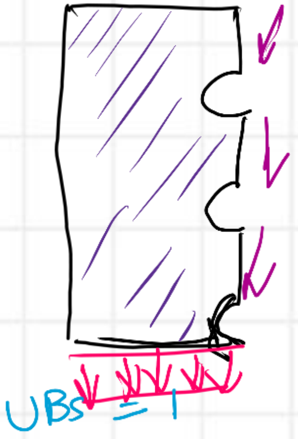
FIGURE 3.21

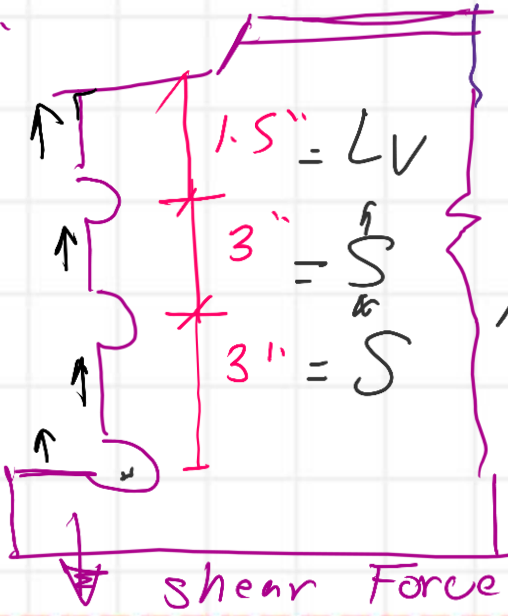


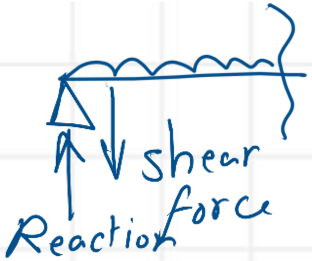


W16x40 → $F_y = 36\,ksi$
$F_u = 58\,ksi$
$t_w = 0.305''$
$d = 16''$









$$A_{nv} = A_{gv} - \sum d_h \cdot t_w$$

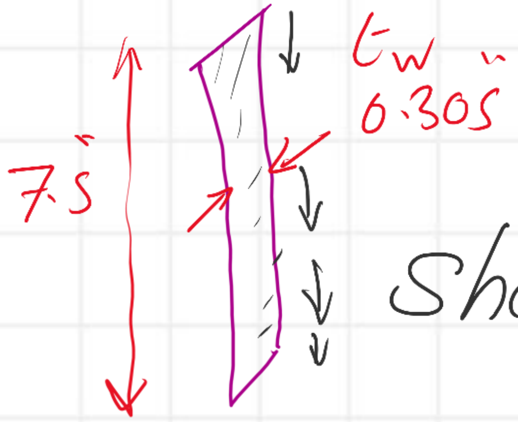
$$= 2.288 - (2)\left(\tfrac{7}{8}\right)(0.305)$$

$$A_{nv} = 1.754 \text{ inch}^2$$

Shear yielding $\rightarrow A_{gv}(F_y)$ $\quad F_y = 36$ ksi

$\Rightarrow t_w = 0.305"$

$d_h = \frac{7}{8}"$



$A_{gv} = (7.50)(0.305) = 2.288$ inch^2

$= 2.29$ inch^2

Shear Stress $= 0.60\, F_y) = 0.6(36) = 21.60$ ksi

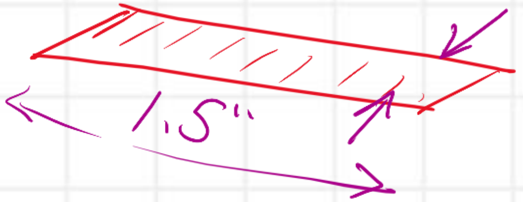
shear yielding Force $= (0.60\, F_y) A_{gv} = 21.60(2.288) = 49.42$ kips

$A_{nt} F_U$

Case of tension rupture

$\boxed{A_{gt} : \text{gross area for tension}}$

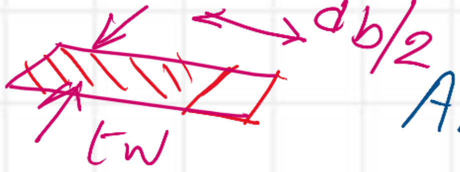
Deduct 1/2 hole



$t_w = 0.305"$

$A_{gt} = 1.5(0.305)$

$= 0.458$ inch^2



$A_{nt} = A_{gt} - \frac{1}{2} d_h t_w$

$= 0.458 - \left(\frac{7}{16}\right)(0.305)$

$= 0.324$ inch^2

$U_{BS} = 1$, $F_U = 58$ ksi

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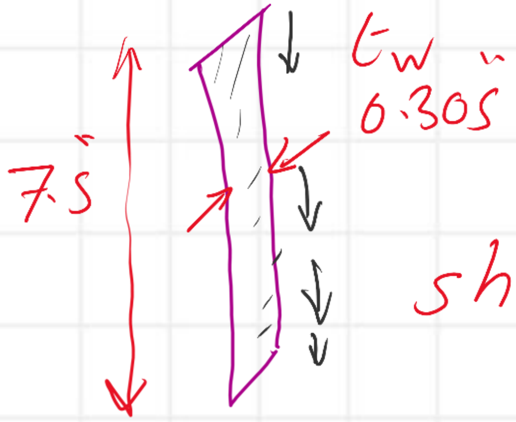
Case of shear rupture

$F_u = 58\ ksi$; $\boxed{A_{nv} \cdot F_u}$

$\Rightarrow t_w = 0.305''$

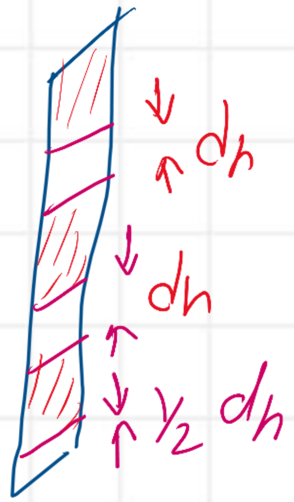


$A_{gv} = 2.288\ inch^2$

$A_{nv} = A_{gv} - 2.5(d_h)(t_w)$

$d_h = \frac{7}{8}''$

$A_{nv} = 2.288 - [0.6672] = 1.621\ inch^2$



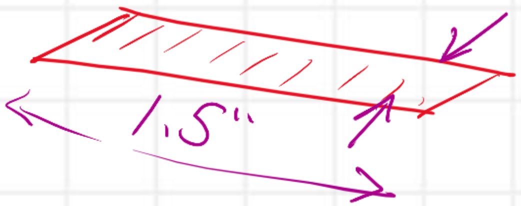
shear stress $= (0.60)(F_u)$

$= 0.6(58) = 34.80\ ksi$

$$\text{shear rupture} = \underbrace{34.80}_{0.6F_u}\ (\underbrace{1.621}_{A_{nv}}) = 56.411\ \text{kips}$$

Case of tension rupture

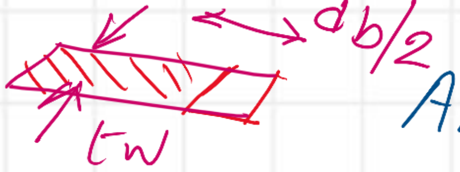
A_{gt} : gross area for tension



$t_w = 0.305''$

$A_{gt} = 1.5(0.305)$

$= 0.458\ inch^2$



$A_{nt} = A_{gt} - \frac{1}{2} d_h t_w$

$= 0.458 - (\frac{7}{16})(0.305)$

$= 0.324\ inch^2$

$U_{bs} = 1$, $F_u = 58\ ksi$

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We have $A_{gv} = 2.288$ inch^2 → $A_{nt} = 0.3241$ inch^2

$A_{nv} = 1.621$ inch^2

shear yielding $= (0.60 F_y)(A_{gv})$

$= 49.42$ kips

Tension rupture

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

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

$R_n = 49.42 + 18.798 = 68.218$

$\phi R_{n_1} = 0.75(68.21) = 51.16$ kips

$\phi R_n = \min(51.16,\ 56.41)$

$= 51.20$ kips

Shear rupture $= 56.411$ kips

Tension rupture $= 18.798$ kips

Failure is Controlled by shear yielding + Tension rupture

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

$= 56.411 + 18.798 = 75.208$ kips

$\phi R_{n_2} = 0.75(75.21) = 56.41$ kips

LRFD Design

Shear yielding = 49.42 kips

Tension rupture =

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

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: $\dfrac{1}{\Omega_{bs}} R_n \qquad \Omega = 2$

$= \dfrac{1}{2} \cdot \min(68.218, 75.208) = \dfrac{1}{2}(68.218) = 34.109$ kips

ASD Design

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Author's Solution

LRFD Method

Shear yielding governs and the design strength for block shear is given by AISC 360 Eq. J4-5 as

$$\phi R_n = \phi(0.6F_yA_{gv} + U_{bs}F_uA_{nt})$$
$$= (0.75)(0.305\text{ in})\left(162\ \frac{\text{kips}}{\text{in}} + 61.48\ \frac{\text{kips}}{\text{in}}\right)$$
$$= 51.12\text{ kips}$$

ASD Method

Shear yielding governs, and the allowable strength for block shear is given by AISC 360 Eq. J4-5 as

$$\frac{R_n}{\Omega} = \frac{0.6F_yA_{gv} + U_{bs}F_uA_{nt}}{\Omega}$$
$$= \frac{(0.305\text{ in})\left(162\ \frac{\text{kips}}{\text{in}} + 61.48\ \frac{\text{kips}}{\text{in}}\right)}{2}$$
$$= 34.08\text{ kips}$$

Reference LRFD