Solved problem SEGUI

Example 3.7

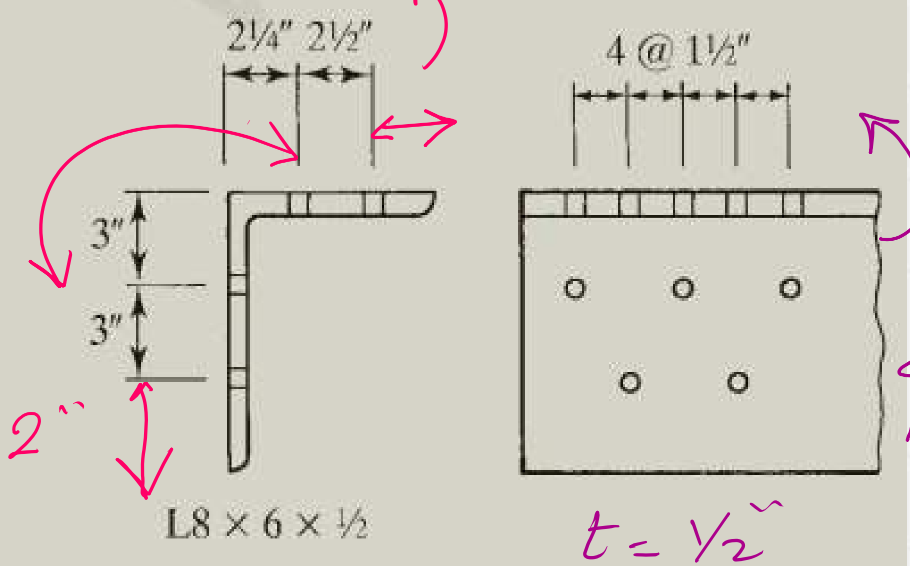
An angle with staggered fasteners in each leg is shown in Figure 3.17. A36 steel is used, and holes are for ⅞-inch-diameter bolts.

a. Determine the design strength for LRFD.

b. Determine the allowable strength for ASD.

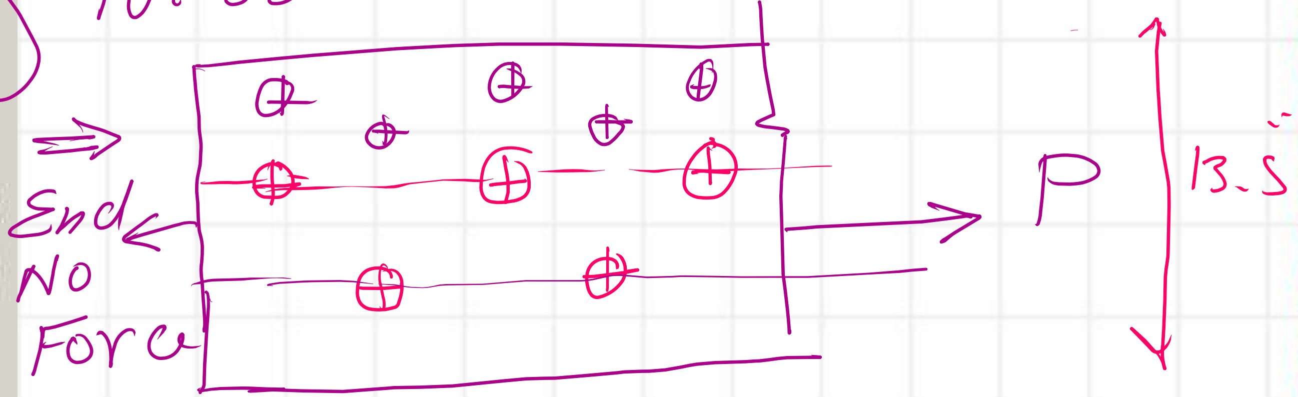
FIGURE 3.17

$6 - 4.75 = 1.25''$



A36 Steel
$F_y : 36$ ksi
$F_u : 58$ ksi

$d_b = 7/8''$
$d_h = 1''$



CL From bolt → bolt $= 2.25 + 3 - \frac{1}{2} = 5.25 - 0.5 = 4.75''$

Height of plate $= 8 + 6 - \overset{t}{1/2} = 13.50''$

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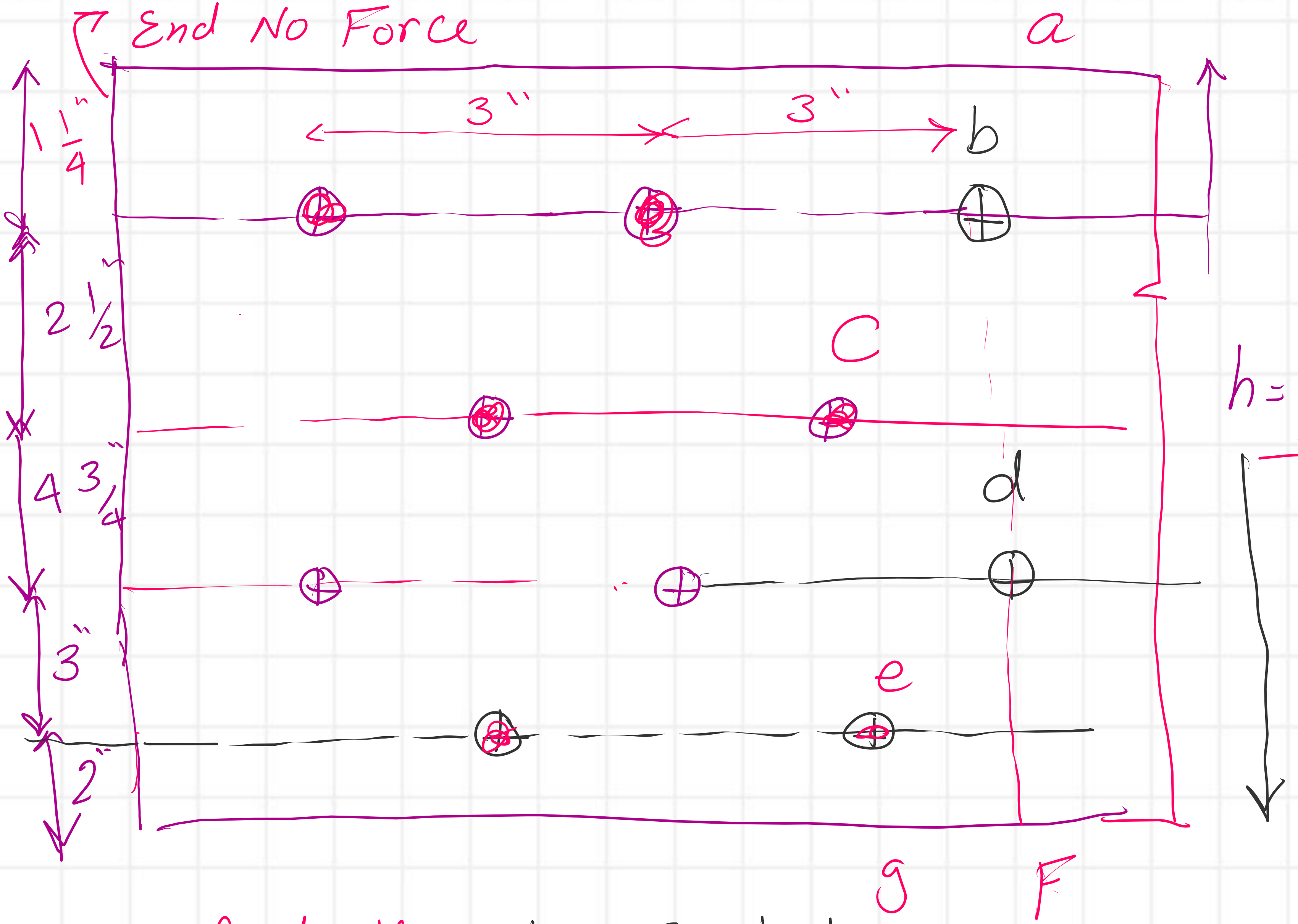

$$h = 13\frac{1}{2}" = 3 + 2 + 4\frac{3}{4} + 2\frac{1}{2}" + 1\frac{1}{4}" = 13\frac{1}{2}"$$

No. of bolts = 10 Each bolt carries P/10

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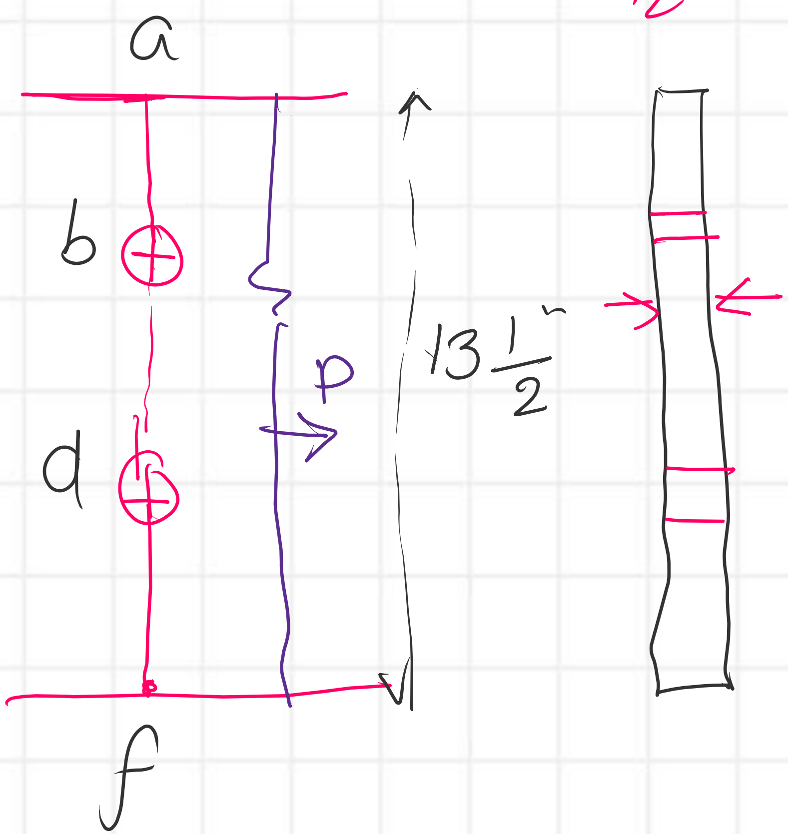
Route a b c f



$t_p = \frac{1}{2}$"

$d_h = 1$"

From Table 1-7

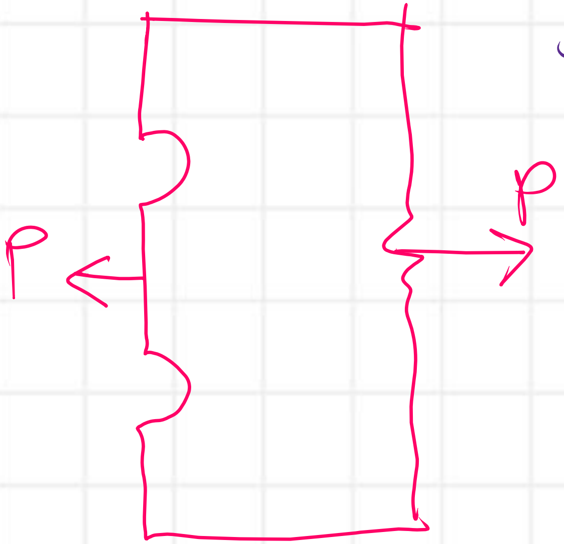
$8 \times 6 \times \frac{1}{2}$" $\Rightarrow A_g =$

$A_g = 6.80 \text{ inch}^2$

Deduct 3 holes areas

$A_h = 2(1")(\frac{1}{2}) = 1.00 \text{ inch}^2$

$A_n = 6.80 - 1.00 = 5.80 \text{ inch}^2$



section $\Rightarrow$ 100% P

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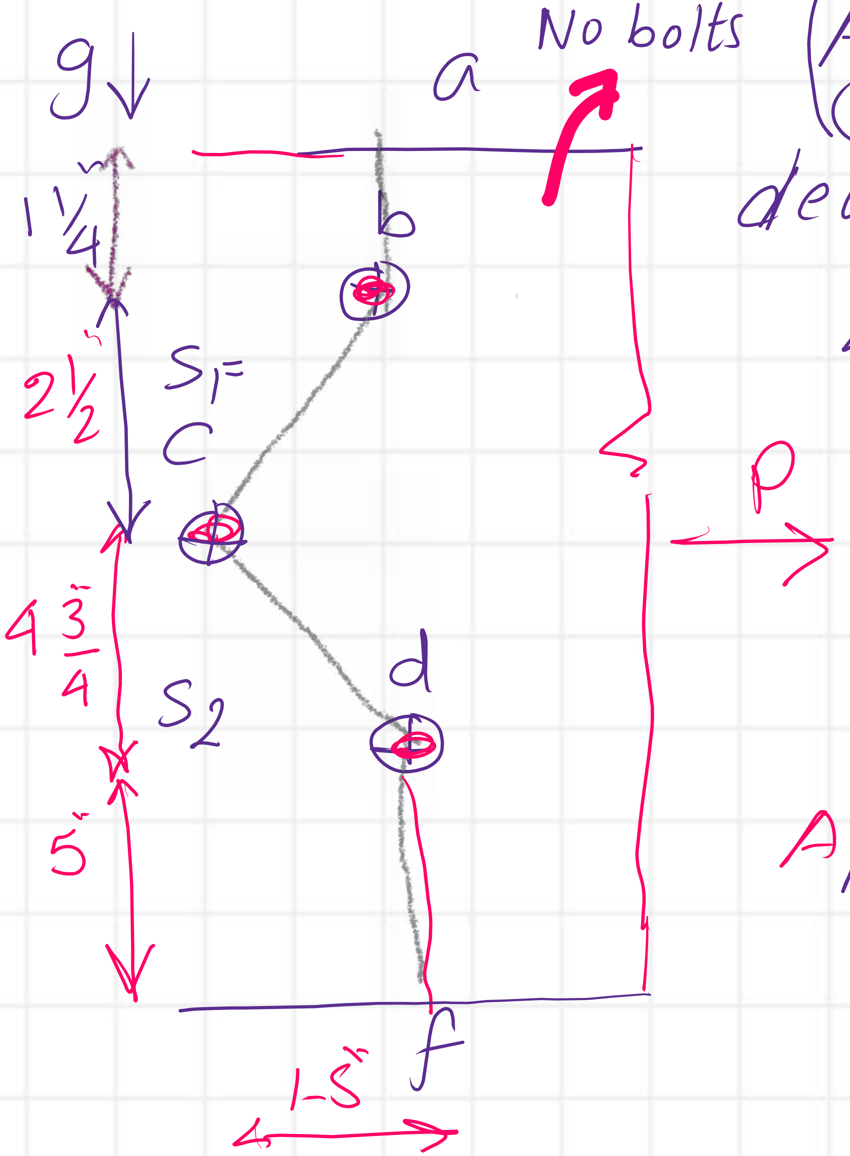
Route ABCdf

$S \rightarrow$

$d_h = 1''$, $t_L = 1/2''$



$(A_g = 6.80 \text{ inch}^2)$

deduct 3 holes areas $= 3(1'')(1/2) = 1.50 \text{ inch}^2$

Add $\sum \frac{S^2}{4g} . t$

$$\left(\frac{(1.5)^2}{4(2.5)}\right)\left(\frac{1}{2}\right) + \frac{(1.5)^2}{(4.75)}\left(\frac{1}{2}\right) - \frac{9}{80} + 0.237$$

$= 0.349 \text{ inch}^2$

$A_n = 6.80 - 1.50 + 0.349 = 5.649 \text{ inch}^2$

$\gg$ 100% P

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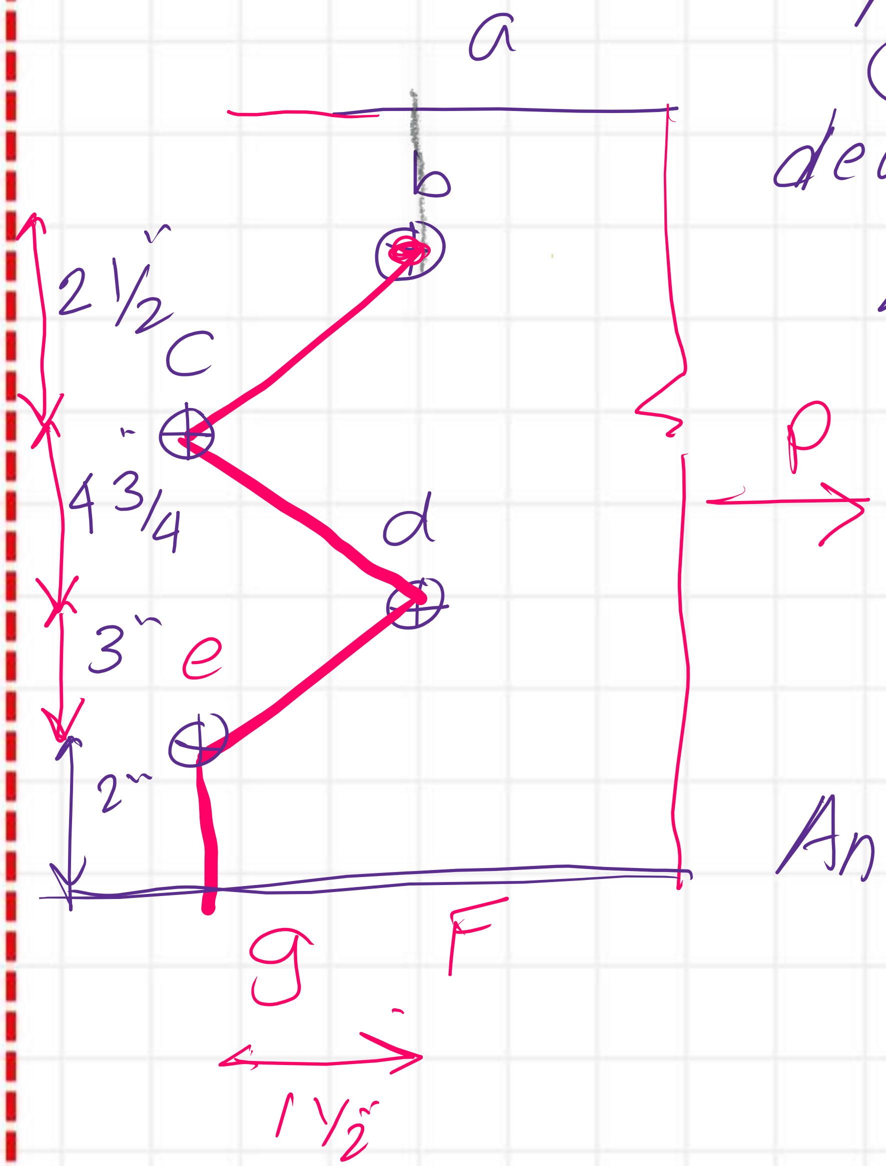
Route abcdeg

$d_h = 1''$, $t_L = \frac{1}{2}''$



$A_g = 6.80$ inch^2

deduct holes areas $= 4(1'')(\frac{1}{2}) = 2.00$ inch^2

Add $\sum \frac{S^2}{4g} \cdot t$

$\left(\frac{(1.5)^2}{4(2.5)}\left(\frac{1}{2}\right) + \frac{(1.5)^2}{4(4.75)}\left(\frac{1}{2}\right) + \frac{(1.5)^2}{4(3)}\frac{1}{2}\right)$

$= \frac{9}{80} + \frac{9}{152} + \frac{3}{32} = 0.265$ inch^2

$A_n = 6.80 - 2.0 + 0.265 = 5.065$ inch^2

$\Rightarrow 100\%\ P$

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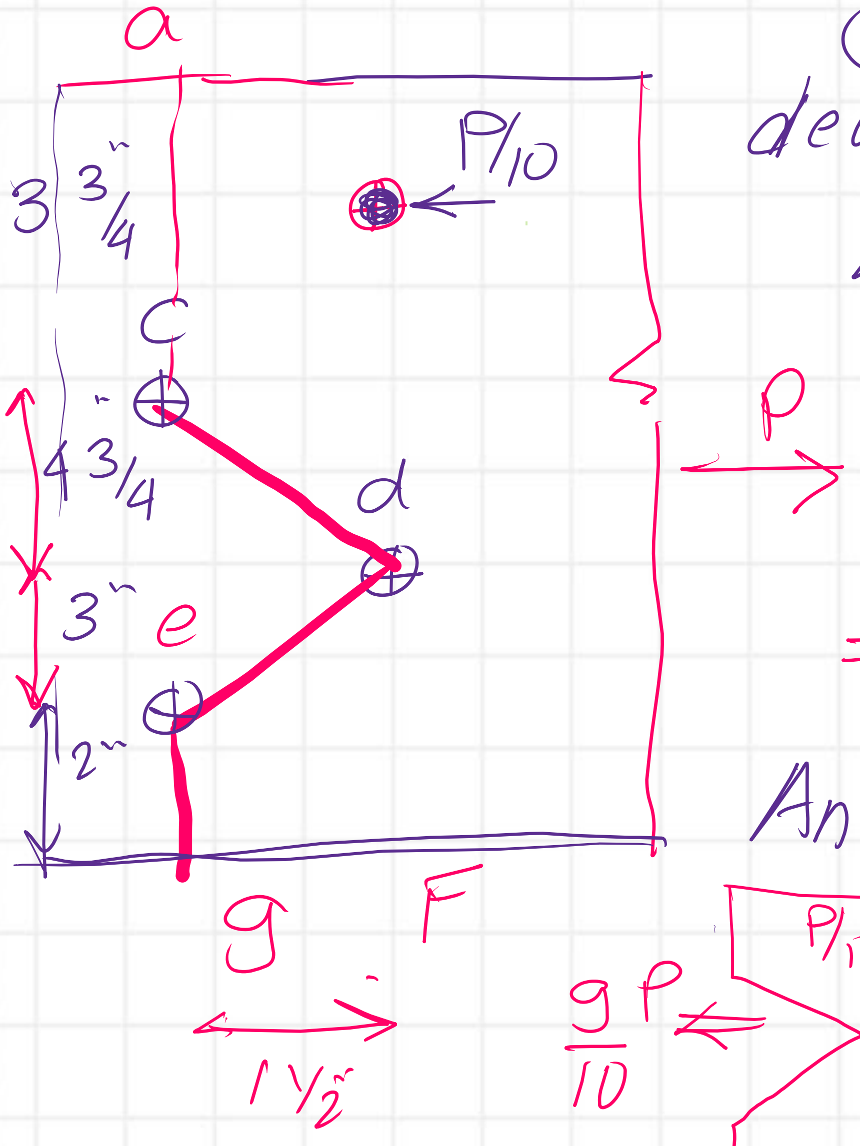
Route $\underline{acdeg}$

$d_h = 1''$, $t_L = \frac{1}{2}''$



$A_g = 6.80 \text{ inch}^2$

deduct holes areas $= 3(1'')(\frac{1}{2}) = 1.50 \text{ inch}^2$

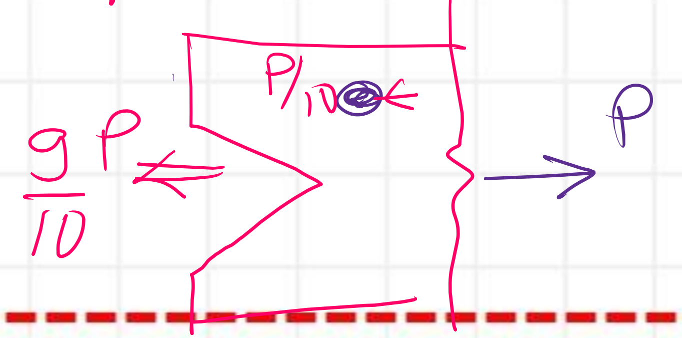
Add $\sum \frac{S^2}{4g} \cdot t$

$\left(\frac{(1.5)^2}{4(4.75)}\right)\left(\frac{1}{2}\right) + \left(\frac{1.5^2}{4(3)}\right)\left(\frac{1}{2}\right)$

$= \frac{9}{152} + \frac{3}{32} = 0.153 \text{ inch}^2$

$A_n = 6.80 - 1.5 + 0.153 = 5.453 \text{ inch}^2$

$\frac{9}{10}P$



$A_n = 5.453\left(\frac{10}{9}\right) = 6.059 \text{ inch}^2$

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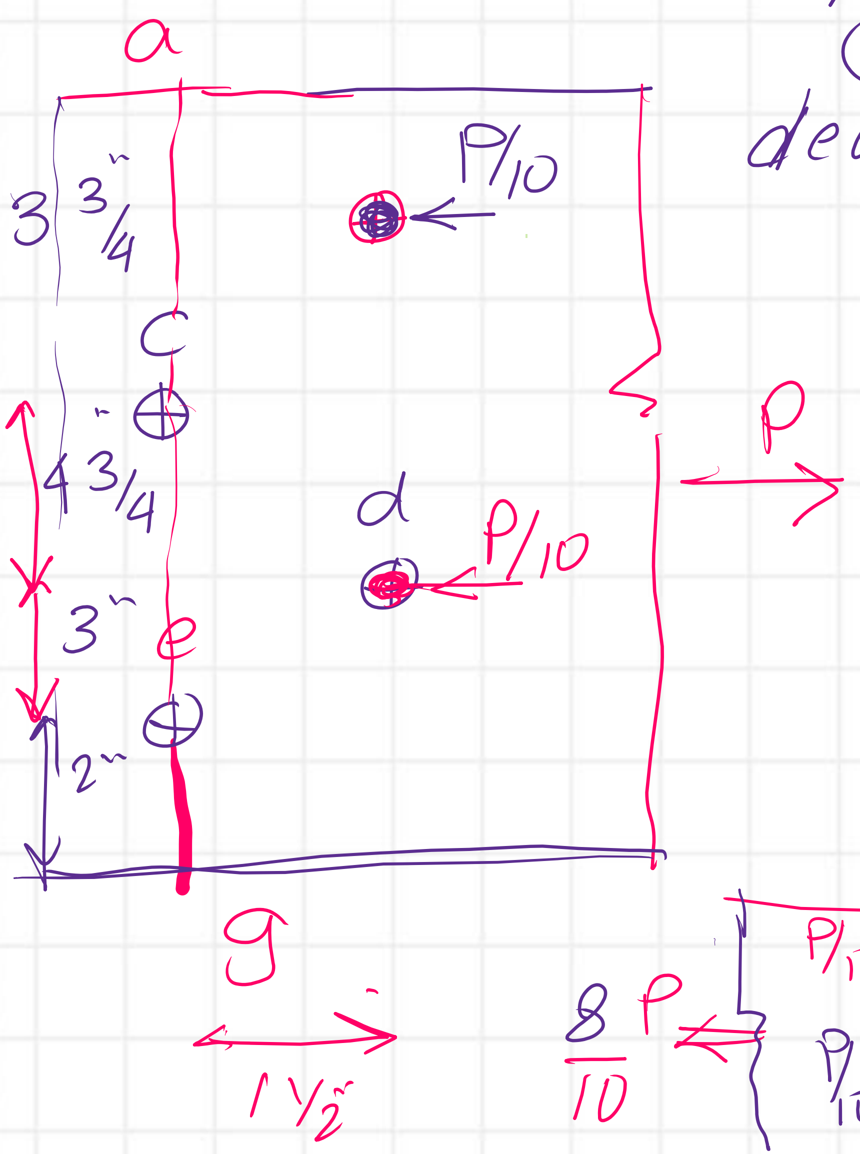
Route aceg

$d_h = 1''$, $t_L = \frac{1}{2}''$



$A_g = 6.80 \text{ inch}^2$

deduct holes areas $= 2(1'')(\frac{1}{2}) = 1.0 \text{ inch}^2$

No staggerd bolts

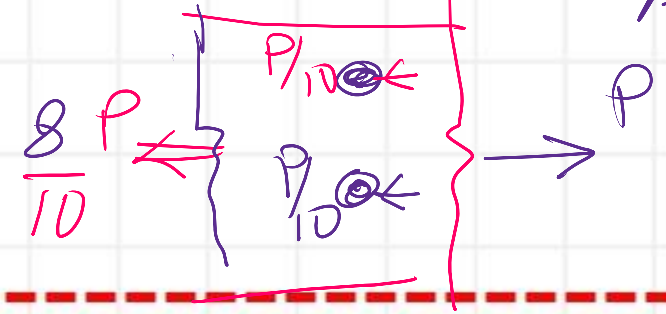
$A_n = 6.80 - 1.0 = 5.80 \text{ inch}^2$

$\Rightarrow$ Section has $\frac{8}{10}P$

$A_n = \frac{10}{8}(5.80) = 7.25 \text{ inch}^2$

$\Rightarrow \frac{8}{10}P$

$A_n = \frac{10}{8}(7.25) = 9.06 \text{ inch}^2$



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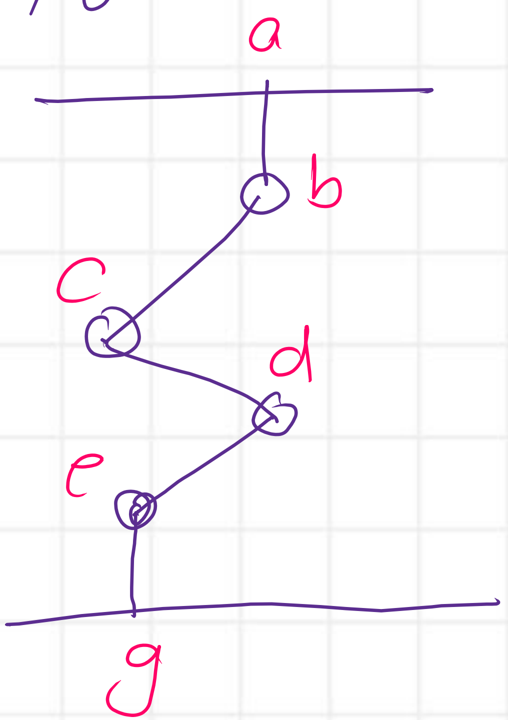
Summary of Routes

Route	A_n : 100%
abcf	5.80 $inch^2$
abcdf	5.649 $inch^2$
abcdeg	5.065 $inch^2$ ⟹ min
acdeg	6.059 $inch^2$
aceg	9.06 $inch^2$

$A_g = 6.80\ inch^2$

$F_y = 36\ ksi$

$F_u = 58\ ksi$



Select min $A_n = 5.065\ inch^2$ $U = 1$ $A_e = 5.065\ inch^2$

LRFD Tensile yielding $\phi A_g F_y = 0.9(6.8)(36)$

$= 220.32\,k \Rightarrow 220\ kips$

Tensile rupture

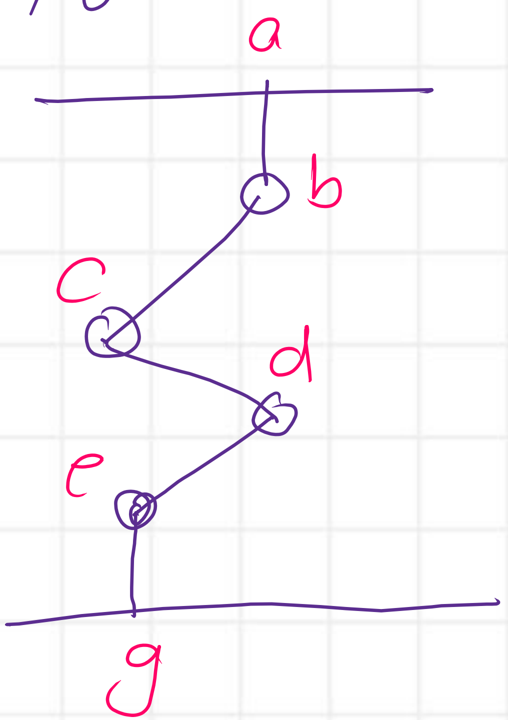
$\phi A_e \cdot F_u = 0.75(5.065)(58) = 220.33\,k$

Summary of Routes

$A_g = 6.80\ \text{inch}^2$

$F_y = 36\ \text{ksi}$

$F_u = 58\ \text{ksi}$



Summary of Routes	A_n: 100%
abcf	$5.80\ \text{inch}^2$
abcdf	$5.649\ \text{inch}^2$
abcdeg	$5.065\ \text{inch}^2$ ⟹ min
acdeg	$6.059\ \text{inch}^2$
aceg	$9.06\ \text{inch}^2$

Select min $A_n = 5.065\ \text{inch}^2$ $\quad U = 1 \quad A_e = 5.065\ \text{inch}^2$

ASD Tensile yielding $\frac{1}{\Omega} A_g F_y = \frac{1}{1.67}(6.8)(36)$

$= 146.59$ kips ⟹ 147 kips

Tensile rupture

$\frac{1}{\Omega} A_e \cdot F_u = \frac{1}{2}(5.065)(58) = 146.89$ kips