Appendix L. Unstiffened Seat and Double Angle Connections

Unstiffened Seat Design: FB1 into Column B2/B3

W21x62 ---> W12x40

Load:

$V_{FB1} := 44.537\ kip$ From FB1 Design

$R_u := V_{FB1} = 44.537\ kip$

Dimensions:

W21x62 -> $d_{FB1} := 21\ in$ $t_{wFB1} := 0.40\ in$ $Fy := 50\ ksi$ $Fu := 65\ ksi$

W12x40 -> $d_c := 11.9\ in$ $t_{wc} := 0.295\ in$ $Fy_{angle} := 36\ ksi$ $Fu_{angle} := 58\ ksi$

Bolts -> $d_b := \frac{3}{4}\ in$ A490-X bolts in standard holes

1. Determine Bearing Length (Table 9-4)-

$\phi R_1 := 56\ kip$ $\phi R_2 := 20\ \frac{kip}{in}$ $\phi R_3 := 71.7\ kip$ $\phi R_4 := 5.37\ \frac{kip}{in}$

a) Web Local Yielding

$l_{b1} := \frac{(R_u - \phi R_1)}{\phi R_2} = -0.573\ in$

$k_{des} := 1.12\ in$

b) Web Local Crippling

*Assume lb/d<0.2

$l_{b2} := \frac{(R_u - \phi R_3)}{\phi R_4} = -5.058\ in$

$l_b := \max(l_{b1}, l_{b2}, k_{des}) = 1.12\ in$

Check Assumption

$\frac{l_b}{d_{FB1}} = 0.053$ < 0.2 ok

Assume $l_b := 1.125\ in$

2. Select Angle (Table 10-5)-

@length = 6" ----> $t_{a1} := \frac{5}{8}\ in$ $\phi R_{n1} := 60.8\ kip$

@length = 8" ----> $t_{a2} := \frac{5}{8}\ in$ $\phi R_{n2} := 81.0\ kip$

$MinAngleLeg := 3.5\ in$

Select 6"

3. Determine Bolt Layout Based on Bolts in Double Shear (Table 10-5)-

$d_b = 0.75\ in$, Group B, X thread, $R_u = 44.537\ kip$, $L := 6\ in$,
$t_{a1} = 0.625\ in$

Connection Type (A) -----> $\therefore$ 4"x4"x5/8"x6" L

4. Check Bolt Bearing on Column Web (J3, Bolts - eqn J3-6a)-

$\phi R_n := 0.75 \cdot 2.4 \cdot d_b \cdot t_{wc} \cdot Fu \cdot 2 = 51.773\ kip$ $> R_u = 44.537\ kip$ ok

5. Check Bolt Bearing on Angle Web (J3, Bolts - eqn J3-6a)-

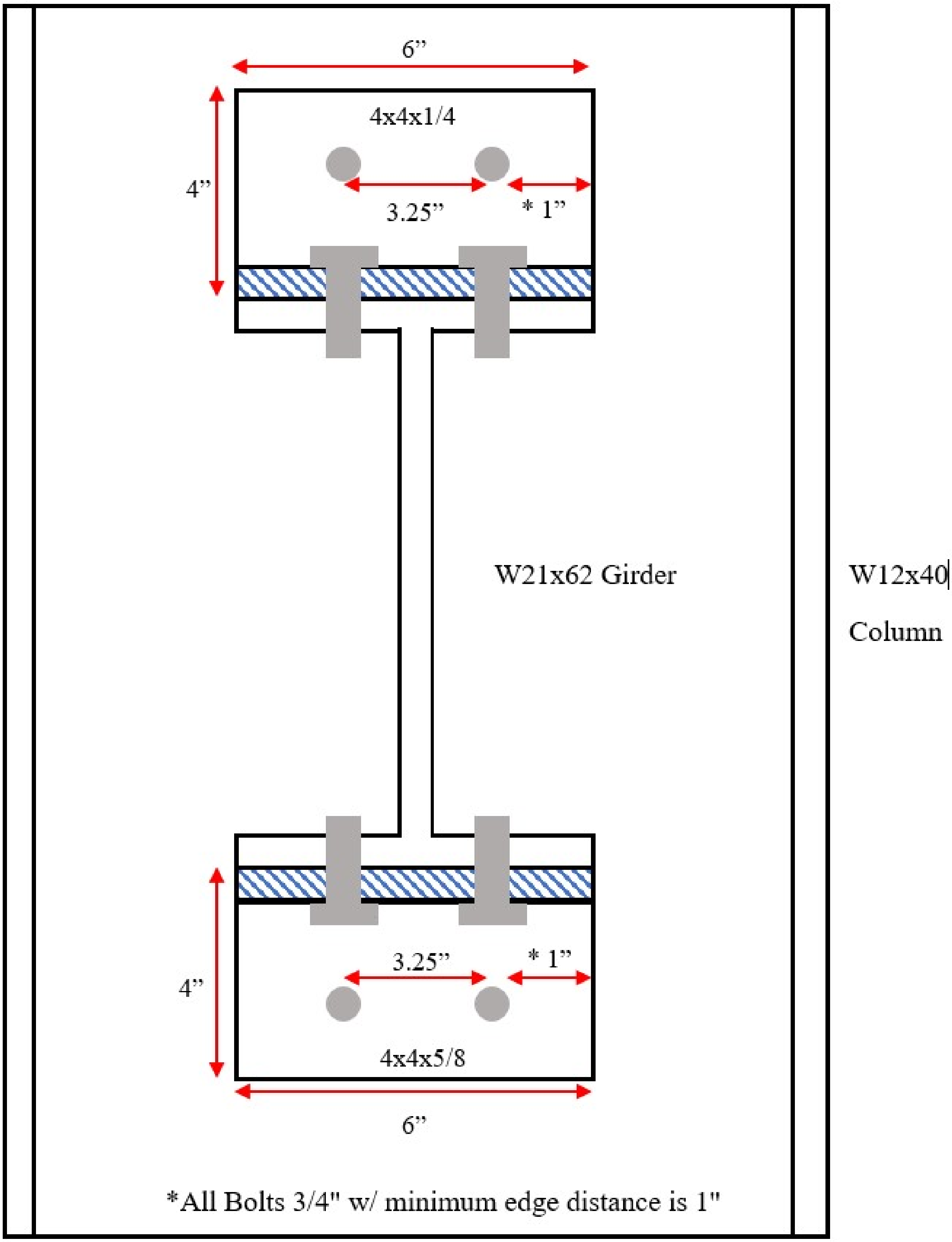
$\phi R_n := 0.75 \cdot 2.4 \cdot d_b \cdot t_{a1} \cdot Fu_{angle} \cdot 2 = 97.875\ kip$ $> R_u = 44.537\ kip$ ok

6. Choose Top Angle (Pg. 10-69)-

Top Angle Select: 4"x4"1/4"x6" L

$\therefore$ Use L4x4x5/8x6" long for Unstiffened Seat, A992 steel

$\because$ Use L4x4x1/4x6" long for Top Angle, A992 steel


6”
4x4x1/4
4”
3.25”
* 1”
W21x62 Girder
W12x40
Column
3.25”
* 1”
4”
4x4x5/8
6”
*All Bolts 3/4" w/ minimum edge distance is 1"

Double Angle Design: FB1 into FG1

W21x62 --> W30x99

Load:

$V_{FB1} := 44.537\ kip$ From FB1 Design

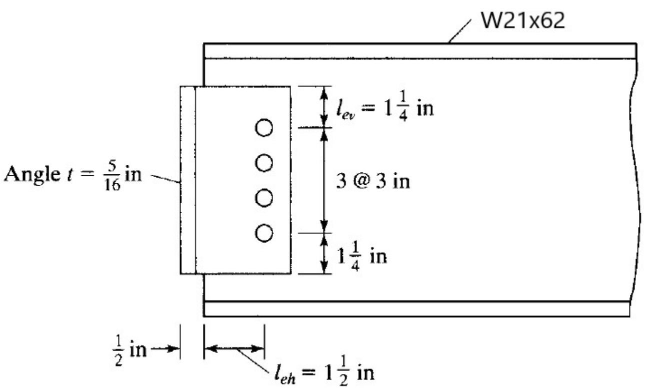
$R_u := V_{FB1} = 44.537\ kip$

Dimensions:

W21x62 -> $d_{FB1} := 21\ in$ $t_{wFB1} := 0.40\ in$ $Fy_{A992} := 50\ ksi$ $Fu_{A992} := 65\ ksi$

W30x99 -> $d_{FG1} := 29.7\ in$ $t_{wFG1} := 0.47\ in$ $Fy_{A36} := 36\ ksi$ $Fu_{A36} := 58\ ksi$

Bolts -> $d_b := \frac{3}{4}\ in$ A490-X bolts in standard holes



Connection Design-

Table 10-1: 4 rows of bolts, 3/4", A490-x (group B), thickness=5/16"

$\phi R_{n0} := 127\ kip$

$h_o := d_{FB1} = 21\ in$ $t_w := t_{wFB1} = 0.4\ in$

$d_c := 0\ in$

Shear Strength of Web (J4-3)-

$Ag_v := (h_o - d_c) \cdot t_w = 8.4\ in^2$

$\phi R_{n1} := 0.6 \cdot Fy \cdot Ag_v = 252\ kip$

Shear Rupture Strength (J4-4)-

$An_v := \left(h_o - 4 \cdot \left(d_b + \frac{1}{16}\ in + \frac{1}{16}\ in\right)\right) \cdot t_w = 7\ in^2$

$\phi R_{n2} := 0.75 \cdot 0.6 \cdot Fu \cdot An_v = 204.75\ kip$

Block Shear Rupture Beam Web (J4.3 Block Shear)-

$\phi FuAn_t := 48.8\ \frac{kip}{in} \cdot t_w = 19.52\ kip$ Table 9-3a: Fu=65ksi, Leh=1.5", bolt=7/8"

$\phi 0.6FyAg_v := 231\ \frac{kip}{in} \cdot t_w = 92.4\ kip$ Table 9-3b: Fy=50ksi, Lev=1.25", n=4

$\phi 0.6FuAn_v := 197\ \frac{kip}{in} \cdot t_w = 78.8\ kip$ Table 9-3c: Fu=65ksi, Lev=1.25", n=4, 7/8"

$\phi R_{n3} := min\left(\left(\phi 0.6FyAg_v + \phi FuAn_t\right), \left(\phi 0.6FuAn_v + \phi FuAn_t\right)\right) = 98.32\ kip$

Strength of Bolted Connection-

Shear Strength of Bolts:

$\phi rn := 75.7\ kip$ /bolt

Table 7-1: Group B, X thread, Double, 7/8"

Bearing/Tearout Strength of Beam (top bolt):

Table 7-5: STD, Fu=65ksi, 7/8"

$\phi rn_{top} := 45.7\ \frac{kip}{in} \cdot t_w = 18.28\ kip$ /bolt

Bearing/Tearout Strength of Beam (all other bolts):

Table 7-4: STD, Fu=65ksi, 7/8"

$\phi rn_{other} := 102\ \frac{kip}{in} \cdot t_w = 40.8\ kip$ /bolt

$$\phi R_{n4} := (1) \cdot min\left(\phi rn, \phi rn_{top}\right) + (3) \cdot \phi rn_{other} = 140.68\ kip$$

Strength of Bolted Connection Grider Side-

$t_{wFG1} = 0.47\ in$

$\phi r_n := 102\ \frac{kip}{in} \cdot t_{wFG1} = 47.94\ kip$ /bolt

Table 7-4: STD, Fu=65ksi, 7/8"

$$\phi R_{n5} := \phi r_n \cdot (8) = 383.52\ kip$$

ANSWER:

$$\therefore \phi Rn_{min} := min\left(\phi R_{n0}, \phi R_{n1}, \phi R_{n2}, \phi R_{n3}, \phi R_{n4}, \phi R_{n5}\right) = 98.32\ kip \ > V_{FB1} = 44.537\ kip$$

$\therefore$ OK

(Block Shear Rupture Beam Web)

$Length := 2 \cdot 1.25\ in + 3 \cdot 3\ in = 11.5\ in$ ~ 12in

Edge Spacing (Table J3.4): $Edge := 1\ in$ $\therefore$ Height=2in

Table 7-15: $H2 := 1.375\ in$, $C1 := 1.1875\ in$

$$\therefore Width := H2 + C1 + Edge + \frac{5}{16}\ in = 3.875\ in$$ ~ 4in

$\therefore$ Use 2L4x2x5/16x12" long, A992 steel

Unstiffened Seat Design: FG1 into Column B2/B3

W30x99 ---> W12x40

*Will need flange coping for FG1 to fit into Column B2/B3

Load:

$V_{FG1} := 63.714\ kip$ From FB1 Design

$R_u := V_{FG1} = 63.714\ kip$

Dimensions:

W30x99 -> $d_{FG1} := 29.7\ in$ $t_{wFG1} := 0.52\ in$ $Fy := 50\ ksi$ $Fu := 65\ ksi$

W12x40 -> $d_c := 11.9\ in$ $t_{wc} := 0.295\ in$ $Fy_{angle} := 36\ ksi$ $Fu_{angle} := 58\ ksi$

Bolts -> $d_b := 1\ in$ A490-X bolts in standard holes

1. Determine Bearing Length (Table 9-4)-

$\phi R_1 := 85.8\ kip$ $\phi R_2 := 26\ \frac{kip}{in}$ $\phi R_3 := 111\ kip$ $\phi R_4 := 7.66\ \frac{kip}{in}$

a) Web Local Yielding

$$l_{b1} := \frac{(R_u - \phi R_1)}{\phi R_2} = -0.849\ in$$

$k_{des} := 1.32\ in$

b) Web Local Crippling

*Assume lb/d<0.2

$$l_{b2} := \frac{(R_u - \phi R_3)}{\phi R_4} = -6.173\ in$$

$$l_b := \max\left(l_{b1}, l_{b2}, k_{des}\right) = 1.32\ in$$

Check Assumption

$$\frac{l_b}{d_{FB1}} = 0.063 \quad < 0.2$$ ok

Assume $l_b := 1.375\ in$

2. Select Angle (Table 10-5)-

@length = 6" ----> $t_{a1} := \frac{3}{4}\ in$ $\phi R_{n1} := 87.5\ kip$

@length = 8" ----> $t_{a2} := \frac{3}{4}\ in$ $\phi R_{n2} := 117\ kip$

$MinAngleLeg := 3.5\ in$

Select 6"

3. Determine Bolt Layout Based on Bolts in Double Shear (Table 10-5)-

$d_b = 1\ in$, Group B, X thread, $R_u = 63.714\ kip$, $L := 6\ in$, $t_{a2} = 0.75\ in$

Connection Type (A) -----> $\therefore$ 4"x4"x3/4"x6" L

4. Check Bolt Bearing on Column Web (J3, Bolts - eqn J3-6a)-

$\phi R_n := 0.75 \cdot 2.4 \cdot d_b \cdot t_{wc} \cdot Fu \cdot 2 = 69.03\ kip$ $> R_u = 63.714\ kip$ ok

5. Check Bolt Bearing on Angle Web (J3, Bolts - eqn J3-6a)-

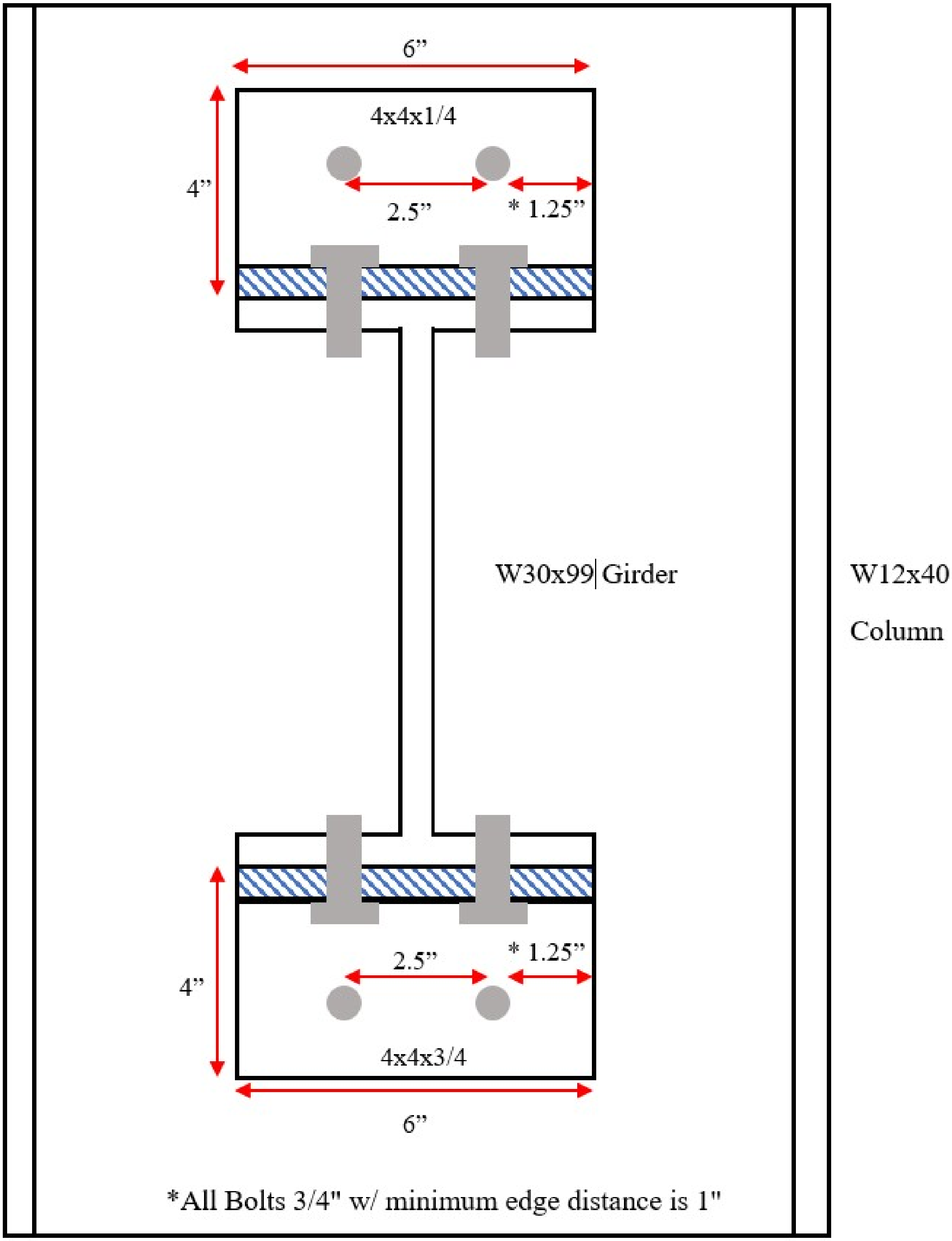
$\phi R_n := 0.75 \cdot 2.4 \cdot d_b \cdot t_{a2} \cdot Fu_{angle} \cdot 2 = 156.6\ kip$ $> R_u = 63.714\ kip$ ok

6. Choose Top Angle (Pg. 10-69)-

Top Angle Select: 4"x4"1/4"x6" L

$\therefore$ Use L4x4x3/4x6" long for Unstiffened Seat, A992 steel

$\because$ Use L4x4x1/4x6" long for Top Angle, A992 steel


6”
4x4x1/4
4”
2.5”
* 1.25”
W30x99 Girder
W12x40
Column
2.5”
* 1.25”
4”
4x4x3/4
6”
*All Bolts 3/4" w/ minimum edge distance is 1"