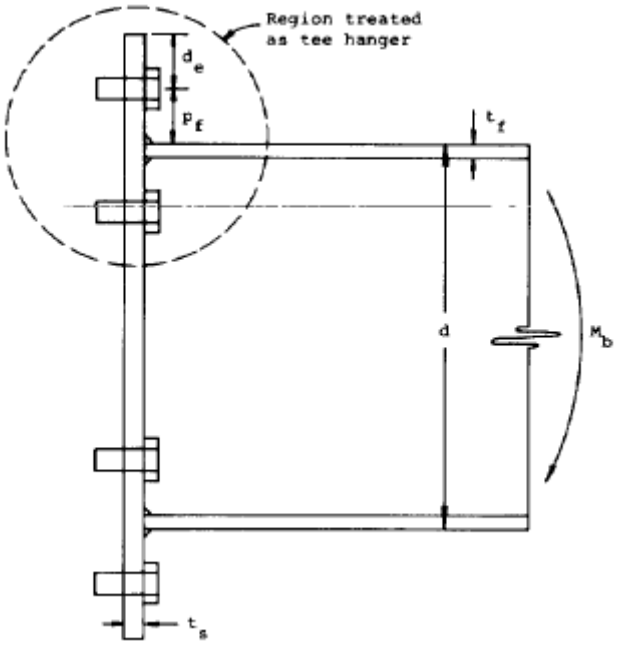
END-PLATE CONNECTION DESIGN

*adapted from N. Krishnamurthy (1978)

Given:



W16x45 section:

$d := 16.12\ in$

$b_f := 7.039\ in$

$t_f := 0.563\ in$

$t_w := 0.346\ in$

$S := 72.5\ in^3$

Steel Grade A36,

$F_y := 36.0\ ksi$

$F_p := 27.0\ ksi$

Bolt Grade A325,

$F_{bt} := 44.0\ ksi$

$F_{bu} := 93.0\ ksi$

Maximum bending moment for maximum bending stress of 0.66 F_y,

$M_b := S \cdot 0.66 \cdot F_y$ $\quad M_b = 1722.6\ kip\ in$

Nominal flange force,

$F_f := \frac{M_b}{d - t_f}$ $\quad F_f = 110.728\ kip$

Bolt area per row,

$a_t := 0.5 \cdot \frac{F_f}{F_{bt}}$ $\quad a_t = 1.258\ in^2$

Provide bolt,

$d_b := 1\ in$

$A_b := 2 \cdot \frac{1}{4} \cdot \pi \cdot d_b^2$ $\quad A_b = 1.571\ in^2$

$msg :=$ if $A_b \geq a_t$ "satisfied" else "not satisfied" $\quad msg = \text{"satisfied"}$

Set edge distance,

$d_e := 1.75 \cdot d_b$ $\quad d_e = 1.75\ in$

Set bolt distance at (say) 1.5 diameters,

$p_f := 1.5 \cdot d_b$ $\quad p_f = 1.5\ in$

Set weld size w_s to transfer F_f to the end plate,

Weld Grade E70

$w_s := \frac{1}{2}\ in$

Effective bolt distance,

$p_e := p_f - 0.25 \cdot d_b - 0.707 \cdot w_s$ $\quad p_e = 0.896\,in$

Split-tee moment,

$M_t := \frac{F_f}{2} \cdot \frac{p_e}{2}$ $\quad M_t = 24.817\,kip\,in$

Material coefficient,

$C_a := 1.29 \cdot \left(\frac{F_y}{F_{bu}}\right)^{0.4} \cdot \left(\frac{F_{bt}}{F_p}\right)^{0.5}$ $\quad C_a = 1.127$

Minimum plate width:

$b_{smin} := b_f + 2 \cdot w_s$ $\quad b_{smin} = 8.039\,in$

Set plate width,

$b_s := 8.5\,in$

$msg := \begin{cases} \text{if } b_s \geq b_{smin} \\ \quad \text{"satisfied"} \\ \text{else} \\ \quad \text{"not satisfied"} \end{cases}$ $\quad msg = \text{"satisfied"}$

Width correction factor,

$C_b := \left(\frac{b_f}{b_s}\right)^{0.5}$ $\quad C_b = 0.91$

Area of beam tension flange,

$A_f := b_f \cdot t_f$ $\quad A_f = 3.963\,in^2$

Area of beam web (between the two flanges),

$A_w := t_w \cdot (d - 2 \cdot t_f)$ $\quad A_w = 5.188\,in^2$

Hence,

$\frac{A_f}{A_w} = 0.764$ $\qquad \frac{p_e}{d_b} = 0.896$

Moment modification factor,

$\alpha_m := C_a \cdot C_b \cdot \left(\frac{A_f}{A_w}\right)^{0.32} \cdot \left(\frac{p_e}{d_b}\right)^{0.25}$ $\quad \alpha_m = 0.915$

Design moment,

$M_d := \alpha_m \cdot M_t$ $\quad M_d = 22.712\,kip\,in$

End-plate thickness,

$t_{smin} := \sqrt{\frac{6 \cdot M_d}{b_s \cdot F_p}}$ $\quad t_{smin} = 0.771\,in$

Try,

$t_s := \frac{13}{16}\,in$

$msg := \begin{cases} \text{if } t_s \geq t_{smin} \\ \quad \text{"satisfied"} \\ \text{else} \\ \quad \text{"not satisfied"} \end{cases}$ $\quad msg = \text{"satisfied"}$

Check effective plate width,

$b_e := b_f + 2 \cdot w_s + t_s$ $\quad b_e = 8.852\ in$

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msg := if b_e ≥ b_s
         "satisfied"
       else
         "not satisfied"
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$msg = \text{"satisfied"}$

Check maximum shear stress,

$f_s := \frac{F_f}{2 \cdot b_s \cdot t_s}$ $\quad f_s = 8.017\ ksi$

Allowable shear stress,

$f_{as} := 0.4 \cdot F_y$ $\quad f_{as} = 14.4\ ksi$

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msg := if f_as ≥ f_s
         "satisfied"
       else
         "not satisfied"
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$\frac{f_s}{f_{as}} = 0.557$

$msg = \text{"satisfied"}$