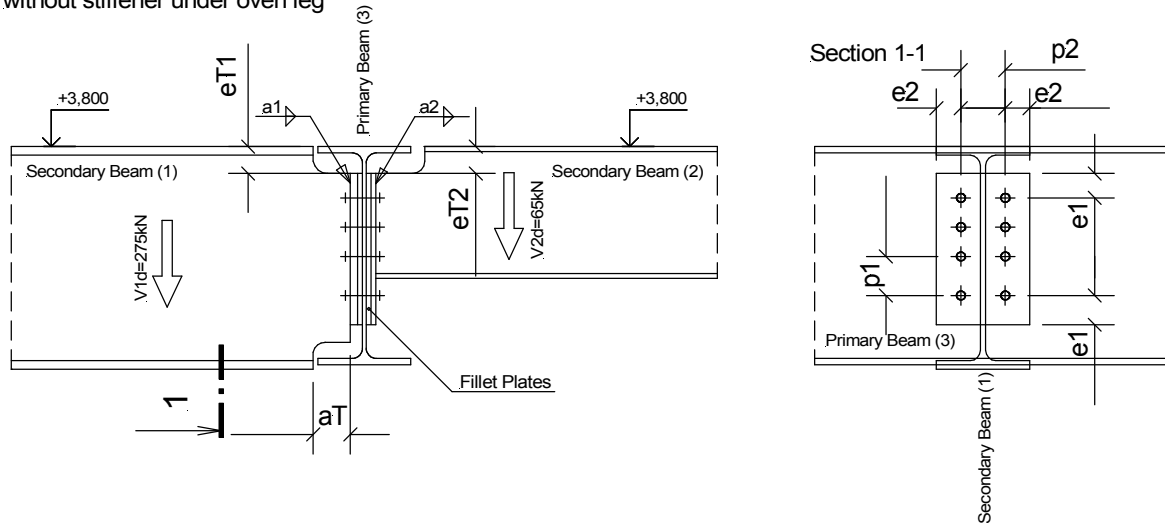


Flexible End Plate Connection

without stiffener under oven leg



Beam (1) IPE 450 O, Beam (2) IPE 270 ⇒ Beam (3) IPE 450 A
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Input Data:

Material / Section / Geometry:

Steel Grade Stahl =	S235
Bolts:	
Size Schr =	M 24
Number of Bolts per column n =	4
Connection Type VB =	SLS
Bolt Grade FK =	8.8
Drilled Hole Clearance Δd =	2,0 mm

Beams:

Secondary Beam Typ1 =	IPEo
Size NH1 =	450
Secondary Beam Typ2 =	IPE
Size NH2 =	270
Primary Beam Typ3 =	IPEa
Size NH3 =	450

End Plates:

Thickness d_{p1} =	15 mm
Thickness d_{p2} =	10 mm
Fillet Plates d_f =	10 mm

End Plate Bolt Spacing:

vertical e_1 =	50 mm
vertical p_1 =	60 mm
horizontal e_2 =	50 mm
bolt distance from axis e =	55 mm

Cut of upper and lower Flange:

Length a_{T1} =	76 mm
Length a_{T2} =	90 mm
Height e_{T0} =	45 mm

Height $e_{Tu} =$ 45 mm

Fillet Welds:

Throat Thickness $a1 =$ 4,0 mm

Throat Thickness $a2 =$ 4,0 mm

Internal Forces:

Design Value - Index "d"

Reaction $V_{1d} =$ 275,00 kN

Reaction $V_{2d} =$ 65,00 kN

Material:

$f_{y,k} =$ TAB("Stahl/DIN"; f_{yk} ; Bez=Stahl)/10 = 24,00 kN/cm²

$f_{uk} =$ TAB("Stahl/DIN"; f_{uk} ; Bez=Stahl)/10 = 36,00 kN/cm²

Partial Safety Factors (acc. to the Slovak NAD):

Safety Factor for Bolts $\gamma_{Mb} =$ 1,45

Safety Factor for Welding $\gamma_{Mw} =$ 1,50

Safety Factor for Section $\gamma_{M0} =$ 1,15

$f_{y,d} = f_{y,k} / \gamma_{M0} =$ 20,87 kN/cm²

$\sigma_{Rd} = f_{y,k} / \gamma_{M0} =$ 20,87 kN/cm²

$\tau_{Rd} = f_{y,k} / (\sqrt{3} * \gamma_{M0}) =$ 12,05 kN/cm²

Factor $\beta_w =$ WENN(Stahl = "S235" ; 0,8; 0,9) = 0,80

$\tau_{w,R,d} = f_{uk} / (\beta_w * \gamma_{Mw}) =$ 30,00 kN/cm²

$f_{y,b,k} =$ TAB("Stahl/Schr"; f_{ybk} ; FK=FK)/10 = 64,00 kN/cm²

$f_{u,b,k} =$ TAB("Stahl/Schr"; f_{ubk} ; FK=FK)/10 = 80,00 kN/cm²

$d =$ TAB("Stahl/Schr"; d; SG=Schr) = 24,0 mm

Hole Diameter $d_0 =$ d+ Δ d = 26,0 mm

$\alpha_a =$ TAB("Stahl/Schr"; α_a ; FK=FK; VB=VB) = 0,60

$A_{Sp} =$ TAB("Stahl/Schr"; A_{sp} ; SG=Schr) = 3,53 cm²

$A_{Sch} =$ TAB("Stahl/Schr"; A_{sch} ; SG=Schr) = 4,52 cm²

Reduction Factor acc. to 6.5.12 (because of fillet plates):

$\beta_p = 9*d / (8*d + 3*d_f) =$ 0,973 < 1

Section Characteristics / Geometry:

Secondary Beam (1):

Web Thickness $t_{w1} =$ TAB("Stahl"/Typ1; s; NH=NH1)/10 = 1,10 cm

Total Height $h_1 =$ TAB("Stahl"/Typ1; h; NH=NH1)/10 = 45,60 cm

Secondary Beam (2):

Web Thickness $t_{w2} =$ TAB("Stahl"/Typ2; s; NH=NH2)/10 = 0,66 cm

Total Height $h_2 =$ TAB("Stahl"/Typ2; h; NH=NH2)/10 = 27,00 cm

Primary Beam (3):

Web Thickness $t_{w3} =$ TAB("Stahl"/Typ3; s; NH=NH3)/10 = 0,76 cm

Total Height $h_3 =$ TAB("Stahl"/Typ3; h; NH=NH3)/10 = 44,70 cm

Relevant Thickness for Bearing Capacity:

$t =$ MIN(d_{p1} ; d_{p2} ; $t_{w3} * 10$) = 7,60 mm

Output Data:**Bolt Spacing Check acc to 6.5.1:**

$$\begin{aligned}
 1,2 \cdot d_0 / e_1 &= 0,62 < 1 \\
 e_1 / \text{MAX}(12 \cdot t; 150) &= 0,33 < 1 \\
 1,5 \cdot d_0 / e_2 &= 0,78 < 1 \\
 e_2 / \text{MAX}(12 \cdot t; 150) &= 0,33 < 1 \\
 2,2 \cdot d_0 / p_1 &= 0,95 < 1 \\
 p_1 / \text{MIN}(14 \cdot t; 200) &= 0,56 < 1
 \end{aligned}$$

Bolt Shear Capacity and Check:

$$\begin{aligned}
 \text{for Shear in Thread } F_{vs,Rd} &= 0,6 \cdot f_{u,b,k} \cdot A_{Sp} / \gamma_{Mb} = 113,7 \text{ kN} \\
 F_{sd} = V_{1d} / (2 \cdot n) &= 34,38 \text{ kN}
 \end{aligned}$$

$$F_{sd} / F_{vs,Rd} = \underline{\underline{0,30 < 1,0}}$$

Bolt Bearing Capacity and Check:

$$\begin{aligned}
 \alpha &= \text{MIN}(e_1 / (3 \cdot d_0); p_1 / (3 \cdot d_0) - 0,25; f_{u,b,k} / f_{uk}; 1) = 0,519 \\
 F_{b,Rd} &= 2,5 \cdot \alpha \cdot f_{uk} \cdot d \cdot t \cdot \gamma_{Mb} / 100 = 58,76 \text{ kN} \\
 F_{sd} &= (V_{1d} + V_{2d}) / (2 \cdot n) = 42,50 \text{ kN}
 \end{aligned}$$

$$F_{sd} / F_{b,Rd} = \underline{\underline{0,72 < 1}}$$

Web Shear Check:

$$\begin{aligned}
 \tau_1 &= V_{1d} / (t_{w1} \cdot (h_1 - ((e_{To} + e_{Tu}) / 10))) = 6,83 \text{ kN/cm}^2 \\
 \tau_1 / \tau_{Rd} &= \underline{\underline{0,567 < 1,0}} \\
 \tau_2 &= V_{2d} / (t_{w2} \cdot (h_2 - ((e_{To} + e_{Tu}) / 10))) = 5,47 \text{ kN/cm}^2 \\
 \tau_2 / \tau_{Rd} &= \underline{\underline{0,454 < 1,0}}
 \end{aligned}$$

End Plate Shear Check:

In an Vertical section of the Holesscolumn:

$$\begin{aligned}
 h_{p1} &= (n-1) \cdot p_1 + 2 \cdot e_1 = 280 \text{ mm} \\
 A_1 &= (h_{p1} - n \cdot d_0) \cdot d_{p1} / 100 = 26,40 \text{ cm}^2 \\
 \tau_1 &= (V_{1d} / 2) / A_1 = 5,21 \text{ kN/cm}^2 \\
 \tau_1 / \tau_{Rd} &= \underline{\underline{0,432 < 1,0}}
 \end{aligned}$$

$$\begin{aligned}
 h_{p2} &= (n-1) \cdot p_1 + 2 \cdot e_1 = 280 \text{ mm} \\
 A_2 &= (h_{p2} - n \cdot d_0) \cdot d_{p2} / 100 = 17,60 \text{ cm}^2 \\
 \tau_2 &= (V_{2d} / 2) / A_2 = 1,85 \text{ kN/cm}^2 \\
 \tau_2 / \tau_{Rd} &= \underline{\underline{0,154 < 1,0}}
 \end{aligned}$$

Fillet Weld Shear Check:

$$\begin{aligned}
 l_{w1} &= h_{p1} / 10 = 28,00 \text{ cm} \\
 A_{w1} &= 2 \cdot a_1 / 10 \cdot l_{w1} = 22,40 \text{ cm}^2 \\
 \tau_{w1} &= V_{1d} / A_{w1} = 12,28 \text{ kN/cm}^2 \\
 \sqrt{(3)} \cdot \tau_{w1} / \tau_{w,R,d} &= \underline{\underline{0,709 < 1,0}}
 \end{aligned}$$

$$\begin{aligned}
 l_{w2} &= h_{p2} / 10 = 28,00 \text{ cm} \\
 A_{w2} &= 2 \cdot a_2 / 10 \cdot l_{w2} = 22,40 \text{ cm}^2 \\
 \tau_{w2} &= V_{2d} / A_{w2} = 2,90 \text{ kN/cm}^2 \\
 \sqrt{(3)} \cdot \tau_{w2} / \tau_{w,R,d} &= \underline{\underline{0,167 < 1,0}}
 \end{aligned}$$

Stress Analysis in Cut out Section and Check:

Characteristics of the Remaining Section (1):

$$\begin{aligned}
 h_{1r} &= h_1 - (e_{To} + e_{Tu})/10 &= & 36,60 \text{ cm} \\
 A_{1r} &= t_{w1} * h_{1r} &= & 40,26 \text{ cm}^2 \\
 a_{d1} &= h_{1r}/2 &= & 18,30 \text{ cm} \\
 a_{z1} &= h_{1r} - a_{d1} &= & 18,30 \text{ cm} \\
 I_{y1r} &= t_{w1} * h_{1r}^3/12 &= & 4494,22 \text{ cm}^4 \\
 S_{y1r} &= t_{w1} * a_{d1}^2/2 &= & 184,19 \text{ cm}^3 \\
 M_{1d} &= V_{1d} * (a_{T1} + d_{p1} + d_f)/10 &= & 2777,50 \text{ kNcm} \\
 \max \sigma_1 &= M_{1d} * a_{d1} / I_{y1r} &= & 11,31 \text{ kN/cm}^2 \\
 \sigma_1 / \sigma_{Rd} &= &= & \underline{\underline{0,542 < 1,0}} \\
 \\
 \max \tau_1 &= V_{1d} * S_{y1r} / (I_{y1r} * t_{w1}) &= & 10,25 \text{ kN/cm}^2 \\
 \tau_1 / \tau_{Rd} &= &= & \underline{\underline{0,851 < 1,0}} \\
 \\
 \sigma_v &= \sqrt{(\sigma_1^2 + 3 * \tau_1^2)} &= & 21,05 \text{ kN/cm}^2 \\
 \sigma_v / \sigma_{Rd} &= &= & \underline{\underline{1,009 < 1,0}}
 \end{aligned}$$

The section (1) is adequate.

Characteristics of the Remaining Section (2):

$$\begin{aligned}
 h_{2r} &= h_2 - e_{To}/10 &= & 22,50 \text{ cm} \\
 A_{2r} &= t_{w2} * h_{2r} &= & 14,85 \text{ cm}^2 \\
 a_{d2} &= h_{2r}/2 &= & 11,25 \text{ cm} \\
 a_{z2} &= h_{2r} - a_{d2} &= & 11,25 \text{ cm} \\
 I_{y2r} &= t_{w2} * h_{2r}^3/12 &= & 626,48 \text{ cm}^4 \\
 S_{y2r} &= t_{w2} * a_{d2}^2/2 &= & 41,77 \text{ cm}^3 \\
 M_{2d} &= V_{2d} * (a_{T2} + d_{p2} + d_f)/10 &= & 715,00 \text{ kNcm} \\
 \max \sigma_2 &= M_{2d} * a_{d2} / I_{y2r} &= & 12,84 \text{ kN/cm}^2 \\
 \sigma_2 / \sigma_{Rd} &= &= & \underline{\underline{0,615 < 1,0}} \\
 \\
 \max \tau_2 &= V_{2d} * S_{y2r} / (I_{y2r} * t_{w2}) &= & 6,57 \text{ kN/cm}^2 \\
 \tau_2 / \tau_{Rd} &= &= & \underline{\underline{0,545 < 1,0}} \\
 \\
 \sigma_v &= \sqrt{(\sigma_2^2 + 3 * \tau_2^2)} &= & 17,16 \text{ kN/cm}^2 \\
 \sigma_v / \sigma_{Rd} &= &= & \underline{\underline{0,822 < 1,0}}
 \end{aligned}$$

The section (2) is adequate.