STRENG s.r.o.
STRUCTURAL ENGINEERING & (RE-) CONSTRUCTION

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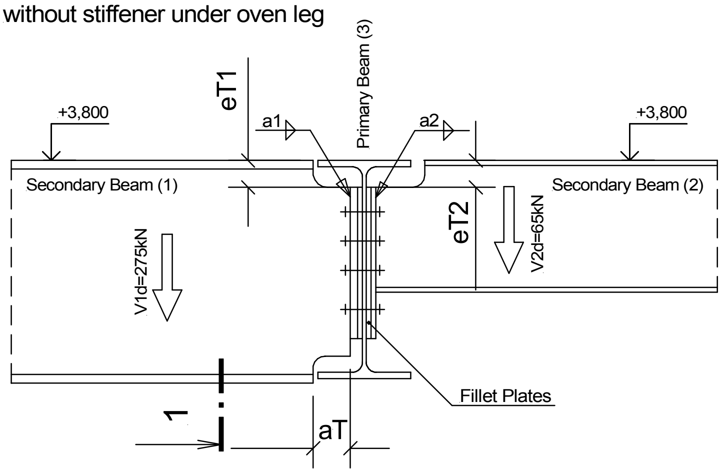
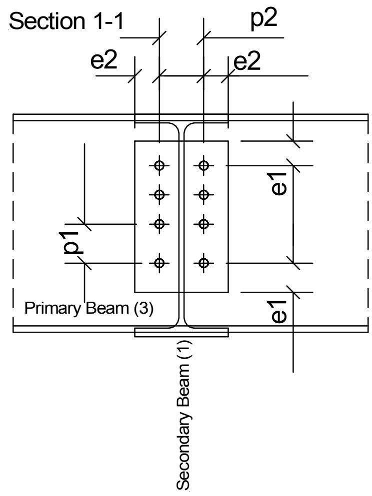
Flexible End Plate Connection

without stiffener under oven leg





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

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 Grage 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
Hight e_{To} =	45 mm

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Hight e_{Tu} = 45 mm

Fillet Welds:
Throat Thickness a1 = 4,0 mm
Throat Thickness a2 = 4,0 mm

Internal Forces:

Design Value - Index "d" (acc. to E-mail from Waterman Partnership 18.10.2004)
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 γ_{Mb}= 1,45
Safety Factor for Welding γ_{Mw}= 1,50
Safety Factor for Section γ_{M0}= 1,15

$f_{y,d}$ =	$f_{y,k} / \gamma_{M0}$	=	20,87 kN/cm²
σ_{Rd} =	$f_{y,k} / \gamma_{M0}$	=	20,87 kN/cm²
τ_{Rd} =	$f_{y,k} / (\sqrt{(3)} * \gamma_{M0})$	=	12,05 kN/cm²
Factor β_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+Δd	=	26,0 mm
α_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):

β_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 Hight 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 Hight 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 Hight 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

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Output Data:

Bolt Spacing Check acc to 6.5.1:

$1{,}2*d_0/e_1$	=	0,62 < 1
e_1/MAX(12*t;150)	=	0,33 < 1
$1{,}5*d_0/e_2$	=	0,78 < 1
e_2/MAX(12*t;150)	=	0,33 < 1
$2{,}2*d_0/p_1$	=	0,95 < 1
p_1/MIN(14*t;200)	=	0,56 < 1

Bolt Shear Capacity and Check:

for Shear in Thread $F_{vs,Rd}$ = $0{,}6*f_{u,b,k}*A_{Sp}/\gamma_{Mb}$ = 113,7 kN

F_{sd} = V_{1d} / (2*n) = 34,38 kN

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

Bolt Bearing Capacity and Check:

α= MIN($e_1/(3*d_0);p_1/(3*d_0)-0{,}25;f_{u,b,k}/f_{uk};1$) = 0,519

$F_{b,Rd}$= $2{,}5*\alpha*f_{uk}*d*t/\gamma_{Mb}/100$ = 58,76 kN

F_{sd} = $(V_{1d}+V_{2d})/(2*n)$ = 42,50 kN

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

Web Shear Check:

τ_1=	$V_{1d} / (t_{w1}*(h_1-((e_{To}+e_{Tu})/10)))$	=	6,83 kN/cm²
τ_1 / τ_{Rd}		=	**0,567 < 1,0**
τ_2=	$V_{2d} / (t_{w2}*(h_2-((e_{To}+e_{Tu})/10)))$	=	5,47 kN/cm²
τ_2 / τ_{Rd}		=	**0,454 < 1,0**

End Plate Shear Check:

In an Verticalsection of the Holescolumn:

h_{p1} =	$(n-1)*p_1+2*e_1$	=	280 mm
A_1=	$(h_{p1} - n*d_0)*d_{p1}/100$	=	26,40 cm²
τ_1 =	$(V_{1d}/2)/A_1$	=	5,21 kN/cm²
τ_1 / τ_{Rd}		=	**0,432 < 1,0**
h_{p2} =	$(n-1)*p_1+2*e_1$	=	280 mm
A_2=	$(h_{p2} - n*d_0)*d_{p2}/100$	=	17,60 cm²
τ_2 =	$(V_{2d}/2)/A_2$	=	1,85 kN/cm²
τ_2 / τ_{Rd}		=	**0,154 < 1,0**

Fillet Weld Shear Check:

l_{w1} =	$h_{p1}/10$	=	28,00 cm
A_{w1} =	$2*a_1/10*l_{w1}$	=	22,40 cm²
τ_{w1} =	V_{1d} / A_{w1}	=	12,28 kN/cm²
$\sqrt{(3)}*\tau_{w1} / \tau_{W,R,d}$		=	**0,709 < 1,0**
l_{w2} =	$h_{p2}/10$	=	28,00 cm
A_{w2} =	$2*a_2/10*l_{w2}$	=	22,40 cm²
τ_{w2} =	V_{2d} / A_{w2}	=	2,90 kN/cm²
$\sqrt{(3)}*\tau_{w2} / \tau_{W,R,d}$		=	**0,167 < 1,0**

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Stress Analysis in Cut out Section and Check:

Characteristics of the Remaining Section (1):

h_{1r} =	$h_1 - (e_{To}+e_{Tu})/10$	=	36,60 cm
A_{1r}=	$t_{w1}*h_{1r}$	=	40,26 cm²
a_{d1} =	$h_{1r}/2$	=	18,30 cm
a_{z1} =	$h_{1r} - a_{d1}$	=	18,30 cm
I_{y1r} =	$t_{w1}*h_{1r}^3/12$	=	4494,22 cm4
S_{y1r} =	$t_{w1}*a_{d1}^2/2$	=	184,19 cm³
M_{1d} =	$V_{1d}*(a_{T1} + d_{p1}+d_f)/10$	=	2777,50 kNcm
max σ_1 =	$M_{1d}*a_{d1}/I_{y1r}$	=	11,31 kN/cm²
σ_1 / σ_{Rd} =	**0,542 < 1,0**		
max τ_1=	$V_{1d}*S_{y1r}/(I_{y1r}*t_{w1})$	=	10,25 kN/cm²
τ_1 / τ_{Rd}		=	**0,851 < 1,0**
σ_v =	$\sqrt{(\sigma_1^2 + 3*\tau_1^2)}$	=	21,05 kN/cm²
σ_v / σ_{Rd}		=	**1,009 < 1,0**

The section (1) is adequate.

Characteristics of the Remaining Section (2):

h_{2r} =	$h_2 - e_{To}/10$	=	22,50 cm
A_{2r}=	$t_{w2}*h_{2r}$	=	14,85 cm²
a_{d2} =	$h_{2r}/2$	=	11,25 cm
a_{z2} =	$h_{2r} - a_{d2}$	=	11,25 cm
I_{y2r} =	$t_{w2}*h_{2r}^3/12$	=	626,48 cm4
S_{y2r} =	$t_{w2}*a_{d2}^2/2$	=	41,77 cm³
M_{2d} =	$V_{2d}*(a_{T2} + d_{p2}+d_f)/10$	=	715,00 kNcm
max σ_2 =	$M_{2d}*a_{d2}/I_{y2r}$	=	12,84 kN/cm²
σ_2 / σ_{Rd} =	**0,615 < 1,0**		
max τ_2=	$V_{2d}*S_{y2r}/(I_{y2r}*t_{w2})$	=	6,57 kN/cm²
τ_2 / τ_{Rd}		=	**0,545 < 1,0**
σ_v =	$\sqrt{(\sigma_2^2 + 3*\tau_2^2)}$	=	17,16 kN/cm²
σ_v / σ_{Rd}		=	**0,822 < 1,0**

The section (2) is adequate.