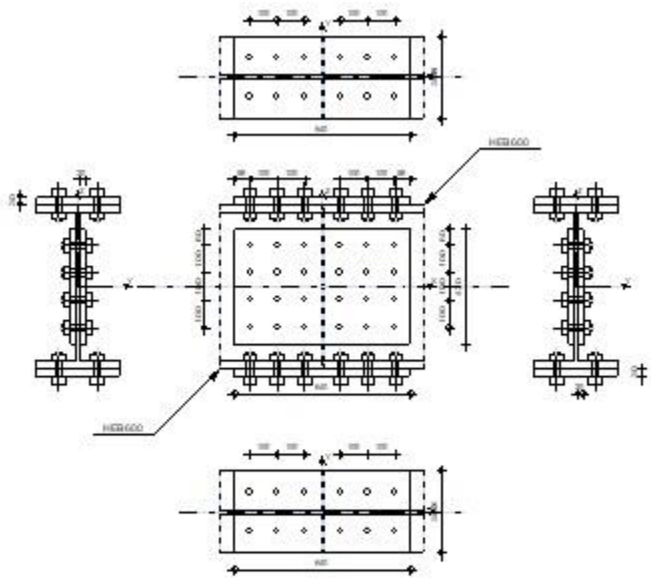
Robot Structural Analysis Professional 2024

Calculation of the beam-to-beam splice connection

EN 1993-1-8:2005/AC:2009

OK

Ratio
0,47



GENERAL

Connection no.: 1
Connection name: Beam Splice

RIGHT BEAM

Section: HEB 600

h_{b1} =	600	[mm]	Height of beam section
b_{fb1} =	300	[mm]	Width of beam section
t_{wb1} =	16	[mm]	Thickness of the web of beam section
t_{fb1} =	30	[mm]	Thickness of the flange of beam section
r_{b1} =	27	[mm]	Radius of beam section fillet
A_{b1} =	269,96	[cm^2]	Cross-sectional area of a beam
I_{yb1} =	171041,00	[cm^4]	Moment of inertia of the beam section

Material: S355

f_{yb1} =	355,00	[MPa]	Resistance
f_{ub1} =	490,00	[MPa]	

LEFT BEAM

Section: HEB 600

h_{b2} =	600	[mm]	Height of beam section
b_{fb2} =	300	[mm]	Width of beam section
t_{wb2} =	16	[mm]	Thickness of the web of beam section
t_{fb2} =	30	[mm]	Thickness of the flange of beam section
r_{b2} =	27	[mm]	Radius of beam section fillet
A_{b2} =	269,96	[cm^2]	Cross-sectional area of a beam

h_{b2} =	600	[mm]	Height of beam section
I_{yb2} =	171041,00	[cm^4]	Moment of inertia of the beam section
Material:	S355		
f_{yb2} =	355,00	[MPa]	Resistance
f_{ub2} =	490,00	[MPa]	

SPLICE PLATE

Type: bilateral

l_{pw} =	640	[mm]	Plate length
h_{pw} =	420	[mm]	Plate height
t_{pw} =	20	[mm]	Plate thickness
Material:	S235		
f_{ypw} =	235,00	[MPa]	Design resistance
f_{upw} =	360,00	[MPa]	Tensile resistance

UPPER EXTERNAL PLATE

l_{pe} =	640	[mm]	Plate length
h_{pe} =	300	[mm]	Plate height
t_{pe} =	30	[mm]	Plate thickness
Material:	S235		
f_{ype} =	235,00	[MPa]	Design resistance
f_{upe} =	360,00	[MPa]	Tensile resistance

LOWER EXTERNAL PLATE

l_{pe} =	640	[mm]	Plate length
h_{pe} =	300	[mm]	Plate height
t_{pe} =	30	[mm]	Plate thickness
Material:	S235		
f_{ype} =	235,00	[MPa]	Design resistance
f_{upe} =	360,00	[MPa]	Tensile resistance

RIGHT SIDE

BOLTS CONNECTING A SPLICE PLATE WITH THE BEAM WEB

The shear plane passes through the UNTHREADED portion of the bolt.
Connection category A

Class =	8.8		Bolt class
d =	24	[mm]	Bolt diameter
d_0 =	26	[mm]	Bolt opening diameter
A_s =	3,53	[cm^2]	Effective section area of a bolt
A_v =	4,52	[cm^2]	Area of bolt section
f_{yb} =	640,00	[MPa]	Yield strength of bolt
f_{ub} =	800,00	[MPa]	Bolt tensile resistance
n_h =	3		Number of bolt columns
n_v =	4		Number of bolt rows
e_1 =	60	[mm]	Level of first bolt
p_2 =	100	[mm]	Horizontal spacing
p_1 =	100	[mm]	Vertical spacing

BOLTS CONNECTING A FLANGE PLATE WITH THE BEAM TOP FLANGE

The shear plane passes through the UNTHREADED portion of the bolt.
Connection category A

Class =	8.8		Bolt class
d =	24	[mm]	Bolt diameter
d_0 =	26	[mm]	Bolt opening diameter
A_s =	3,53	[cm^2]	Effective section area of a bolt
A_v =	4,52	[cm^2]	Area of bolt section
f_{yb} =	640,00	[MPa]	Yield strength of bolt
f_{ub} =	800,00	[MPa]	Bolt tensile resistance
n_h =	1		Number of bolt columns
n_v =	3		Number of bolt rows
e_1 =	60	[mm]	Level of first bolt
p_1 =	100	[mm]	Vertical spacing

BOLTS CONNECTING A FLANGE PLATE WITH THE BEAM BOTTOM FLANGE

The shear plane passes through the UNTHREADED portion of the bolt.
Connection category A

Class =	8.8		Bolt class
d =	24	[mm]	Bolt diameter
d_0 =	26	[mm]	Bolt opening diameter
A_s =	3,53	[cm^2]	Effective section area of a bolt
A_v =	4,52	[cm^2]	Area of bolt section
f_{yb} =	640,00	[MPa]	Yield strength of bolt
f_{ub} =	800,00	[MPa]	Bolt tensile resistance
n_h =	1		Number of bolt columns
n_v =	3		Number of bolt rows
e_1 =	60	[mm]	Level of first bolt
p_1 =	100	[mm]	Vertical spacing

LEFT SIDE

BOLTS CONNECTING A SPLICE PLATE WITH THE BEAM WEB

The shear plane passes through the UNTHREADED portion of the bolt.
Connection category A

Class =	8.8		Bolt class
d =	24	[mm]	Bolt diameter
d_0 =	26	[mm]	Bolt opening diameter
A_s =	3,53	[cm^2]	Effective section area of a bolt
A_v =	4,52	[cm^2]	Area of bolt section
f_{yb} =	640,00	[MPa]	Yield strength of bolt
f_{ub} =	800,00	[MPa]	Bolt tensile resistance
n_h =	3		Number of bolt columns
n_v =	4		Number of bolt rows
e_1 =	60	[mm]	Level of first bolt
p_2 =	100	[mm]	Horizontal spacing
p_1 =	100	[mm]	Vertical spacing

BOLTS CONNECTING A FLANGE PLATE WITH THE BEAM TOP FLANGE

The shear plane passes through the UNTHREADED portion of the bolt.
Connection category A

Class =	8.8		Bolt class
d =	24	[mm]	Bolt diameter
d_0 =	26	[mm]	Bolt opening diameter
A_s =	3,53	[cm^2]	Effective section area of a bolt
A_v =	4,52	[cm^2]	Area of bolt section
f_{yb} =	640,00	[MPa]	Yield strength of bolt
f_{ub} =	800,00	[MPa]	Bolt tensile resistance
n_h =	1		Number of bolt columns
n_v =	3		Number of bolt rows
e_1 =	60	[mm]	Level of first bolt
p_1 =	100	[mm]	Vertical spacing

BOLTS CONNECTING A FLANGE PLATE WITH THE BEAM BOTTOM FLANGE

The shear plane passes through the UNTHREADED portion of the bolt.
Connection category A

Class =	8.8		Bolt class
d =	24	[mm]	Bolt diameter
d_0 =	26	[mm]	Bolt opening diameter
A_s =	3,53	[cm^2]	Effective section area of a bolt
A_v =	4,52	[cm^2]	Area of bolt section
f_{yb} =	640,00	[MPa]	Yield strength of bolt
f_{ub} =	800,00	[MPa]	Bolt tensile resistance
n_h =	1		Number of bolt columns
n_v =	3		Number of bolt rows
e_1 =	60	[mm]	Level of first bolt
p_1 =	100	[mm]	Vertical spacing

MATERIAL FACTORS

γ_{M0} =	1,00	Partial safety factor	[2.2]
γ_{M2} =	1,25	Partial safety factor	[2.2]

LOADS

Case: Manual calculations.

ULTIMATE LIMIT STATE

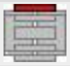
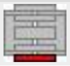
N_{Ed1} =	200,00	[kN]	Axial force
$V_{z,Ed1}$ =	300,00	[kN]	Shear force
$M_{y,Ed1}$ =	300,00	[kN*m]	Bending moment
N_{Ed2} =	200,00	[kN]	Axial force
$V_{z,Ed2}$ =	300,00	[kN]	Shear force
$M_{y,Ed2}$ =	300,00	[kN*m]	Bending moment

RESULTS

Results for one side of connection (geometry and loads are symmetrical)

Axial force

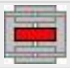
Plate	A_i [cm2]	EQUIVALENT FORCES N_i [kN]	EQUIVALENT FORCES $N_i(M_{y,Ed})$ [kN]	Resultant force $N_{Ed,i}$ [kN]
	A_{pw}= 168,00	96,55	-	**$N_{Ed,pw}$= 96,55**

Plate	A_i [cm2]	EQUIVALENT FORCES N_i [kN]	EQUIVALENT FORCES $N_i(M_{y,Ed})$ [kN]	Resultant force $N_{Ed,i}$ [kN]
	A_{pfue}= 90,00	51,72	418,38	**$N_{Ed,pfue}$= 470,11**
	A_{pfle}= 90,00	51,72	-418,38	**$N_{Ed,pfle}$= -366,66**

$N_i=(N_{Ed}*A_i)/(2*A_{wp}+A_{pfue}+A_{pfle})$

$N_{Ed,i} = N_i+N_i(M_{y,Ed})$

Shear force Z

Plate	A_i [cm2]	$V_{zEd,i}$ [kN]
	$A_{z,pw}$= 168,00	$V_{z,Ed,pw}$= 300,00

Bending moment Y

Plate	$I_{y,i}$ [cm4]	EQUIVALENT FORCES $M_{y,i}$ [kN*m]	Resultant force $M_{y,Ed,i}$ [kN*m]
	$I_{y,pw}$= 24696,00	36,42	**$M_{y,Ed,pw}$= 36,42**
	$I_{y,pfue}$= 89370,00	131,79	**-**
	$I_{y,pfle}$= 89370,00	131,79	**-**

$M_{y,i}=(M_{y,Ed}*I_{y,i})/(2*I_{pw}+I_{pfue}+I_{pfle})$

BOLTS CONNECTING A SPLICE PLATE WITH THE BEAM WEB

BOLT CAPACITIES

$F_{v,Rd}$ = 347,44 [kN] Shear bolt resistance in the unthreaded portion of a bolt $F_{v,Rd}= 0.6*f_{ub}*A_v*m/\gamma_{M2}$

Bolt bearing on the beam

Direction x

k_{1x} = 2,50 Coefficient for calculation of $F_{b,Rd}$ $k_{1x} = \min[2.8*(e_1/d_0)-1.7, 1.4*(p_1/d_0)-1.7, 2.5]$

$k_{1x} > 0.0$ 2,50 > 0,00 verified

α_{bx} = 0,74 Coefficient for calculation of $F_{b,Rd}$ $\alpha_{bx}=\min[e_2/(3*d_0), p_2/(3*d_0)-0.25, f_{ub}/f_u, 1]$

$\alpha_{bx} > 0.0$ 0,74 > 0,00 verified

$F_{b,Rd1x}$ = 268,75 [kN] Bearing resistance of a single bolt $F_{b,Rd1x}=k_{1x}*\alpha_{bx}*f_u*d*\sum t_i/\gamma_{M2}$

Direction z

k_{1z} = 2,50 Coefficient for calculation of $F_{b,Rd}$ $k_{1z}=\min[2.8*(e_2/d_0)-1.7, 1.4*(p_2/d_0)-1.7, 2.5]$

$k_{1z} > 0.0$ 2,50 > 0,00 verified

α_{bz} = 1,00 Coefficient for calculation of $F_{b,Rd}$ $\alpha_{bz}=\min[e_1/(3*d_0), p_1/(3*d_0)-0.25, f_{ub}/f_u, 1]$

$\alpha_{bz} > 0.0$ 1,00 > 0,00 verified

$F_{b,Rd1z}$ = 364,56 [kN] Bearing resistance of a single bolt $F_{b,Rd1z}=k_{1z}*\alpha_{bz}*f_u*d*\sum t_i/\gamma_{M2}$

Bolt bearing on the plate

Direction x

k_{1x} = 2,50 Coefficient for calculation of $F_{b,Rd}$ $k_{1x}=\min[2.8*(e_1/d_0)-1.7, 1.4*(p_1/d_0)-1.7, 2.5]$

$k_{1x} > 0.0$ 2,50 > 0,00 verified

α_{bx} = 0,74 Coefficient for calculation of $F_{b,Rd}$ $\alpha_{bx}=\min[e_2/(3*d_0), p_2/(3*d_0)-0.25, f_{ub}/f_u, 1]$

$\alpha_{bx} > 0.0$ 0,74 > 0,00 verified

$F_{b,Rd2x}$ = 509,54 [kN] Bearing resistance of a single bolt $F_{b,Rd2x}=k_{1x}*\alpha_{bx}*f_u*d*\sum t_i/\gamma_{M2}$

Direction z

k_{1z} = 2,50 Coefficient for calculation of $F_{b,Rd}$ $k_{1z}=\min[2.8*(e_2/d_0)-1.7, 1.4*(p_2/d_0)-1.7, 2.5]$

$k_{1z} > 0.0$ 2,50 > 0,00 verified

α_{bz} = 0,77 Coefficient for calculation of $F_{b,Rd}$ $\alpha_{bz}=\min[e_1/(3*d_0), p_1/(3*d_0)-0.25, f_{ub}/f_u, 1]$

$\alpha_{bz} > 0.0$		0,77 > 0,00	verified	
$F_{b,Rd2z}$ = 531,69	[kN]	Bearing resistance of a single bolt		$F_{b,Rd2z}=k_{1z}*\alpha_{bz}*f_u*d*\sum t_i/\gamma_{M2}$

ULTIMATE LIMIT STATE

Bolt shear

e_0 = 162	[mm]	Shear force eccentricity relative to the center of gravity of a bolt group	$e_0 = e_{2b}+0.5*(s_1+(c-1)*p$
M_y = 85,17	[kN*m]	Real bending moment	$M_y=M_{y,Ed,pw}+V_{z,Ed,pw}*$
$F_{x,N}$ = 8,05	[kN]	Component force in a bolt due to influence of the longitudinal force on the x direction	$F_{x,N}=\|N_{Ed,pw}\|/$
$F_{z,Vz}$ = 25,00	[kN]	Component force in a bolt due to influence of the shear force Vz on the z direction	$F_{z,Vz}=\|V_{z,Ed,pw}\|/$
$F_{x,My}$ = 55,54	[kN]	Component force in a bolt due to influence of the moment My on the x direction	$F_{x,My}=\|M_y\|*z_i/\sum(x_i^2+z$
$F_{z,My}$ = 37,03	[kN]	Component force in a bolt due to influence of the moment My on the z direction	$F_{z,My}=\|M_y\|*x_i/\sum(x_i^2+z$
$F_{x,Ed}$ = 63,59	[kN]	Design total force in a bolt on the direction x	$F_{x,Ed} = F_{x,N}+F_{x,}$
$F_{z,Ed}$ = 62,03	[kN]	Design total force in a bolt on the direction z	$F_{z,Ed} = F_{z,Vz}+F_{z,}$
F_{Ed} = 88,83	[kN]	Resultant shear force in a bolt	$F_{Ed} = \sqrt{(} F_{x,Ed}^2 + F_{z,Ed}^2$
$F_{Rd,x}$ = 268,75	[kN]	Effective design capacity of a bolt on the direction x	$F_{Rdx}=\min(F_{bRd1,x}, F_{bRd2}$
$F_{Rd,z}$ = 364,56	[kN]	Effective design capacity of a bolt on the direction z	$F_{Rdz}=\min(F_{bRd1,z}, F_{bRd2}$

$\|F_{x,Ed}\| \le F_{Rd,x}$	|63,59| < 268,75	verified	(0,24)
$\|F_{z,Ed}\| \le F_{Rd,z}$	|62,03| < 364,56	verified	(0,17)
$F_{Ed} \le F_{v,Rd}$	88,83 < 347,44	verified	(0,26)

BOLTS CONNECTING A FLANGE PLATE WITH THE BEAM TOP FLANGE

BOLT CAPACITIES

$F_{v,Rd}$ = 173,72	[kN]	Shear resistance of the shank of a single bolt	$F_{v,Rd}= 0.6*f_{ub}*A_v*m/\gamma_{M2}$

Bolt bearing on the beam flange

Direction x

k_{1x} = 2,50		Coefficient for calculation of $F_{b,Rd}$		$k_{1x}=\min[2.8*(e_2/d_0)-1.7, 2.5]$
$k_{1x} > 0.0$		2,50 > 0,00	verified	
α_{bx} = 0,77		Coefficient for calculation of $F_{b,Rd}$		$\alpha_{bx}=\min[e_1/(3*d_0), p_1/(3*d_0)-0.25, f_{ub}/f_u, 1]$
$\alpha_{bx} > 0.0$		0,77 > 0,00	verified	
$F_{b,Rd1x}$ = 542,77	[kN]	Bearing resistance of a single bolt		$F_{b,Rd1x}=k_{1x}*\alpha_{bx}*f_u*d*\sum t_i/\gamma_{M2}$

Direction y

k_{1y} = 2,50		Coefficient for calculation of $F_{b,Rd}$		$k_{1y} = \min[2.8*(e_1/d_0)-1.7, 1.4*(p_1/d_0)-1.7, 2.5]$
$k_{1y} > 0.0$		2,50 > 0,00	verified	
α_{by} = 1,00		Coefficient for calculation of $F_{b,Rd}$		$\alpha_{by}=\min[e_2/(3*d_0), f_{ub}/f_u, 1]$
$\alpha_{by} > 0.0$		1,00 > 0,00	verified	
$F_{b,Rd1y}$ = 705,60	[kN]	Bearing resistance of a single bolt		$F_{b,Rd1y}=k_{1y}*\alpha_{by}*f_u*d*\sum t_i/\gamma_{M2}$

Bolt bearing on the plate

Direction x

k_{1x} = 2,50		Coefficient for calculation of $F_{b,Rd}$		$k_{1x}=\min[2.8*(e_2/d_0)-1.7, 2.5]$
$k_{1x} > 0.0$		2,50 > 0,00	verified	
α_{bx} = 0,71		Coefficient for calculation of $F_{b,Rd}$		$\alpha_{bx}=\min[e_1/(3*d_0), p_1/(3*d_0)-0.25, f_{ub}/f_u, 1]$
$\alpha_{bx} > 0.0$		0,71 > 0,00	verified	
$F_{b,Rd2x}$ = 365,54	[kN]	Bearing resistance of a single bolt		$F_{b,Rd2x}=k_{1x}*\alpha_{bx}*f_u*d*\sum t_i/\gamma_{M2}$

Direction y

k_{1y} = 2,50		Coefficient for calculation of $F_{b,Rd}$		$k_{1y}=\min[2.8*(e_1/d_0)-1.7, 1.4*(p_1/d_0)-1.7, 2.5]$
$k_{1y} > 0.0$		2,50 > 0,00	verified	
α_{by} = 1,00		Coefficient for calculation of $F_{b,Rd}$		$\alpha_{by}=\min[e_2/(3*d_0), f_{ub}/f_u, 1]$
$\alpha_{by} > 0.0$		1,00 > 0,00	verified	
$F_{b,Rd2y}$ = 518,40	[kN]	Bearing resistance of a single bolt		$F_{b,Rd2y}=k_{1y}*\alpha_{by}*f_u*d*\sum t_i/\gamma_{M2}$

ULTIMATE LIMIT STATE

Bolt shear

F_{Ed} =	81,84	[kN]	Shear force in a bolt		$F_{Ed}=N_{Ed,pfue}/n_b$
β_{Lf} =	1,00		Reduction factor for long connections		β_{Lf} = max(0.75, min(1; 1-(L-15*d)/(200*d)))
F_{Rd} =	173,72	[kN]	Effective design capacity of a bolt		F_{Rd} = min($F_{v,Rd}$; $F_{b,Rd1}$; $F_{b,Rd2}$)
$\|F_{Ed}\| \le \beta_{Lf}*F_{Rd}$			$\|81,84\| < 173,72$	verified	(0,47)

BOLTS CONNECTING A FLANGE PLATE WITH THE BEAM BOTTOM FLANGE

BOLT CAPACITIES

$F_{v,Rd}$ =	173,72	[kN]	Shear resistance of the shank of a single bolt		$F_{v,Rd}$= 0.6*f_{ub}*A_v*m/γ_{M2}
Bolt bearing on the beam flange					
Direction x					
k_{1x} =	2,50		Coefficient for calculation of $F_{b,Rd}$		k_{1x}=min[2.8*(e_2/d_0)-1.7, 2.5]
k_{1x} > 0.0			2,50 > 0,00	verified	
α_{bx} =	0,77		Coefficient for calculation of $F_{b,Rd}$		α_{bx}=min[e_1/(3*d_0), p_1/(3*d_0)-0.25, f_{ub}/f_u, 1]
α_{bx} > 0.0			0,77 > 0,00	verified	
$F_{b,Rd1x}$ =	542,77	[kN]	Bearing resistance of a single bolt		$F_{b,Rd1x}$=k_{1x}*α_{bx}*f_u*d*∑t_i/γ_{M2}
Direction y					
k_{1y} =	2,50		Coefficient for calculation of $F_{b,Rd}$		k_{1y} = min[2.8*(e_1/d_0)-1.7, 1.4*(p_1/d_0)-1.7, 2.5]
k_{1y} > 0.0			2,50 > 0,00	verified	
α_{by} =	1,00		Coefficient for calculation of $F_{b,Rd}$		α_{by}=min[e_2/(3*d_0), f_{ub}/f_u, 1]
α_{by} > 0.0			1,00 > 0,00	verified	
$F_{b,Rd1y}$ =	705,60	[kN]	Bearing resistance of a single bolt		$F_{b,Rd1y}$=k_{1y}*α_{by}*f_u*d*∑t_i/γ_{M2}
Bolt bearing on the plate					
Direction x					
k_{1x} =	2,50		Coefficient for calculation of $F_{b,Rd}$		k_{1x}=min[2.8*(e_2/d_0)-1.7, 2.5]
k_{1x} > 0.0			2,50 > 0,00	verified	
α_{bx} =	0,71		Coefficient for calculation of $F_{b,Rd}$		α_{bx}=min[e_1/(3*d_0), p_1/(3*d_0)-0.25, f_{ub}/f_u, 1]
α_{bx} > 0.0			0,71 > 0,00	verified	
$F_{b,Rd2x}$ =	365,54	[kN]	Bearing resistance of a single bolt		$F_{b,Rd2x}$=k_{1x}*α_{bx}*f_u*d*∑t_i/γ_{M2}
Direction y					
k_{1y} =	2,50		Coefficient for calculation of $F_{b,Rd}$		k_{1y}=min[2.8*(e_1/d_0)-1.7, 1.4*(p_1/d_0)-1.7, 2.5]
k_{1y} > 0.0			2,50 > 0,00	verified	
α_{by} =	1,00		Coefficient for calculation of $F_{b,Rd}$		α_{by}=min[e_2/(3*d_0), f_{ub}/f_u, 1]
α_{by} > 0.0			1,00 > 0,00	verified	
$F_{b,Rd2y}$ =	518,40	[kN]	Bearing resistance of a single bolt		$F_{b,Rd2y}$=k_{1y}*α_{by}*f_u*d*∑t_i/γ_{M2}

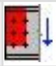
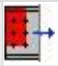
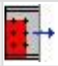
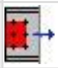
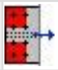
ULTIMATE LIMIT STATE

Bolt shear

F_{Ed} =	-64,60	[kN]	Shear force in a bolt		$F_{Ed}=N_{Ed,pfle}/n_b$
β_{Lf} =	1,00		Reduction factor for long connections		β_{Lf} = max(0.75, min(1; 1-(L-15*d)/(200*d)))
F_{Rd} =	173,72	[kN]	Effective design capacity of a bolt		F_{Rd} = min($F_{v,Rd}$; $F_{b,Rd1}$; $F_{b,Rd2}$)
$\|F_{Ed}\| \le \beta_{Lf}*F_{Rd}$			$\|-64,60\| < 173,72$	verified	(0,37)

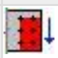
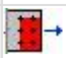
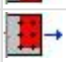
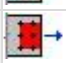
VERIFICATION OF THE SECTION DUE TO BLOCK TEARING - [3.10]

BEAM

Nr	Model	A_{nv} [cm2]	A_{nt} [cm2]	V_0 [kN]	$V_{eff,Rd}$ [kN]	$\lvert V_0\rvert/V_{eff,Rd}$	Status
1		55,64	29,84	300,00 (*1)	1725,31 (*)	0,17	verified
2		29,84	155,57	96,55 (*2)	6709,92 (**)	0,01	verified
3		29,84	155,57	96,55 (*2)	6709,92 (**)	0,01	verified
4		59,67	34,41	96,55 (*2)	2571,97 (**)	0,04	verified
5		58,50	20,10	491,03 (*3)	3973,86 (***)	0,12	verified

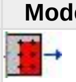
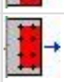
(*1) $V_0 = V_{zEd1}$
(*2) $V_0 = N_{wEd}$
(*3) $V_0 = N_{fuEd}$
(*) $V_{effRd} = 0.5*f_u*A_{nt}/\gamma_{M2} + (1/\sqrt{3})*f_y*A_{nv}/\gamma_{M0}$
(**) $V_{effRd} = f_u*A_{nt}/\gamma_{M2} + (1/\sqrt{3})*f_y*A_{nv}/\gamma_{M0}$
(***) $V_{effRd} = 2*[f_u*A_{nt}/\gamma_{M2} + (1/\sqrt{3})*f_y*A_{nv}/\gamma_{M0}]$

SPLICE PLATE

Nr	Model	A_{nv} [cm2]	A_{nt} [cm2]	V_0 [kN]	$V_{eff,Rd}$ [kN]	$\lvert V_0\rvert/V_{eff,Rd}$	Status
1		53,80	38,50	150,00 (*1)	1284,34 (*)	0,12	verified
2		38,50	53,80	48,28 (*2)	2071,80 (**)	0,02	verified
3		38,50	53,80	48,28 (*2)	2071,80 (**)	0,02	verified
4		77,00	44,40	48,28 (*2)	2323,44 (**)	0,02	verified

(*1) $V_0 = 0.5*V_{zEd1}$
(*2) $V_0 = 0.5*N_{wEd}$
(*) $V_{effRd} = 0.5*f_u*A_{nt}/\gamma_{M2} + (1/\sqrt{3})*f_y*A_{nv}/\gamma_{M0}$
(**) $V_{effRd} = f_u*A_{nt}/\gamma_{M2} + (1/\sqrt{3})*f_y*A_{nv}/\gamma_{M0}$

UPPER EXTERNAL PLATE

Nr	Model	A_{nv} [cm2]	A_{nt} [cm2]	V_0 [kN]	$V_{eff,Rd}$ [kN]	$\lvert V_0\rvert/V_{eff,Rd}$	Status
1		57,00	54,30	470,11 (*1)	2337,20 (**)	0,20	verified
2		114,00	34,20	470,11 (*1)	2531,68 (**)	0,19	verified

(*1) $V_0 = N_{fueEd}$
(**) $V_{effRd} = f_u*A_{nt}/\gamma_{M2} + (1/\sqrt{3})*f_y*A_{nv}/\gamma_{M0}$

VERIFICATION OF SECTIONS WEAKENED BY OPENINGS - [5.4]

BEAM

A_t = 141,53 [cm^2] Area of tension zone of the gross section
$A_{t,net}$ = 117,87 [cm^2] Net area of the section in tension

$0.9*(A_{t,net}/A_t) \geq (f_y*\gamma_{M2})/(f_u*\gamma_{M0})$ 0,75 < 0,91

W = 5701,37 [cm^3] Elastic section modulus
W_{net} = 5701,37 [cm^3] Elastic section modulus
$M_{c,Rdnet}$ = 2023,99 [kN*m] Design resistance of the section for bending $M_{c,Rdnet} = W_{net}*f_{yp}/\gamma_{M0}$

$\|M_0\| \le M_{c,Rdnet}$	|300,00| < 2023,99	verified		(0,15)
$A =$ 269,96	[cm^2]	Area of tension zone of the gross section		$A=h_{pi}*t_{pi}$
$A_{net} =$ 222,64	[cm^2]	Net cross-sectional area		$A_{net}=A-n_v*d_0*t_{pi}$
$N_{pl,Rd} =$ 9583,51	[kN]	Design plastic resistance of the gross section		$N_{pl,Rd}=A*f_y/\gamma_{M0}$
$N_{u,Rd} =$ 7854,67	[kN]	Design ultimate resistance to normal force of the net section		$N_{u,Rd}=0.9*A_{net}*f_u/\gamma_{M2}$
$F_{Ed} =$ 200,00	[kN]			$A=h_{pi}*t_{pi}$
$\|F_{Ed}\| \le N_{u,Rd}$	|200,00| < 7854,67	verified		(0,03)
$\|F_{Ed}\| \le N_{pl,Rd}$	|200,00| < 9583,51	verified		(0,02)
$A_v =$ 93,00	[cm^2]	Effective section area for shear		$A_v = h_p*t_p$
$A_{v,net} =$ 76,88	[cm^2]	Net area of a section effective for shear		$A_{vnet}=A_v-n_v*d_0*t_p$
$V_{pl,Rd} =$ 1906,12	[kN]	Design plastic resistance for shear		$V_{pl,Rd}=(A_v*f_{yp})/(\sqrt{3}*\gamma_{M0})$
$\|V_0\| \le V_{pl,Rd}$	|300,00| < 1906,12	verified		(0,16)

SPLICE PLATE

$A_t =$ 45,33	[cm^2]	Area of tension zone of the gross section		
$A_{t,net} =$ 34,93	[cm^2]	Net area of the section in tension		
$0.9*(A_{t,net}/A_t) \ge (f_y*\gamma_{M2})/(f_u*\gamma_{M0})$	0,69 < 0,82			
$W =$ 588,00	[cm^3]	Elastic section modulus		
$W_{net} =$ 556,25	[cm^3]	Elastic section modulus		
$M_{c,Rdnet} =$ 130,72	[kN*m]	Design resistance of the section for bending		$M_{c,Rdnet} = W_{net}*f_{yp}/\gamma_{M0}$
$\|M_0\| \le M_{c,Rdnet}$	|42,58| < 130,72	verified		(0,33)
$A =$ 84,00	[cm^2]	Area of tension zone of the gross section		$A=h_{pi}*t_{pi}$
$A_{net} =$ 63,20	[cm^2]	Net cross-sectional area		$A_{net}=A-n_v*d_0*t_{pi}$
$N_{pl,Rd} =$ 1974,00	[kN]	Design plastic resistance of the gross section		$N_{pl,Rd}=A*f_y/\gamma_{M0}$
$N_{u,Rd} =$ 1638,14	[kN]	Design ultimate resistance to normal force of the net section		$N_{u,Rd}=0.9*A_{net}*f_u/\gamma_{M2}$
$F_{Ed} =$ 48,28	[kN]			$F_{Ed} = N_{Ed,pw}$
$\|F_{Ed}\| \le N_{u,Rd}$	|48,28| < 1638,14	verified		(0,03)
$\|F_{Ed}\| \le N_{pl,Rd}$	|48,28| < 1974,00	verified		(0,02)
$A_v =$ 84,00	[cm^2]	Effective section area for shear		$A_v = h_p*t_p$
$A_{v,net} =$ 63,20	[cm^2]	Net area of a section effective for shear		$A_{vnet}=A_v-n_v*d_0*t_p$
$V_{pl,Rd} =$ 1139,69	[kN]	Design plastic resistance for shear		$V_{pl,Rd}=(A_v*f_{yp})/(\sqrt{3}*\gamma_{M0})$
$\|V_0\| \le V_{pl,Rd}$	|150,00| < 1139,69	verified		(0,13)

UPPER EXTERNAL PLATE

$A =$ 90,00	[cm^2]	Area of tension zone of the gross section		$A=h_{pi}*t_{pi}$
$A_{net} =$ 74,40	[cm^2]	Net cross-sectional area		$A_{net}=A-n_v*d_0*t_{pi}$
$N_{pl,Rd} =$ 2115,00	[kN]	Design plastic resistance of the gross section		$N_{pl,Rd}=A*f_y/\gamma_{M0}$
$N_{u,Rd} =$ 1928,45	[kN]	Design ultimate resistance to normal force of the net section		$N_{u,Rd}=0.9*A_{net}*f_u/\gamma_{M2}$
$F_{Ed} =$ 470,11	[kN]			$F_{Ed} = N_{Ed,pfue}$
$\|F_{Ed}\| \le N_{u,Rd}$	|470,11| < 1928,45	verified		(0,24)
$\|F_{Ed}\| \le N_{pl,Rd}$	|470,11| < 2115,00	verified		(0,22)

LOWER EXTERNAL PLATE

$A =$ 90,00	[cm^2]	Area of tension zone of the gross section		$A=h_{pi}*t_{pi}$
$A_{net} =$ 74,40	[cm^2]	Net cross-sectional area		$A_{net}=A-n_v*d_0*t_{pi}$
$N_{pl,Rd} =$ 2115,00	[kN]	Design plastic resistance of the gross section		$N_{pl,Rd}=A*f_y/\gamma_{M0}$
$N_{u,Rd} =$ 1928,45	[kN]	Design ultimate resistance to normal force of the net section		$N_{u,Rd}=0.9*A_{net}*f_u/\gamma_{M2}$
$F_{Ed} =$ -366,66	[kN]			$F_{Ed} = N_{Ed,pfli}$
$\|F_{Ed}\| \le N_{u,Rd}$	|-366,66| < 1928,45	verified		(0,19)
$\|F_{Ed}\| \le N_{pl,Rd}$	|-366,66| < 2115,00	verified		(0,17)

Connection conforms to the code	Ratio 0,47