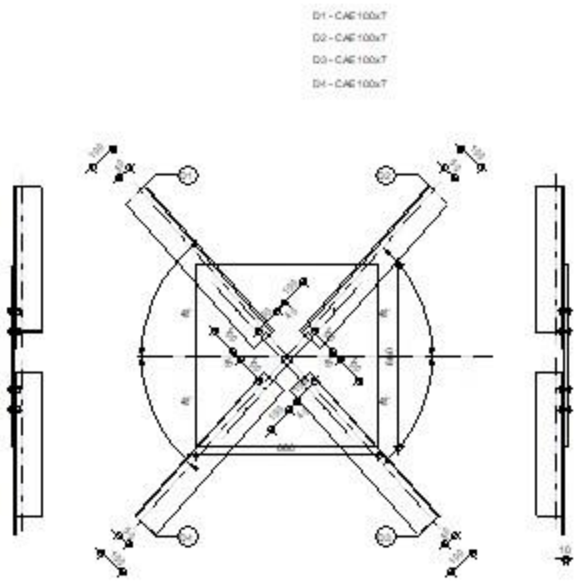
Autodesk Robot Structural Analysis Professional 2020

Calculations of the connection with the gusset plate

NF EN 1993-1-8:2005/NA:2007/AC:2009

OK

Ratio
0.20



GENERAL

Connection no.: 27
Connection name: Gusset plate: bracing
Structure node: 352
Structure bars: 337, 338, 336, 339,

GEOMETRY

BARS

		Bar 1	Bar 2	Bar 3	Bar 4		
Bar no.:		337	338	336	339		
Section:		CAE 100x7	CAE 100x7	CAE 100x7	CAE 100x7		
	h	100	100	100	100		mm
	b_f	100	100	100	100		mm
	t_w	7	7	7	7		mm
	t_f	7	7	7	7		mm
	r	12	12	12	12		mm
	A	13.66	13.66	13.66	13.66		cm2
Material:		ACIER	ACIER	ACIER	ACIER		
	f_y	235.00	235.00	235.00	235.00		MPa
	f_u	365.00	365.00	365.00	365.00		MPa
Angle	α	48.4	48.4	48.4	48.4		Deg
Length	l	0.00	0.00	0.00	0.00		m

BOLTS

Bar 1

The shear plane passes through the UNTHREADED portion of the bolt.

Class =	8.8		Bolt class
d =	10	[mm]	Bolt diameter
d_0 =	11	[mm]	Bolt opening diameter
A_s =	0.58	[cm^2]	Effective section area of a bolt
A_v =	0.79	[cm^2]	Area of bolt section
f_{yb} =	550.00	[MPa]	Yield point
f_{ub} =	800.00	[MPa]	Bolt tensile resistance
n =	2		Number of bolt columns

Bolt spacing 100 [mm]

e_1 =	40	[mm]	Distance of the center of gravity of first bolt from the member end
e_2 =	50	[mm]	Distance of the axis of bolts from the member edge
e_c =	100	[mm]	Distance of the member end from the point of intersection of member axes

Bar 2

The shear plane passes through the UNTHREADED portion of the bolt.

Class =	8.8		Bolt class
d =	10	[mm]	Bolt diameter
d_0 =	11	[mm]	Bolt opening diameter
A_s =	0.58	[cm^2]	Effective section area of a bolt
A_v =	0.79	[cm^2]	Area of bolt section
f_{yb} =	550.00	[MPa]	Yield point
f_{ub} =	800.00	[MPa]	Bolt tensile resistance
n =	2		Number of bolt columns

Bolt spacing 100 [mm]

e_1 =	40	[mm]	Distance of the center of gravity of first bolt from the member end
e_2 =	50	[mm]	Distance of the axis of bolts from the member edge
e_c =	100	[mm]	Distance of the member end from the point of intersection of member axes

Bar 3

The shear plane passes through the UNTHREADED portion of the bolt.

Class =	8.8		Bolt class
d =	10	[mm]	Bolt diameter
d_0 =	11	[mm]	Bolt opening diameter
A_s =	0.58	[cm^2]	Effective section area of a bolt
A_v =	0.79	[cm^2]	Area of bolt section
f_{yb} =	550.00	[MPa]	Yield point
f_{ub} =	800.00	[MPa]	Bolt tensile resistance
n =	2		Number of bolt columns

Bolt spacing 100 [mm]

e_1 =	40	[mm]	Distance of the center of gravity of first bolt from the member end
e_2 =	50	[mm]	Distance of the axis of bolts from the member edge
e_c =	100	[mm]	Distance of the member end from the point of intersection of member axes

Bar 4

The shear plane passes through the UNTHREADED portion of the bolt.

Class =	8.8		Bolt class
d =	10	[mm]	Bolt diameter
d_0 =	11	[mm]	Bolt opening diameter
A_s =	0.58	[cm^2]	Effective section area of a bolt
A_v =	0.79	[cm^2]	Area of bolt section
f_{yb} =	550.00	[MPa]	Yield point
f_{ub} =	800.00	[MPa]	Bolt tensile resistance

Class = 8.8 Bolt class
n = 2 Number of bolt columns
Bolt spacing 100 [mm]
e_1 = 40 [mm] Distance of the center of gravity of first bolt from the member end
e_2 = 50 [mm] Distance of the axis of bolts from the member edge
e_c = 100 [mm] Distance of the member end from the point of intersection of member axes

GUSSET PLATE

l_p =	660	[mm]	Plate length
h_p =	660	[mm]	Plate height
t_p =	10	[mm]	Plate thickness

Parameters

h_1 =	0	[mm]	Cut
v_1 =	0	[mm]	Cut
h_2 =	0	[mm]	Cut
v_2 =	0	[mm]	Cut
h_3 =	0	[mm]	Cut
v_3 =	0	[mm]	Cut
h_4 =	0	[mm]	Cut
v_4 =	0	[mm]	Cut

Center of gravity of the plate with respect to the center of gravity of bars (0;0)
e_V = 330 [mm] Vertical distance of the plate edge from the point of intersection of member axes
e_H = 330 [mm] Horizontal distance of the plate edge from the point of intersection of member axes
Material: ACIER
f_y = 235.00 [MPa] Resistance

MATERIAL FACTORS

γ_{M0} =	1.00	Partial safety factor	[2.2]
γ_{M2} =	1.25	Partial safety factor	[2.2]

LOADS

Case: 16: ULS /102/ 1*1.35 + 2*1.35 + 3*1.35 + 4*1.35 + 5*1.35 + 6*1.35 + 7*1.05 + 8*1.05 + 9*1.05 +

$N_{b1,Ed}$ =	7.57	[kN]	Axial force
$N_{b2,Ed}$ =	-10.90	[kN]	Axial force
$N_{b3,Ed}$ =	7.33	[kN]	Axial force
$N_{b4,Ed}$ =	-11.20	[kN]	Axial force

RESULTS

BAR 1

BOLT CAPACITIES

$F_{v,Rd}$ = 30.16 [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 bar

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} = 1.00 Coefficient determined by bolt spacing α_{bx}=min[e_1/(3*d_0), p_1/(3*d_0)-0.25, f_{ub}/f_u, 1]

$\alpha_{bx} > 0.0$		1.00 > 0.00	verified	
$F_{b,Rd1x}$ = 51.10	[kN]	Design capacity in the limit state of plastification of the opening wall		$F_{b,Rd1x}=k_{1x}*\alpha_{bx}*f_u*d*t_i/\gamma_{M2}$
Direction z				
k_{1z} = 2.50		Coefficient for calculation of $F_{b,Rd}$		$k_{1z}=\min[2.8*(e_1/d_0)-1.7, 1.4*(p_1/d_0)-1.7, 2.5]$
$k_{1z} > 0.0$		2.50 > 0.00	verified	
α_{bz} = 1.00		Coefficient for calculation of $F_{b,Rd}$		$\alpha_{bz}=\min[e_2/(3*d_0), f_{ub}/f_u, 1]$
$\alpha_{bz} > 0.0$		1.00 > 0.00	verified	
$F_{b,Rd1z}$ = 51.10	[kN]	Bearing resistance of a single bolt		$F_{b,Rd1z}=k_{1z}*\alpha_{bz}*f_u*d*t_i/\gamma_{M2}$

Bolt bearing on the plate

Direction x				
k_{1x} = 2.50		Coefficient for calculation of $F_{b,Rd}$		$k_1=\min[2.8*(e_2/d_0)-1.7, 2.5]$
$k_{1x} > 0.0$		2.50 > 0.00	verified	
α_{bx} = 1.00		Coefficient determined by bolt spacing		$\alpha_{bx}=\min[e_1/(3*d_0), p_1/(3*d_0)-0.25, f_{ub}/f_u, 1]$
$\alpha_{bx} > 0.0$		1.00 > 0.00	verified	
$F_{b,Rd2x}$ = 73.00	[kN]	Design capacity in the limit state of plastification of the opening wall		$F_{b,Rd2x}=k_1*\alpha_b*f_u*d*t_i/\gamma_{M2}$
Direction z				
k_{1z} = 2.50		Coefficient for calculation of $F_{b,Rd}$		$k_{1z}=\min[2.8*(e_1/d_0)-1.7, 1.4*(p_1/d_0)-1.7, 2.5]$
$k_{1z} > 0.0$		2.50 > 0.00	verified	
α_{bz} = 1.00		Coefficient for calculation of $F_{b,Rd}$		$\alpha_{bz}=\min[e_2/(3*d_0), f_{ub}/f_u, 1]$
$\alpha_{bz} > 0.0$		1.00 > 0.00	verified	
$F_{b,Rd2z}$ = 73.00	[kN]	Bearing resistance of a single bolt		$F_{b,Rd2z}=k_{1z}*\alpha_{bz}*f_u*d*t_i/\gamma_{M2}$

VERIFICATION OF A CONNECTION DUE TO FORCES ACTING ON BOLTS

Bolt shear

e =	23	[mm]	Axial force eccentricity relative to the bolt axis		
M_0 =	0.17	[kN*m]	Real bending moment		$M_0=N_{b1,Ed}*e$
F_{NSd} =	3.78	[kN]	Component force in a bolt due to influence of the longitudinal force		$F_{NSd} = N_{b1,Ed}/n$
F_{MSd} =	1.75	[kN]	Component force in a bolt due to influence of the moment		$F_{MSd}=M_0*x_{max}/\Sigma x_i^2$
$F_{x,Ed}$ =	3.78	[kN]	Design total force in a bolt on the direction x		$F_{x,Ed} = F_{NSd}$
$F_{z,Ed}$ =	1.75	[kN]	Design total force in a bolt on the direction z		$F_{z,Ed} = F_{MSd}$
F_{Ed} =	4.17	[kN]	Resultant shear force in a bolt		$F_{Ed} = \sqrt{(F_{x,Ed}^2 + F_{z,Ed}^2)}$
F_{Rdx} =	51.10	[kN]	Effective design capacity of a bolt on the direction x		$F_{Rdx}=\min(F_{bRd1x}, F_{bRd2x})$
F_{Rdz} =	51.10	[kN]	Effective design capacity of a bolt on the direction z		$F_{Rdz}=\min(F_{bRd1z}, F_{bRd2z})$
$\|F_{x,Ed}\| \le F_{Rdx}$			|3.78| < 51.10	verified	(0.07)
$\|F_{z,Ed}\| \le F_{Rdz}$			|1.75| < 51.10	verified	(0.03)
$F_{Ed} \le F_{vRd}$			4.17 < 30.16	verified	(0.14)

VERIFICATION OF A SECTION WEAKENED BY OPENINGS

β_2 =	0.70		Reduction coefficient		[Table 3.8]
A_{net} =	12.89	[cm²]	Net cross-sectional area		$A_{net} = A - d_0*t_{f1}$
$N_{u,Rd}$ =	263.47	[kN]	Design plastic resistance of the net section		$N_{u,Rd} = (\beta_2*A_{net}*f_{u1})/\gamma_{M2}$
$N_{pl,Rd}$ =	288.91	[kN]	Design plastic resistance of the gross section		$N_{pl,Rd} = (0.9*A*f_{y1})/\gamma_{M2}$
$\|N_{b1,Ed}\| \le N_{u,Rd}$			|7.57| < 263.47	verified	(0.03)
$\|N_{b1,Ed}\| \le N_{pl,Rd}$			|7.57| < 288.91	verified	(0.03)

BAR VERIFICATION - BLOCK TEARING

A_{nt} =	3.11	[cm²]	Net area of the section in tension		
A_{nv} =	8.64	[cm²]	Area of the section in shear		
V_{effRd} =	162.77	[kN]	Design capacity of a section weakened by openings		$V_{effRd}=0.5*f_u*A_{nt}/\gamma_{M2} + (1/\sqrt{3})*f_y*A_{nv}/\gamma_{M0}$
$\|N_{b1,Ed}\| \le V_{effRd}$			|7.57| < 162.77	verified	(0.05)

BAR 2

BOLT CAPACITIES

$F_{v,Rd}$ =	30.16	[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 bar

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} =	1.00		Coefficient determined by bolt spacing	$\alpha_{bx}=\min[e_1/(3*d_0), p_1/(3*d_0)-0.25, f_{ub}/f_u, 1]$
$\alpha_{bx} > 0.0$		1.00 > 0.00	verified	
$F_{b,Rd1x}$ =	51.10	[kN]	Design capacity in the limit state of plastification of the opening wall	$F_{b,Rd1x}=k_{1x}*\alpha_{bx}*f_u*d*t_i/\gamma_{M2}$

Direction z

k_{1z} =	2.50		Coefficient for calculation of $F_{b,Rd}$	$k_{1z}=\min[2.8*(e_1/d_0)-1.7, 1.4*(p_1/d_0)-1.7, 2.5]$
$k_{1z} > 0.0$		2.50 > 0.00	verified	
α_{bz} =	1.00		Coefficient for calculation of $F_{b,Rd}$	$\alpha_{bz}=\min[e_2/(3*d_0), f_{ub}/f_u, 1]$
$\alpha_{bz} > 0.0$		1.00 > 0.00	verified	
$F_{b,Rd1z}$ =	51.10	[kN]	Bearing resistance of a single bolt	$F_{b,Rd1z}=k_{1z}*\alpha_{bz}*f_u*d*t_i/\gamma_{M2}$

Bolt bearing on the plate

Direction x

k_{1x} =	2.50		Coefficient for calculation of $F_{b,Rd}$	$k_1=\min[2.8*(e_2/d_0)-1.7, 2.5]$
$k_{1x} > 0.0$		2.50 > 0.00	verified	
α_{bx} =	1.00		Coefficient determined by bolt spacing	$\alpha_{bx}=\min[e_1/(3*d_0), p_1/(3*d_0)-0.25, f_{ub}/f_u, 1]$
$\alpha_{bx} > 0.0$		1.00 > 0.00	verified	
$F_{b,Rd2x}$ =	73.00	[kN]	Design capacity in the limit state of plastification of the opening wall	$F_{b,Rd2x}=k_1*\alpha_b*f_u*d*t_i/\gamma_{M2}$

Direction z

k_{1z} =	2.50		Coefficient for calculation of $F_{b,Rd}$	$k_{1z}=\min[2.8*(e_1/d_0)-1.7, 1.4*(p_1/d_0)-1.7, 2.5]$
$k_{1z} > 0.0$		2.50 > 0.00	verified	
α_{bz} =	1.00		Coefficient for calculation of $F_{b,Rd}$	$\alpha_{bz}=\min[e_2/(3*d_0), f_{ub}/f_u, 1]$
$\alpha_{bz} > 0.0$		1.00 > 0.00	verified	
$F_{b,Rd2z}$ =	73.00	[kN]	Bearing resistance of a single bolt	$F_{b,Rd2z}=k_{1z}*\alpha_{bz}*f_u*d*t_i/\gamma_{M2}$

VERIFICATION OF A CONNECTION DUE TO FORCES ACTING ON BOLTS

Bolt shear

e =	23	[mm]	Axial force eccentricity relative to the bolt axis	
M_0 =	-0.25	[kN*m]	Real bending moment	$M_0=N_{b2,Ed}*e$
F_{NSd} =	-5.45	[kN]	Component force in a bolt due to influence of the longitudinal force	$F_{NSd} = N_{b2,Ed}/n$
F_{MSd} =	-2.52	[kN]	Component force in a bolt due to influence of the moment	$F_{MSd}=M_0*x_{max}/\Sigma x_i^2$
$F_{x,Ed}$ =	-5.45	[kN]	Design total force in a bolt on the direction x	$F_{x,Ed} = F_{NSd}$
$F_{z,Ed}$ =	-2.52	[kN]	Design total force in a bolt on the direction z	$F_{z,Ed} = F_{MSd}$
F_{Ed} =	6.00	[kN]	Resultant shear force in a bolt	$F_{Ed} = \sqrt{(F_{x,Ed}^2 + F_{z,Ed}^2)}$
F_{Rdx} =	51.10	[kN]	Effective design capacity of a bolt on the direction x	$F_{Rdx}=\min(F_{bRd1x}, F_{bRd2x})$
F_{Rdz} =	51.10	[kN]	Effective design capacity of a bolt on the direction z	$F_{Rdz}=\min(F_{bRd1z}, F_{bRd2z})$

$\lvert F_{x,Ed}\rvert \le F_{Rdx}$	|-5.45| < 51.10	verified	(0.11)
$\lvert F_{z,Ed}\rvert \le F_{Rdz}$	|-2.52| < 51.10	verified	(0.05)
$F_{Ed} \le F_{vRd}$	6.00 < 30.16	verified	(0.20)

VERIFICATION OF A SECTION WEAKENED BY OPENINGS

β_2 =	0.70		Reduction coefficient	[Table 3.8]
A_{net} =	12.89	[cm^2]	Net cross-sectional area	$A_{net} = A - d_0*t_{f2}$

β_2 =	0.70		Reduction coefficient	[Table 3.8]
$N_{u,Rd}$ =	263.47	[kN]	Design plastic resistance of the net section	$N_{u,Rd} = (\beta_2 * A_{net} * f_{u2})/\gamma_{M2}$
$N_{pl,Rd}$ =	288.91	[kN]	Design plastic resistance of the gross section	$N_{pl,Rd} = (0.9*A*f_{y2})/\gamma_{M2}$
$\lvert N_{b2,Ed}\rvert \le N_{u,Rd}$			$\lvert -10.90\rvert < 263.47$ verified	(0.04)
$\lvert N_{b2,Ed}\rvert \le N_{pl,Rd}$			$\lvert -10.90\rvert < 288.91$ verified	(0.04)

BAR VERIFICATION - BLOCK TEARING

A_{nt} =	3.11	[cm^2]	Net area of the section in tension	
A_{nv} =	8.64	[cm^2]	Area of the section in shear	
V_{effRd} =	162.77	[kN]	Design capacity of a section weakened by openings	$V_{effRd}=0.5*f_u*A_{nt}/\gamma_{M2} + (1/\sqrt{3})*f_y*A_{nv}/\gamma_{M0}$
$\lvert N_{b2,Ed}\rvert \le V_{effRd}$			$\lvert -10.90\rvert < 162.77$ verified	(0.07)

BAR 3

BOLT CAPACITIES

$F_{v,Rd}$ =	30.16	[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 bar

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} =	1.00		Coefficient determined by bolt spacing	$\alpha_{bx}=\min[e_1/(3*d_0), p_1/(3*d_0)-0.25, f_{ub}/f_u, 1]$
$\alpha_{bx} > 0.0$			$1.00 > 0.00$ verified	
$F_{b,Rd1x}$ =	51.10	[kN]	Design capacity in the limit state of plastification of the opening wall	$F_{b,Rd1x}=k_{1x}*\alpha_{bx}*f_u*d*t_i/\gamma_{M2}$

Direction z

k_{1z} =	2.50		Coefficient for calculation of $F_{b,Rd}$	$k_{1z}=\min[2.8*(e_1/d_0)-1.7, 1.4*(p_1/d_0)-1.7, 2.5]$
$k_{1z} > 0.0$			$2.50 > 0.00$ verified	
α_{bz} =	1.00		Coefficient for calculation of $F_{b,Rd}$	$\alpha_{bz}=\min[e_2/(3*d_0), f_{ub}/f_u, 1]$
$\alpha_{bz} > 0.0$			$1.00 > 0.00$ verified	
$F_{b,Rd1z}$ =	51.10	[kN]	Bearing resistance of a single bolt	$F_{b,Rd1z}=k_{1z}*\alpha_{bz}*f_u*d*t_i/\gamma_{M2}$

Bolt bearing on the plate

Direction x

k_{1x} =	2.50		Coefficient for calculation of $F_{b,Rd}$	$k_1=\min[2.8*(e_2/d_0)-1.7, 2.5]$
$k_{1x} > 0.0$			$2.50 > 0.00$ verified	
α_{bx} =	1.00		Coefficient determined by bolt spacing	$\alpha_{bx}=\min[e_1/(3*d_0), p_1/(3*d_0)-0.25, f_{ub}/f_u, 1]$
$\alpha_{bx} > 0.0$			$1.00 > 0.00$ verified	
$F_{b,Rd2x}$ =	73.00	[kN]	Design capacity in the limit state of plastification of the opening wall	$F_{b,Rd2x}=k_1*\alpha_b*f_u*d*t_i/\gamma_{M2}$

Direction z

k_{1z} =	2.50		Coefficient for calculation of $F_{b,Rd}$	$k_{1z}=\min[2.8*(e_1/d_0)-1.7, 1.4*(p_1/d_0)-1.7, 2.5]$
$k_{1z} > 0.0$			$2.50 > 0.00$ verified	
α_{bz} =	1.00		Coefficient for calculation of $F_{b,Rd}$	$\alpha_{bz}=\min[e_2/(3*d_0), f_{ub}/f_u, 1]$
$\alpha_{bz} > 0.0$			$1.00 > 0.00$ verified	
$F_{b,Rd2z}$ =	73.00	[kN]	Bearing resistance of a single bolt	$F_{b,Rd2z}=k_{1z}*\alpha_{bz}*f_u*d*t_i/\gamma_{M2}$

VERIFICATION OF A CONNECTION DUE TO FORCES ACTING ON BOLTS

Bolt shear

e =	23	[mm]	Axial force eccentricity relative to the bolt axis	
M_0 =	0.17	[kN*m]	Real bending moment	$M_0=N_{b3,Ed}*e$
F_{NSd} =	3.66	[kN]	Component force in a bolt due to influence of the longitudinal force	$F_{NSd} = N_{b3,Ed}/n$
F_{MSd} =	1.69	[kN]	Component force in a bolt due to influence of the moment	$F_{MSd}=M_0*x_{max}/\Sigma x_i^2$
$F_{x,Ed}$ =	3.66	[kN]	Design total force in a bolt on the direction x	$F_{x,Ed} = F_{NSd}$

$e =$	23	[mm]	Axial force eccentricity relative to the bolt axis	
$F_{z,Ed} =$	1.69	[kN]	Design total force in a bolt on the direction z	$F_{z,Ed} = F_{MSd}$
$F_{Ed} =$	4.04	[kN]	Resultant shear force in a bolt	$F_{Ed} = \sqrt{(F_{x,Ed}^2 + F_{z,Ed}^2)}$
$F_{Rdx} =$	51.10	[kN]	Effective design capacity of a bolt on the direction x	$F_{Rdx}=\min(F_{bRd1x}, F_{bRd2x})$
$F_{Rdz} =$	51.10	[kN]	Effective design capacity of a bolt on the direction z	$F_{Rdz}=\min(F_{bRd1z}, F_{bRd2z})$

$\lvert F_{x,Ed}\rvert \le F_{Rdx}$	|3.66| < 51.10	verified	(0.07)
$\lvert F_{z,Ed}\rvert \le F_{Rdz}$	|1.69| < 51.10	verified	(0.03)
$F_{Ed} \le F_{vRd}$	4.04 < 30.16	verified	(0.13)

VERIFICATION OF A SECTION WEAKENED BY OPENINGS

$\beta_2 =$	0.70		Reduction coefficient	[Table 3.8]
$A_{net} =$	12.89	[cm^2]	Net cross-sectional area	$A_{net} = A - d_0*t_{f3}$
$N_{u,Rd} =$	263.47	[kN]	Design plastic resistance of the net section	$N_{u,Rd} = (\beta_2*A_{net}*f_{u3})/\gamma_{M2}$
$N_{pl,Rd} =$	288.91	[kN]	Design plastic resistance of the gross section	$N_{pl,Rd} = (0.9*A*f_{y3})/\gamma_{M2}$

$\lvert N_{b3,Ed}\rvert \le N_{u,Rd}$	|7.33| < 263.47	verified	(0.03)
$\lvert N_{b3,Ed}\rvert \le N_{pl,Rd}$	|7.33| < 288.91	verified	(0.03)

BAR VERIFICATION - BLOCK TEARING

$A_{nt} =$	3.11	[cm^2]	Net area of the section in tension	
$A_{nv} =$	8.64	[cm^2]	Area of the section in shear	
$V_{effRd} =$	162.77	[kN]	Design capacity of a section weakened by openings	$V_{effRd}=0.5*f_u*A_{nt}/\gamma_{M2} + (1/\sqrt{3})*f_y*A_{nv}/\gamma_{M0}$

$\lvert N_{b3,Ed}\rvert \le V_{effRd}$	|7.33| < 162.77	verified	(0.05)

BAR 4

BOLT CAPACITIES

$F_{v,Rd} =$	30.16	[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 bar

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
$\alpha_{bx} =$	1.00		Coefficient determined by bolt spacing	$\alpha_{bx}=\min[e_1/(3*d_0), p_1/(3*d_0)-0.25, f_{ub}/f_u, 1]$
$\alpha_{bx} > 0.0$			1.00 > 0.00	verified
$F_{b,Rd1x} =$	51.10	[kN]	Design capacity in the limit state of plastification of the opening wall	$F_{b,Rd1x}=k_{1x}*\alpha_{bx}*f_u*d*t_i/\gamma_{M2}$

Direction z

$k_{1z} =$	2.50		Coefficient for calculation of $F_{b,Rd}$	$k_{1z}=\min[2.8*(e_1/d_0)-1.7, 1.4*(p_1/d_0)-1.7, 2.5]$
$k_{1z} > 0.0$			2.50 > 0.00	verified
$\alpha_{bz} =$	1.00		Coefficient for calculation of $F_{b,Rd}$	$\alpha_{bz}=\min[e_2/(3*d_0), f_{ub}/f_u, 1]$
$\alpha_{bz} > 0.0$			1.00 > 0.00	verified
$F_{b,Rd1z} =$	51.10	[kN]	Bearing resistance of a single bolt	$F_{b,Rd1z}=k_{1z}*\alpha_{bz}*f_u*d*t_i/\gamma_{M2}$

Bolt bearing on the plate

Direction x

$k_{1x} =$	2.50		Coefficient for calculation of $F_{b,Rd}$	$k_1=\min[2.8*(e_2/d_0)-1.7, 2.5]$
$k_{1x} > 0.0$			2.50 > 0.00	verified
$\alpha_{bx} =$	1.00		Coefficient determined by bolt spacing	$\alpha_{bx}=\min[e_1/(3*d_0), p_1/(3*d_0)-0.25, f_{ub}/f_u, 1]$
$\alpha_{bx} > 0.0$			1.00 > 0.00	verified
$F_{b,Rd2x} =$	73.00	[kN]	Design capacity in the limit state of plastification of the opening wall	$F_{b,Rd2x}=k_1*\alpha_b*f_u*d*t_i/\gamma_{M2}$

Direction z

$k_{1z} =$	2.50		Coefficient for calculation of $F_{b,Rd}$	$k_{1z}=\min[2.8*(e_1/d_0)-1.7, 1.4*(p_1/d_0)-1.7, 2.5]$
$k_{1z} > 0.0$			2.50 > 0.00	verified

α_{bz} =	1.00		Coefficient for calculation of $F_{b,Rd}$	α_{bz}=min[e_2/(3*d_0), f_{ub}/f_u, 1]
α_{bz} > 0.0			1.00 > 0.00 verified	
$F_{b,Rd2z}$ =	73.00	[kN]	Bearing resistance of a single bolt	$F_{b,Rd2z}$=k_{1z}*α_{bz}*f_u*d*t_i/γ_{M2}

VERIFICATION OF A CONNECTION DUE TO FORCES ACTING ON BOLTS

Bolt shear

e =	23	[mm]	Axial force eccentricity relative to the bolt axis	
M_0 =	-0.26	[kN*m]	Real bending moment	M_0=$N_{b4,Ed}$*e
F_{NSd} =	-5.60	[kN]	Component force in a bolt due to influence of the longitudinal force	F_{NSd} = $N_{b4,Ed}$/n
F_{MSd} =	-2.59	[kN]	Component force in a bolt due to influence of the moment	F_{MSd}=M_0*x_{max}/Σx_i^2
$F_{x,Ed}$ =	-5.60	[kN]	Design total force in a bolt on the direction x	$F_{x,Ed}$ = F_{NSd}
$F_{z,Ed}$ =	-2.59	[kN]	Design total force in a bolt on the direction z	$F_{z,Ed}$ = F_{MSd}
F_{Ed} =	6.17	[kN]	Resultant shear force in a bolt	F_{Ed} = $\sqrt{(F_{x,Ed}^2 + F_{z,Ed}^2)}$
F_{Rdx} =	51.10	[kN]	Effective design capacity of a bolt on the direction x	F_{Rdx}=min(F_{bRd1x}, F_{bRd2x})
F_{Rdz} =	51.10	[kN]	Effective design capacity of a bolt on the direction z	F_{Rdz}=min(F_{bRd1z}, F_{bRd2z})

$\lvert F_{x,Ed}\rvert \le F_{Rdx}$	$\lvert -5.60\rvert$ < 51.10	verified	(0.11)
$\lvert F_{z,Ed}\rvert \le F_{Rdz}$	$\lvert -2.59\rvert$ < 51.10	verified	(0.05)
$F_{Ed} \le F_{vRd}$	6.17 < 30.16	verified	(0.20)

VERIFICATION OF A SECTION WEAKENED BY OPENINGS

β_2 =	0.70		Reduction coefficient	[Table 3.8]
A_{net} =	12.89	[cm^2]	Net cross-sectional area	A_{net} = A - d_0*t_{f4}
$N_{u,Rd}$ =	263.47	[kN]	Design plastic resistance of the net section	$N_{u,Rd}$ = (β_2*A_{net}*f_{u4})/γ_{M2}
$N_{pl,Rd}$ =	288.91	[kN]	Design plastic resistance of the gross section	$N_{pl,Rd}$ = (0.9*A*f_{y4})/γ_{M2}

$\lvert N_{b4,Ed}\rvert \le N_{u,Rd}$	$\lvert -11.20\rvert$ < 263.47	verified	(0.04)
$\lvert N_{b4,Ed}\rvert \le N_{pl,Rd}$	$\lvert -11.20\rvert$ < 288.91	verified	(0.04)

BAR VERIFICATION - BLOCK TEARING

A_{nt} =	3.11	[cm^2]	Net area of the section in tension	
A_{nv} =	8.64	[cm^2]	Area of the section in shear	
V_{effRd} =	162.77	[kN]	Design capacity of a section weakened by openings	V_{effRd}=0.5*f_u*A_{nt}/γ_{M2} + (1/$\sqrt{3}$)*f_y*A_{nv}/γ_{M0}

$\lvert N_{b4,Ed}\rvert \le V_{effRd}$	$\lvert -11.20\rvert$ < 162.77	verified	(0.07)

Connection conforms to the code	Ratio	0.20