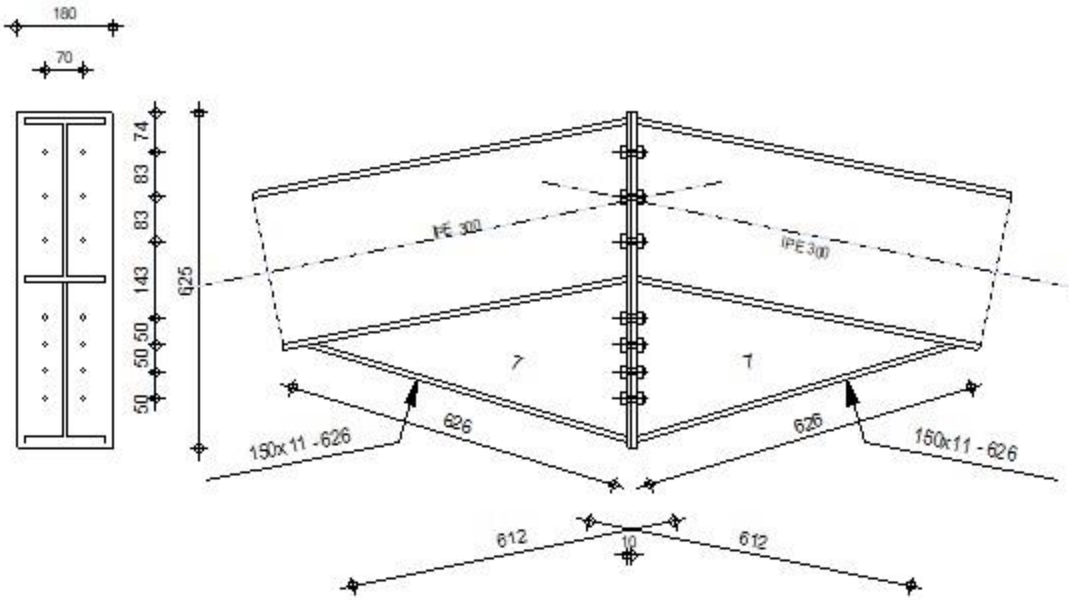
	Autodesk Robot Structural Analysis Professional 2020 **Design of fixed beam-to-beam connection** NF EN 1993-1-8:2005/NA:2007/AC:2009	OK Ratio **0.49**



GENERAL

Connection no.: 28
Connection name: Beam-Beam
Structure node: 41
Structure bars: 41, 42

GEOMETRY

LEFT SIDE

BEAM

Section: IPE 300
Bar no.: 41

α =	-168.7	[Deg]	Inclination angle
h_{bl} =	300	[mm]	Height of beam section
b_{fbl} =	150	[mm]	Width of beam section
t_{wbl} =	7	[mm]	Thickness of the web of beam section
t_{fbl} =	11	[mm]	Thickness of the flange of beam section
r_{bl} =	15	[mm]	Radius of beam section fillet
A_{bl} =	53.81	[cm^2]	Cross-sectional area of a beam
I_{xbl} =	8356.11	[cm^4]	Moment of inertia of the beam section

Material: ACIER

f_{yb} =	235.00	[MPa]	Resistance

RIGHT SIDE

BEAM

Section:	IPE 300		
Bar no.:	42		
α =	-11.3	[Deg]	Inclination angle
h_{br} =	300	[mm]	Height of beam section
b_{fbr} =	150	[mm]	Width of beam section
t_{wbr} =	7	[mm]	Thickness of the web of beam section
t_{fbr} =	11	[mm]	Thickness of the flange of beam section
r_{br} =	15	[mm]	Radius of beam section fillet
A_{br} =	53.81	[cm^2]	Cross-sectional area of a beam
I_{xbr} =	8356.11	[cm^4]	Moment of inertia of the beam section
Material:	ACIER		
f_{yb} =	235.00	[MPa]	Resistance

BOLTS

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

d =	12	[mm]	Bolt diameter
Class =	8.8		Bolt class
F_{tRd} =	48.38	[kN]	Tensile resistance of a bolt
n_h =	2		Number of bolt columns
n_v =	7		Number of bolt rows
h_1 =	74	[mm]	Distance between first bolt and upper edge of front plate

Horizontal spacing e_i = 70 [mm]

Vertical spacing p_i = 83;83;143;50;50;50 [mm]

PLATE

h_{pr} =	625	[mm]	Plate height
b_{pr} =	180	[mm]	Plate width
t_{pr} =	10	[mm]	Plate thickness
Material:	ACIER		
f_{ypr} =	235.00	[MPa]	Resistance

LOWER STIFFENER

w_{rd} =	150	[mm]	Plate width
t_{frd} =	11	[mm]	Flange thickness
h_{rd} =	300	[mm]	Plate height
t_{wrd} =	7	[mm]	Web thickness
l_{rd} =	612	[mm]	Plate length
α_d =	16.7	[Deg]	Inclination angle
Material:	ACIER		
f_{ybu} =	235.00	[MPa]	Resistance

FILLET WELDS

a_w =	5	[mm]	Web weld
a_f =	8	[mm]	Flange weld
a_{fd} =	5	[mm]	Horizontal weld

MATERIAL FACTORS

γ_{M0} =	1.00	Partial safety factor	[2.2]
γ_{M1} =	1.00	Partial safety factor	[2.2]
γ_{M2} =	1.25	Partial safety factor	[2.2]
γ_{M3} =	1.10	Partial safety factor	[2.2]

LOADS

Ultimate limit state

Case: 16: ULS /43/ 1*1.35 + 2*1.35 + 3*1.35 + 4*1.35 + 5*1.35 + 6*1.35 + 7*1.50 + 9*1.50 + 15*0.90

$M_{b1,Ed}$ =	-53.59	[kN*m]	Bending moment in the right beam
$V_{b1,Ed}$ =	-2.17	[kN]	Shear force in the right beam
$N_{b1,Ed}$ =	-21.22	[kN]	Axial force in the right beam

RESULTS

BEAM RESISTANCES

COMPRESSION

A_b = 53.81 [cm^2] Area EN1993-1-1:[6.2.4]

$N_{cb,Rd} = A_b f_{yb} / \gamma_{M0}$

$N_{cb,Rd}$ = 1264.54 [kN] Design compressive resistance of the section EN1993-1-1:[6.2.4]

SHEAR

A_{vb} = 46.98 [cm^2] Shear area EN1993-1-1:[6.2.6.(3)]

$V_{cb,Rd} = A_{vb} (f_{yb} / \sqrt{3}) / \gamma_{M0}$

$V_{cb,Rd}$ = 637.41 [kN] Design sectional resistance for shear EN1993-1-1:[6.2.6.(2)]

$V_{b1,Ed} / V_{cb,Rd} \leq 1,0$ 0.00 < 1.00 verified (0.00)

BENDING - PLASTIC MOMENT (WITHOUT BRACKETS)

W_{plb} = 628.36 [cm^3] Plastic section modulus EN1993-1-1:[6.2.5.(2)]

$M_{b,pl,Rd} = W_{plb} f_{yb} / \gamma_{M0}$

$M_{b,pl,Rd}$ = 147.66 [kN*m] Plastic resistance of the section for bending (without stiffeners) EN1993-1-1:[6.2.5.(2)]

BENDING ON THE CONTACT SURFACE WITH PLATE OR CONNECTED ELEMENT

W_{pl} = 1372.44 [cm^3] Plastic section modulus EN1993-1-1:[6.2.5]

$M_{cb,Rd} = W_{pl} f_{yb} / \gamma_{M0}$

$M_{cb,Rd}$ = 322.52 [kN*m] Design resistance of the section for bending EN1993-1-1:[6.2.5]

FLANGE AND WEB - COMPRESSION

$M_{cb,Rd}$ = 322.52 [kN*m] Design resistance of the section for bending EN1993-1-1:[6.2.5]

h_f = 595 [mm] Distance between the centroids of flanges [6.2.6.7.(1)]

$F_{c,fb,Rd} = M_{cb,Rd} / h_f$

$F_{c,fb,Rd}$ = 542.15 [kN] Resistance of the compressed flange and web [6.2.6.7.(1)]

WEB OR BRACKET FLANGE - COMPRESSION - LEVEL OF THE BEAM BOTTOM FLANGE

Bearing:

β =	11.3	[Deg]	Angle between the front plate and the beam	
γ =	16.7	[Deg]	Inclination angle of the bracket plate	
$b_{eff,c,wb}$ =	174	[mm]	Effective width of the web for compression	[6.2.6.2.(1)]
A_{vb} =	25.68	[cm^2]	Shear area	EN1993-1-1:[6.2.6.(3)]
ω =	0.88		Reduction factor for interaction with shear	[6.2.6.2.(1)]
$\sigma_{com,Ed}$ =	0.00	[MPa]	Maximum compressive stress in web	[6.2.6.2.(2)]
k_{wc} =	1.00		Reduction factor conditioned by compressive stresses	[6.2.6.2.(2)]

$F_{c,wb,Rd1} = [\omega\ k_{wc}\ b_{eff,c,wb}\ t_{wb}\ f_{yb} / \gamma_{M0}] \cos(\gamma) / \sin(\gamma - \beta)$

$F_{c,wb,Rd1} =$ 518.96 [kN] Beam web resistance [6.2.6.2.(1)]

Buckling:

$d_{wb} =$ 249 [mm] Height of compressed web [6.2.6.2.(1)]

$\lambda_p =$ 0.91 Plate slenderness of an element [6.2.6.2.(1)]

$\rho =$ 0.86 Reduction factor for element buckling [6.2.6.2.(1)]

$F_{c,wb,Rd2} = [\omega\ k_{wc}\ \rho\ b_{eff,c,wb}\ t_{wb}\ f_{yb} / \gamma_{M1}] \cos(\gamma) / \sin(\gamma - \beta)$

$F_{c,wb,Rd2} =$ 443.88 [kN] Beam web resistance [6.2.6.2.(1)]

Resistance of the bracket flange

$F_{c,wb,Rd3} = b_b\ t_b\ f_{yb} / (0.8*\gamma_{M0})$

$F_{c,wb,Rd3} =$ 471.47 [kN] Resistance of the bracket flange [6.2.6.7.(1)]

Final resistance:

$F_{c,wb,Rd,low} = \mathrm{Min}\ (F_{c,wb,Rd1}\ ,\ F_{c,wb,Rd2}\ ,\ F_{c,wb,Rd3})$

$F_{c,wb,Rd,low} =$ 443.88 [kN] Beam web resistance [6.2.6.2.(1)]

GEOMETRICAL PARAMETERS OF A CONNECTION

EFFECTIVE LENGTHS AND PARAMETERS - FRONT PLATE

Nr	m	m_x	e	e_x	p	$l_{eff,cp}$	$l_{eff,nc}$	$l_{eff,1}$	$l_{eff,2}$	$l_{eff,cp,g}$	$l_{eff,nc,g}$	$l_{eff,1,g}$	$l_{eff,2,g}$
1	26	-	55	-	50	162	172	162	172	131	111	111	111
2	26	-	55	-	50	162	172	162	172	100	50	50	50
3	26	-	55	-	50	162	172	162	172	100	50	50	50
4	26	-	55	-	97	162	172	162	172	193	97	97	97
5	26	-	55	-	113	162	172	162	172	226	113	113	113
6	26	-	55	-	83	162	172	162	172	166	83	83	83
7	26	-	55	-	83	162	172	162	172	164	127	127	127

m – Bolt distance from the web

m_x – Bolt distance from the beam flange

e – Bolt distance from the outer edge

e_x – Bolt distance from the horizontal outer edge

p – Distance between bolts

$l_{eff,cp}$ – Effective length for a single bolt in the circular failure mode

$l_{eff,nc}$ – Effective length for a single bolt in the non-circular failure mode

$l_{eff,1}$ – Effective length for a single bolt for mode 1

$l_{eff,2}$ – Effective length for a single bolt for mode 2

$l_{eff,cp,g}$ – Effective length for a group of bolts in the circular failure mode

$l_{eff,nc,g}$ – Effective length for a group of bolts in the non-circular failure mode

$l_{eff,1,g}$ – Effective length for a group of bolts for mode 1

$l_{eff,2,g}$ – Effective length for a group of bolts for mode 2

CONNECTION RESISTANCE FOR COMPRESSION

$N_{j,Rd} = \mathrm{Min}\ (\ N_{cb,Rd}2\ F_{c,wb,Rd,low}\ )$

$N_{j,Rd} =$ 887.76 [kN] Connection resistance for compression [6.2]

$N_{b1,Ed} / N_{j,Rd} \le 1{,}0$ 0.02 < 1.00 verified (0.02)

CONNECTION RESISTANCE FOR BENDING

CONNECTION RESISTANCE FOR BENDING $M_{j,Rd}$

$M_{j,Rd} = \sum h_j\ F_{tj,Rd}$

$M_{j,Rd} =$ 109.48 [kN*m] Connection resistance for bending [6.2]

$M_{b1,Ed} / M_{j,Rd} \le 1{,}0$ 0.49 < 1.00 verified (0.49)

CONNECTION RESISTANCE FOR SHEAR

α_v =	0.60		Coefficient for calculation of $F_{v,Rd}$	[Table 3.4]
β_{Lf} =	0.88		Reduction factor for long connections	[3.8]
$F_{v,Rd}$ =	38.38	[kN]	Shear resistance of a single bolt	[Table 3.4]
$F_{t,Rd,max}$ =	48.38	[kN]	Tensile resistance of a single bolt	[Table 3.4]
$F_{b,Rd,int}$ =	87.60	[kN]	Bearing resistance of an intermediate bolt	[Table 3.4]
$F_{b,Rd,ext}$ =	87.60	[kN]	Bearing resistance of an outermost bolt	[Table 3.4]

Nr	$F_{tj,Rd,N}$	$F_{tj,Ed,N}$	$F_{tj,Rd,M}$	$F_{tj,Ed,M}$	$F_{tj,Ed}$	$F_{vj,Rd}$
1	96.77	-3.03	88.55	43.34	40.31	53.92
2	96.77	-3.03	51.54	25.23	22.20	64.18
3	96.77	-3.03	39.57	19.37	16.34	67.50
4	96.77	-3.03	40.52	19.83	16.80	67.24
5	96.77	-3.03	24.75	12.12	9.08	71.61
6	96.77	-3.03	15.60	7.64	4.61	74.15
7	96.77	-3.03	6.45	3.16	0.13	76.69

$F_{tj,Rd,N}$ – Bolt row resistance for simple tension
$F_{tj,Ed,N}$ – Force due to axial force in a bolt row
$F_{tj,Rd,M}$ – Bolt row resistance for simple bending
$F_{tj,Ed,M}$ – Force due to moment in a bolt row
$F_{tj,Ed}$ – Maximum tensile force in a bolt row
$F_{vj,Rd}$ – Reduced bolt row resistance

$F_{tj,Ed,N} = N_{j,Ed}\, F_{tj,Rd,N} / N_{j,Rd}$
$F_{tj,Ed,M} = M_{j,Ed}\, F_{tj,Rd,M} / M_{j,Rd}$
$F_{tj,Ed} = F_{tj,Ed,N} + F_{tj,Ed,M}$
$F_{vj,Rd} = \mathrm{Min}\,(n_h\, F_{v,Ed}\, (1 - F_{tj,Ed}/ (1.4\, n_h\, F_{t,Rd,max}),\, n_h\, F_{v,Rd}\, ,\, n_h\, F_{b,Rd}))$

$V_{j,Rd} = n_h \sum_1^n F_{vj,Rd}$				[Table 3.4]
$V_{j,Rd}$ =	475.31	[kN]	Connection resistance for shear	[Table 3.4]
$V_{b1,Ed} / V_{j,Rd} \leq 1,0$	0.00 < 1.00		verified	(0.00)

WELD RESISTANCE

A_w =	117.56	[cm^2]	Area of all welds	[4.5.3.2(2)]
A_{wy} =	63.33	[cm^2]	Area of horizontal welds	[4.5.3.2(2)]
A_{wz} =	54.24	[cm^2]	Area of vertical welds	[4.5.3.2(2)]
I_{wy} =	54216.21	[cm^4]	Moment of inertia of the weld arrangement with respect to the hor. axis	[4.5.3.2(5)]
$\sigma_{\perp max}=\tau_{\perp max}$ =	-21.88	[MPa]	Normal stress in a weld	[4.5.3.2(6)]
$\sigma_{\perp}=\tau_{\perp}$ =	-19.90	[MPa]	Stress in a vertical weld	[4.5.3.2(5)]
τ_{II} =	-0.40	[MPa]	Tangent stress	[4.5.3.2(5)]
β_w =	0.80		Correlation coefficient	[4.5.3.2(7)]

$\sqrt{[\sigma_{\perp max}^2 + 3*(\tau_{\perp max}^2)]} \leq f_u/(\beta_w*\gamma_{M2})$	43.77 < 365.00	verified	(0.12)
$\sqrt{[\sigma_{\perp}^2 + 3*(\tau_{\perp}^2+\tau_{II}^2)]} \leq f_u/(\beta_w*\gamma_{M2})$	39.81 < 365.00	verified	(0.11)
$\sigma_{\perp} \leq 0.9*f_u/\gamma_{M2}$	21.88 < 262.80	verified	(0.08)

Connection conforms to the code	Ratio	0.49