

Project: Amsterdam industrial

Project no: 20239010

Author: Dave the Engineer



Project data

Project name Amsterdam industrial
Project number 20239010
Author Dave the Engineer
Description Bracing
Date 10.03.2023
Code EN

Material

Steel S 235

Project item CON1

Design

Name CON1
Description
Analysis Stress, strain/ loads in equilibrium

Members

Geometry

Name	Cross-section	β – Direction [°]	γ - Pitch [°]	α - Rotation [°]	Offset ex [mm]	Offset ey [mm]	Offset ez [mm]
K1	5 - K120/120/8	180,0	0,0	0,0	0	0	0
K2	5 - K120/120/8	0,0	90,0	180,0	0	0	0
D1	6 - AC120/80/6	180,0	30,0	90,0	0	-20	0
D2	6 - AC120/80/6	0,0	30,0	90,0	0	-20	0
D3	6 - AC120/80/6	180,0	-55,0	90,0	0	0	0
D4	6 - AC120/80/6	0,0	-55,0	90,0	0	0	0

Supports and forces

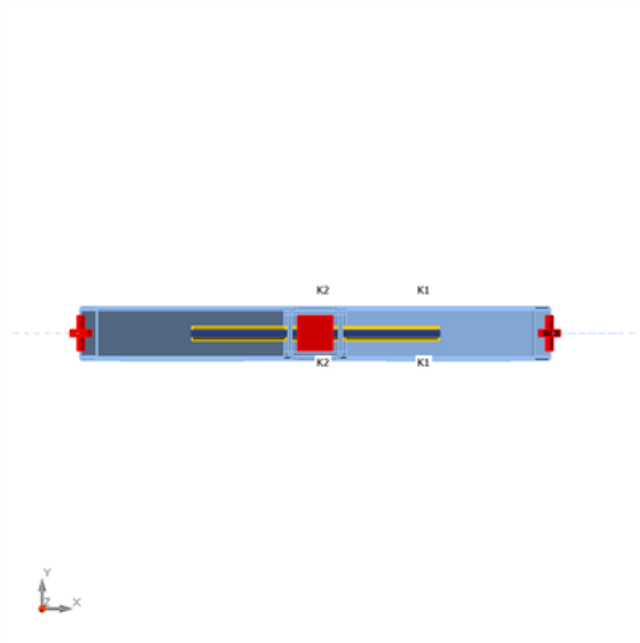
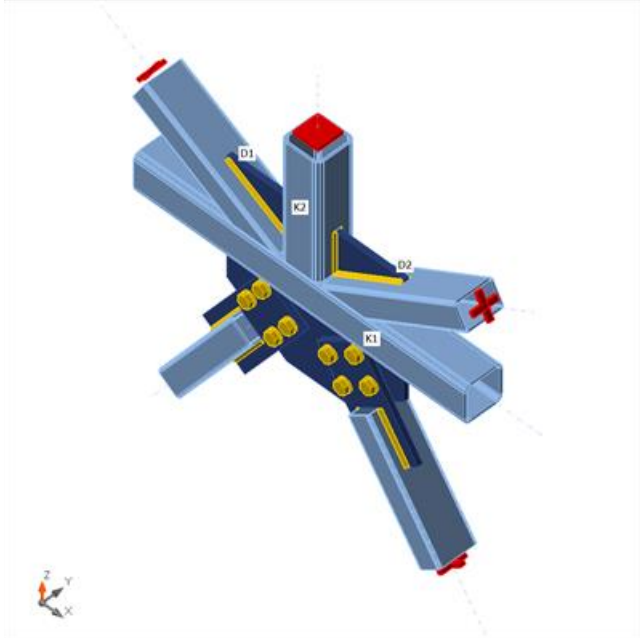
Name	Support	Forces in	X [mm]
K1 / begin		Position	0
K1 / end		Position	0
K2 / end	N-Vy-Vz-Mx-My-Mz	Position	0
D1 / end	Mx-My-Mz	Position	0

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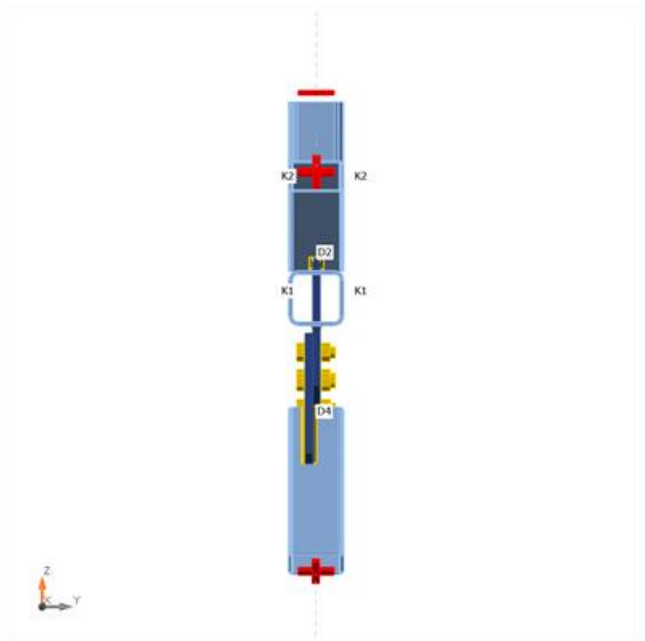
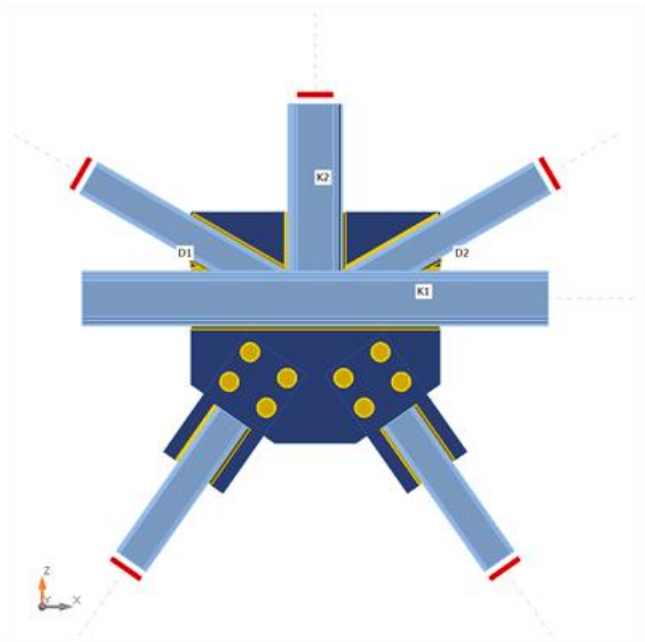
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D2 / end	Mx-My-Mz	Position	0
D3 / end	Mx-My-Mz	Position	0
D4 / end	Mx-My-Mz	Position	0



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Cross-sections

Name	Material
5 - K120/120/8	S 235
6 - AC120/80/6	S 235

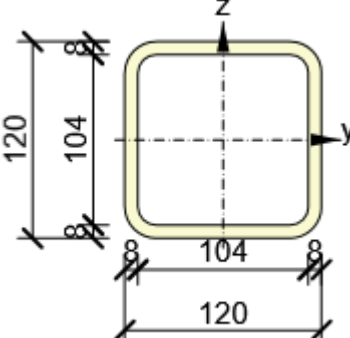
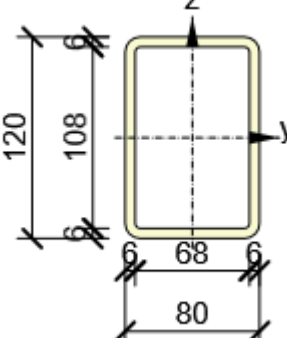
Cross-sections

Name	Material	Drawing
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5 - K120/120/8	S 235	
6 - AC120/80/6	S 235	

Bolts

Name	Bolt assembly	Diameter [mm]	f_u [MPa]	Gross area [mm ²]
M24 8.8	M24 8.8	24	800,0	452

Load effects (forces in equilibrium)

Name	Member	N [kN]	V _y [kN]	V _z [kN]	M _x [kNm]	M _y [kNm]	M _z [kNm]
LE1	K1 / End	-250,0	0,0	0,0	0,0	0,0	0,0
	K2 / End	134,6	0,0	0,0	0,0	0,0	0,0
	D1 / End	300,0	0,0	0,0	0,0	0,0	0,0
	D2 / End	250,0	0,0	0,0	0,0	0,0	0,0
	D3 / End	250,0	0,0	0,0	0,0	0,0	0,0
	D4 / End	250,0	0,0	0,0	0,0	0,0	0,0
	K1 / Begin	206,7	0,0	0,0	0,0	0,0	0,0

Unbalanced forces

Name	X [kN]	Y [kN]	Z [kN]	M _x [kNm]	M _y [kNm]	M _z [kNm]
LE1	0,0	0,0	0,0	0,2	1,0	0,0

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Check

Summary

Name	Value	Check status
Analysis	100,0%	OK
Plates	$1,3 < 5,0\%$	OK
Bolts	$97,2 < 100\%$	OK
Welds	$99,0 < 100\%$	OK
Buckling	Not calculated	
GMNA	Calculated	

Plates

Name	t_p [mm]	Loads	σ_{Ed} [MPa]	ϵ_{Pl} [%]	$\sigma_{c,Ed}$ [MPa]	Status
K1	8,0	LE1	200,7	0,0	0,0	OK
K2	8,0	LE1	134,4	0,0	0,0	OK
D1	6,0	LE1	237,8	1,3	0,0	OK
D2	6,0	LE1	236,1	0,5	0,0	OK
D3	6,0	LE1	236,0	0,5	0,0	OK
D4	6,0	LE1	236,0	0,5	0,0	OK
Algemene plaat1	15,0	LE1	235,2	0,1	21,9	OK
Gesneden plaat1	16,0	LE1	236,9	0,9	23,8	OK
Gesneden plaat2	16,0	LE1	236,9	0,9	24,2	OK

Design data

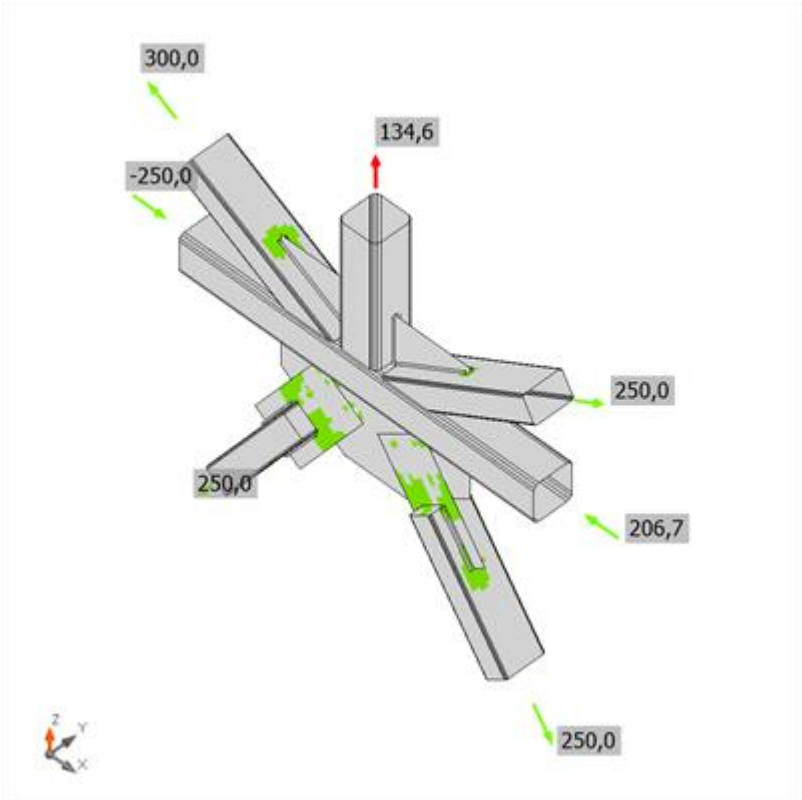
Material	f_y [MPa]	ϵ_{lim} [%]
S 235	235,0	5,0

Symbol explanation

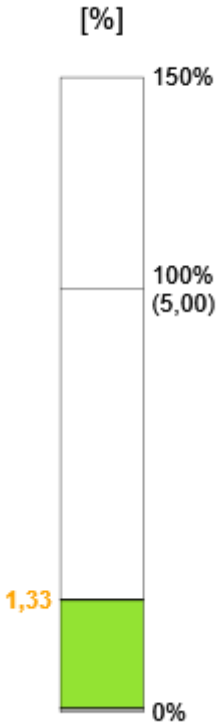
t_p	Plate thickness
σ_{Ed}	Equivalent stress
ϵ_{Pl}	Plastic strain
$\sigma_{c,Ed}$	Contact stress
f_y	Yield strength
ϵ_{lim}	Limit of plastic strain



Overall check, LE1



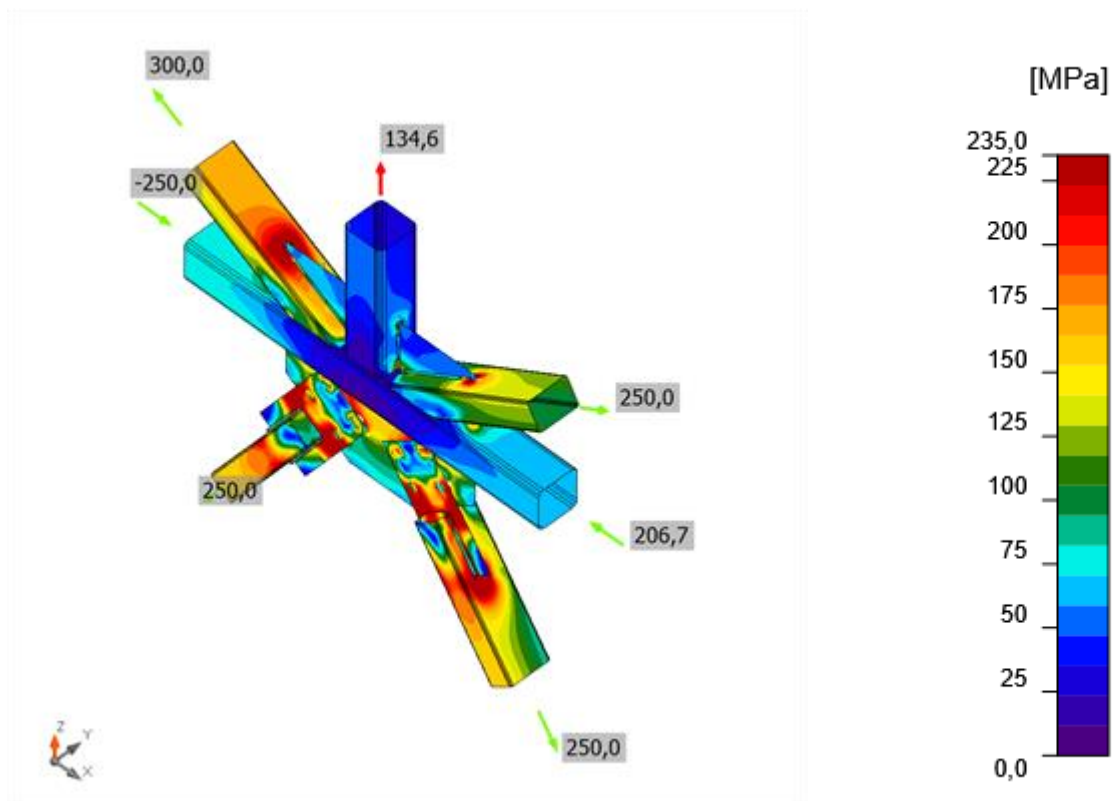
Strain check, LE1



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Equivalent stress, LE1

Bolts

Shape	Item	Grade	Loads	$F_{t,Ed}$ [kN]	$F_{v,Ed}$ [kN]	$F_{b,Rd}$ [kN]	U_{t_t} [%]	U_{t_s} [%]	$U_{t_{ts}}$ [%]	Status
	B1	M24 8.8 - 1	LE1	17,7	61,5	65,1	8,7	94,4	51,6	OK
	B2	M24 8.8 - 1	LE1	23,6	63,2	65,1	11,6	97,1	54,9	OK
	B3	M24 8.8 - 1	LE1	20,0	63,2	131,3	9,8	48,1	53,6	OK
	B4	M24 8.8 - 1	LE1	9,3	62,1	131,3	4,6	47,3	49,1	OK
	B5	M24 8.8 - 1	LE1	23,7	63,3	65,1	11,6	97,2	55,0	OK
	B6	M24 8.8 - 1	LE1	17,6	61,4	65,1	8,7	94,3	51,5	OK
	B7	M24 8.8 - 1	LE1	9,2	62,2	131,3	4,5	47,4	49,2	OK
	B8	M24 8.8 - 1	LE1	19,9	63,1	131,3	9,8	48,0	53,5	OK

Design data

Grade	$F_{t,Rd}$ [kN]	$B_{p,Rd}$ [kN]	$F_{v,Rd}$ [kN]
M24 8.8 - 1	203,3	309,4	135,6

Symbol explanation

- $F_{t,Ed}$ Tension force
- $F_{v,Ed}$ Resultant of bolt shear forces V_y and V_z in shear planes
- $F_{b,Rd}$ Plate bearing resistance EN 1993-1-8 – Tab. 3.4

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U_t Utilization in tension
 U_s Utilization in shear
 U_{ts} Interaction of tension and shear EN 1993-1-8 – Tab. 3.4
 $F_{t,Rd}$ Bolt tension resistance EN 1993-1-8 – Tab. 3.4
 $B_{p,Rd}$ Punching shear resistance EN 1993-1-8 – Tab. 3.4
 $F_{v,Rd}$ Bolt shear resistance EN 1993-1-8 – Tab. 3.4

Detailed result for B1

Tension resistance check (EN 1993-1-8 – Tab. 3.4)

$$F_{t,Rd} = \frac{k_2 f_{ub} A_s}{\gamma_{M2}} = 203,3 \text{ kN} \geq F_{t,Ed} = 17,7 \text{ kN}$$

Where:

$k_2 = 0,90$ – Factor
 $f_{ub} = 800,0 \text{ MPa}$ – Ultimate tensile strength of the bolt
 $A_s = 353 \text{ mm}^2$ – Tensile stress area of the bolt
 $\gamma_{M2} = 1,25$ – Safety factor

Punching resistance check (EN 1993-1-8 – Tab. 3.4)

$$B_{p,Rd} = \frac{0,6 \pi d_m t_p f_u}{\gamma_{M2}} = 309,4 \text{ kN} \geq F_{t,Ed} = 17,7 \text{ kN}$$

Where:

$d_m = 38 \text{ mm}$ – The mean of the across points and across flats dimensions of the bolt head or the nut, whichever is smaller
 $t_p = 15 \text{ mm}$ – Plate thickness
 $f_u = 360,0 \text{ MPa}$ – Ultimate strength
 $\gamma_{M2} = 1,25$ – Safety factor

Shear resistance check (EN 1993-1-8 – Tab. 3.4)

$$F_{v,Rd} = \frac{\beta_p \alpha_v f_{ub} A}{\gamma_{M2}} = 135,6 \text{ kN} \geq F_{v,Ed} = 61,5 \text{ kN}$$

Where:

$\beta_p = 1,00$ – Reduction factor for packing
 $\alpha_v = 0,60$ – Reduction factor for shear stress
 $f_{ub} = 800,0 \text{ MPa}$ – Ultimate tensile strength of the bolt
 $A = 353 \text{ mm}^2$ – Gross cross-section area of the bolt
 $\gamma_{M2} = 1,25$ – Safety factor

Bearing resistance check (EN 1993-1-8 – Tab. 3.4)

$$F_{b,Rd} = \frac{k_1 \alpha_b f_u d_t}{\gamma_{M2}} = 65,1 \text{ kN} \geq F_{b,Ed} = 61,5 \text{ kN}$$

Where:

$k_1 = \min(2,8 \frac{e_2}{d_0} - 1,7, 1,4 \frac{p_2}{d_0} - 1,7, 2,5) = 1,53$ – Factor for edge distance and bolt spacing perpendicular to the direction of load transfer
 $\alpha_b = \min(\frac{e_1}{3d_0}, \frac{p_1}{3d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1) = 0,38$ – Factor for end distance and bolt spacing in direction of load transfer

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$$e_2 = 30 \text{ mm}$$

$$p_2 = 100 \text{ mm}$$

$$d_0 = 26 \text{ mm}$$

$$e_1 = 30 \text{ mm}$$

$$p_1 = \infty \text{ mm}$$

$$f_{ub} = 800,0 \text{ MPa}$$

$$f_u = 360,0 \text{ MPa}$$

$$d = 24 \text{ mm}$$

$$t = 16 \text{ mm}$$

$$\gamma_{M2} = 1,25$$

- Distance to the plate edge perpendicular to the shear force
- Distance between bolts perpendicular to the shear force
- Bolt hole diameter
- Distance to the plate edge in the direction of the shear force
- Distance between bolts in the direction of the shear force
- Ultimate tensile strength of the bolt
- Ultimate strength of the plate
- Nominal diameter of the fastener
- Thickness of the plate
- Safety factor

Utilization in tension

$$\frac{F_{t,Ed}}{\min(F_{t,Rd}; B_{p,Rd})} = 0,09 \leq 1,0$$

Where:

$$F_{t,Ed} = 17,7 \text{ kN} \quad \text{– Tensile force}$$

$$F_{t,Rd} = 203,3 \text{ kN} \quad \text{– Tension resistance}$$

$$B_{p,Rd} = 309,4 \text{ kN} \quad \text{– Punching resistance}$$

Utilization in shear

$$\max\left(\frac{F_{v,Ed}}{F_{v,Rd}}; \frac{F_{b,Ed}}{F_{b,Rd}}\right) = 0,94 \leq 1,0$$

Where:

$$F_{v,Ed} = 61,5 \text{ kN} \quad \text{– Shear force (in decisive shear plane)}$$

$$F_{v,Rd} = 135,6 \text{ kN} \quad \text{– Shear resistance}$$

$$F_{b,Ed} = 61,5 \text{ kN} \quad \text{– Bearing force (for decisive plate)}$$

$$F_{b,Rd} = 65,1 \text{ kN} \quad \text{– Bearing resistance}$$

Interaction of tension and shear (EN 1993-1-8 – Tab. 3.4)

$$\frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1,4 F_{t,Rd}} = 0,52 \leq 1,0$$

Where:

$$F_{v,Ed} = 61,5 \text{ kN} \quad \text{– Shear force (in decisive shear plane)}$$

$$F_{v,Rd} = 135,6 \text{ kN} \quad \text{– Shear resistance}$$

$$F_{t,Ed} = 17,7 \text{ kN} \quad \text{– Tensile force}$$

$$F_{t,Rd} = 203,3 \text{ kN} \quad \text{– Tension resistance}$$

Detailed result for B2

Tension resistance check (EN 1993-1-8 – Tab. 3.4)

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$$F_{t,Rd} = \frac{k_2 f_{ub} A_s}{\gamma_{M2}} = 203,3 \text{ kN} \geq F_{t,Ed} = 23,6 \text{ kN}$$

Where:

- $k_2 = 0,90$ – Factor
- $f_{ub} = 800,0 \text{ MPa}$ – Ultimate tensile strength of the bolt
- $A_s = 353 \text{ mm}^2$ – Tensile stress area of the bolt
- $\gamma_{M2} = 1,25$ – Safety factor

Punching resistance check (EN 1993-1-8 – Tab. 3.4)

$$B_{p,Rd} = \frac{0,6 \pi d_m t_p f_u}{\gamma_{M2}} = 309,4 \text{ kN} \geq F_{t,Ed} = 23,6 \text{ kN}$$

Where:

- $d_m = 38 \text{ mm}$ – The mean of the across points and across flats dimensions of the bolt head or the nut, whichever is smaller
- $t_p = 15 \text{ mm}$ – Plate thickness
- $f_u = 360,0 \text{ MPa}$ – Ultimate strength
- $\gamma_{M2} = 1,25$ – Safety factor

Shear resistance check (EN 1993-1-8 – Tab. 3.4)

$$F_{v,Rd} = \frac{\beta_p \alpha_v f_{ub} A}{\gamma_{M2}} = 135,6 \text{ kN} \geq F_{v,Ed} = 63,2 \text{ kN}$$

Where:

- $\beta_p = 1,00$ – Reduction factor for packing
- $\alpha_v = 0,60$ – Reduction factor for shear stress
- $f_{ub} = 800,0 \text{ MPa}$ – Ultimate tensile strength of the bolt
- $A = 353 \text{ mm}^2$ – Gross cross-section area of the bolt
- $\gamma_{M2} = 1,25$ – Safety factor

Bearing resistance check (EN 1993-1-8 – Tab. 3.4)

$$F_{b,Rd} = \frac{k_1 \alpha_b f_u d t}{\gamma_{M2}} = 65,1 \text{ kN} \geq F_{b,Ed} = 63,2 \text{ kN}$$

Where:

- $k_1 = \min(2,8 \frac{e_2}{d_0} - 1,7, 1,4 \frac{p_2}{d_0} - 1,7, 2,5) = 1,53$ – Factor for edge distance and bolt spacing perpendicular to the direction of load transfer
- $\alpha_b = \min(\frac{e_1}{3d_0}, \frac{p_1}{3d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1) = 0,38$ – Factor for end distance and bolt spacing in direction of load transfer
- $e_2 = 30 \text{ mm}$ – Distance to the plate edge perpendicular to the shear force
- $p_2 = 100 \text{ mm}$ – Distance between bolts perpendicular to the shear force
- $d_0 = 26 \text{ mm}$ – Bolt hole diameter
- $e_1 = 30 \text{ mm}$ – Distance to the plate edge in the direction of the shear force
- $p_1 = \infty \text{ mm}$ – Distance between bolts in the direction of the shear force
- $f_{ub} = 800,0 \text{ MPa}$ – Ultimate tensile strength of the bolt

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$$f_u = 360,0 \text{ MPa}$$

– Ultimate strength of the plate

$$d = 24 \text{ mm}$$

– Nominal diameter of the fastener

$$t = 16 \text{ mm}$$

– Thickness of the plate

$$\gamma_{M2} = 1,25$$

– Safety factor

Utilization in tension

$$\frac{F_{t,Ed}}{\min(F_{t,Rd}; B_{p,Rd})} = 0,12 \leq 1,0$$

Where:

$$F_{t,Ed} = 23,6 \text{ kN} \quad \text{– Tensile force}$$

$$F_{t,Rd} = 203,3 \text{ kN} \quad \text{– Tension resistance}$$

$$B_{p,Rd} = 309,4 \text{ kN} \quad \text{– Punching resistance}$$

Utilization in shear

$$\max\left(\frac{F_{v,Ed}}{F_{v,Rd}}; \frac{F_{b,Ed}}{F_{b,Rd}}\right) = 0,97 \leq 1,0$$

Where:

$$F_{v,Ed} = 63,2 \text{ kN} \quad \text{– Shear force (in decisive shear plane)}$$

$$F_{v,Rd} = 135,6 \text{ kN} \quad \text{– Shear resistance}$$

$$F_{b,Ed} = 63,2 \text{ kN} \quad \text{– Bearing force (for decisive plate)}$$

$$F_{b,Rd} = 65,1 \text{ kN} \quad \text{– Bearing resistance}$$

Interaction of tension and shear (EN 1993-1-8 – Tab. 3.4)

$$\frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1,4 F_{t,Rd}} = 0,55 \leq 1,0$$

Where:

$$F_{v,Ed} = 63,2 \text{ kN} \quad \text{– Shear force (in decisive shear plane)}$$

$$F_{v,Rd} = 135,6 \text{ kN} \quad \text{– Shear resistance}$$

$$F_{t,Ed} = 23,6 \text{ kN} \quad \text{– Tensile force}$$

$$F_{t,Rd} = 203,3 \text{ kN} \quad \text{– Tension resistance}$$

Detailed result for B3

Tension resistance check (EN 1993-1-8 – Tab. 3.4)

$$F_{t,Rd} = \frac{k_2 f_{ub} A_s}{\gamma_{M2}} = 203,3 \text{ kN} \geq F_{t,Ed} = 20,0 \text{ kN}$$

Where:

$$k_2 = 0,90 \quad \text{– Factor}$$

$$f_{ub} = 800,0 \text{ MPa} \quad \text{– Ultimate tensile strength of the bolt}$$

$$A_s = 353 \text{ mm}^2 \quad \text{– Tensile stress area of the bolt}$$

$$\gamma_{M2} = 1,25 \quad \text{– Safety factor}$$

Punching resistance check (EN 1993-1-8 – Tab. 3.4)

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$$B_{p,Rd} = \frac{0,6 \pi d_m t_p f_u}{\gamma_{M2}} = 309,4 \text{ kN} \geq F_{t,Ed} = 20,0 \text{ kN}$$

Where:

- $d_m = 38 \text{ mm}$ – The mean of the across points and across flats dimensions of the bolt head or the nut, whichever is smaller
- $t_p = 15 \text{ mm}$ – Plate thickness
- $f_u = 360,0 \text{ MPa}$ – Ultimate strength
- $\gamma_{M2} = 1,25$ – Safety factor

Shear resistance check (EN 1993-1-8 – Tab. 3.4)

$$F_{v,Rd} = \frac{\beta_p \alpha_v f_{ub} A}{\gamma_{M2}} = 135,6 \text{ kN} \geq F_{v,Ed} = 63,2 \text{ kN}$$

Where:

- $\beta_p = 1,00$ – Reduction factor for packing
- $\alpha_v = 0,60$ – Reduction factor for shear stress
- $f_{ub} = 800,0 \text{ MPa}$ – Ultimate tensile strength of the bolt
- $A = 353 \text{ mm}^2$ – Gross cross-section area of the bolt
- $\gamma_{M2} = 1,25$ – Safety factor

Bearing resistance check (EN 1993-1-8 – Tab. 3.4)

$$F_{b,Rd} = \frac{k_1 \alpha_b f_u d t}{\gamma_{M2}} = 131,3 \text{ kN} \geq F_{b,Ed} = 63,2 \text{ kN}$$

Where:

- $k_1 = \min(2,8 \frac{e_2}{d_0} - 1,7, 1,4 \frac{p_2}{d_0} - 1,7, 2,5) = 1,53$ – Factor for edge distance and bolt spacing perpendicular to the direction of load transfer
- $\alpha_b = \min(\frac{e_1}{3d_0}, \frac{p_1}{3d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1) = 0,78$ – Factor for end distance and bolt spacing in direction of load transfer
- $e_2 = 30 \text{ mm}$ – Distance to the plate edge perpendicular to the shear force
- $p_2 = 100 \text{ mm}$ – Distance between bolts perpendicular to the shear force
- $d_0 = 26 \text{ mm}$ – Bolt hole diameter
- $e_1 = 110 \text{ mm}$ – Distance to the plate edge in the direction of the shear force
- $p_1 = 80 \text{ mm}$ – Distance between bolts in the direction of the shear force
- $f_{ub} = 800,0 \text{ MPa}$ – Ultimate tensile strength of the bolt
- $f_u = 360,0 \text{ MPa}$ – Ultimate strength of the plate
- $d = 24 \text{ mm}$ – Nominal diameter of the fastener
- $t = 16 \text{ mm}$ – Thickness of the plate
- $\gamma_{M2} = 1,25$ – Safety factor

Utilization in tension

$$\frac{F_{t,Ed}}{\min(F_{t,Rd}; B_{p,Rd})} = 0,10 \leq 1,0$$

Where:

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$$\begin{aligned} F_{t,Ed} &= 20,0 \text{ kN} && \text{– Tensile force} \\ F_{t,Rd} &= 203,3 \text{ kN} && \text{– Tension resistance} \\ B_{p,Rd} &= 309,4 \text{ kN} && \text{– Punching resistance} \end{aligned}$$

Utilization in shear

$$\max\left(\frac{F_{v,Ed}}{F_{v,Rd}}, \frac{F_{b,Ed}}{F_{b,Rd}}\right) = 0,48 \leq 1,0$$

Where:

$$\begin{aligned} F_{v,Ed} &= 63,2 \text{ kN} && \text{– Shear force (in decisive shear plane)} \\ F_{v,Rd} &= 135,6 \text{ kN} && \text{– Shear resistance} \\ F_{b,Ed} &= 63,2 \text{ kN} && \text{– Bearing force (for decisive plate)} \\ F_{b,Rd} &= 131,3 \text{ kN} && \text{– Bearing resistance} \end{aligned}$$

Interaction of tension and shear (EN 1993-1-8 – Tab. 3.4)

$$\frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1,4 F_{t,Rd}} = 0,54 \leq 1,0$$

Where:

$$\begin{aligned} F_{v,Ed} &= 63,2 \text{ kN} && \text{– Shear force (in decisive shear plane)} \\ F_{v,Rd} &= 135,6 \text{ kN} && \text{– Shear resistance} \\ F_{t,Ed} &= 20,0 \text{ kN} && \text{– Tensile force} \\ F_{t,Rd} &= 203,3 \text{ kN} && \text{– Tension resistance} \end{aligned}$$

Detailed result for B4

Tension resistance check (EN 1993-1-8 – Tab. 3.4)

$$F_{t,Rd} = \frac{k_2 f_{ub} A_s}{\gamma_{M2}} = 203,3 \text{ kN} \geq F_{t,Ed} = 9,3 \text{ kN}$$

Where:

$$\begin{aligned} k_2 &= 0,90 && \text{– Factor} \\ f_{ub} &= 800,0 \text{ MPa} && \text{– Ultimate tensile strength of the bolt} \\ A_s &= 353 \text{ mm}^2 && \text{– Tensile stress area of the bolt} \\ \gamma_{M2} &= 1,25 && \text{– Safety factor} \end{aligned}$$

Punching resistance check (EN 1993-1-8 – Tab. 3.4)

$$B_{p,Rd} = \frac{0,6 \pi d_m t_p f_u}{\gamma_{M2}} = 309,4 \text{ kN} \geq F_{t,Ed} = 9,3 \text{ kN}$$

Where:

$$\begin{aligned} d_m &= 38 \text{ mm} && \text{– The mean of the across points and across flats dimensions of the bolt head or the nut, whichever is smaller} \\ t_p &= 15 \text{ mm} && \text{– Plate thickness} \\ f_u &= 360,0 \text{ MPa} && \text{– Ultimate strength} \\ \gamma_{M2} &= 1,25 && \text{– Safety factor} \end{aligned}$$

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Shear resistance check (EN 1993-1-8 – Tab. 3.4)

$$F_{v,Rd} = \frac{\beta_p \alpha_v f_{ub} A}{\gamma_{M2}} = 135,6 \text{ kN} \geq F_{v,Ed} = 62,1 \text{ kN}$$

Where:

- $\beta_p = 1,00$ – Reduction factor for packing
- $\alpha_v = 0,60$ – Reduction factor for shear stress
- $f_{ub} = 800,0 \text{ MPa}$ – Ultimate tensile strength of the bolt
- $A = 353 \text{ mm}^2$ – Gross cross-section area of the bolt
- $\gamma_{M2} = 1,25$ – Safety factor

Bearing resistance check (EN 1993-1-8 – Tab. 3.4)

$$F_{b,Rd} = \frac{k_1 \alpha_b f_u d t}{\gamma_{M2}} = 131,3 \text{ kN} \geq F_{b,Ed} = 62,1 \text{ kN}$$

Where:

- $k_1 = \min(2,8 \frac{e_2}{d_0} - 1,7, 1,4 \frac{p_2}{d_0} - 1,7, 2,5) = 1,53$ – Factor for edge distance and bolt spacing perpendicular to the direction of load transfer
- $\alpha_b = \min(\frac{e_1}{3d_0}, \frac{p_1}{3d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1) = 0,78$ – Factor for end distance and bolt spacing in direction of load transfer
- $e_2 = 30 \text{ mm}$ – Distance to the plate edge perpendicular to the shear force
- $p_2 = 100 \text{ mm}$ – Distance between bolts perpendicular to the shear force
- $d_0 = 26 \text{ mm}$ – Bolt hole diameter
- $e_1 = 110 \text{ mm}$ – Distance to the plate edge in the direction of the shear force
- $p_1 = 80 \text{ mm}$ – Distance between bolts in the direction of the shear force
- $f_{ub} = 800,0 \text{ MPa}$ – Ultimate tensile strength of the bolt
- $f_u = 360,0 \text{ MPa}$ – Ultimate strength of the plate
- $d = 24 \text{ mm}$ – Nominal diameter of the fastener
- $t = 16 \text{ mm}$ – Thickness of the plate
- $\gamma_{M2} = 1,25$ – Safety factor

Utilization in tension

$$\frac{F_{t,Ed}}{\min(F_{t,Rd}; B_{p,Rd})} = 0,05 \leq 1,0$$

Where:

- $F_{t,Ed} = 9,3 \text{ kN}$ – Tensile force
- $F_{t,Rd} = 203,3 \text{ kN}$ – Tension resistance
- $B_{p,Rd} = 309,4 \text{ kN}$ – Punching resistance

Utilization in shear

$$\max(\frac{F_{v,Ed}}{F_{v,Rd}}; \frac{F_{b,Ed}}{F_{b,Rd}}) = 0,47 \leq 1,0$$

Where:

- $F_{v,Ed} = 62,1 \text{ kN}$ – Shear force (in decisive shear plane)

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$$F_{v,Rd} = 135,6 \text{ kN} \quad - \text{ Shear resistance}$$

$$F_{b,Ed} = 62,1 \text{ kN} \quad - \text{ Bearing force (for decisive plate)}$$

$$F_{b,Rd} = 131,3 \text{ kN} \quad - \text{ Bearing resistance}$$

Interaction of tension and shear (EN 1993-1-8 – Tab. 3.4)

$$\frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1,4 F_{t,Rd}} = 0,49 \leq 1,0$$

Where:

$$F_{v,Ed} = 62,1 \text{ kN} \quad - \text{ Shear force (in decisive shear plane)}$$

$$F_{v,Rd} = 135,6 \text{ kN} \quad - \text{ Shear resistance}$$

$$F_{t,Ed} = 9,3 \text{ kN} \quad - \text{ Tensile force}$$

$$F_{t,Rd} = 203,3 \text{ kN} \quad - \text{ Tension resistance}$$

Detailed result for B5

Tension resistance check (EN 1993-1-8 – Tab. 3.4)

$$F_{t,Rd} = \frac{k_2 f_{ub} A_s}{\gamma_{M2}} = 203,3 \text{ kN} \geq F_{t,Ed} = 23,7 \text{ kN}$$

Where:

$$k_2 = 0,90 \quad - \text{ Factor}$$

$$f_{ub} = 800,0 \text{ MPa} \quad - \text{ Ultimate tensile strength of the bolt}$$

$$A_s = 353 \text{ mm}^2 \quad - \text{ Tensile stress area of the bolt}$$

$$\gamma_{M2} = 1,25 \quad - \text{ Safety factor}$$

Punching resistance check (EN 1993-1-8 – Tab. 3.4)

$$B_{p,Rd} = \frac{0,6 \pi d_m t_p f_u}{\gamma_{M2}} = 309,4 \text{ kN} \geq F_{t,Ed} = 23,7 \text{ kN}$$

Where:

$$d_m = 38 \text{ mm} \quad - \text{ The mean of the across points and across flats dimensions of the bolt head or the nut, whichever is smaller}$$

$$t_p = 15 \text{ mm} \quad - \text{ Plate thickness}$$

$$f_u = 360,0 \text{ MPa} \quad - \text{ Ultimate strength}$$

$$\gamma_{M2} = 1,25 \quad - \text{ Safety factor}$$

Shear resistance check (EN 1993-1-8 – Tab. 3.4)

$$F_{v,Rd} = \frac{\beta_p \alpha_v f_{ub} A}{\gamma_{M2}} = 135,6 \text{ kN} \geq F_{v,Ed} = 63,3 \text{ kN}$$

Where:

$$\beta_p = 1,00 \quad - \text{ Reduction factor for packing}$$

$$\alpha_v = 0,60 \quad - \text{ Reduction factor for shear stress}$$

$$f_{ub} = 800,0 \text{ MPa} \quad - \text{ Ultimate tensile strength of the bolt}$$

$$A = 353 \text{ mm}^2 \quad - \text{ Gross cross-section area of the bolt}$$

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$$\gamma_{M2} = 1,25 \quad - \text{Safety factor}$$

Bearing resistance check (EN 1993-1-8 – Tab. 3.4)

$$F_{b,Rd} = \frac{k_1 \alpha_b f_u d t}{\gamma_{M2}} = 65,1 \text{ kN} \geq F_{b,Ed} = 63,3 \text{ kN}$$

Where:

$k_1 = \min(2,8 \frac{e_2}{d_0} - 1,7, 1,4 \frac{p_2}{d_0} - 1,7, 2,5) = 1,53$	– Factor for edge distance and bolt spacing perpendicular to the direction of load transfer
$\alpha_b = \min(\frac{e_1}{3d_0}, \frac{p_1}{3d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1) = 0,38$	– Factor for end distance and bolt spacing in direction of load transfer
$e_2 = 30 \text{ mm}$	– Distance to the plate edge perpendicular to the shear force
$p_2 = 100 \text{ mm}$	– Distance between bolts perpendicular to the shear force
$d_0 = 26 \text{ mm}$	– Bolt hole diameter
$e_1 = 30 \text{ mm}$	– Distance to the plate edge in the direction of the shear force
$p_1 = \infty \text{ mm}$	– Distance between bolts in the direction of the shear force
$f_{ub} = 800,0 \text{ MPa}$	– Ultimate tensile strength of the bolt
$f_u = 360,0 \text{ MPa}$	– Ultimate strength of the plate
$d = 24 \text{ mm}$	– Nominal diameter of the fastener
$t = 16 \text{ mm}$	– Thickness of the plate
$\gamma_{M2} = 1,25$	– Safety factor

Utilization in tension

$$\frac{F_{t,Ed}}{\min(F_{t,Rd}; B_{p,Rd})} = 0,12 \leq 1,0$$

Where:

$F_{t,Ed} = 23,7 \text{ kN}$	– Tensile force
$F_{t,Rd} = 203,3 \text{ kN}$	– Tension resistance
$B_{p,Rd} = 309,4 \text{ kN}$	– Punching resistance

Utilization in shear

$$\max(\frac{F_{v,Ed}}{F_{v,Rd}}; \frac{F_{b,Ed}}{F_{b,Rd}}) = 0,97 \leq 1,0$$

Where:

$F_{v,Ed} = 63,3 \text{ kN}$	– Shear force (in decisive shear plane)
$F_{v,Rd} = 135,6 \text{ kN}$	– Shear resistance
$F_{b,Ed} = 63,3 \text{ kN}$	– Bearing force (for decisive plate)
$F_{b,Rd} = 65,1 \text{ kN}$	– Bearing resistance

Interaction of tension and shear (EN 1993-1-8 – Tab. 3.4)

$$\frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1,4 F_{t,Rd}} = 0,55 \leq 1,0$$

Where:

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$F_{v,Ed} = 63,3 \text{ kN}$ – Shear force (in decisive shear plane)

$F_{v,Rd} = 135,6 \text{ kN}$ – Shear resistance

$F_{t,Ed} = 23,7 \text{ kN}$ – Tensile force

$F_{t,Rd} = 203,3 \text{ kN}$ – Tension resistance

Detailed result for B6

Tension resistance check (EN 1993-1-8 – Tab. 3.4)

$$F_{t,Rd} = \frac{k_2 f_{ub} A_s}{\gamma_{M2}} = 203,3 \text{ kN} \geq F_{t,Ed} = 17,6 \text{ kN}$$

Where:

$k_2 = 0,90$ – Factor

$f_{ub} = 800,0 \text{ MPa}$ – Ultimate tensile strength of the bolt

$A_s = 353 \text{ mm}^2$ – Tensile stress area of the bolt

$\gamma_{M2} = 1,25$ – Safety factor

Punching resistance check (EN 1993-1-8 – Tab. 3.4)

$$B_{p,Rd} = \frac{0,6 \pi d_m t_p f_u}{\gamma_{M2}} = 309,4 \text{ kN} \geq F_{t,Ed} = 17,6 \text{ kN}$$

Where:

$d_m = 38 \text{ mm}$ – The mean of the across points and across flats dimensions of the bolt head or the nut, whichever is smaller

$t_p = 15 \text{ mm}$ – Plate thickness

$f_u = 360,0 \text{ MPa}$ – Ultimate strength

$\gamma_{M2} = 1,25$ – Safety factor

Shear resistance check (EN 1993-1-8 – Tab. 3.4)

$$F_{v,Rd} = \frac{\beta_p \alpha_v f_{ub} A}{\gamma_{M2}} = 135,6 \text{ kN} \geq F_{v,Ed} = 61,4 \text{ kN}$$

Where:

$\beta_p = 1,00$ – Reduction factor for packing

$\alpha_v = 0,60$ – Reduction factor for shear stress

$f_{ub} = 800,0 \text{ MPa}$ – Ultimate tensile strength of the bolt

$A = 353 \text{ mm}^2$ – Gross cross-section area of the bolt

$\gamma_{M2} = 1,25$ – Safety factor

Bearing resistance check (EN 1993-1-8 – Tab. 3.4)

$$F_{b,Rd} = \frac{k_1 \alpha_b f_u d t}{\gamma_{M2}} = 65,1 \text{ kN} \geq F_{b,Ed} = 61,4 \text{ kN}$$

Where:

$k_1 = \min(2,8 \frac{e_2}{d_0} - 1,7, 1,4 \frac{p_2}{d_0} - 1,7, 2,5) = 1,53$ – Factor for edge distance and bolt spacing perpendicular to the direction of load transfer

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$$\alpha_b = \min\left(\frac{e_1}{3d_0}, \frac{p_1}{3d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1\right) = 0,38$$

$$e_2 = 30 \text{ mm}$$

$$p_2 = 100 \text{ mm}$$

$$d_0 = 26 \text{ mm}$$

$$e_1 = 30 \text{ mm}$$

$$p_1 = \infty \text{ mm}$$

$$f_{ub} = 800,0 \text{ MPa}$$

$$f_u = 360,0 \text{ MPa}$$

$$d = 24 \text{ mm}$$

$$t = 16 \text{ mm}$$

$$\gamma_{M2} = 1,25$$

– Factor for end distance and bolt spacing in direction of load transfer

– Distance to the plate edge perpendicular to the shear force

– Distance between bolts perpendicular to the shear force

– Bolt hole diameter

– Distance to the plate edge in the direction of the shear force

– Distance between bolts in the direction of the shear force

– Ultimate tensile strength of the bolt

– Ultimate strength of the plate

– Nominal diameter of the fastener

– Thickness of the plate

– Safety factor

Utilization in tension

$$\frac{F_{t,Ed}}{\min(F_{t,Rd}; B_{p,Rd})} = 0,09 \leq 1,0$$

Where:

$$F_{t,Ed} = 17,6 \text{ kN} \quad \text{– Tensile force}$$

$$F_{t,Rd} = 203,3 \text{ kN} \quad \text{– Tension resistance}$$

$$B_{p,Rd} = 309,4 \text{ kN} \quad \text{– Punching resistance}$$

Utilization in shear

$$\max\left(\frac{F_{v,Ed}}{F_{v,Rd}}, \frac{F_{b,Ed}}{F_{b,Rd}}\right) = 0,94 \leq 1,0$$

Where:

$$F_{v,Ed} = 61,4 \text{ kN} \quad \text{– Shear force (in decisive shear plane)}$$

$$F_{v,Rd} = 135,6 \text{ kN} \quad \text{– Shear resistance}$$

$$F_{b,Ed} = 61,4 \text{ kN} \quad \text{– Bearing force (for decisive plate)}$$

$$F_{b,Rd} = 65,1 \text{ kN} \quad \text{– Bearing resistance}$$

Interaction of tension and shear (EN 1993-1-8 – Tab. 3.4)

$$\frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1,4 F_{t,Rd}} = 0,51 \leq 1,0$$

Where:

$$F_{v,Ed} = 61,4 \text{ kN} \quad \text{– Shear force (in decisive shear plane)}$$

$$F_{v,Rd} = 135,6 \text{ kN} \quad \text{– Shear resistance}$$

$$F_{t,Ed} = 17,6 \text{ kN} \quad \text{– Tensile force}$$

$$F_{t,Rd} = 203,3 \text{ kN} \quad \text{– Tension resistance}$$

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Detailed result for B7

Tension resistance check (EN 1993-1-8 – Tab. 3.4)

$$F_{t,Rd} = \frac{k_2 f_{ub} A_s}{\gamma_{M2}} = 203,3 \text{ kN} \geq F_{t,Ed} = 9,2 \text{ kN}$$

Where:

- $k_2 = 0,90$ – Factor
- $f_{ub} = 800,0 \text{ MPa}$ – Ultimate tensile strength of the bolt
- $A_s = 353 \text{ mm}^2$ – Tensile stress area of the bolt
- $\gamma_{M2} = 1,25$ – Safety factor

Punching resistance check (EN 1993-1-8 – Tab. 3.4)

$$B_{p,Rd} = \frac{0,6 \pi d_m t_p f_u}{\gamma_{M2}} = 309,4 \text{ kN} \geq F_{t,Ed} = 9,2 \text{ kN}$$

Where:

- $d_m = 38 \text{ mm}$ – The mean of the across points and across flats dimensions of the bolt head or the nut, whichever is smaller
- $t_p = 15 \text{ mm}$ – Plate thickness
- $f_u = 360,0 \text{ MPa}$ – Ultimate strength
- $\gamma_{M2} = 1,25$ – Safety factor

Shear resistance check (EN 1993-1-8 – Tab. 3.4)

$$F_{v,Rd} = \frac{\beta_p \alpha_v f_{ub} A}{\gamma_{M2}} = 135,6 \text{ kN} \geq F_{v,Ed} = 62,2 \text{ kN}$$

Where:

- $\beta_p = 1,00$ – Reduction factor for packing
- $\alpha_v = 0,60$ – Reduction factor for shear stress
- $f_{ub} = 800,0 \text{ MPa}$ – Ultimate tensile strength of the bolt
- $A = 353 \text{ mm}^2$ – Gross cross-section area of the bolt
- $\gamma_{M2} = 1,25$ – Safety factor

Bearing resistance check (EN 1993-1-8 – Tab. 3.4)

$$F_{b,Rd} = \frac{k_1 \alpha_b f_u d t}{\gamma_{M2}} = 131,3 \text{ kN} \geq F_{b,Ed} = 62,2 \text{ kN}$$

Where:

- $k_1 = \min(2,8 \frac{e_2}{d_0} - 1,7, 1,4 \frac{p_2}{d_0} - 1,7, 2,5) = 1,53$ – Factor for edge distance and bolt spacing perpendicular to the direction of load transfer
- $\alpha_b = \min(\frac{e_1}{3d_0}, \frac{p_1}{3d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1) = 0,78$ – Factor for end distance and bolt spacing in direction of load transfer
- $e_2 = 30 \text{ mm}$ – Distance to the plate edge perpendicular to the shear force
- $p_2 = 100 \text{ mm}$ – Distance between bolts perpendicular to the shear force
- $d_0 = 26 \text{ mm}$ – Bolt hole diameter
- $e_1 = 110 \text{ mm}$ – Distance to the plate edge in the direction of the shear force

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$$p_1 = 80 \text{ mm}$$

– Distance between bolts in the direction of the shear force

$$f_{ub} = 800,0 \text{ MPa}$$

– Ultimate tensile strength of the bolt

$$f_u = 360,0 \text{ MPa}$$

– Ultimate strength of the plate

$$d = 24 \text{ mm}$$

– Nominal diameter of the fastener

$$t = 16 \text{ mm}$$

– Thickness of the plate

$$\gamma_{M2} = 1,25$$

– Safety factor

Utilization in tension

$$\frac{F_{t,Ed}}{\min(F_{t,Rd}; B_{p,Rd})} = 0,05 \leq 1,0$$

Where:

$$F_{t,Ed} = 9,2 \text{ kN} \quad \text{– Tensile force}$$

$$F_{t,Rd} = 203,3 \text{ kN} \quad \text{– Tension resistance}$$

$$B_{p,Rd} = 309,4 \text{ kN} \quad \text{– Punching resistance}$$

Utilization in shear

$$\max\left(\frac{F_{v,Ed}}{F_{v,Rd}}; \frac{F_{b,Ed}}{F_{b,Rd}}\right) = 0,47 \leq 1,0$$

Where:

$$F_{v,Ed} = 62,2 \text{ kN} \quad \text{– Shear force (in decisive shear plane)}$$

$$F_{v,Rd} = 135,6 \text{ kN} \quad \text{– Shear resistance}$$

$$F_{b,Ed} = 62,2 \text{ kN} \quad \text{– Bearing force (for decisive plate)}$$

$$F_{b,Rd} = 131,3 \text{ kN} \quad \text{– Bearing resistance}$$

Interaction of tension and shear (EN 1993-1-8 – Tab. 3.4)

$$\frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1,4 F_{t,Rd}} = 0,49 \leq 1,0$$

Where:

$$F_{v,Ed} = 62,2 \text{ kN} \quad \text{– Shear force (in decisive shear plane)}$$

$$F_{v,Rd} = 135,6 \text{ kN} \quad \text{– Shear resistance}$$

$$F_{t,Ed} = 9,2 \text{ kN} \quad \text{– Tensile force}$$

$$F_{t,Rd} = 203,3 \text{ kN} \quad \text{– Tension resistance}$$

Detailed result for B8

Tension resistance check (EN 1993-1-8 – Tab. 3.4)

$$F_{t,Rd} = \frac{k_2 f_{ub} A_s}{\gamma_{M2}} = 203,3 \text{ kN} \geq F_{t,Ed} = 19,9 \text{ kN}$$

Where:

$$k_2 = 0,90 \quad \text{– Factor}$$

$$f_{ub} = 800,0 \text{ MPa} \quad \text{– Ultimate tensile strength of the bolt}$$

$$A_s = 353 \text{ mm}^2 \quad \text{– Tensile stress area of the bolt}$$

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$$\gamma_{M2} = 1,25 \quad - \text{Safety factor}$$

Punching resistance check (EN 1993-1-8 – Tab. 3.4)

$$B_{p,Rd} = \frac{0,6 \pi d_m t_p f_u}{\gamma_{M2}} = 309,4 \text{ kN} \geq F_{t,Ed} = 19,9 \text{ kN}$$

Where:

$d_m = 38 \text{ mm}$	– The mean of the across points and across flats dimensions of the bolt head or the nut, whichever is smaller
$t_p = 15 \text{ mm}$	– Plate thickness
$f_u = 360,0 \text{ MPa}$	– Ultimate strength
$\gamma_{M2} = 1,25$	– Safety factor

Shear resistance check (EN 1993-1-8 – Tab. 3.4)

$$F_{v,Rd} = \frac{\beta_p \alpha_v f_{ub} A}{\gamma_{M2}} = 135,6 \text{ kN} \geq F_{v,Ed} = 63,1 \text{ kN}$$

Where:

$\beta_p = 1,00$	– Reduction factor for packing
$\alpha_v = 0,60$	– Reduction factor for shear stress
$f_{ub} = 800,0 \text{ MPa}$	– Ultimate tensile strength of the bolt
$A = 353 \text{ mm}^2$	– Gross cross-section area of the bolt
$\gamma_{M2} = 1,25$	– Safety factor

Bearing resistance check (EN 1993-1-8 – Tab. 3.4)

$$F_{b,Rd} = \frac{k_1 \alpha_b f_u d t}{\gamma_{M2}} = 131,3 \text{ kN} \geq F_{b,Ed} = 63,1 \text{ kN}$$

Where:

$k_1 = \min(2,8 \frac{e_2}{d_0} - 1,7, 1,4 \frac{p_2}{d_0} - 1,7, 2,5) = 1,53$	– Factor for edge distance and bolt spacing perpendicular to the direction of load transfer
$\alpha_b = \min(\frac{e_1}{3d_0}, \frac{p_1}{3d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1) = 0,78$	– Factor for end distance and bolt spacing in direction of load transfer
$e_2 = 30 \text{ mm}$	– Distance to the plate edge perpendicular to the shear force
$p_2 = 100 \text{ mm}$	– Distance between bolts perpendicular to the shear force
$d_0 = 26 \text{ mm}$	– Bolt hole diameter
$e_1 = 110 \text{ mm}$	– Distance to the plate edge in the direction of the shear force
$p_1 = 80 \text{ mm}$	– Distance between bolts in the direction of the shear force
$f_{ub} = 800,0 \text{ MPa}$	– Ultimate tensile strength of the bolt
$f_u = 360,0 \text{ MPa}$	– Ultimate strength of the plate
$d = 24 \text{ mm}$	– Nominal diameter of the fastener
$t = 16 \text{ mm}$	– Thickness of the plate
$\gamma_{M2} = 1,25$	– Safety factor

Utilization in tension

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$$\frac{F_{t,Ed}}{\min(F_{t,Rd}; B_{p,Rd})} = 0,10 \leq 1,0$$

Where:

$$\begin{aligned} F_{t,Ed} &= 19,9 \text{ kN} && \text{-- Tensile force} \\ F_{t,Rd} &= 203,3 \text{ kN} && \text{-- Tension resistance} \\ B_{p,Rd} &= 309,4 \text{ kN} && \text{-- Punching resistance} \end{aligned}$$

Utilization in shear

$$\max\left(\frac{F_{v,Ed}}{F_{v,Rd}}; \frac{F_{b,Ed}}{F_{b,Rd}}\right) = 0,48 \leq 1,0$$

Where:

$$\begin{aligned} F_{v,Ed} &= 63,1 \text{ kN} && \text{-- Shear force (in decisive shear plane)} \\ F_{v,Rd} &= 135,6 \text{ kN} && \text{-- Shear resistance} \\ F_{b,Ed} &= 63,1 \text{ kN} && \text{-- Bearing force (for decisive plate)} \\ F_{b,Rd} &= 131,3 \text{ kN} && \text{-- Bearing resistance} \end{aligned}$$

Interaction of tension and shear (EN 1993-1-8 – Tab. 3.4)

$$\frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1,4 F_{t,Rd}} = 0,54 \leq 1,0$$

Where:

$$\begin{aligned} F_{v,Ed} &= 63,1 \text{ kN} && \text{-- Shear force (in decisive shear plane)} \\ F_{v,Rd} &= 135,6 \text{ kN} && \text{-- Shear resistance} \\ F_{t,Ed} &= 19,9 \text{ kN} && \text{-- Tensile force} \\ F_{t,Rd} &= 203,3 \text{ kN} && \text{-- Tension resistance} \end{aligned}$$

Welds

Item	Edge	T _w [mm]	L [mm]	Loads	σ _{w,Ed} [MPa]	ε _{pl} [%]	σ _⊥ [MPa]	T [MPa]	T _⊥ [MPa]	Ut [%]	Ut _c [%]	Status
D3-w 2	Gesneden plaat1	▲ 6,0 ▲	149	LE1	353,9	0,8	-10,1	111,2	171,3	98,3	35,1	OK
		▲ 6,0 ▲	149	LE1	355,9	2,1	81,3	-200,0	-5,1	98,9	37,6	OK
D3-w 4	Gesneden plaat1	▲ 6,0 ▲	149	LE1	353,8	0,7	55,1	-164,4	117,0	98,3	42,8	OK
		▲ 6,0 ▲	149	LE1	354,7	1,3	77,7	195,7	-40,5	98,5	30,2	OK
D4-w 4	Gesneden plaat2	▲ 6,0 ▲	149	LE1	353,8	0,7	55,7	163,4	118,4	98,3	42,8	OK
		▲ 6,0 ▲	149	LE1	354,7	1,3	78,2	-195,6	-40,7	98,5	30,1	OK
D4-w 2	Gesneden plaat2	▲ 6,0 ▲	149	LE1	353,9	0,8	-10,7	-112,4	170,6	98,3	35,2	OK
		▲ 6,0 ▲	149	LE1	355,9	2,1	81,1	200,0	-5,0	98,9	37,6	OK
Algemene plaat1	K1-w 1	▲ 6,0	547	LE1	319,0	0,0	89,0	164,1	65,8	88,6	18,6	OK
Algemene plaat1	K1-w 1	▲ 6,0	547	LE1	352,9	0,0	-81,4	-157,0	-121,0	98,0	10,5	OK

Algemene plaat1	K1-w 3	▲ 6,0	547	LE1	352,9	0,0	-11,7	188,4	-77,1	98,0	17,5	OK
Algemene plaat1	K1-w 3	▲ 6,0	547	LE1	352,8	0,0	62,8	-195,2	45,8	98,0	16,4	OK
Algemene plaat1	D1-w 2	▲ 6,0	236	LE1	353,3	0,3	-48,6	-201,5	-14,6	98,1	32,3	OK
Algemene plaat1	D1-w 2	▲ 6,0	236	LE1	353,2	0,3	-56,1	200,9	-12,8	98,1	35,0	OK
Algemene plaat1	D1-w 4	▲ 6,0	66	LE1	356,3	2,4	2,4	-204,3	24,1	99,0	77,4	OK
Algemene plaat1	D1-w 4	▲ 6,0	66	LE1	355,9	2,2	7,3	205,1	11,3	98,9	75,3	OK
Algemene plaat1	D2-w 2	▲ 6,0	236	LE1	352,9	0,0	-51,0	-201,1	14,1	98,0	26,6	OK
Algemene plaat1	D2-w 2	▲ 6,0	236	LE1	352,9	0,1	-40,3	202,1	11,3	98,0	24,1	OK
Algemene plaat1	D2-w 4	▲ 6,0	66	LE1	353,9	0,8	2,4	-204,2	6,8	98,3	72,5	OK
Algemene plaat1	D2-w 4	▲ 6,0	66	LE1	354,2	1,0	-4,5	202,5	28,6	98,4	75,4	OK
Algemene plaat1	K2-w 1	▲ 5,0	129	LE1	352,8	0,0	133,6	-136,4	-130,2	98,0	34,8	OK
Algemene plaat1	K2-w 1	▲ 5,0	129	LE1	290,5	0,0	-10,6	165,8	24,6	80,7	28,3	OK
Algemene plaat1	K2-w 3	▲ 5,0	129	LE1	283,2	0,0	-10,8	-161,7	23,1	78,7	27,8	OK
Algemene plaat1	K2-w 3	▲ 5,0	129	LE1	341,7	0,0	132,5	129,9	-127,3	94,9	34,9	OK

Design data

Material	β_w [-]	$\sigma_{w,Rd}$ [MPa]	0.9σ [MPa]
S 235	0,80	360,0	259,2

Symbol explanation

T_w	Throat thickness a
L	Length
$\sigma_{w,Ed}$	Equivalent stress
ϵ_{Pl}	Strain
$\sigma_{\perp}$	Perpendicular stress
$\tau_{\parallel}$	Shear stress parallel to weld axis
$\tau_{\perp}$	Shear stress perpendicular to weld axis
Ut	Utilization
Ut _c	Weld capacity utilization
β_w	Correlation factor EN 1993-1-8 – Tab. 4.1
$\sigma_{w,Rd}$	Equivalent stress resistance
0.9σ	Perpendicular stress resistance: $0.9 \cdot f_u / \gamma_{M2}$
▲	Fillet weld

Detailed result for D3-w 2 / Gesneden plaat1 - 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 353,9 \text{ MPa}$$

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$$\sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} = 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 10,1 \text{ MPa}$$

where:

$$f_u = 360,0 \text{ MPa} \quad \text{– Ultimate strength}$$

$$\beta_w = 0,80 \quad \text{– Correlation factor EN 1993-1-8 – Tab. 4.1}$$

$$\gamma_{M2} = 1,25 \quad \text{– Safety factor}$$

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,98 \leq 1,0$$

Where:

$$\sigma_{w,Ed} = 353,9 \text{ MPa} \quad \text{– Maximum normal stress transverse to the axis of the weld}$$

$$\sigma_{w,Rd} = 360,0 \text{ MPa} \quad \text{– Equivalent stress resistance}$$

$$|\sigma_{\perp}| = -10,1 \text{ MPa} \quad \text{– Normal stress perpendicular to the throat}$$

$$\sigma_{\perp,Rd} = 259,2 \text{ MPa} \quad \text{– Perpendicular stress resistance}$$

Detailed result for D3-w 2 / Gesneden plaat1 - 2

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0,5} = 355,9 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} = 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 81,3 \text{ MPa}$$

where:

$$f_u = 360,0 \text{ MPa} \quad \text{– Ultimate strength}$$

$$\beta_w = 0,80 \quad \text{– Correlation factor EN 1993-1-8 – Tab. 4.1}$$

$$\gamma_{M2} = 1,25 \quad \text{– Safety factor}$$

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,99 \leq 1,0$$

Where:

$$\sigma_{w,Ed} = 355,9 \text{ MPa} \quad \text{– Maximum normal stress transverse to the axis of the weld}$$

$$\sigma_{w,Rd} = 360,0 \text{ MPa} \quad \text{– Equivalent stress resistance}$$

$$|\sigma_{\perp}| = 81,3 \text{ MPa} \quad \text{– Normal stress perpendicular to the throat}$$

$$\sigma_{\perp,Rd} = 259,2 \text{ MPa} \quad \text{– Perpendicular stress resistance}$$

Detailed result for D3-w 4 / Gesneden plaat1 - 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0,5} = 353,8 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} = 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 55,1 \text{ MPa}$$

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where:

$$\begin{aligned} f_u &= 360,0 \text{ MPa} && \text{– Ultimate strength} \\ \beta_w &= 0,80 && \text{– Correlation factor EN 1993-1-8 – Tab. 4.1} \\ \gamma_{M2} &= 1,25 && \text{– Safety factor} \end{aligned}$$

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,98 \leq 1,0$$

Where:

$$\begin{aligned} \sigma_{w,Ed} &= 353,8 \text{ MPa} && \text{– Maximum normal stress transverse to the axis of the weld} \\ \sigma_{w,Rd} &= 360,0 \text{ MPa} && \text{– Equivalent stress resistance} \\ |\sigma_{\perp}| &= 55,1 \text{ MPa} && \text{– Normal stress perpendicular to the throat} \\ \sigma_{\perp,Rd} &= 259,2 \text{ MPa} && \text{– Perpendicular stress resistance} \end{aligned}$$

Detailed result for D3-w 4 / Gesneden plaat1 - 2

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\begin{aligned} \sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) &= 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 354,7 \text{ MPa} \\ \sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} &= 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 77,7 \text{ MPa} \end{aligned}$$

where:

$$\begin{aligned} f_u &= 360,0 \text{ MPa} && \text{– Ultimate strength} \\ \beta_w &= 0,80 && \text{– Correlation factor EN 1993-1-8 – Tab. 4.1} \\ \gamma_{M2} &= 1,25 && \text{– Safety factor} \end{aligned}$$

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,99 \leq 1,0$$

Where:

$$\begin{aligned} \sigma_{w,Ed} &= 354,7 \text{ MPa} && \text{– Maximum normal stress transverse to the axis of the weld} \\ \sigma_{w,Rd} &= 360,0 \text{ MPa} && \text{– Equivalent stress resistance} \\ |\sigma_{\perp}| &= 77,7 \text{ MPa} && \text{– Normal stress perpendicular to the throat} \\ \sigma_{\perp,Rd} &= 259,2 \text{ MPa} && \text{– Perpendicular stress resistance} \end{aligned}$$

Detailed result for D4-w 4 / Gesneden plaat2 - 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\begin{aligned} \sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) &= 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 353,8 \text{ MPa} \\ \sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} &= 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 55,7 \text{ MPa} \end{aligned}$$

where:

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- $f_u = 360,0 \text{ MPa}$ – Ultimate strength
 $\beta_w = 0,80$ – Correlation factor EN 1993-1-8 – Tab. 4.1
 $\gamma_{M2} = 1,25$ – Safety factor

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,98 \leq 1,0$$

Where:

- $\sigma_{w,Ed} = 353,8 \text{ MPa}$ – Maximum normal stress transverse to the axis of the weld
 $\sigma_{w,Rd} = 360,0 \text{ MPa}$ – Equivalent stress resistance
 $|\sigma_{\perp}| = 55,7 \text{ MPa}$ – Normal stress perpendicular to the throat
 $\sigma_{\perp,Rd} = 259,2 \text{ MPa}$ – Perpendicular stress resistance

Detailed result for D4-w 4 / Gesneden plaat2 - 2

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 354,7 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} = 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 78,2 \text{ MPa}$$

where:

- $f_u = 360,0 \text{ MPa}$ – Ultimate strength
 $\beta_w = 0,80$ – Correlation factor EN 1993-1-8 – Tab. 4.1
 $\gamma_{M2} = 1,25$ – Safety factor

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,99 \leq 1,0$$

Where:

- $\sigma_{w,Ed} = 354,7 \text{ MPa}$ – Maximum normal stress transverse to the axis of the weld
 $\sigma_{w,Rd} = 360,0 \text{ MPa}$ – Equivalent stress resistance
 $|\sigma_{\perp}| = 78,2 \text{ MPa}$ – Normal stress perpendicular to the throat
 $\sigma_{\perp,Rd} = 259,2 \text{ MPa}$ – Perpendicular stress resistance

Detailed result for D4-w 2 / Gesneden plaat2 - 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 353,9 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} = 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 10,7 \text{ MPa}$$

where:

- $f_u = 360,0 \text{ MPa}$ – Ultimate strength

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$\beta_w = 0,80$ – Correlation factor EN 1993-1-8 – Tab. 4.1

$\gamma_{M2} = 1,25$ – Safety factor

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,98 \leq 1,0$$

Where:

$\sigma_{w,Ed} = 353,9$ MPa – Maximum normal stress transverse to the axis of the weld

$\sigma_{w,Rd} = 360,0$ MPa – Equivalent stress resistance

$|\sigma_{\perp}| = -10,7$ MPa – Normal stress perpendicular to the throat

$\sigma_{\perp,Rd} = 259,2$ MPa – Perpendicular stress resistance

Detailed result for D4-w 2 / Gesneden plaat2 - 2

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0,5} = 355,9 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} = 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 81,1 \text{ MPa}$$

where:

$f_u = 360,0$ MPa – Ultimate strength

$\beta_w = 0,80$ – Correlation factor EN 1993-1-8 – Tab. 4.1

$\gamma_{M2} = 1,25$ – Safety factor

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,99 \leq 1,0$$

Where:

$\sigma_{w,Ed} = 355,9$ MPa – Maximum normal stress transverse to the axis of the weld

$\sigma_{w,Rd} = 360,0$ MPa – Equivalent stress resistance

$|\sigma_{\perp}| = 81,1$ MPa – Normal stress perpendicular to the throat

$\sigma_{\perp,Rd} = 259,2$ MPa – Perpendicular stress resistance

Detailed result for Algemene plaat1 / K1-w 1 - 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0,5} = 319,0 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} = 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 89,0 \text{ MPa}$$

where:

$f_u = 360,0$ MPa – Ultimate strength

$\beta_w = 0,80$ – Correlation factor EN 1993-1-8 – Tab. 4.1

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$$\gamma_{M2} = 1,25 \quad - \text{Safety factor}$$

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,89 \leq 1,0$$

Where:

$$\sigma_{w,Ed} = 319,0 \text{ MPa} \quad - \text{Maximum normal stress transverse to the axis of the weld}$$

$$\sigma_{w,Rd} = 360,0 \text{ MPa} \quad - \text{Equivalent stress resistance}$$

$$|\sigma_{\perp}| = 89,0 \text{ MPa} \quad - \text{Normal stress perpendicular to the throat}$$

$$\sigma_{\perp,Rd} = 259,2 \text{ MPa} \quad - \text{Perpendicular stress resistance}$$

Detailed result for Algemene plaat1 / K1-w 1 - 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 352,9 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} = 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 81,4 \text{ MPa}$$

where:

$$f_u = 360,0 \text{ MPa} \quad - \text{Ultimate strength}$$

$$\beta_w = 0,80 \quad - \text{Correlation factor EN 1993-1-8 – Tab. 4.1}$$

$$\gamma_{M2} = 1,25 \quad - \text{Safety factor}$$

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,98 \leq 1,0$$

Where:

$$\sigma_{w,Ed} = 352,9 \text{ MPa} \quad - \text{Maximum normal stress transverse to the axis of the weld}$$

$$\sigma_{w,Rd} = 360,0 \text{ MPa} \quad - \text{Equivalent stress resistance}$$

$$|\sigma_{\perp}| = 81,4 \text{ MPa} \quad - \text{Normal stress perpendicular to the throat}$$

$$\sigma_{\perp,Rd} = 259,2 \text{ MPa} \quad - \text{Perpendicular stress resistance}$$

Detailed result for Algemene plaat1 / K1-w 3 - 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 352,9 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} = 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 11,7 \text{ MPa}$$

where:

$$f_u = 360,0 \text{ MPa} \quad - \text{Ultimate strength}$$

$$\beta_w = 0,80 \quad - \text{Correlation factor EN 1993-1-8 – Tab. 4.1}$$

$$\gamma_{M2} = 1,25 \quad - \text{Safety factor}$$

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,98 \leq 1,0$$

Where:

$\sigma_{w,Ed} = 352,9$ MPa – Maximum normal stress transverse to the axis of the weld

$\sigma_{w,Rd} = 360,0$ MPa – Equivalent stress resistance

$|\sigma_{\perp}| = -11,7$ MPa – Normal stress perpendicular to the throat

$\sigma_{\perp,Rd} = 259,2$ MPa – Perpendicular stress resistance

Detailed result for Algemene plaat1 / K1-w 3 - 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 352,8 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} = 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 62,8 \text{ MPa}$$

where:

$f_u = 360,0$ MPa – Ultimate strength

$\beta_w = 0,80$ – Correlation factor EN 1993-1-8 – Tab. 4.1

$\gamma_{M2} = 1,25$ – Safety factor

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,98 \leq 1,0$$

Where:

$\sigma_{w,Ed} = 352,8$ MPa – Maximum normal stress transverse to the axis of the weld

$\sigma_{w,Rd} = 360,0$ MPa – Equivalent stress resistance

$|\sigma_{\perp}| = 62,8$ MPa – Normal stress perpendicular to the throat

$\sigma_{\perp,Rd} = 259,2$ MPa – Perpendicular stress resistance

Detailed result for Algemene plaat1 / D1-w 2 - 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 353,3 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} = 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 48,6 \text{ MPa}$$

where:

$f_u = 360,0$ MPa – Ultimate strength

$\beta_w = 0,80$ – Correlation factor EN 1993-1-8 – Tab. 4.1

$\gamma_{M2} = 1,25$ – Safety factor

Stress utilization

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$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,98 \leq 1,0$$

Where:

$\sigma_{w,Ed} = 353,3$ MPa – Maximum normal stress transverse to the axis of the weld

$\sigma_{w,Rd} = 360,0$ MPa – Equivalent stress resistance

$|\sigma_{\perp}| = -48,6$ MPa – Normal stress perpendicular to the throat

$\sigma_{\perp,Rd} = 259,2$ MPa – Perpendicular stress resistance

Detailed result for Algemene plaat1 / D1-w 2 - 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 353,2 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} = 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 56,1 \text{ MPa}$$

where:

$f_u = 360,0$ MPa – Ultimate strength

$\beta_w = 0,80$ – Correlation factor EN 1993-1-8 – Tab. 4.1

$\gamma_{M2} = 1,25$ – Safety factor

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,98 \leq 1,0$$

Where:

$\sigma_{w,Ed} = 353,2$ MPa – Maximum normal stress transverse to the axis of the weld

$\sigma_{w,Rd} = 360,0$ MPa – Equivalent stress resistance

$|\sigma_{\perp}| = -56,1$ MPa – Normal stress perpendicular to the throat

$\sigma_{\perp,Rd} = 259,2$ MPa – Perpendicular stress resistance

Detailed result for Algemene plaat1 / D1-w 4 - 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 356,3 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} = 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 2,4 \text{ MPa}$$

where:

$f_u = 360,0$ MPa – Ultimate strength

$\beta_w = 0,80$ – Correlation factor EN 1993-1-8 – Tab. 4.1

$\gamma_{M2} = 1,25$ – Safety factor

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,99 \leq 1,0$$

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Where:

$\sigma_{w,Ed} = 356,3 \text{ MPa}$ – Maximum normal stress transverse to the axis of the weld

$\sigma_{w,Rd} = 360,0 \text{ MPa}$ – Equivalent stress resistance

$|\sigma_{\perp}| = 2,4 \text{ MPa}$ – Normal stress perpendicular to the throat

$\sigma_{\perp,Rd} = 259,2 \text{ MPa}$ – Perpendicular stress resistance

Detailed result for Algemene plaat1 / D1-w 4 - 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 355,9 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} = 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 7,3 \text{ MPa}$$

where:

$f_u = 360,0 \text{ MPa}$ – Ultimate strength

$\beta_w = 0,80$ – Correlation factor EN 1993-1-8 – Tab. 4.1

$\gamma_{M2} = 1,25$ – Safety factor

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,99 \leq 1,0$$

Where:

$\sigma_{w,Ed} = 355,9 \text{ MPa}$ – Maximum normal stress transverse to the axis of the weld

$\sigma_{w,Rd} = 360,0 \text{ MPa}$ – Equivalent stress resistance

$|\sigma_{\perp}| = 7,3 \text{ MPa}$ – Normal stress perpendicular to the throat

$\sigma_{\perp,Rd} = 259,2 \text{ MPa}$ – Perpendicular stress resistance

Detailed result for Algemene plaat1 / D2-w 2 - 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 352,9 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} = 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 51,0 \text{ MPa}$$

where:

$f_u = 360,0 \text{ MPa}$ – Ultimate strength

$\beta_w = 0,80$ – Correlation factor EN 1993-1-8 – Tab. 4.1

$\gamma_{M2} = 1,25$ – Safety factor

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,98 \leq 1,0$$

Where:

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$\sigma_{w,Ed} = 352,9 \text{ MPa}$ – Maximum normal stress transverse to the axis of the weld

$\sigma_{w,Rd} = 360,0 \text{ MPa}$ – Equivalent stress resistance

$|\sigma_{\perp}| = -51,0 \text{ MPa}$ – Normal stress perpendicular to the throat

$\sigma_{\perp,Rd} = 259,2 \text{ MPa}$ – Perpendicular stress resistance

Detailed result for Algemene plaat1 / D2-w 2 - 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 352,9 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} = 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 40,3 \text{ MPa}$$

where:

$f_u = 360,0 \text{ MPa}$ – Ultimate strength

$\beta_w = 0,80$ – Correlation factor EN 1993-1-8 – Tab. 4.1

$\gamma_{M2} = 1,25$ – Safety factor

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,98 \leq 1,0$$

Where:

$\sigma_{w,Ed} = 352,9 \text{ MPa}$ – Maximum normal stress transverse to the axis of the weld

$\sigma_{w,Rd} = 360,0 \text{ MPa}$ – Equivalent stress resistance

$|\sigma_{\perp}| = -40,3 \text{ MPa}$ – Normal stress perpendicular to the throat

$\sigma_{\perp,Rd} = 259,2 \text{ MPa}$ – Perpendicular stress resistance

Detailed result for Algemene plaat1 / D2-w 4 - 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 353,9 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} = 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 2,4 \text{ MPa}$$

where:

$f_u = 360,0 \text{ MPa}$ – Ultimate strength

$\beta_w = 0,80$ – Correlation factor EN 1993-1-8 – Tab. 4.1

$\gamma_{M2} = 1,25$ – Safety factor

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,98 \leq 1,0$$

Where:

$\sigma_{w,Ed} = 353,9 \text{ MPa}$ – Maximum normal stress transverse to the axis of the weld

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- $\sigma_{w,Rd} = 360,0 \text{ MPa}$ – Equivalent stress resistance
- $|\sigma_{\perp}| = 2,4 \text{ MPa}$ – Normal stress perpendicular to the throat
- $\sigma_{\perp,Rd} = 259,2 \text{ MPa}$ – Perpendicular stress resistance

Detailed result for Algemene plaat1 / D2-w 4 - 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 354,2 \text{ MPa}$$
$$\sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} = 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 4,5 \text{ MPa}$$

where:

- $f_u = 360,0 \text{ MPa}$ – Ultimate strength
- $\beta_w = 0,80$ – Correlation factor EN 1993-1-8 – Tab. 4.1
- $\gamma_{M2} = 1,25$ – Safety factor

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,98 \leq 1,0$$

Where:

- $\sigma_{w,Ed} = 354,2 \text{ MPa}$ – Maximum normal stress transverse to the axis of the weld
- $\sigma_{w,Rd} = 360,0 \text{ MPa}$ – Equivalent stress resistance
- $|\sigma_{\perp}| = -4,5 \text{ MPa}$ – Normal stress perpendicular to the throat
- $\sigma_{\perp,Rd} = 259,2 \text{ MPa}$ – Perpendicular stress resistance

Detailed result for Algemene plaat1 / K2-w 1 - 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 352,8 \text{ MPa}$$
$$\sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} = 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 133,6 \text{ MPa}$$

where:

- $f_u = 360,0 \text{ MPa}$ – Ultimate strength
- $\beta_w = 0,80$ – Correlation factor EN 1993-1-8 – Tab. 4.1
- $\gamma_{M2} = 1,25$ – Safety factor

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,98 \leq 1,0$$

Where:

- $\sigma_{w,Ed} = 352,8 \text{ MPa}$ – Maximum normal stress transverse to the axis of the weld
- $\sigma_{w,Rd} = 360,0 \text{ MPa}$ – Equivalent stress resistance

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$|\sigma_{\perp}| = 133,6 \text{ MPa}$ – Normal stress perpendicular to the throat

$\sigma_{\perp,Rd} = 259,2 \text{ MPa}$ – Perpendicular stress resistance

Detailed result for Algemene plaat1 / K2-w 1 - 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 290,5 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} = 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 10,6 \text{ MPa}$$

where:

$f_u = 360,0 \text{ MPa}$ – Ultimate strength

$\beta_w = 0,80$ – Correlation factor EN 1993-1-8 – Tab. 4.1

$\gamma_{M2} = 1,25$ – Safety factor

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,81 \leq 1,0$$

Where:

$\sigma_{w,Ed} = 290,5 \text{ MPa}$ – Maximum normal stress transverse to the axis of the weld

$\sigma_{w,Rd} = 360,0 \text{ MPa}$ – Equivalent stress resistance

$|\sigma_{\perp}| = 10,6 \text{ MPa}$ – Normal stress perpendicular to the throat

$\sigma_{\perp,Rd} = 259,2 \text{ MPa}$ – Perpendicular stress resistance

Detailed result for Algemene plaat1 / K2-w 3 - 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 283,2 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} = 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 10,8 \text{ MPa}$$

where:

$f_u = 360,0 \text{ MPa}$ – Ultimate strength

$\beta_w = 0,80$ – Correlation factor EN 1993-1-8 – Tab. 4.1

$\gamma_{M2} = 1,25$ – Safety factor

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,79 \leq 1,0$$

Where:

$\sigma_{w,Ed} = 283,2 \text{ MPa}$ – Maximum normal stress transverse to the axis of the weld

$\sigma_{w,Rd} = 360,0 \text{ MPa}$ – Equivalent stress resistance

$|\sigma_{\perp}| = 10,8 \text{ MPa}$ – Normal stress perpendicular to the throat

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$$\sigma_{\perp,Rd} = 259,2 \text{ MPa} \quad - \text{ Perpendicular stress resistance}$$

Detailed result for Algemene plaat1 / K2-w 3 - 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 360,0 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 341,7 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0,9 f_u / \gamma_{M2} = 259,2 \text{ MPa} \geq |\sigma_{\perp}| = 132,5 \text{ MPa}$$

where:

$$f_u = 360,0 \text{ MPa} \quad - \text{ Ultimate strength}$$

$$\beta_w = 0,80 \quad - \text{ Correlation factor EN 1993-1-8 – Tab. 4.1}$$

$$\gamma_{M2} = 1,25 \quad - \text{ Safety factor}$$

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}} ; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0,95 \leq 1,0$$

Where:

$$\sigma_{w,Ed} = 341,7 \text{ MPa} \quad - \text{ Maximum normal stress transverse to the axis of the weld}$$

$$\sigma_{w,Rd} = 360,0 \text{ MPa} \quad - \text{ Equivalent stress resistance}$$

$$|\sigma_{\perp}| = 132,5 \text{ MPa} \quad - \text{ Normal stress perpendicular to the throat}$$

$$\sigma_{\perp,Rd} = 259,2 \text{ MPa} \quad - \text{ Perpendicular stress resistance}$$

Buckling

Buckling analysis was not calculated.

Cost estimation

Steel

Steel grade	Total weight [kg]	Unit cost [€/kg]	Cost [€]
S 235	40,04	2,00	80,09

Bolts

Bolt assembly	Total weight [kg]	Unit cost [€/kg]	Cost [€]
M24 8.8	4,42	5,00	22,10

Welds

Weld type	Throat thickness [mm]	Leg size [mm]	Total weight [kg]	Unit cost [€/kg]	Cost [€]
Double fillet	6,0	8,5	1,30	40,00	52,12

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Fillet rear	5,0	7,1	0,10	40,00	4,08
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Hole drilling

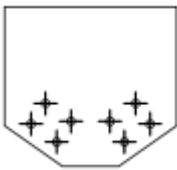
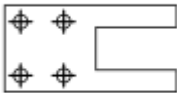
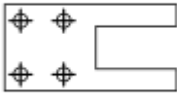
Bolt assembly cost [€]	Percentage of bolt assembly cost [%]	Cost [€]
22,10	30,0	6,63

Cost summary

Cost estimation summary	Cost [€]
Total estimated cost	165,02

Bill of material

Manufacturing operations

Name	Plates [mm]	Shape	Nr.	Welds [mm]	Length [mm]	Bolts	Nr.
Algemene plaat1	P15,0x550,0-510,0 (S 235)		1			M24 8.8	8
Gesneden plaat1	P16,0x320,0-160,0 (S 235)		1	Double fillet: a = 6,0	300,0	M24 8.8	4
Gesneden plaat2	P16,0x320,0-160,0 (S 235)		1	Double fillet: a = 6,0	300,0	M24 8.8	4
CUT1				Fillet: a = 6,0	2200,0		
CUT3							
CUT4							
CUT5				Fillet: a = 6,0	605,4		
CUT6				Fillet: a = 6,0	605,4		
CUT7							
CUT8				Fillet: a = 5,0	520,0		

Welds

Type	Material	Throat thickness [mm]	Leg size [mm]	Length [mm]
Double fillet	S 235	6,0	8,5	600,0
Fillet	S 235	6,0	8,5	3410,8

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Fillet	S 235	5,0	7,1	520,0
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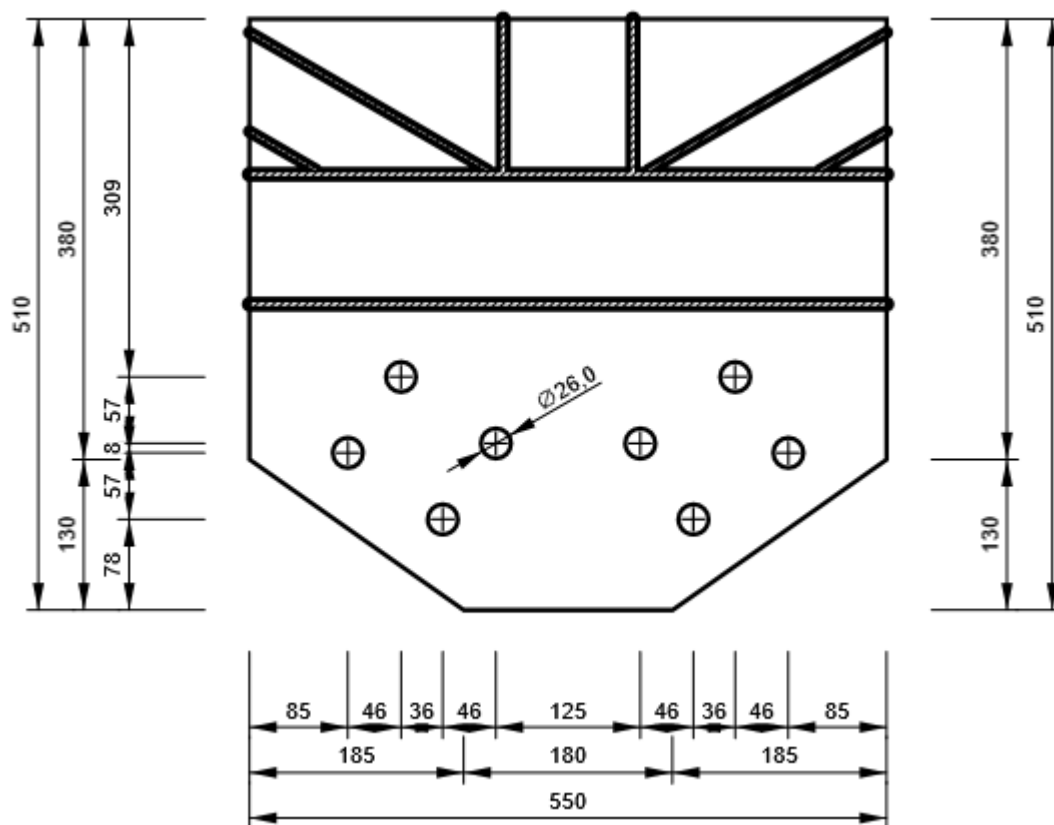
Bolts

Name	Grip length [mm]	Count
M24 8.8	31	8

Drawing

Algemene plaat1

P15,0x510-550 (S 235)



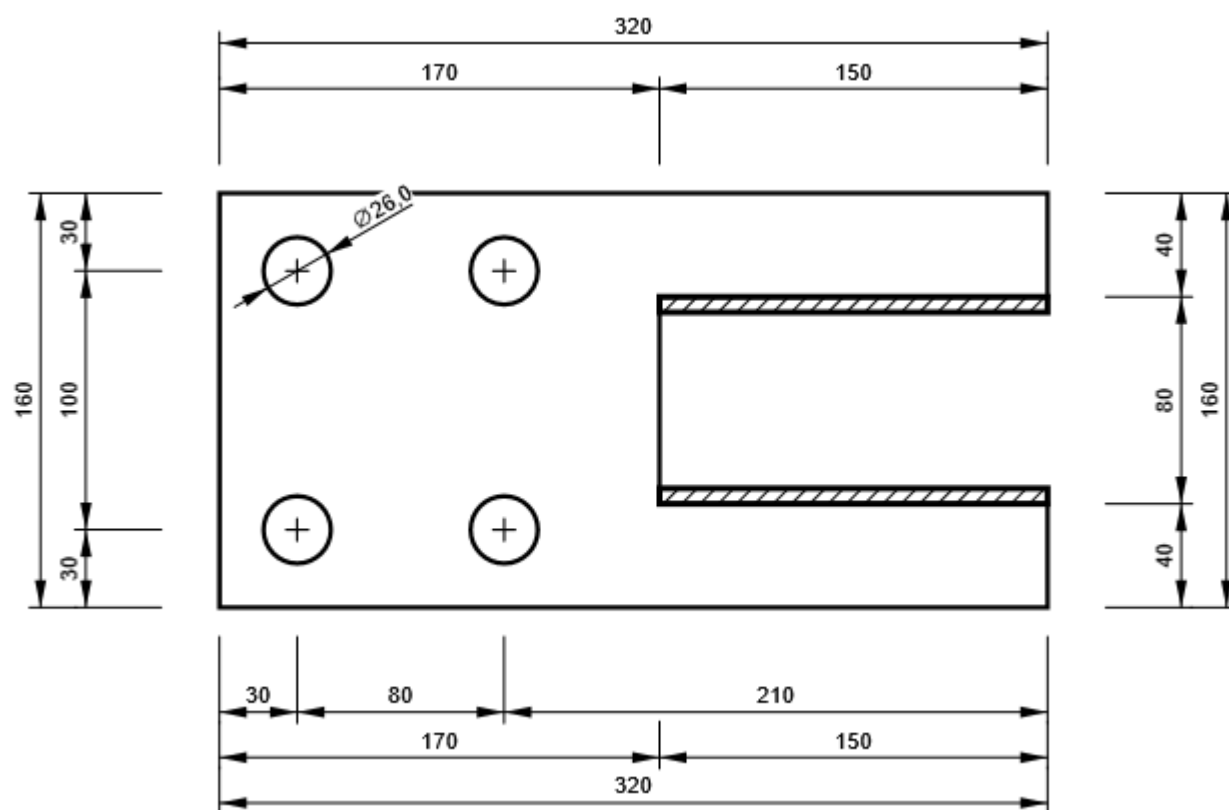
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Gesneden plaat1

P16,0x160-320 (S 235)



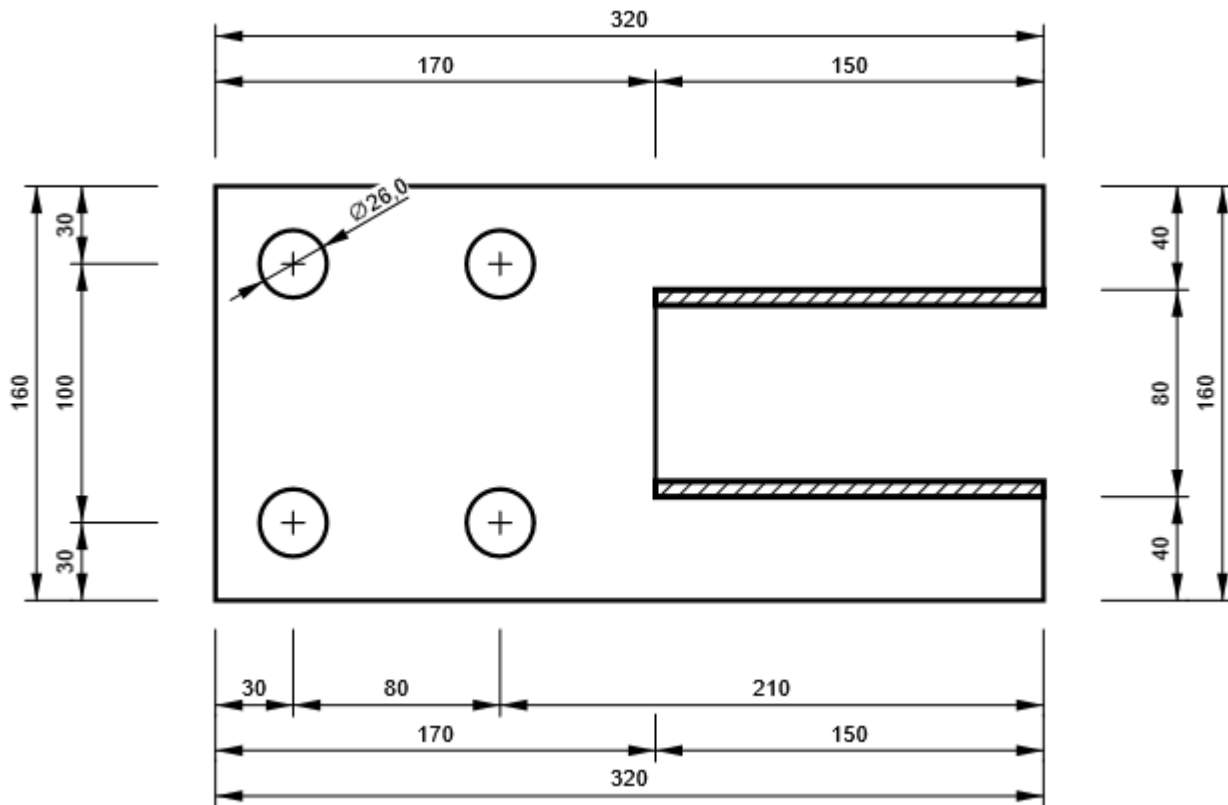
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Gesneden plaat2

P16,0x160-320 (S 235)



Code settings

Item	Value	Unit	Reference
Safety factor γ_{M0}	1,00	-	EN 1993-1-1: 6.1
Safety factor γ_{M1}	1,00	-	EN 1993-1-1: 6.1
Safety factor γ_{M2}	1,25	-	EN 1993-1-1: 6.1
Safety factor γ_{M3}	1,25	-	EN 1993-1-8: 2.2
Safety factor γ_c	1,50	-	EN 1992-1-1: 2.4.2.4
Safety factor γ_{Inst}	1,20	-	EN 1992-4: Table 4.1
Joint coefficient β_j	0,67	-	EN 1993-1-8: 6.2.5
Effective area - influence of mesh size	0,10	-	
Friction coefficient - concrete	0,25	-	EN 1993-1-8
Friction coefficient in slip-resistance	0,30	-	EN 1993-1-8 tab 3.7
Limit plastic strain	0,05	-	EN 1993-1-5
Detailing	No		
Distance between bolts [d]	2,20	-	EN 1993-1-8: tab 3.3
Distance between bolts and edge [d]	1,20	-	EN 1993-1-8: tab 3.3
Concrete breakout resistance check	Both		EN 1992-4: 7.2.1.4 and 7.2.2.5
Use calculated α_b in bearing check.	Yes		EN 1993-1-8: tab 3.4
Cracked concrete	Yes		EN 1992-4
Local deformation check	No		CIDECT DG 1, 3 - 1.1
Local deformation limit	0,03	-	CIDECT DG 1, 3 - 1.1
Geometrical nonlinearity (GMNA)	Yes		Analysis with large deformations for hollow section joints

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Braced system	No		EN 1993-1-8: 5.2.2.5
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