Project:
Project no:
Author:

Project data

Project name	
Project number	
Author	
Description	
Date	8/29/2023
Code	AISC/ACI

Material

Steel	A572 Gr.50, A36
Concrete	4000 psi, 4000

Project item CON1

Design

Name	CON1
Description	
Analysis	Stress, strain/ loads in equilibrium
Design code	AISC 360-22 (LRFD) / ACI 318-14

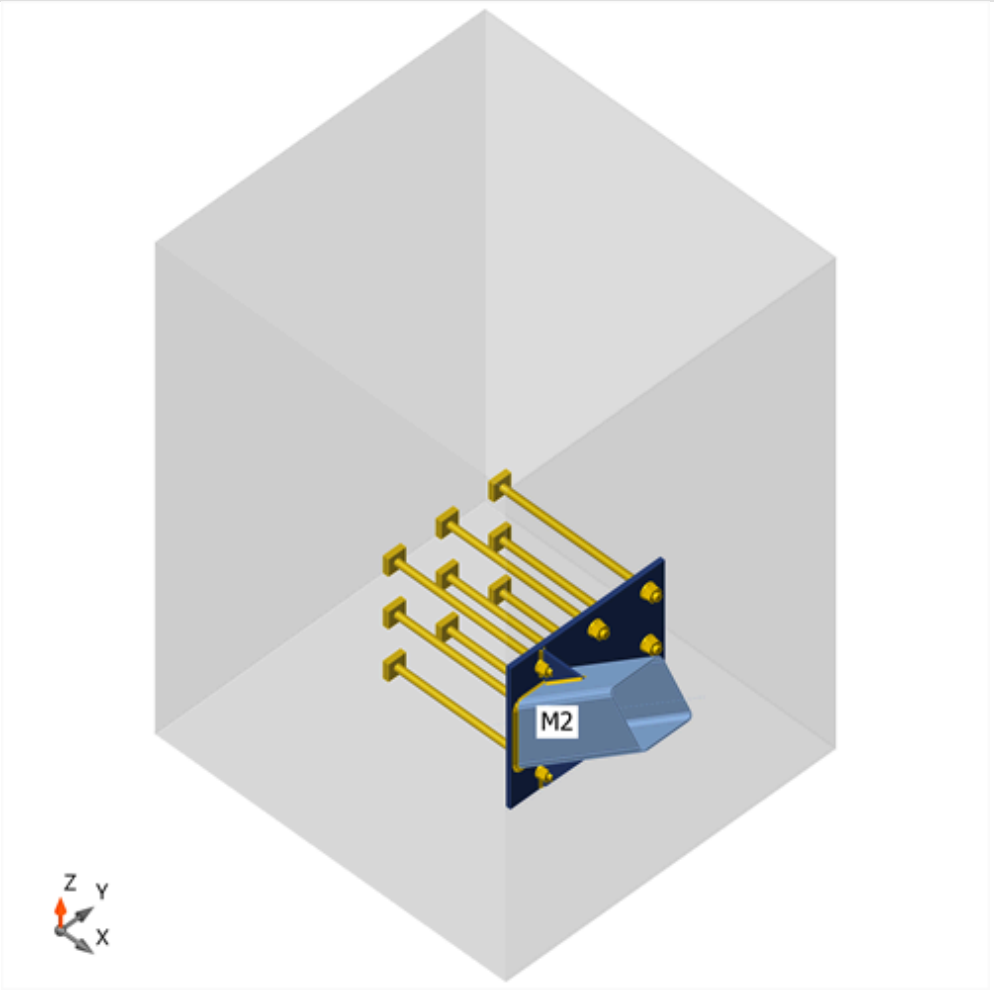
Members

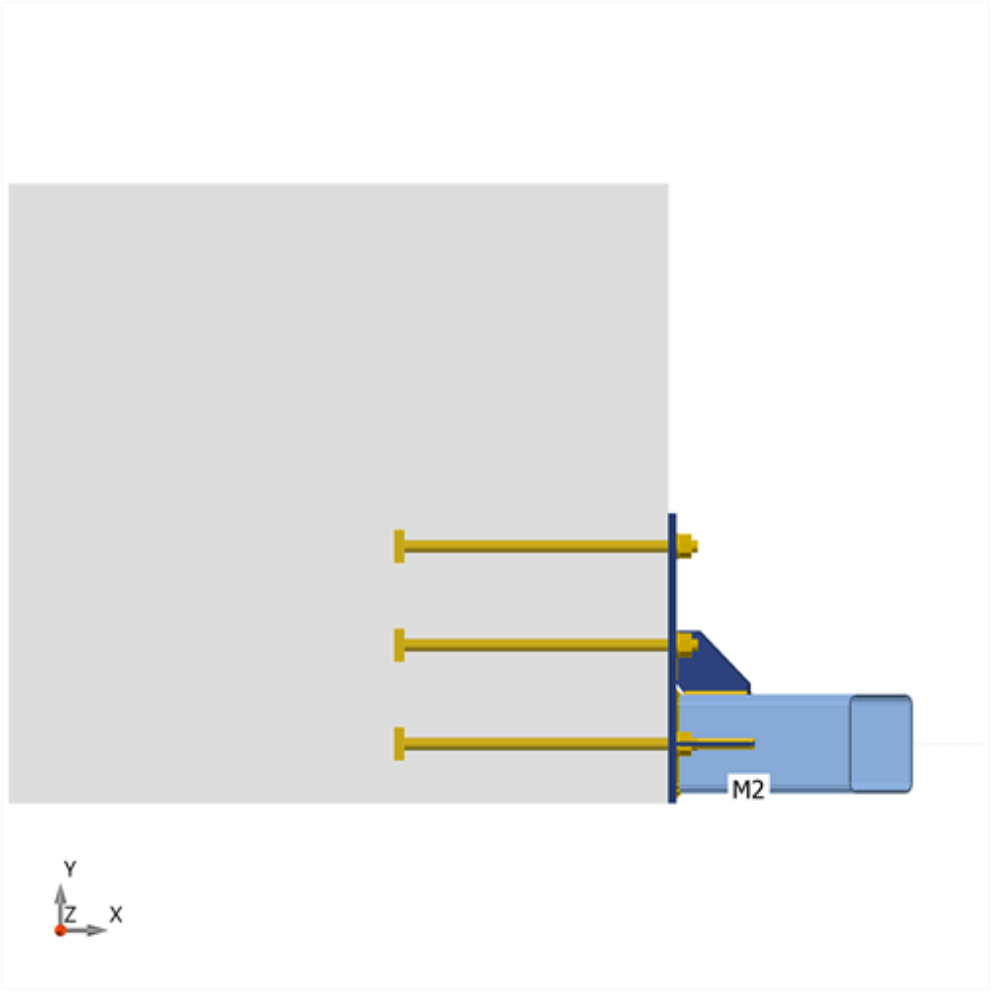
Geometry

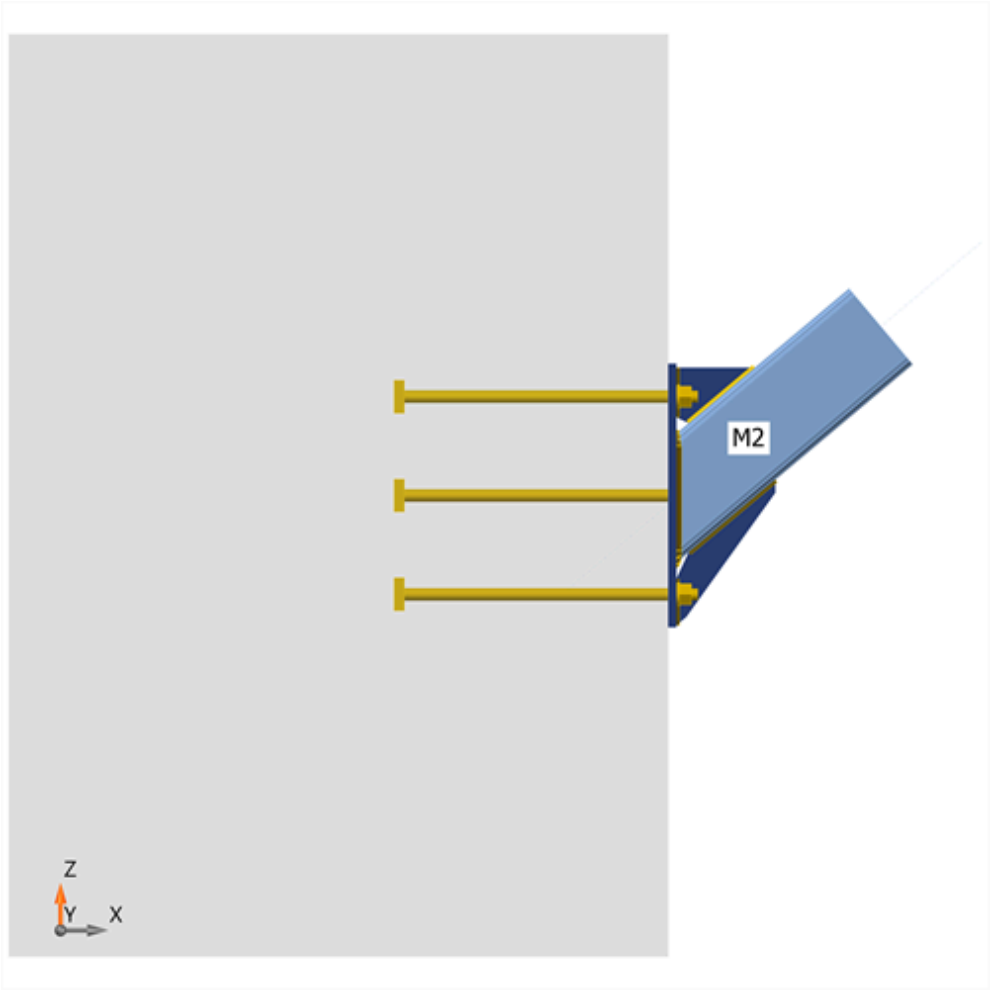
Name	Cross-section	β – Direction [°]	γ - Pitch [°]	α - Rotation [°]	Offset ex [mm]	Offset ey [mm]	Offset ez [mm]
M2	3 - RHS150x150	0.0	40.0	0.0	0	0	-200

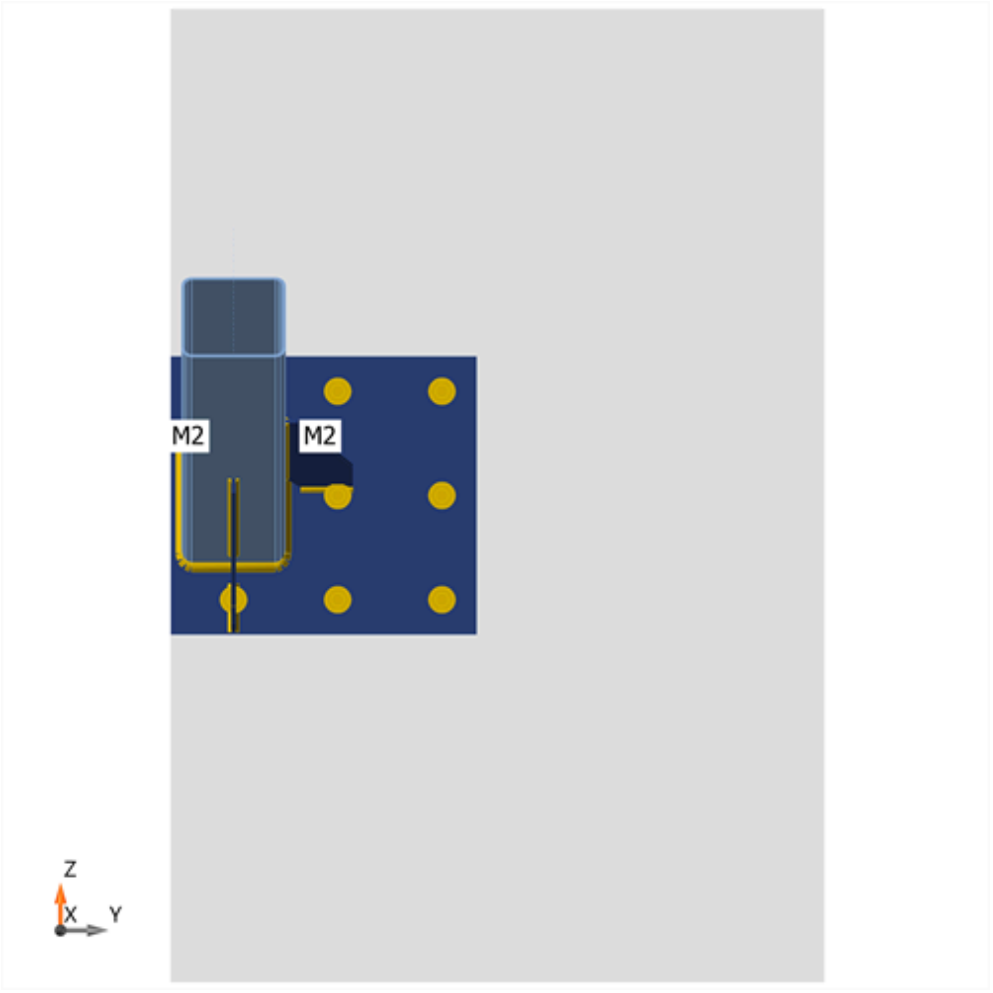
Supports and forces

Name	Support	Forces in	X [mm]
M2 / end		Bolts	0




M2
Y
Z
X

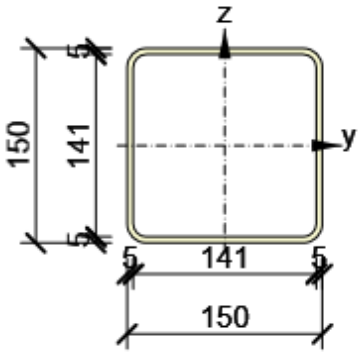

M2
Z
Y
X



Cross-sections

Name	Material
3 - RHS150x150	A36

Cross-sections

Name	Material	Drawing
3 - RHS150x150	A36	

Anchors

Name	Diameter [mm]	f_y [MPa]	f_u [MPa]	Gross area [mm^2]
3/4 F1554 Gr.36	19	248.2	400.0	285

Load effects (forces in equilibrium)

Name	Member	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
LE1	M2 / End	115.0	20.0	-1.0	0.0	7.0	-7.0
LE2	M2 / End	100.0	-20.0	-1.0	0.0	6.3	-6.3

Unbalanced forces

Name	X [kN]	Y [kN]	Z [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
LE1	88.7	20.0	73.2	7.6	-16.0	-2.8
LE2	77.2	-20.0	63.5	1.0	-13.7	-7.4

Foundation block

Item	Value	Unit
CB 1		
Dimensions	1400 x 940	mm
Depth	1000	mm
Anchor	3/4 F1554 Gr.36	
Anchoring length	400	mm
Shear force transfer	Anchors	

Check

Summary

Name	Value	Check status
Analysis	100.0%	OK
Plates	0.4 < 5.0%	OK
Loc. deformation	0.4 < 3%	OK
Anchors	61.3 < 100%	OK
Welds	75.4 < 100%	OK
Concrete block	5.1 < 100%	OK
Buckling	Not calculated	
GMNA	Calculated	

Plates

Name	t_p [mm]	Loads	σ_{Ed} [MPa]	ε_{Pl} [%]	$\sigma_{c,Ed}$ [MPa]	Status
M2	4.75	LE1	224.2	0.4	0.0	OK
SP1	12.70	LE1	172.1	0.0	0.0	OK
SP2	6.35	LE1	166.0	0.0	0.0	OK
RIB1	6.35	LE2	28.0	0.0	0.0	OK
RIB2	6.35	LE1	221.0	0.1	0.0	OK

Design data

Material	F_y [MPa]	ε_{lim} [%]
A36	248.2	5.0

Detailed result for M2

Design values used in the analysis

$\phi F_y =$ 223.4 MPa

Where:

$F_y = 248.2$ MPa – characteristic yield strength

$\phi = 0.90$ – resistance factor for steel material AISC 360-22 – B3.1

Detailed result for SP1

Design values used in the analysis

$\phi F_y =$ 223.4 MPa

Where:

$F_y = 248.2$ MPa – characteristic yield strength

$\phi = 0.90$ – resistance factor for steel material AISC 360-22 – B3.1

Detailed result for SP2

Design values used in the analysis

$\phi F_y =$ 223.4 MPa

Where:

$F_y = 248.2$ MPa – characteristic yield strength

$\phi = 0.90$ – resistance factor for steel material AISC 360-22 – B3.1

Detailed result for RIB1

Design values used in the analysis

$\phi F_y =$ 223.4 MPa

Where:

$F_y = 248.2$ MPa – characteristic yield strength

$\phi = 0.90$ – resistance factor for steel material AISC 360-22 – B3.1

Detailed result for RIB2

Design values used in the analysis

$\phi F_y =$ 223.4 MPa

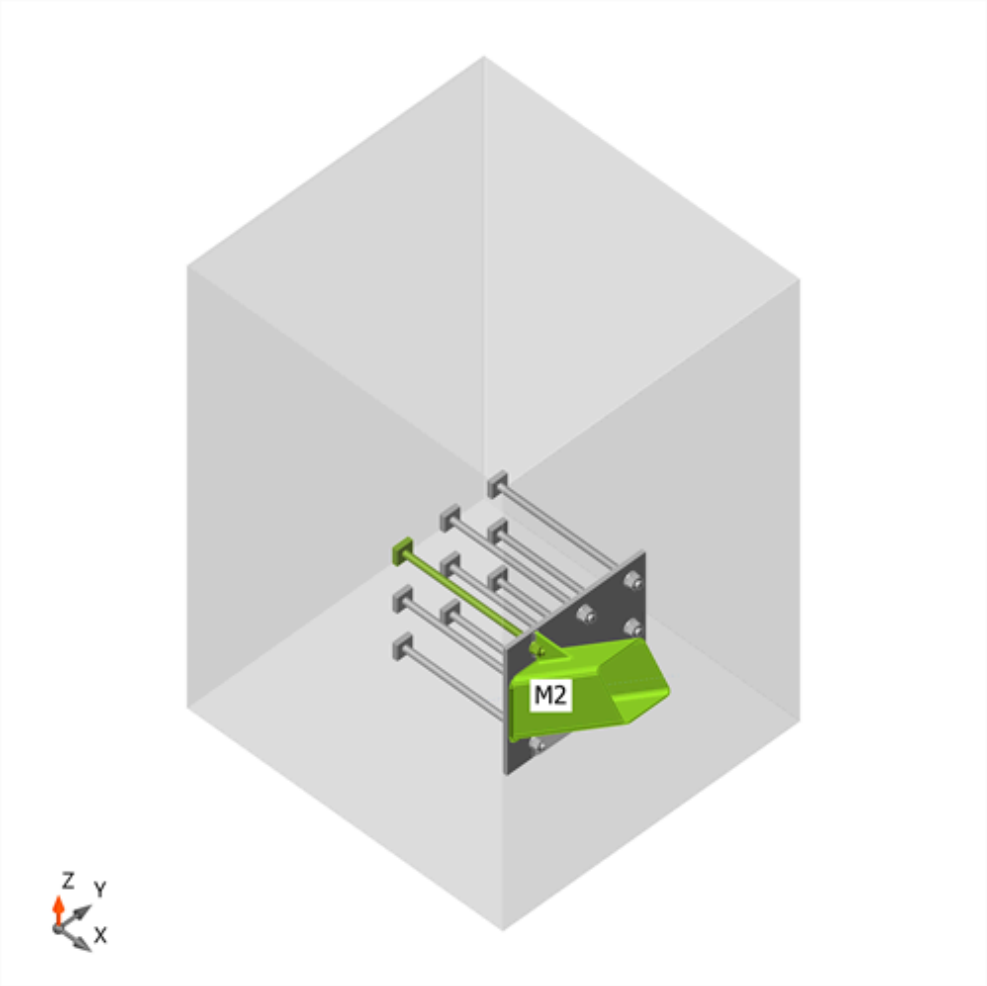
Where:

$F_y = 248.2$ MPa – characteristic yield strength

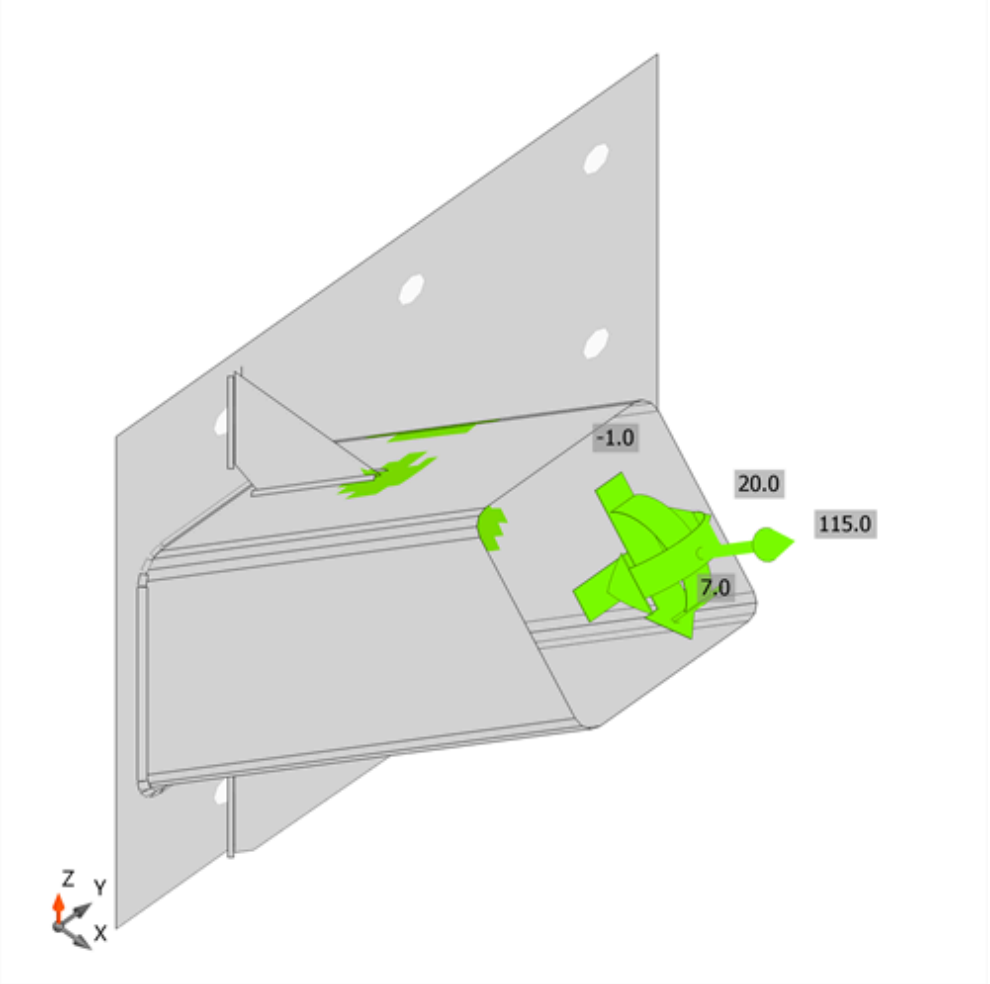
$\phi = 0.90$ – resistance factor for steel material AISC 360-22 – B3.1

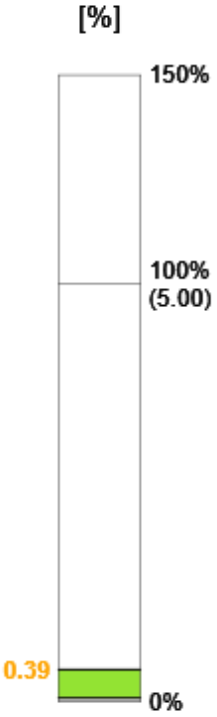
Loc. deformation

Name	d_0 [mm]	Loads	δ [mm]	δ_{lim} [mm]	δ/d_0 [%]	Check status
M2	150	LE1	1	5	0.4	OK

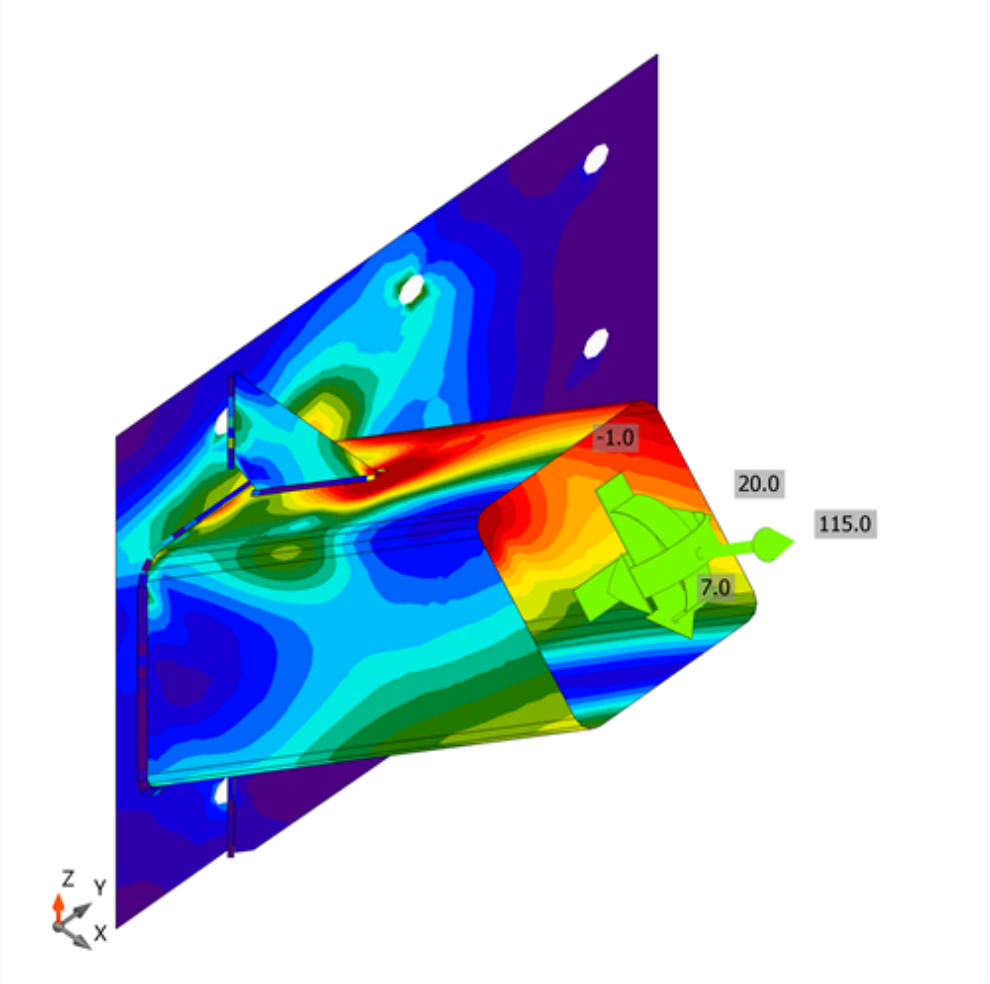


Overall check, LE1



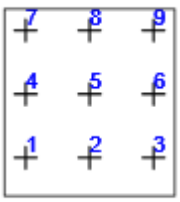


Strain check, LE1



Equivalent stress, LE1

Anchors

Shape	Item	Loads	N_f [kN]	V [kN]	ϕN_p [kN]	ϕN_{sb} [kN]	Ut_t [%]	Ut_s [%]	Ut_{ts} [%]	Detailing	Status
	A1	LE1	35.0	13.2	342.1	132.2	58.0	39.2	61.3	OK	OK
	A2	LE1	28.3	12.0	342.1	132.2	46.9	35.7	46.3	OK	OK
	A3	LE1	3.7	11.5	342.1	132.2	6.2	34.2	17.7	OK	OK
	A4	LE1	11.5	10.0	342.1	132.2	19.1	29.7	19.6	OK	OK
	A5	LE1	27.6	8.6	342.1	132.2	45.8	25.4	37.4	OK	OK
	A6	LE2	4.3	8.8	342.1	132.2	7.1	26.2	12.0	OK	OK
	A7	LE1	0.0	7.2	342.1	0.0	0.0	21.4	7.7	OK	OK
	A8	LE1	0.0	5.0	342.1	0.0	0.0	14.8	4.1	OK	OK
	A9	LE2	0.1	6.5	342.1	132.2	0.2	19.2	6.4	OK	OK

Design data

Grade	ϕN_{sa} [kN]	ϕV_{sa} [kN]
3/4 F1554 Gr.36 - 1	60.3	33.6

Detailed result for A1

Concrete splitting failure during installation should be evaluated by ACI 355.2 requirements.

Anchor tensile resistance (ACI 318-14 – 17.4.1)

$\phi N_{sa} = \phi \cdot A_{se,N} \cdot f_{uta} =$ 60.3 kN ≥ $N_f =$ 35.0 kN

Where:

$\phi =$ 0.70 – resistance factor

$A_{se,N} =$ 215 mm^2 – tensile stress area

$f_{uta} =$ 400.0 MPa – specified tensile strength of anchor steel:

- $f_{uta} = \min(860\ \text{MPa}, 1.9 \cdot f_{ya},\ f_u)$, where:
  - $f_{ya} =$ 248.2 MPa – specified yield strength of anchor steel
  - $f_u =$ 400.0 MPa – specified ultimate strength of anchor steel

Concrete pullout resistance (ACI 318-14 – 17.4.3)

$\phi N_{pn} = \phi \cdot \Psi_{c,P} \cdot N_p =$ 342.1 kN ≥ $N_f =$ 35.0 kN

Where:

$\phi =$ 0.70 – resistance factor

$\Psi_{c,P} =$ 1.00 – modification factor for concrete condition

$N_p =$ 488.7 kN – basic concrete pullout strength for headed anchor:

- $N_{pr} = 8 \cdot A_{brg} \cdot f'_c$, where:
  - $A_{brg} =$ 2215 mm^2 – bearing area of the head of stud or anchor bolt
  - $f'_c =$ 27.6 MPa – concrete compressive strength

Concrete sideface blowout resistance (ACI 318-14 – 17.4.4)

$\phi N_{sb} = r_c \cdot N_{sbg} =$ 132.2 kN ≥ $N_f =$ 35.0 kN

Where:

$r_c =$ 0.64 – reduction factor for anchor close to an edge or multiple anchors with small spacing:

- $r_c = \min(\frac{1+\frac{c_{a2}}{c_{a1}}}{4}, \frac{1+\frac{s}{6 \cdot c_{a1}}}{2}),\ 0.5 \le r_c \le 1$, where:
  - $c_{a1} =$ 90 mm – shorter distance from an anchor to an edge
  - $c_{a2} =$ 550 mm – longer distance from an anchor to an edge
  - $s =$ 150 mm – spacing between anchors

$N_{sbg} =$ 206.9 kN – concrete side-face blowout strength of headed anchor in tension:

- $N_{sb} = \phi \cdot 13.0 \cdot c_{a1} \cdot \sqrt{A_{brg}} \cdot \sqrt{f'_c}$, where:
  - $A_{brg} =$ 2215 mm^2 – bearing area of the head of stud or anchor bolt
  - $f'_c =$ 27.6 MPa – concrete compressive strength
  - $\phi =$ 0.70 – resistance factor

Shear resistance (ACI 318-14 – 17.5.1)

$\phi V_{sa} = \phi \cdot 0.6 \cdot A_{se,V} \cdot f_{uta} =$ 33.6 kN ≥ $V =$ 13.2 kN

Where:

$\phi =$ 0.65 – resistance factor

$A_{se,V} =$ 215 mm^2 – tensile stress area

$f_{uta} =$ 400.0 MPa – specified tensile strength of anchor steel:

- $f_{uta} = \min(860\ \text{MPa}, 1.9 \cdot f_{ya},\ f_u)$, where:
  - $f_{ya} =$ 248.2 MPa – specified yield strength of anchor steel
  - $f_u =$ 400.0 MPa – specified ultimate strength of anchor steel

Interaction of tensile and shear forces (ACI 318-14 – R17.6)

${U_{tt}}^{5/3} + {U_{ts}}^{5/3} =$ 0.61 ≤ 1.0

Where:

$U_{tt} =$ 0.58 – maximum ratio of factored tensile force and tensile resistance determined from all appropriate failure modes

$U_{ts} =$ 0.39 – maximum ratio of factored shear force and shear resistance determined from all appropriate failure modes

Supplementary reinforcement (ACI 318-14 – 17.4.2.9; ACI 318-14 – 17.5.2.9)

Supplementary reinforcement should resist force of 110.0 kN in tension and 75.8 kN in shear. Only current load effect considered.

Detailed result for A2

Concrete splitting failure during installation should be evaluated by ACI 355.2 requirements.

Anchor tensile resistance (ACI 318-14 – 17.4.1)

$\phi N_{sa} = \phi \cdot A_{se,N} \cdot f_{uta} =$ 60.3 kN ≥ $N_f =$ 28.3 kN

Where:

$\phi =$ 0.70 – resistance factor

$A_{se,N} =$ 215 mm^2 – tensile stress area

$f_{uta} =$ 400.0 MPa – specified tensile strength of anchor steel:

- $f_{uta} = \min(860\ \text{MPa}, 1.9 \cdot f_{ya},\ f_u)$, where:
  - $f_{ya} =$ 248.2 MPa – specified yield strength of anchor steel
  - $f_u =$ 400.0 MPa – specified ultimate strength of anchor steel

Concrete pullout resistance (ACI 318-14 – 17.4.3)

$\phi N_{pn} = \phi \cdot \Psi_{c,P} \cdot N_p =$ 342.1 kN ≥ $N_f =$ 28.3 kN

Where:

$\phi =$ 0.70 – resistance factor

$\Psi_{c,P} =$ 1.00 – modification factor for concrete condition

$N_p =$ 488.7 kN – basic concrete pullout strength for headed anchor:

- $N_{pr} = 8 \cdot A_{brg} \cdot f'_c$, where:
  - $A_{brg} =$ 2215 mm^2 – bearing area of the head of stud or anchor bolt
  - $f'_c =$ 27.6 MPa – concrete compressive strength

Concrete sideface blowout resistance (ACI 318-14 – 17.4.4)

$\phi N_{sb} = r_c \cdot N_{sbg} =$ 132.2 kN ≥ $N_f =$ 28.3 kN

Where:

$r_c =$ 0.64 – reduction factor for anchor close to an edge or multiple anchors with small spacing:

- $r_c = \min(\frac{1+\frac{c_{a2}}{c_{a1}}}{4}, \frac{1+\frac{s}{6 \cdot c_{a1}}}{2}),\ 0.5 \le r_c \le 1$, where:
  - $c_{a1} =$ 90 mm – shorter distance from an anchor to an edge
  - $c_{a2} =$ 550 mm – longer distance from an anchor to an edge
  - $s =$ 150 mm – spacing between anchors

$N_{sbg} =$ 206.9 kN – concrete side-face blowout strength of headed anchor in tension:

- $N_{sb} = \phi \cdot 13.0 \cdot c_{a1} \cdot \sqrt{A_{bgr}} \cdot \sqrt{f'_c}$, where:
  - $A_{bgr} =$ 2215 mm^2 – bearing area of the head of stud or anchor bolt
  - $f'_c =$ 27.6 MPa – concrete compressive strength
  - $\phi =$ 0.70 – resistance factor

Shear resistance (ACI 318-14 – 17.5.1)

$\phi V_{sa} = \phi \cdot 0.6 \cdot A_{se,V} \cdot f_{uta} =$ 33.6 kN ≥ $V =$ 12.0 kN

Where:

$\phi =$ 0.65 – resistance factor

$A_{se,V} =$ 215 mm^2 – tensile stress area

$f_{uta} =$ 400.0 MPa – specified tensile strength of anchor steel:

- $f_{uta} = \min(860\ \text{MPa}, 1.9 \cdot f_{ya},\ f_u)$, where:
  - $f_{ya} =$ 248.2 MPa – specified yield strength of anchor steel
  - $f_u =$ 400.0 MPa – specified ultimate strength of anchor steel

Interaction of tensile and shear forces (ACI 318-14 – R17.6)

$$U_{tt}{}^{5/3} + U_{ts}{}^{5/3} = \quad 0.46 \quad \leq \quad 1.0$$

Where:

$U_{tt} = 0.47$ – maximum ratio of factored tensile force and tensile resistance determined from all appropriate failure modes

$U_{ts} = 0.36$ – maximum ratio of factored shear force and shear resistance determined from all appropriate failure modes

Supplementary reinforcement (ACI 318-14 – 17.4.2.9; ACI 318-14 – 17.5.2.9)

Supplementary reinforcement should resist force of 110.0 kN in tension and 75.8 kN in shear. Only current load effect considered.

Detailed result for A3

Concrete splitting failure during installation should be evaluated by ACI 355.2 requirements.

Anchor tensile resistance (ACI 318-14 – 17.4.1)

$$\phi N_{sa} = \phi \cdot A_{se,N} \cdot f_{uta} = \quad 60.3 \quad \text{kN} \quad \geq \quad N_f = \quad 3.7 \quad \text{kN}$$

Where:

$\phi = 0.70$ – resistance factor

$A_{se,N} = 215$ mm^2 – tensile stress area

$f_{uta} = 400.0$ MPa – specified tensile strength of anchor steel:

- $f_{uta} = \min(860 \text{ MPa}, 1.9 \cdot f_{ya}, \ f_u)$, where:
  - $f_{ya} =$ 248.2 MPa – specified yield strength of anchor steel
  - $f_u =$ 400.0 MPa – specified ultimate strength of anchor steel

Concrete pullout resistance (ACI 318-14 – 17.4.3)

$$\phi N_{pn} = \phi \cdot \Psi_{c,P} \cdot N_p = \quad 342.1 \quad \text{kN} \quad \geq \quad N_f = \quad 3.7 \quad \text{kN}$$

Where:

$\phi = 0.70$ – resistance factor

$\Psi_{c,P} = 1.00$ – modification factor for concrete condition

$N_p = 488.7$ kN – basic concrete pullout strength for headed anchor:

- $N_{pr} = 8 \cdot A_{brg} \cdot f'_c$, where:
  - $A_{brg} =$ 2215 mm^2 – bearing area of the head of stud or anchor bolt
  - $f'_c =$ 27.6 MPa – concrete compressive strength

Concrete sideface blowout resistance (ACI 318-14 – 17.4.4)

$\phi N_{sb} = r_c \cdot N_{sbg} =$ 132.2 kN ≥ $N_f =$ 3.7 kN

Where:

$r_c =$ 0.64 – reduction factor for anchor close to an edge or multiple anchors with small spacing:

- $r_c = \min(\frac{1+\frac{c_{a2}}{c_{a1}}}{4}, \frac{1+\frac{s}{6 \cdot c_{a1}}}{2}),\ 0.5 \le r_c \le 1$, where:
  - $c_{a1} =$ 90 mm – shorter distance from an anchor to an edge
  - $c_{a2} =$ 550 mm – longer distance from an anchor to an edge
  - $s =$ 150 mm – spacing between anchors

$N_{sbg} =$ 206.9 kN – concrete side-face blowout strength of headed anchor in tension:

- $N_{sb} = \phi \cdot 13.0 \cdot c_{a1} \cdot \sqrt{A_{bgr}} \cdot \sqrt{f'_c}$, where:
  - $A_{bgr} =$ 2215 mm^2 – bearing area of the head of stud or anchor bolt
  - $f'_c =$ 27.6 MPa – concrete compressive strength
  - $\phi =$ 0.70 – resistance factor

Shear resistance (ACI 318-14 – 17.5.1)

$\phi V_{sa} = \phi \cdot 0.6 \cdot A_{se,V} \cdot f_{uta} =$ 33.6 kN ≥ $V =$ 11.5 kN

Where:

$\phi =$ 0.65 – resistance factor

$A_{se,V} =$ 215 mm^2 – tensile stress area

$f_{uta} =$ 400.0 MPa – specified tensile strength of anchor steel:

- $f_{uta} = \min(860\ \text{MPa}, 1.9 \cdot f_{ya},\ f_u)$, where:
  - $f_{ya} =$ 248.2 MPa – specified yield strength of anchor steel
  - $f_u =$ 400.0 MPa – specified ultimate strength of anchor steel

Interaction of tensile and shear forces (ACI 318-14 – R17.6)

${U_{tt}}^{5/3} + {U_{ts}}^{5/3} =$ 0.18 ≤ 1.0

Where:

$U_{tt} =$ 0.06 – maximum ratio of factored tensile force and tensile resistance determined from all appropriate failure modes

$U_{ts} =$ 0.34 – maximum ratio of factored shear force and shear resistance determined from all appropriate failure modes

Supplementary reinforcement (ACI 318-14 – 17.4.2.9; ACI 318-14 – 17.5.2.9)

Supplementary reinforcement should resist force of 110.0 kN in tension and 75.8 kN in shear. Only current load effect considered.

Detailed result for A4

Concrete splitting failure during installation should be evaluated by ACI 355.2 requirements.

Anchor tensile resistance (ACI 318-14 – 17.4.1)

$\phi N_{sa} = \phi \cdot A_{se,N} \cdot f_{uta} =$ 60.3 kN ≥ $N_f =$ 11.5 kN

Where:

$\phi =$ 0.70 – resistance factor

$A_{se,N} =$ 215 mm^2 – tensile stress area

$f_{uta} =$ 400.0 MPa – specified tensile strength of anchor steel:

- $f_{uta} = \min(860\ \text{MPa}, 1.9 \cdot f_{ya},\ f_u)$, where:
  - $f_{ya} =$ 248.2 MPa – specified yield strength of anchor steel
  - $f_u =$ 400.0 MPa – specified ultimate strength of anchor steel

Concrete pullout resistance (ACI 318-14 – 17.4.3)

$\phi N_{pn} = \phi \cdot \Psi_{c,P} \cdot N_p =$ 342.1 kN ≥ $N_f =$ 11.5 kN

Where:

$\phi =$ 0.70 – resistance factor

$\Psi_{c,P} =$ 1.00 – modification factor for concrete condition

$N_p =$ 488.7 kN – basic concrete pullout strength for headed anchor:

- $N_{pr} = 8 \cdot A_{brg} \cdot f'_c$, where:
  - $A_{brg} =$ 2215 mm^2 – bearing area of the head of stud or anchor bolt
  - $f'_c =$ 27.6 MPa – concrete compressive strength

Concrete sideface blowout resistance (ACI 318-14 – 17.4.4)

$\phi N_{sb} = r_c \cdot N_{sbg} =$ 132.2 kN ≥ $N_f =$ 11.5 kN

Where:

$r_c =$ 0.64 – reduction factor for anchor close to an edge or multiple anchors with small spacing:

- $r_c = \min(\frac{1+\frac{c_{a2}}{c_{a1}}}{4}, \frac{1+\frac{s}{6 \cdot c_{a1}}}{2}),\ 0.5 \le r_c \le 1$, where:
  - $c_{a1} =$ 90 mm – shorter distance from an anchor to an edge
  - $c_{a2} =$ 550 mm – longer distance from an anchor to an edge
  - $s =$ 150 mm – spacing between anchors

$N_{sbg} =$ 206.9 kN – concrete side-face blowout strength of headed anchor in tension:

- $N_{sb} = \phi \cdot 13.0 \cdot c_{a1} \cdot \sqrt{A_{bgr}} \cdot \sqrt{f'_c}$, where:
  - $A_{bgr} =$ 2215 mm^2 – bearing area of the head of stud or anchor bolt
  - $f'_c =$ 27.6 MPa – concrete compressive strength
  - $\phi =$ 0.70 – resistance factor

Shear resistance (ACI 318-14 – 17.5.1)

$\phi V_{sa} = \phi \cdot 0.6 \cdot A_{se,V} \cdot f_{uta} =$ 33.6 kN ≥ $V =$ 10.0 kN

Where:

$\phi =$ 0.65 – resistance factor

$A_{se,V} =$ 215 mm^2 – tensile stress area

$f_{uta} =$ 400.0 MPa – specified tensile strength of anchor steel:

- $f_{uta} = \min(860\ \text{MPa}, 1.9 \cdot f_{ya},\ f_u)$, where:
  - $f_{ya} =$ 248.2 MPa – specified yield strength of anchor steel
  - $f_u =$ 400.0 MPa – specified ultimate strength of anchor steel

Interaction of tensile and shear forces (ACI 318-14 – R17.6)

${U_{tt}}^{5/3} + {U_{ts}}^{5/3} =$ 0.20 ≤ 1.0

Where:

$U_{tt} =$ 0.19 – maximum ratio of factored tensile force and tensile resistance determined from all appropriate failure modes

$U_{ts} =$ 0.30 – maximum ratio of factored shear force and shear resistance determined from all appropriate failure modes

Supplementary reinforcement (ACI 318-14 – 17.4.2.9; ACI 318-14 – 17.5.2.9)

Supplementary reinforcement should resist force of 110.0 kN in tension and 75.8 kN in shear. Only current load effect considered.

Detailed result for A5

Concrete splitting failure during installation should be evaluated by ACI 355.2 requirements.

Anchor tensile resistance (ACI 318-14 – 17.4.1)

$\phi N_{sa} = \phi \cdot A_{se,N} \cdot f_{uta} =$ 60.3 kN ≥ $N_f =$ 27.6 kN

Where:

$\phi =$ 0.70 – resistance factor

$A_{se,N} =$ 215 mm^2 – tensile stress area

$f_{uta} =$ 400.0 MPa – specified tensile strength of anchor steel:

- $f_{uta} = \min(860\ \text{MPa}, 1.9 \cdot f_{ya},\ f_u)$, where:
  - $f_{ya} =$ 248.2 MPa – specified yield strength of anchor steel
  - $f_u =$ 400.0 MPa – specified ultimate strength of anchor steel

Concrete pullout resistance (ACI 318-14 – 17.4.3)

$\phi N_{pn} = \phi \cdot \Psi_{c,P} \cdot N_p =$ 342.1 kN ≥ $N_f =$ 27.6 kN

Where:

$\phi =$ 0.70 – resistance factor

$\Psi_{c,P} =$ 1.00 – modification factor for concrete condition

$N_p =$ 488.7 kN – basic concrete pullout strength for headed anchor:

- $N_{pr} = 8 \cdot A_{brg} \cdot f'_c$, where:
  - $A_{brg} =$ 2215 mm^2 – bearing area of the head of stud or anchor bolt
  - $f'_c =$ 27.6 MPa – concrete compressive strength

Concrete sideface blowout resistance (ACI 318-14 – 17.4.4)

$\phi N_{sb} = r_c \cdot N_{sbg} =$ 132.2 kN ≥ $N_f =$ 27.6 kN

Where:

$r_c =$ 0.64 – reduction factor for anchor close to an edge or multiple anchors with small spacing:

- $r_c = \min(\frac{1+\frac{c_{a2}}{c_{a1}}}{4}, \frac{1+\frac{s}{6 \cdot c_{a1}}}{2}),\ 0.5 \le r_c \le 1$, where:
  - $c_{a1} =$ 90 mm – shorter distance from an anchor to an edge
  - $c_{a2} =$ 550 mm – longer distance from an anchor to an edge
  - $s =$ 150 mm – spacing between anchors

$N_{sbg} =$ 206.9 kN – concrete side-face blowout strength of headed anchor in tension:

- $N_{sb} = \phi \cdot 13.0 \cdot c_{a1} \cdot \sqrt{A_{bgr}} \cdot \sqrt{f'_c}$, where:
  - $A_{bgr} =$ 2215 mm^2 – bearing area of the head of stud or anchor bolt
  - $f'_c =$ 27.6 MPa – concrete compressive strength
  - $\phi =$ 0.70 – resistance factor

Shear resistance (ACI 318-14 – 17.5.1)

$\phi V_{sa} = \phi \cdot 0.6 \cdot A_{se,V} \cdot f_{uta} =$ 33.6 kN ≥ $V =$ 8.6 kN

Where:

$\phi =$ 0.65 – resistance factor

$A_{se,V} =$ 215 mm^2 – tensile stress area

$f_{uta} =$ 400.0 MPa – specified tensile strength of anchor steel:

- $f_{uta} = \min(860\ \text{MPa}, 1.9 \cdot f_{ya},\ f_u)$, where:
  - $f_{ya} =$ 248.2 MPa – specified yield strength of anchor steel
  - $f_u =$ 400.0 MPa – specified ultimate strength of anchor steel

Interaction of tensile and shear forces (ACI 318-14 – R17.6)

$$U_{tt}{}^{5/3} + U_{ts}{}^{5/3} = \quad 0.37 \quad \leq \quad 1.0$$

Where:

$U_{tt} = 0.46$ – maximum ratio of factored tensile force and tensile resistance determined from all appropriate failure modes

$U_{ts} = 0.25$ – maximum ratio of factored shear force and shear resistance determined from all appropriate failure modes

Supplementary reinforcement (ACI 318-14 – 17.4.2.9; ACI 318-14 – 17.5.2.9)

Supplementary reinforcement should resist force of 110.0 kN in tension and 75.8 kN in shear. Only current load effect considered.

Detailed result for A6

Concrete splitting failure during installation should be evaluated by ACI 355.2 requirements.

Anchor tensile resistance (ACI 318-14 – 17.4.1)

$$\phi N_{sa} = \phi \cdot A_{se,N} \cdot f_{uta} = \quad 60.3 \quad \text{kN} \quad \geq \quad N_f = \quad 4.3 \quad \text{kN}$$

Where:

$\phi = 0.70$ – resistance factor

$A_{se,N} = 215$ mm^2 – tensile stress area

$f_{uta} = 400.0$ MPa – specified tensile strength of anchor steel:

- $f_{uta} = \min(860 \text{ MPa}, 1.9 \cdot f_{ya}, \ f_u)$, where:
  - $f_{ya} =$ 248.2 MPa – specified yield strength of anchor steel
  - $f_u =$ 400.0 MPa – specified ultimate strength of anchor steel

Concrete pullout resistance (ACI 318-14 – 17.4.3)

$$\phi N_{pn} = \phi \cdot \Psi_{c,P} \cdot N_p = \quad 342.1 \quad \text{kN} \quad \geq \quad N_f = \quad 4.3 \quad \text{kN}$$

Where:

$\phi = 0.70$ – resistance factor

$\Psi_{c,P} = 1.00$ – modification factor for concrete condition

$N_p = 488.7$ kN – basic concrete pullout strength for headed anchor:

- $N_{pr} = 8 \cdot A_{brg} \cdot f'_c$, where:
  - $A_{brg} =$ 2215 mm^2 – bearing area of the head of stud or anchor bolt
  - $f'_c =$ 27.6 MPa – concrete compressive strength

Concrete sideface blowout resistance (ACI 318-14 – 17.4.4)

$\phi N_{sb} = r_c \cdot N_{sbg} =$ 132.2 kN ≥ $N_f =$ 4.3 kN

Where:

$r_c =$ 0.64 – reduction factor for anchor close to an edge or multiple anchors with small spacing:

- $r_c = \min(\frac{1+\frac{c_{a2}}{c_{a1}}}{4}, \frac{1+\frac{s}{6 \cdot c_{a1}}}{2}),\ 0.5 \le r_c \le 1$, where:
  - $c_{a1} =$ 90 mm – shorter distance from an anchor to an edge
  - $c_{a2} =$ 550 mm – longer distance from an anchor to an edge
  - $s =$ 150 mm – spacing between anchors

$N_{sbg} =$ 206.9 kN – concrete side-face blowout strength of headed anchor in tension:

- $N_{sb} = \phi \cdot 13.0 \cdot c_{a1} \cdot \sqrt{A_{bgr}} \cdot \sqrt{f'_c}$, where:
  - $A_{bgr} =$ 2215 mm^2 – bearing area of the head of stud or anchor bolt
  - $f'_c =$ 27.6 MPa – concrete compressive strength
  - $\phi =$ 0.70 – resistance factor

Shear resistance (ACI 318-14 – 17.5.1)

$\phi V_{sa} = \phi \cdot 0.6 \cdot A_{se,V} \cdot f_{uta} =$ 33.6 kN ≥ $V =$ 8.8 kN

Where:

$\phi =$ 0.65 – resistance factor

$A_{se,V} =$ 215 mm^2 – tensile stress area

$f_{uta} =$ 400.0 MPa – specified tensile strength of anchor steel:

- $f_{uta} = \min(860\ \text{MPa}, 1.9 \cdot f_{ya},\ f_u)$, where:
  - $f_{ya} =$ 248.2 MPa – specified yield strength of anchor steel
  - $f_u =$ 400.0 MPa – specified ultimate strength of anchor steel

Interaction of tensile and shear forces (ACI 318-14 – R17.6)

${U_{tt}}^{5/3} + {U_{ts}}^{5/3} =$ 0.12 ≤ 1.0

Where:

$U_{tt} =$ 0.07 – maximum ratio of factored tensile force and tensile resistance determined from all appropriate failure modes

$U_{ts} =$ 0.26 – maximum ratio of factored shear force and shear resistance determined from all appropriate failure modes

Supplementary reinforcement (ACI 318-14 – 17.4.2.9; ACI 318-14 – 17.5.2.9)

Supplementary reinforcement should resist force of 97.5 kN in tension and 66.6 kN in shear. Only current load effect considered.

Detailed result for A7

Anchor tensile resistance (ACI 318-14 – 17.4.1)

$\phi N_{sa} = \phi \cdot A_{se,N} \cdot f_{uta} =$ 60.3 kN ≥ $N_f =$ 0.0 kN

Where:

$\phi =$ 0.70 – resistance factor

$A_{se,N} =$ 215 mm^2 – tensile stress area

$f_{uta} =$ 400.0 MPa – specified tensile strength of anchor steel:

- $f_{uta} = \min(860\ \text{MPa}, 1.9 \cdot f_{ya},\ f_u)$, where:
  - $f_{ya} =$ 248.2 MPa – specified yield strength of anchor steel
  - $f_u =$ 400.0 MPa – specified ultimate strength of anchor steel

Concrete pullout resistance (ACI 318-14 – 17.4.3)

$\phi N_{pn} = \phi \cdot \Psi_{c,P} \cdot N_p =$ 342.1 kN ≥ $N_f =$ 0.0 kN

Where:

$\phi =$ 0.70 – resistance factor

$\Psi_{c,P} =$ 1.00 – modification factor for concrete condition

$N_p =$ 488.7 kN – basic concrete pullout strength for headed anchor:

- $N_{pr} = 8 \cdot A_{brg} \cdot f'_c$, where:
  - $A_{brg} =$ 2215 mm^2 – bearing area of the head of stud or anchor bolt
  - $f'_c =$ 27.6 MPa – concrete compressive strength

Shear resistance (ACI 318-14 – 17.5.1)

$\phi V_{sa} = \phi \cdot 0.6 \cdot A_{se,V} \cdot f_{uta} =$ 33.6 kN ≥ $V =$ 7.2 kN

Where:

$\phi =$ 0.65 – resistance factor

$A_{se,V} =$ 215 mm^2 – tensile stress area

$f_{uta} =$ 400.0 MPa – specified tensile strength of anchor steel:

- $f_{uta} = \min(860\ \text{MPa}, 1.9 \cdot f_{ya},\ f_u)$, where:
  - $f_{ya} =$ 248.2 MPa – specified yield strength of anchor steel
  - $f_u =$ 400.0 MPa – specified ultimate strength of anchor steel

Interaction of tensile and shear forces (ACI 318-14 – R17.6)

${U_{tt}}^{5/3} + {U_{ts}}^{5/3} =$ 0.08 ≤ 1.0

Where:

$U_{tt} =$ 0.00 – maximum ratio of factored tensile force and tensile resistance determined from all appropriate failure modes

$U_{ts} =$ 0.21 – maximum ratio of factored shear force and shear resistance determined from all appropriate failure modes

Supplementary reinforcement (ACI 318-14 – 17.4.2.9; ACI 318-14 – 17.5.2.9)

Supplementary reinforcement should resist force of 110.0 kN in tension and 75.8 kN in shear. Only current load effect considered.

Detailed result for A8

Anchor tensile resistance (ACI 318-14 – 17.4.1)

$$\phi N_{sa} = \phi \cdot A_{se,N} \cdot f_{uta} = \quad 60.3 \quad \text{kN} \quad \geq \quad N_f = \quad 0.0 \quad \text{kN}$$

Where:

$\phi = 0.70$ – resistance factor

$A_{se,N} = 215$ mm^2 – tensile stress area

$f_{uta} = 400.0$ MPa – specified tensile strength of anchor steel:

- $f_{uta} = \min(860 \text{ MPa}, 1.9 \cdot f_{ya}, \ f_u)$, where:
  - $f_{ya} =$ 248.2 MPa – specified yield strength of anchor steel
  - $f_u =$ 400.0 MPa – specified ultimate strength of anchor steel

Concrete pullout resistance (ACI 318-14 – 17.4.3)

$$\phi N_{pn} = \phi \cdot \Psi_{c,P} \cdot N_p = \quad 342.1 \quad \text{kN} \quad \geq \quad N_f = \quad 0.0 \quad \text{kN}$$

Where:

$\phi = 0.70$ – resistance factor

$\Psi_{c,P} = 1.00$ – modification factor for concrete condition

$N_p = 488.7$ kN – basic concrete pullout strength for headed anchor:

- $N_{pr} = 8 \cdot A_{brg} \cdot f'_c$, where:
  - $A_{brg} =$ 2215 mm^2 – bearing area of the head of stud or anchor bolt
  - $f'_c =$ 27.6 MPa – concrete compressive strength

Shear resistance (ACI 318-14 – 17.5.1)

$$\phi V_{sa} = \phi \cdot 0.6 \cdot A_{se,V} \cdot f_{uta} = \quad 33.6 \quad \text{kN} \quad \geq \quad V = \quad 5.0 \quad \text{kN}$$

Where:

$\phi = 0.65$ – resistance factor

$A_{se,V} = 215$ mm^2 – tensile stress area

$f_{uta} = 400.0$ MPa – specified tensile strength of anchor steel:

- $f_{uta} = \min(860 \text{ MPa}, 1.9 \cdot f_{ya}, \ f_u)$, where:
  - $f_{ya} =$ 248.2 MPa – specified yield strength of anchor steel
  - $f_u =$ 400.0 MPa – specified ultimate strength of anchor steel

Interaction of tensile and shear forces (ACI 318-14 – R17.6)

$$U_{tt}{}^{5/3} + U_{ts}{}^{5/3} = \quad 0.04 \quad \leq \quad 1.0$$

Where:

$U_{tt} = 0.00$ – maximum ratio of factored tensile force and tensile resistance determined from all appropriate failure modes

$U_{ts} = 0.15$ – maximum ratio of factored shear force and shear resistance determined from all appropriate failure modes

Supplementary reinforcement (ACI 318-14 – 17.4.2.9; ACI 318-14 – 17.5.2.9)

Supplementary reinforcement should resist force of 110.0 kN in tension and 75.8 kN in shear. Only current load effect considered.

Detailed result for A9

Concrete splitting failure during installation should be evaluated by ACI 355.2 requirements.

Anchor tensile resistance (ACI 318-14 – 17.4.1)

$\phi N_{sa} = \phi \cdot A_{se,N} \cdot f_{uta} =$ 60.3 kN ≥ $N_f =$ 0.1 kN

Where:

$\phi =$ 0.70 – resistance factor

$A_{se,N} =$ 215 mm^2 – tensile stress area

$f_{uta} =$ 400.0 MPa – specified tensile strength of anchor steel:

- $f_{uta} = \min(860\ \text{MPa}, 1.9 \cdot f_{ya},\ f_u)$, where:
  - $f_{ya} =$ 248.2 MPa – specified yield strength of anchor steel
  - $f_u =$ 400.0 MPa – specified ultimate strength of anchor steel

Concrete pullout resistance (ACI 318-14 – 17.4.3)

$\phi N_{pn} = \phi \cdot \Psi_{c,P} \cdot N_p =$ 342.1 kN ≥ $N_f =$ 0.1 kN

Where:

$\phi =$ 0.70 – resistance factor

$\Psi_{c,P} =$ 1.00 – modification factor for concrete condition

$N_p =$ 488.7 kN – basic concrete pullout strength for headed anchor:

- $N_{pr} = 8 \cdot A_{brg} \cdot f'_c$, where:
  - $A_{brg} =$ 2215 mm^2 – bearing area of the head of stud or anchor bolt
  - $f'_c =$ 27.6 MPa – concrete compressive strength

Concrete sideface blowout resistance (ACI 318-14 – 17.4.4)

$\phi N_{sb} = r_c \cdot N_{sbg} =$ 132.2 kN ≥ $N_f =$ 0.1 kN

Where:

$r_c =$ 0.64 – reduction factor for anchor close to an edge or multiple anchors with small spacing:

- $r_c = \min(\frac{1+\frac{c_{a2}}{c_{a1}}}{4}, \frac{1+\frac{s}{6 \cdot c_{a1}}}{2}),\ 0.5 \le r_c \le 1$, where:
  - $c_{a1} =$ 90 mm – shorter distance from an anchor to an edge
  - $c_{a2} =$ 550 mm – longer distance from an anchor to an edge
  - $s =$ 150 mm – spacing between anchors

$N_{sbg} =$ 206.9 kN – concrete side-face blowout strength of headed anchor in tension:

- $N_{sb} = \phi \cdot 13.0 \cdot c_{a1} \cdot \sqrt{A_{bgr}} \cdot \sqrt{f'_c}$, where:
  - $A_{bgr} =$ 2215 mm^2 – bearing area of the head of stud or anchor bolt
  - $f'_c =$ 27.6 MPa – concrete compressive strength
  - $\phi =$ 0.70 – resistance factor

Shear resistance (ACI 318-14 – 17.5.1)

$\phi V_{sa} = \phi \cdot 0.6 \cdot A_{se,V} \cdot f_{uta} =$ 33.6 kN ≥ $V =$ 6.5 kN

Where:

$\phi =$ 0.65 – resistance factor

$A_{se,V} =$ 215 mm^2 – tensile stress area

$f_{uta} =$ 400.0 MPa – specified tensile strength of anchor steel:

- $f_{uta} = \min(860\ \text{MPa}, 1.9 \cdot f_{ya},\ f_u)$, where:
  - $f_{ya} =$ 248.2 MPa – specified yield strength of anchor steel
  - $f_u =$ 400.0 MPa – specified ultimate strength of anchor steel

Interaction of tensile and shear forces (ACI 318-14 – R17.6)

${U_{tt}}^{5/3} + {U_{ts}}^{5/3} =$ 0.06 ≤ 1.0

Where:

$U_{tt} =$ 0.00 – maximum ratio of factored tensile force and tensile resistance determined from all appropriate failure modes

$U_{ts} =$ 0.19 – maximum ratio of factored shear force and shear resistance determined from all appropriate failure modes

Supplementary reinforcement (ACI 318-14 – 17.4.2.9; ACI 318-14 – 17.5.2.9)

Supplementary reinforcement should resist force of 97.5 kN in tension and 66.6 kN in shear. Only current load effect considered.

Welds

Item	Edge	Xu	t_w [mm]	w [mm]	L [mm]	L_c [mm]	Loads	F_n [kN]	ϕR_n [kN]	Ut [%]	Ut_c [%]	Detailing	Status
M2-w 2	SP2	E70xx	◢ 3.54 ◣	◢ 5.00 ◣	123	8	LE1	5.5	7.3	75.4	40.4	OK	OK
		E70xx	◢ 3.54 ◣	◢ 5.00 ◣	123	8	LE1	5.4	7.2	75.2	40.3	OK	OK
SP1	SP2	E70xx	◢ 3.54 ◣	◢ 5.00 ◣	74	8	LE1	3.2	7.4	43.6	22.9	OK	OK
		E70xx	◢ 3.54 ◣	◢ 5.00 ◣	74	8	LE1	2.1	7.4	28.2	13.6	OK	OK
SP1	RIB1	E70xx	◢ 3.54 ◣	◢ 5.00 ◣	70	12	LE2	1.4	10.5	12.9	0.0	OK	OK
		E70xx	◢ 3.54 ◣	◢ 5.00 ◣	70	12	LE2	1.4	10.5	13.6	5.0	OK	OK
M2-w 1	RIB1	E70xx	◢ 3.54 ◣	◢ 5.00 ◣	170	9	LE1	0.6	7.8	8.2	0.0	OK	OK
		E70xx	◢ 3.54 ◣	◢ 5.00 ◣	169	9	LE1	0.4	7.4	5.3	0.0	OK	OK
SP1	RIB2	E70xx	◢ 3.54 ◣	◢ 5.00 ◣	74	8	LE1	2.5	7.4	34.0	17.6	OK	OK
		E70xx	◢ 3.54 ◣	◢ 5.00 ◣	74	8	LE1	4.2	7.4	56.4	31.6	OK	OK
M2-w 3	RIB2	E70xx	◢ 3.54 ◣	◢ 5.00 ◣	130	8	LE1	4.7	7.3	64.0	33.2	OK	OK
		E70xx	◢ 3.54 ◣	◢ 5.00 ◣	130	8	LE1	4.8	7.3	66.1	34.1	OK	OK
SP1	M2	E70xx	◢ 5.66 ◣	◢ 8.00 ◣	639	7	LE1	4.8	9.4	51.1	31.2	OK	OK
		E70xx	◢ 5.66 ◣	◢ 8.00 ◣	640	7	LE1	7.1	9.4	75.2	50.7	OK	OK

Design data

Material	F_{exx} [MPa]
E70xx	482.6

Detailed result for M2-w 2 / SP2 - 1

Weld resistance check (AISC 360-22 – J2-4)

$$\phi R_n = \phi \cdot F_{nw} \cdot A_{we} = \quad 7.3 \quad \text{kN} \quad \geq \quad F_n = \quad 5.5 \quad \text{kN}$$

Where:

$F_{nw} =$ 335.4 MPa – nominal stress of weld material:

- $F_{nw} = 0.6 \cdot F_{EXX} \cdot (1 + 0.5 \cdot sin^{1.5}\theta)$, where:
  - $F_{EXX} =$ 482.6 MPa – electrode classification number, i.e. minimum specified tensile strength
  - $\theta =$ 27.7° – angle of loading measured from the weld longitudinal axis

$A_{we} =$ 29 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Base metal capacity check (AISC 360-22 – J2-2)

$\phi R_n = \phi \cdot F_{nBM} \cdot A_{BM} =$ 7.4 kN ≥ $F_n =$ 5.5 kN

Where:
$F_{nBM} =$ 240.0 MPa – nominal stress of the base metal:

- $F_{nBM} = 0.6 \cdot F_u$, where:
  - $F_u =$ 400.0 MPa – tensile strength of the connected material

$A_{BM} =$ 41 mm^2 – cross-sectional area of base metal:

- $A_{BM} = A_{we} \cdot \sqrt{2}$, where:
  - $A_{we} =$ 29 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Detailed result for M2-w 2 / SP2 - 2

Weld resistance check (AISC 360-22 – J2-4)

$\phi R_n = \phi \cdot F_{nw} \cdot A_{we} =$ 7.2 kN ≥ $F_n =$ 5.4 kN

Where:
$F_{nw} =$ 331.9 MPa – nominal stress of weld material:

- $F_{nw} = 0.6 \cdot F_{EXX} \cdot (1 + 0.5 \cdot sin^{1.5}\theta)$, where:
  - $F_{EXX} =$ 482.6 MPa – electrode classification number, i.e. minimum specified tensile strength
  - $\theta =$ 26.1° – angle of loading measured from the weld longitudinal axis

$A_{we} =$ 29 mm^2 – effective area of weld critical element
$\phi =$ 0.75 – resistance factor for welded connections

Base metal capacity check (AISC 360-22 – J2-2)

$\phi R_n = \phi \cdot F_{nBM} \cdot A_{BM} =$ 7.4 kN ≥ $F_n =$ 5.4 kN

Where:
$F_{nBM} =$ 240.0 MPa – nominal stress of the base metal:

- $F_{nBM} = 0.6 \cdot F_u$, where:
  - $F_u =$ 400.0 MPa – tensile strength of the connected material

$A_{BM} =$ 41 mm^2 – cross-sectional area of base metal:

- $A_{BM} = A_{we} \cdot \sqrt{2}$, where:
  - $A_{we} =$ 29 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Detailed result for SP1 / SP2 - 1

Weld resistance check (AISC 360-22 – J2-4)

$\phi R_n = \phi \cdot F_{nw} \cdot A_{we} =$ 8.9 kN ≥ $F_n =$ 3.2 kN

Where:

$F_{nw} =$ 408.0 MPa – nominal stress of weld material:

- $F_{nw} = 0.6 \cdot F_{EXX} \cdot (1 + 0.5 \cdot sin^{1.5}\theta)$, where:
  - $F_{EXX} =$ 482.6 MPa – electrode classification number, i.e. minimum specified tensile strength
  - $\theta =$ 61.0° – angle of loading measured from the weld longitudinal axis

$A_{we} =$ 29 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Base metal capacity check (AISC 360-22 – J2-2)

$\phi R_n = \phi \cdot F_{nBM} \cdot A_{BM} =$ 7.4 kN ≥ $F_n =$ 3.2 kN

Where:

$F_{nBM} =$ 240.0 MPa – nominal stress of the base metal:

- $F_{nBM} = 0.6 \cdot F_u$, where:
  - $F_u =$ 400.0 MPa – tensile strength of the connected material

$A_{BM} =$ 41 mm^2 – cross-sectional area of base metal:

- $A_{BM} = A_{we} \cdot \sqrt{2}$, where:
  - $A_{we} =$ 29 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Detailed result for SP1 / SP2 - 2

Weld resistance check (AISC 360-22 – J2-4)

$\phi R_n = \phi \cdot F_{nw} \cdot A_{we} =$ 9.1 kN ≥ $F_n =$ 2.1 kN

Where:

$F_{nw} =$ 416.5 MPa – nominal stress of weld material:

- $F_{nw} = 0.6 \cdot F_{EXX} \cdot (1 + 0.5 \cdot sin^{1.5}\theta)$, where:
  - $F_{EXX} =$ 482.6 MPa – electrode classification number, i.e. minimum specified tensile strength
  - $\theta =$ 66.4° – angle of loading measured from the weld longitudinal axis

$A_{we} =$ 29 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Base metal capacity check (AISC 360-22 – J2-2)

$\phi R_n = \phi \cdot F_{nBM} \cdot A_{BM} =$ 7.4 kN ≥ $F_n =$ 2.1 kN

Where:
$F_{nBM} =$ 240.0 MPa – nominal stress of the base metal:

- $F_{nBM} = 0.6 \cdot F_u$, where:
  - $F_u =$ 400.0 MPa – tensile strength of the connected material

$A_{BM} =$ 41 mm^2 – cross-sectional area of base metal:

- $A_{BM} = A_{we} \cdot \sqrt{2}$, where:
  - $A_{we} =$ 29 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Detailed result for SP1 / RIB1 - 1

Weld resistance check (AISC 360-22 – J2-4)

$\phi R_n = \phi \cdot F_{nw} \cdot A_{we} =$ 11.8 kN ≥ $F_n =$ 1.4 kN

Where:
$F_{nw} =$ 382.3 MPa – nominal stress of weld material:

- $F_{nw} = 0.6 \cdot F_{EXX} \cdot (1 + 0.5 \cdot sin^{1.5}\theta)$, where:
  - $F_{EXX} =$ 482.6 MPa – electrode classification number, i.e. minimum specified tensile strength
  - $\theta =$ 48.0° – angle of loading measured from the weld longitudinal axis

$A_{we} =$ 41 mm^2 – effective area of weld critical element
$\phi =$ 0.75 – resistance factor for welded connections

Base metal capacity check (AISC 360-22 – J2-2)

$\phi R_n = \phi \cdot F_{nBM} \cdot A_{BM} =$ 10.5 kN ≥ $F_n =$ 1.4 kN

Where:
$F_{nBM} =$ 240.0 MPa – nominal stress of the base metal:

- $F_{nBM} = 0.6 \cdot F_u$, where:
  - $F_u =$ 400.0 MPa – tensile strength of the connected material

$A_{BM} =$ 58 mm^2 – cross-sectional area of base metal:

- $A_{BM} = A_{we} \cdot \sqrt{2}$, where:
  - $A_{we} =$ 41 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Detailed result for SP1 / RIB1 - 2

Weld resistance check (AISC 360-22 – J2-4)

$\phi R_n = \phi \cdot F_{nw} \cdot A_{we} =$ 11.7 kN ≥ $F_n =$ 1.4 kN

Where:

$F_{nw} =$ 379.6 MPa – nominal stress of weld material:

- $F_{nw} = 0.6 \cdot F_{EXX} \cdot (1 + 0.5 \cdot sin^{1.5}\theta)$, where:
  - $F_{EXX} =$ 482.6 MPa – electrode classification number, i.e. minimum specified tensile strength
  - $\theta =$ 46.8° – angle of loading measured from the weld longitudinal axis

$A_{we} =$ 41 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Base metal capacity check (AISC 360-22 – J2-2)

$\phi R_n = \phi \cdot F_{nBM} \cdot A_{BM} =$ 10.5 kN ≥ $F_n =$ 1.4 kN

Where:

$F_{nBM} =$ 240.0 MPa – nominal stress of the base metal:

- $F_{nBM} = 0.6 \cdot F_u$, where:
  - $F_u =$ 400.0 MPa – tensile strength of the connected material

$A_{BM} =$ 58 mm^2 – cross-sectional area of base metal:

- $A_{BM} = A_{we} \cdot \sqrt{2}$, where:
  - $A_{we} =$ 41 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Detailed result for M2-w 1 / RIB1 - 1

Weld resistance check (AISC 360-22 – J2-4)

$\phi R_n = \phi \cdot F_{nw} \cdot A_{we} =$ 7.8 kN ≥ $F_n =$ 0.6 kN

Where:

$F_{nw} =$ 310.0 MPa – nominal stress of weld material:

- $F_{nw} = 0.6 \cdot F_{EXX} \cdot (1 + 0.5 \cdot sin^{1.5}\theta)$, where:
  - $F_{EXX} =$ 482.6 MPa – electrode classification number, i.e. minimum specified tensile strength
  - $\theta =$ 15.7° – angle of loading measured from the weld longitudinal axis

$A_{we} =$ 33 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Base metal capacity check (AISC 360-22 – J2-2)

$\phi R_n = \phi \cdot F_{nBM} \cdot A_{BM} =$ 8.5 kN ≥ $F_n =$ 0.6 kN

Where:
$F_{nBM} =$ 240.0 MPa – nominal stress of the base metal:

- $F_{nBM} = 0.6 \cdot F_u$, where:
  - $F_u =$ 400.0 MPa – tensile strength of the connected material

$A_{BM} =$ 47 mm^2 – cross-sectional area of base metal:

- $A_{BM} = A_{we} \cdot \sqrt{2}$, where:
  - $A_{we} =$ 33 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Detailed result for M2-w 1 / RIB1 - 2

Weld resistance check (AISC 360-22 – J2-4)

$\phi R_n = \phi \cdot F_{nw} \cdot A_{we} =$ 7.4 kN ≥ $F_n =$ 0.4 kN

Where:
$F_{nw} =$ 296.2 MPa – nominal stress of weld material:

- $F_{nw} = 0.6 \cdot F_{EXX} \cdot (1 + 0.5 \cdot sin^{1.5}\theta)$, where:
  - $F_{EXX} =$ 482.6 MPa – electrode classification number, i.e. minimum specified tensile strength
  - $\theta =$ 7.3° – angle of loading measured from the weld longitudinal axis

$A_{we} =$ 33 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Base metal capacity check (AISC 360-22 – J2-2)

$\phi R_n = \phi \cdot F_{nBM} \cdot A_{BM} =$ 8.5 kN ≥ $F_n =$ 0.4 kN

Where:
$F_{nBM} =$ 240.0 MPa – nominal stress of the base metal:

- $F_{nBM} = 0.6 \cdot F_u$, where:
  - $F_u =$ 400.0 MPa – tensile strength of the connected material

$A_{BM} =$ 47 mm^2 – cross-sectional area of base metal:

- $A_{BM} = A_{we} \cdot \sqrt{2}$, where:
  - $A_{we} =$ 33 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Detailed result for SP1 / RIB2 - 1

Weld resistance check (AISC 360-22 – J2-4)

$\phi R_n = \phi \cdot F_{nw} \cdot A_{we} =$ 9.4 kN ≥ $F_n =$ 2.5 kN

Where:

$F_{nw} =$ 429.0 MPa – nominal stress of weld material:

- $F_{nw} = 0.6 \cdot F_{EXX} \cdot (1 + 0.5 \cdot sin^{1.5}\theta)$, where:
  - $F_{EXX} =$ 482.6 MPa – electrode classification number, i.e. minimum specified tensile strength
  - $\theta =$ 77.2° – angle of loading measured from the weld longitudinal axis

$A_{we} =$ 29 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Base metal capacity check (AISC 360-22 – J2-2)

$\phi R_n = \phi \cdot F_{nBM} \cdot A_{BM} =$ 7.4 kN ≥ $F_n =$ 2.5 kN

Where:

$F_{nBM} =$ 240.0 MPa – nominal stress of the base metal:

- $F_{nBM} = 0.6 \cdot F_u$, where:
  - $F_u =$ 400.0 MPa – tensile strength of the connected material

$A_{BM} =$ 41 mm^2 – cross-sectional area of base metal:

- $A_{BM} = A_{we} \cdot \sqrt{2}$, where:
  - $A_{we} =$ 29 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Detailed result for SP1 / RIB2 - 2

Weld resistance check (AISC 360-22 – J2-4)

$\phi R_n = \phi \cdot F_{nw} \cdot A_{we} =$ 9.4 kN ≥ $F_n =$ 4.2 kN

Where:

$F_{nw} =$ 431.9 MPa – nominal stress of weld material:

- $F_{nw} = 0.6 \cdot F_{EXX} \cdot (1 + 0.5 \cdot sin^{1.5}\theta)$, where:
  - $F_{EXX} =$ 482.6 MPa – electrode classification number, i.e. minimum specified tensile strength
  - $\theta =$ 81.4° – angle of loading measured from the weld longitudinal axis

$A_{we} =$ 29 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Base metal capacity check (AISC 360-22 – J2-2)

$\phi R_n = \phi \cdot F_{nBM} \cdot A_{BM} =$ 7.4 kN ≥ $F_n =$ 4.2 kN

Where:
$F_{nBM} =$ 240.0 MPa – nominal stress of the base metal:

- $F_{nBM} = 0.6 \cdot F_u$, where:
  - $F_u =$ 400.0 MPa – tensile strength of the connected material

$A_{BM} =$ 41 mm^2 – cross-sectional area of base metal:

- $A_{BM} = A_{we} \cdot \sqrt{2}$, where:
  - $A_{we} =$ 29 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Detailed result for M2-w 3 / RIB2 - 1

Weld resistance check (AISC 360-22 – J2-4)

$\phi R_n = \phi \cdot F_{nw} \cdot A_{we} =$ 7.7 kN ≥ $F_n =$ 4.7 kN

Where:
$F_{nw} =$ 360.0 MPa – nominal stress of weld material:

- $F_{nw} = 0.6 \cdot F_{EXX} \cdot (1 + 0.5 \cdot sin^{1.5}\theta)$, where:
  - $F_{EXX} =$ 482.6 MPa – electrode classification number, i.e. minimum specified tensile strength
  - $\theta =$ 38.2° – angle of loading measured from the weld longitudinal axis

$A_{we} =$ 29 mm^2 – effective area of weld critical element
$\phi =$ 0.75 – resistance factor for welded connections

Base metal capacity check (AISC 360-22 – J2-2)

$\phi R_n = \phi \cdot F_{nBM} \cdot A_{BM} =$ 7.3 kN ≥ $F_n =$ 4.7 kN

Where:
$F_{nBM} =$ 240.0 MPa – nominal stress of the base metal:

- $F_{nBM} = 0.6 \cdot F_u$, where:
  - $F_u =$ 400.0 MPa – tensile strength of the connected material

$A_{BM} =$ 40 mm^2 – cross-sectional area of base metal:

- $A_{BM} = A_{we} \cdot \sqrt{2}$, where:
  - $A_{we} =$ 29 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Detailed result for M2-w 3 / RIB2 - 2

Weld resistance check (AISC 360-22 – J2-4)

$\phi R_n = \phi \cdot F_{nw} \cdot A_{we} =$ 7.6 kN ≥ $F_n =$ 4.8 kN

Where:

$F_{nw} =$ 356.2 MPa – nominal stress of weld material:

- $F_{nw} = 0.6 \cdot F_{EXX} \cdot (1 + 0.5 \cdot sin^{1.5}\theta)$, where:
  - $F_{EXX} =$ 482.6 MPa – electrode classification number, i.e. minimum specified tensile strength
  - $\theta =$ 36.6° – angle of loading measured from the weld longitudinal axis

$A_{we} =$ 29 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Base metal capacity check (AISC 360-22 – J2-2)

$\phi R_n = \phi \cdot F_{nBM} \cdot A_{BM} =$ 7.3 kN ≥ $F_n =$ 4.8 kN

Where:

$F_{nBM} =$ 240.0 MPa – nominal stress of the base metal:

- $F_{nBM} = 0.6 \cdot F_u$, where:
  - $F_u =$ 400.0 MPa – tensile strength of the connected material

$A_{BM} =$ 40 mm^2 – cross-sectional area of base metal:

- $A_{BM} = A_{we} \cdot \sqrt{2}$, where:
  - $A_{we} =$ 29 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Detailed result for SP1 / M2 - 1

Weld resistance check (AISC 360-22 – J2-4)

$\phi R_n = \phi \cdot F_{nw} \cdot A_{we} =$ 9.6 kN ≥ $F_n =$ 4.8 kN

Where:

$F_{nw} =$ 344.6 MPa – nominal stress of weld material:

- $F_{nw} = 0.6 \cdot F_{EXX} \cdot (1 + 0.5 \cdot sin^{1.5}\theta)$, where:
  - $F_{EXX} =$ 482.6 MPa – electrode classification number, i.e. minimum specified tensile strength
  - $\theta =$ 31.6° – angle of loading measured from the weld longitudinal axis

$A_{we} =$ 37 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Base metal capacity check (AISC 360-22 – J2-2)

$\phi R_n = \phi \cdot F_{nBM} \cdot A_{BM} =$ 9.4 kN ≥ $F_n =$ 4.8 kN

Where:
$F_{nBM} =$ 240.0 MPa – nominal stress of the base metal:

- $F_{nBM} = 0.6 \cdot F_u$, where:
  - $F_u =$ 400.0 MPa – tensile strength of the connected material

$A_{BM} =$ 52 mm^2 – cross-sectional area of base metal:

- $A_{BM} = A_{we} \cdot \sqrt{2}$, where:
  - $A_{we} =$ 37 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Detailed result for SP1 / M2 - 2

Weld resistance check (AISC 360-22 – J2-4)

$\phi R_n = \phi \cdot F_{nw} \cdot A_{we} =$ 10.1 kN ≥ $F_n =$ 7.1 kN

Where:
$F_{nw} =$ 363.9 MPa – nominal stress of weld material:

- $F_{nw} = 0.6 \cdot F_{EXX} \cdot (1 + 0.5 \cdot sin^{1.5}\theta)$, where:
  - $F_{EXX} =$ 482.6 MPa – electrode classification number, i.e. minimum specified tensile strength
  - $\theta =$ 39.9° – angle of loading measured from the weld longitudinal axis

$A_{we} =$ 37 mm^2 – effective area of weld critical element
$\phi =$ 0.75 – resistance factor for welded connections

Base metal capacity check (AISC 360-22 – J2-2)

$\phi R_n = \phi \cdot F_{nBM} \cdot A_{BM} =$ 9.4 kN ≥ $F_n =$ 7.1 kN

Where:
$F_{nBM} =$ 240.0 MPa – nominal stress of the base metal:

- $F_{nBM} = 0.6 \cdot F_u$, where:
  - $F_u =$ 400.0 MPa – tensile strength of the connected material

$A_{BM} =$ 52 mm^2 – cross-sectional area of base metal:

- $A_{BM} = A_{we} \cdot \sqrt{2}$, where:
  - $A_{we} =$ 37 mm^2 – effective area of weld critical element

$\phi =$ 0.75 – resistance factor for welded connections

Concrete block

Item	Loads	A_1 [mm^2]	A_2 [mm^2]	σ [MPa]	$\phi f_{p,max}$ [MPa]	Ut [%]	Status
CB 1	LE1	22105	44750	1.1	21.7	5.1	OK

Detailed result for CB 1

Concrete block compressive resistance check (AISC 360-22 – J8)

$\phi_c f_{p,max} =$ 21.7 MPa ≥ $\sigma =$ 1.1 MPa

Where:

$f_{p,max} =$ 33.4 MPa – concrete block design bearing strength:

- $f_{p,max} = 0.85 \cdot f'_c \cdot \sqrt{\frac{A_2}{A_1}} \leq 1.7 \cdot f'_c$, where:
  - $f'_c =$ 27.6 MPa – concrete compressive strength
  - $A_1 =$ 22105 mm^2 – base plate area in contact with concrete surface
  - $A_2 =$ 44750 mm^2 – concrete supporting surface

$\phi_c =$ 0.65 – resistance factor for concrete

Buckling

Buckling analysis was not calculated.

Cost estimation

Steel

Steel grade	Total weight [kg]	Unit cost [US$/kg]	Cost [US$]
A36	18.77	2.50	46.93

Bolts

Bolt assembly	Total weight [kg]	Unit cost [US$/kg]	Cost [US$]
3/4 F1554 Gr.36	3.40	6.00	20.39

Welds

Weld type	Throat thickness [mm]	Leg size [mm]	Total weight [kg]	Unit cost [US$/kg]	Cost [US$]
Fillet weld	5.66	8.00	0.32	45.00	14.57
Fillet weld	3.54	5.00	0.13	45.00	5.70

Hole drilling

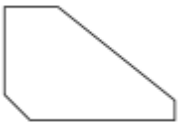
Bolt assembly cost [US$]	Percentage of bolt assembly cost [%]	Cost [US$]
20.39	30.0	6.12

Cost summary

Cost estimation summary	Cost [US$]
Total estimated cost	93.71

Bill of material

Manufacturing operations

Name	Plates [mm]	Shape	Nr.	Welds [mm]	Length [mm]	Bolts	Nr.
SP1	P12.70x400-440 (A36)		1			3/4 F1554 Gr.36	9
CUT1				Double fillet: 8.00	645		
SP2	P6.35x146-97 (A36)		1				
RIB1	P6.35x221-150 (A36)		1	Double fillet: 5.00	241		
RIB2	P6.35x84-119 (A36)		1	Double fillet: 5.00	205		

Symbol explanation

Fillet weld	leg size of weld

Welds

Type	Material	Throat thickness [mm]	Leg size [mm]	Length [mm]
Double fillet	E70xx	5.66	8.00	645
Double fillet	E70xx	3.54	5.00	645

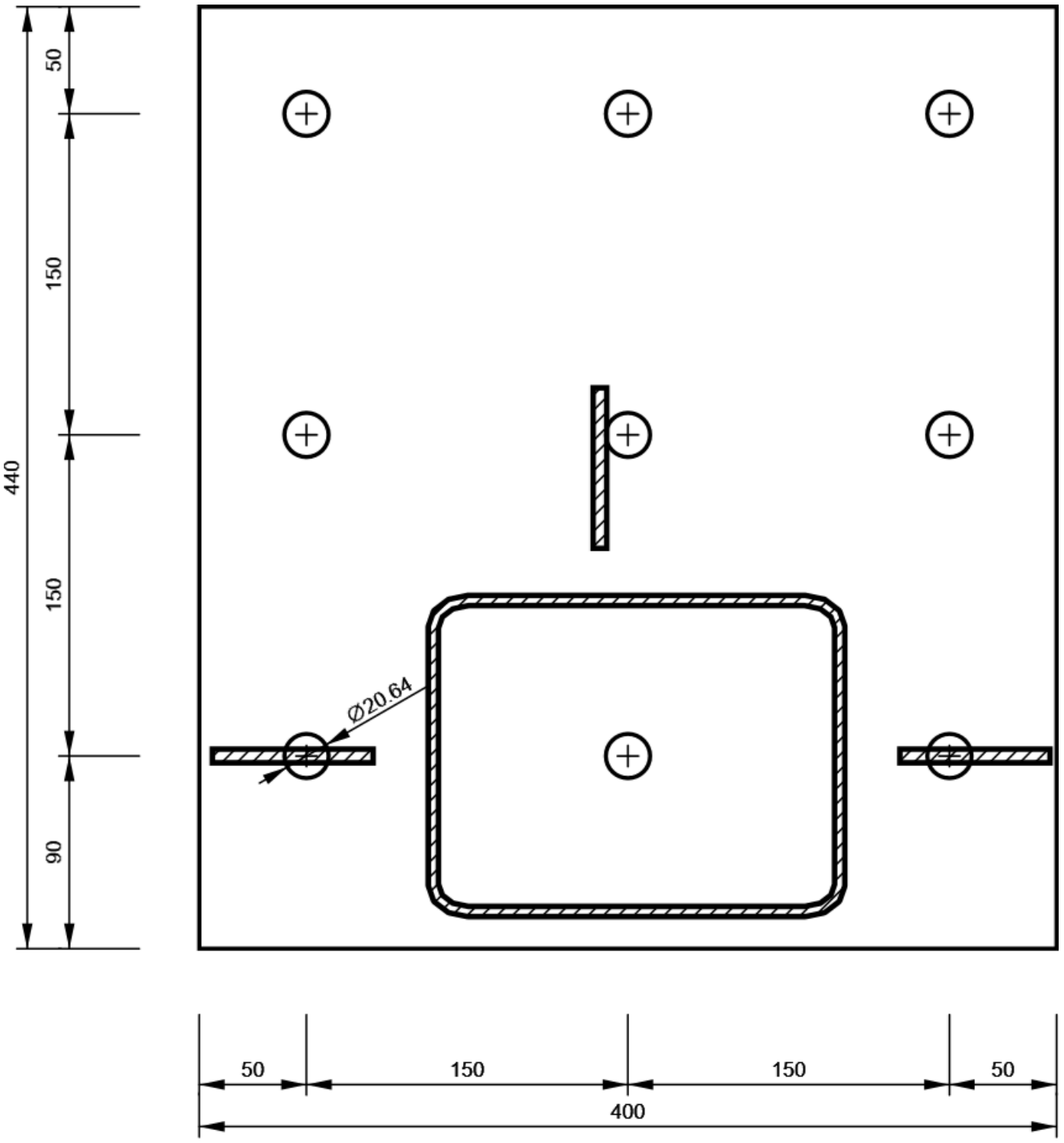
Anchors

Name	Length [mm]	Drill length [mm]	Count
3/4 F1554 Gr.36	413	400	9

Drawing

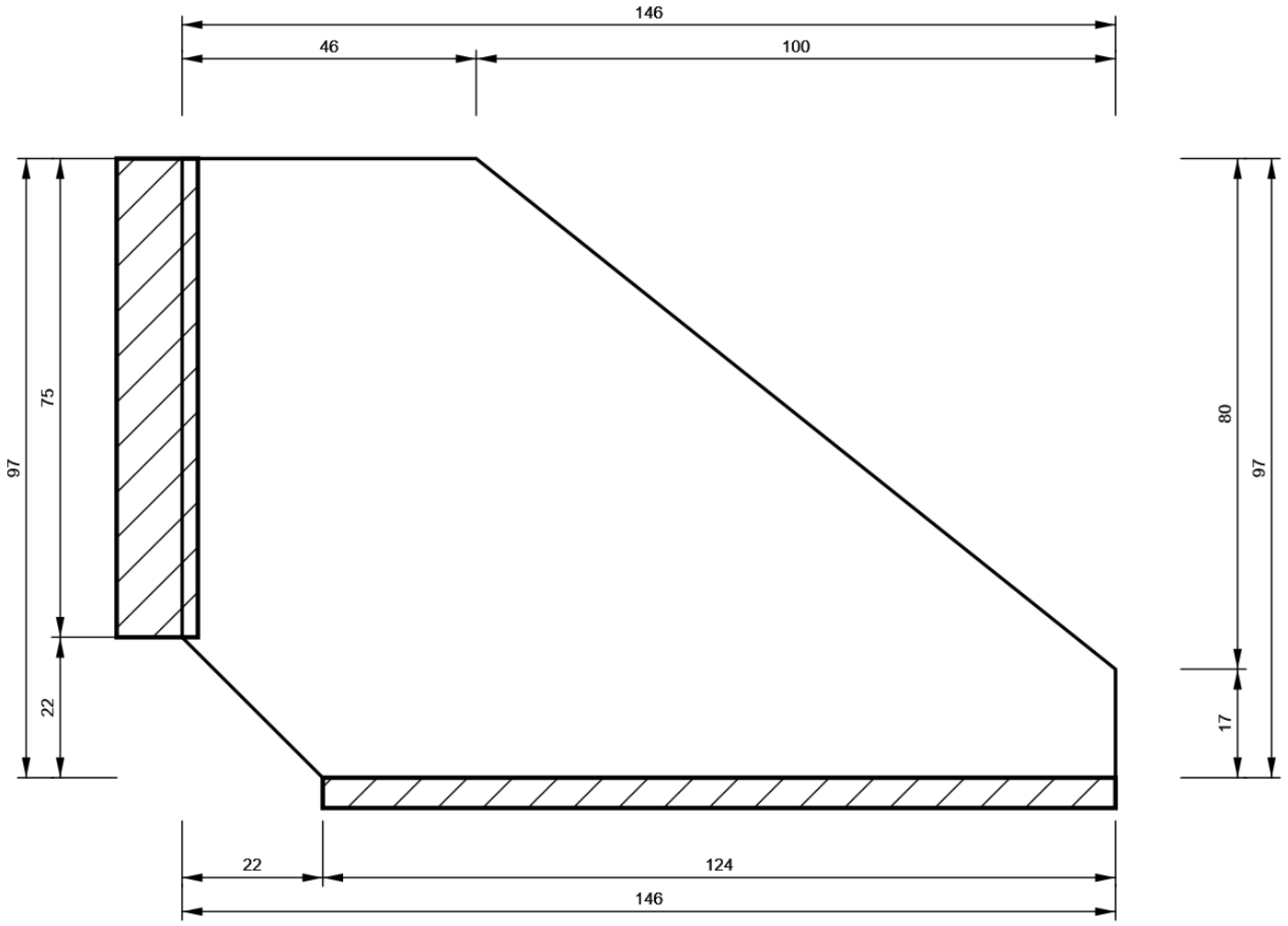
SP1

P12.70x440-400 (A36)



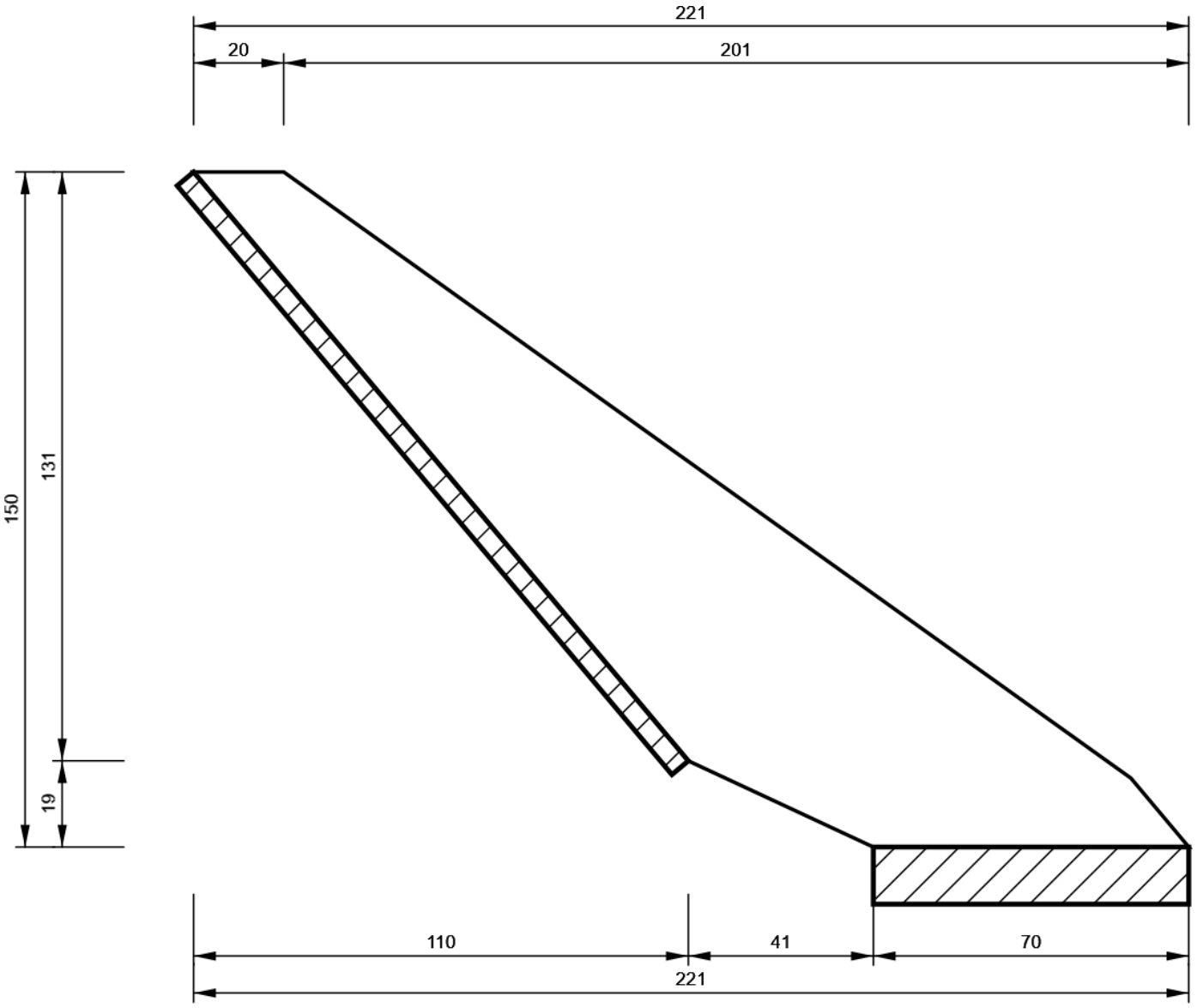
SP2

P6.35x97-146 (A36)



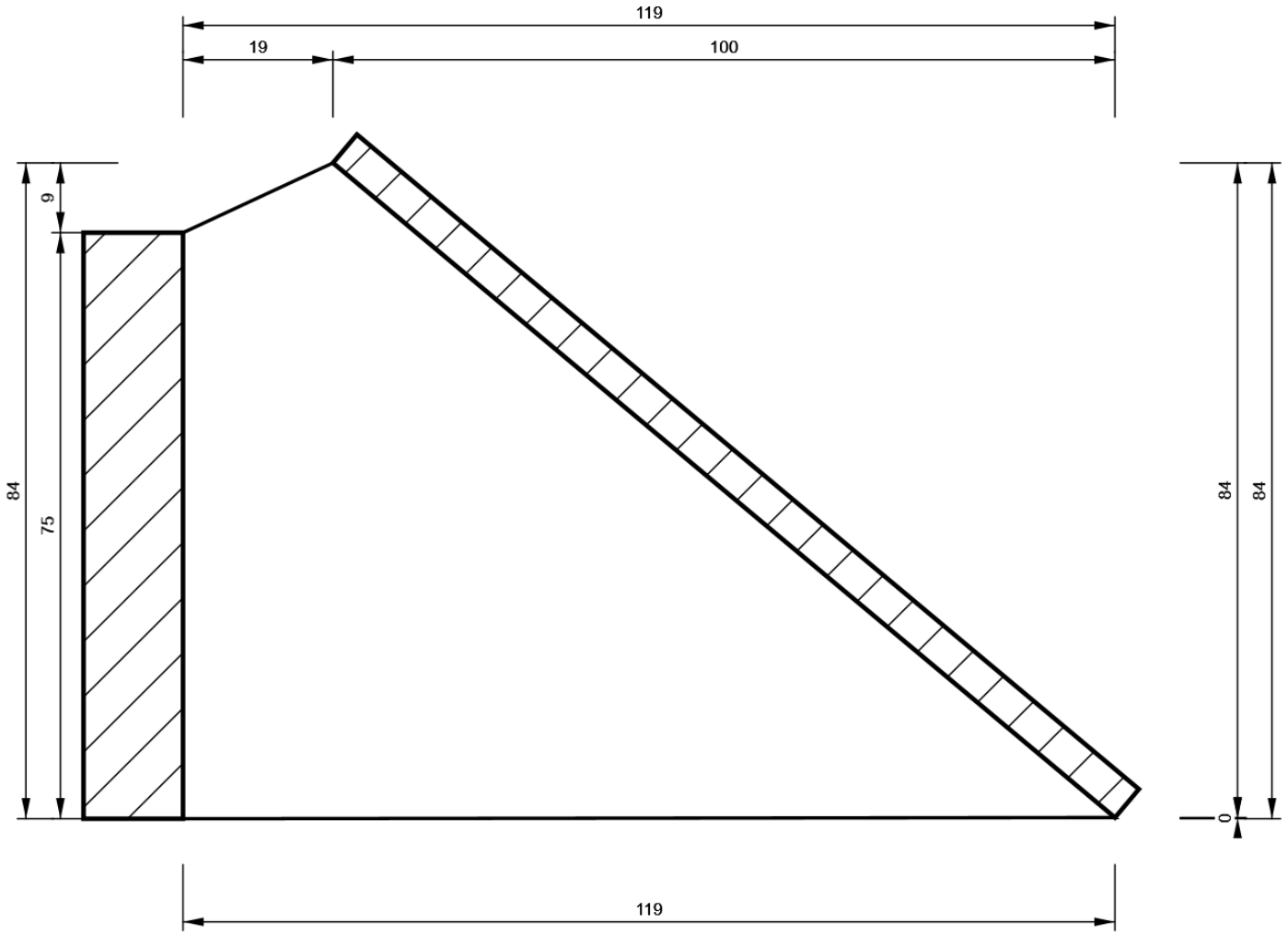
RIB1

P6.35x150-221 (A36)



RIB2

P6.35x119-84 (A36)



Symbol explanation

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
N_f	Tension force
V	Resultant of bolt shear forces Vy and Vz in shear planes
ϕN_p	Pullout strength in tension - ACI 318-14 – 17.4.3
ϕN_{sb}	Concrete side-face blowout strength in tension - ACI 318-14 – 17.4.4
Ut_t	Utilization in tension
Ut_s	Utilization in shear
Ut_{ts}	Utilization in tension and shear
ϕN_{sa}	Steel strength of anchor in tension - ACI 318-14 – 17.4.1
ϕV_{sa}	Steel strength of anchor in shear - ACI 318-14 – 17.5.1
t_w	Throat thickness of weld
w	Leg size of weld
L	Length of weld
L_c	Length of weld critical element
F_n	Force in weld critical element
ϕR_n	Weld resistance - AISC 360-22 – J2-4
Ut	Utilization
Ut_c	Weld capacity estimation
◢	Fillet weld
F_{exx}	Ultimate strength as rated by electrode classification number
A_1	Loaded area
A_2	Supporting area
σ	Average stress in concrete
$\phi f_{p,max}$	Concrete bearing resistance
d_0	Cross-section size
δ	Local cross-section deformation
δ_{lim}	Allowed deformation

Code settings

Item	Value	Unit	Reference
Friction coefficient - concrete	0.40	-	ACI 349-01 – B.6.1.4
Friction coefficient in slip-resistance	0.30	-	AISC 360-22 – J3.9
Limit plastic strain	0.05	-	
Detailing	Yes		
Distance between bolts [d]	2.66	-	AISC 360-22 – J3.4
Concrete breakout resistance check	None		
Base metal capacity check at weld fusion face	Yes		AISC 360-22 – J2-2
Deformation at bolt hole at service load is design consideration	Yes		AISC 360-22 – J3.11
Cracked concrete	Yes		ACI 318-14 – 17
Local deformation check	Yes		
Local deformation limit	0.03	-	CIDECT DG 1, 3 – 1.1
Geometrical nonlinearity (GMNA)	Yes		Analysis with large deformations for hollow section joints