Project data

Project name	Steel to concrete connection
Project number	
Author	
Description	
Date	4/10/2025
Code	AISC/ACI

Material

Steel	A992, A572 Gr.50, A500. Gr. C, A572 Gr.50, A572 Gr.50
Concrete	4000 psi

Project item Base plate connection

Design

Name	Base plate connection
Description	
Analysis	Stress, strain/ loads in equilibrium
Design code	AISC 360-22 (LRFD) / ACI 318-19

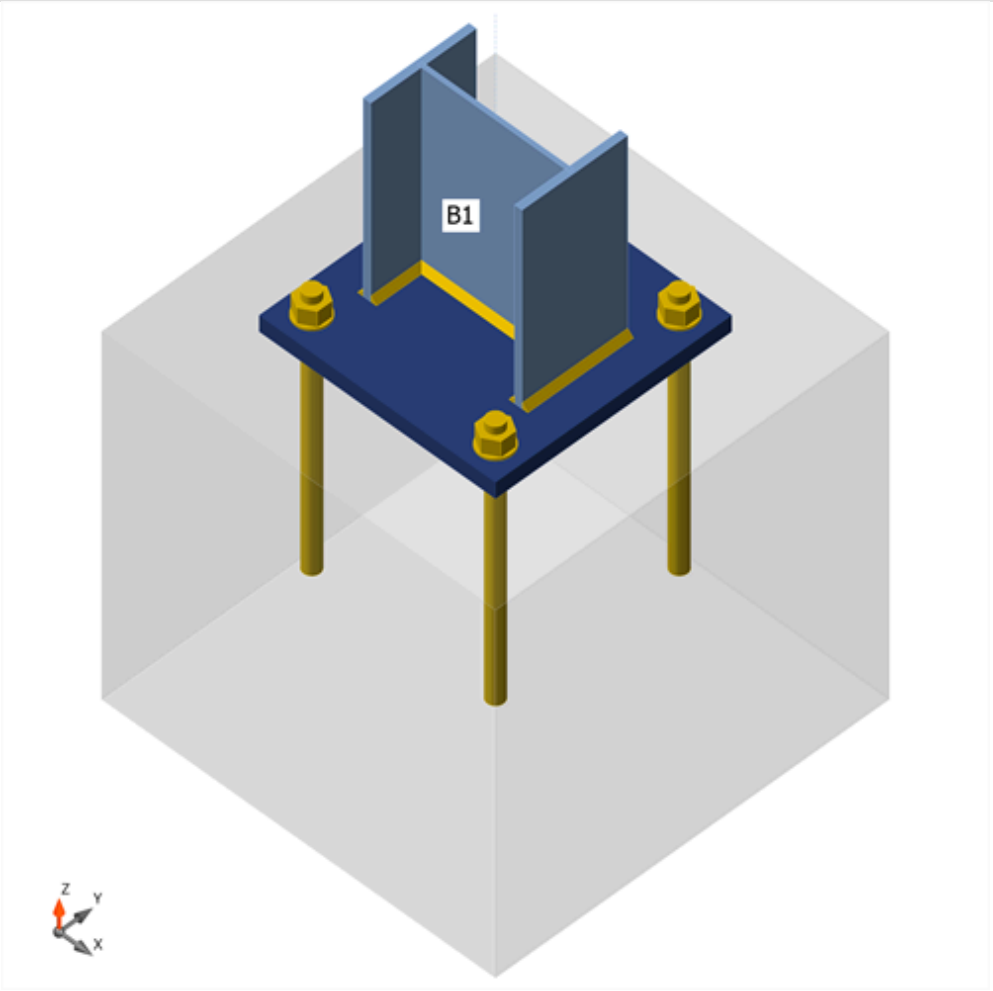
Members

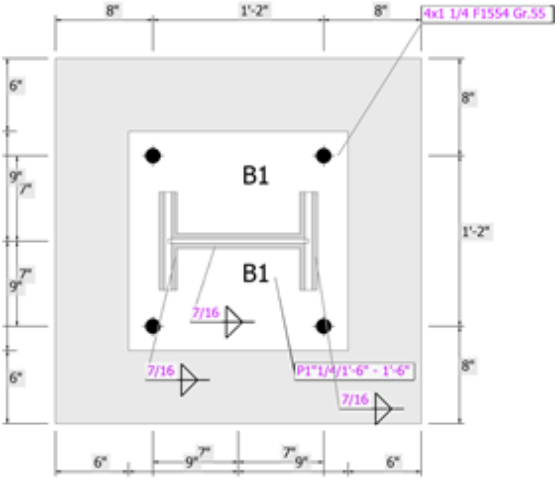
Geometry

Name	Cross-section	β – Direction [°]	γ - Pitch [°]	α - Rotation [°]	Offset ex [in]	Offset ey [in]	Offset ez [in]
B1	2 - W12X45	0.0	90.0	0.0	0"	0"	0"

Supports and forces

Name	Support	Forces in	X [in]
B1 / end		Node	0"





Base plate (BP1)

Cross-sections

Name	Material
2 - W12X45	A992

Anchors

Name	Diameter [in]	f_y [ksi]	f_u [ksi]	Gross area [in^2]
1 1/4 F1554 Gr.55	1"1/4	55.0	75.0	1.2272

Load effects (forces in equilibrium)

Name	Member	N [kip]	Vy [kip]	Vz [kip]	Mx [kip.ft]	My [kip.ft]	Mz [kip.ft]
N+Vz+My	B1 / End	17.00	0.00	10.00	0.00	60.00	0.00
Uplift+Vz	B1 / End	80.00	0.00	20.00	0.00	0.00	0.00
Uplift+Vy	B1 / End	80.00	20.00	0.00	0.00	0.00	0.00

Unbalanced forces

Name	X [kip]	Y [kip]	Z [kip]	Mx [kip.ft]	My [kip.ft]	Mz [kip.ft]
N+Vz+My	-10.00	0.00	17.00	0.00	60.00	0.00
Uplift+Vz	-20.00	0.00	80.00	0.00	0.00	0.00
Uplift+Vy	0.00	20.00	80.00	0.00	0.00	0.00

Foundation block

Item	Value	Unit
CB 1		
Dimensions	2'-6" x 2'-6"	in
Depth	2'-4"	in
Anchor	1 1/4 F1554 Gr.55	
Anchoring length	1'-6"	in
Shear force transfer	Anchors	

Check

Summary

Name	Value	Check status
Analysis	100.0%	OK
Plates	0.0 < 5.0%	OK
Anchors	62.8 < 100%	OK
Welds	80.8 < 100%	OK
Concrete block	14.6 < 100%	OK
Buckling	Not calculated	

Plates

Name	Material	t_p [in]	Loads	σ_{Ed} [ksi]	ε_{Pl} [%]	$\sigma_{c,Ed}$ [ksi]	Status
B1-bfl 1	A992	9/16	Uplift+Vy	34.9	0.0	0.0	OK
B1-tfl 1	A992	9/16	N+Vz+My	39.8	0.0	0.0	OK
B1-w 1	A992	5/16	Uplift+Vz	16.7	0.0	0.0	OK
BP1	A572 Gr.50	1"1/4	N+Vz+My	43.6	0.0	0.0	OK

Design data

Material	F_y [ksi]	ε_{lim} [%]
A992	50.0	5.0
A572 Gr.50	50.0	5.0

Detailed result for B1-tfl 1

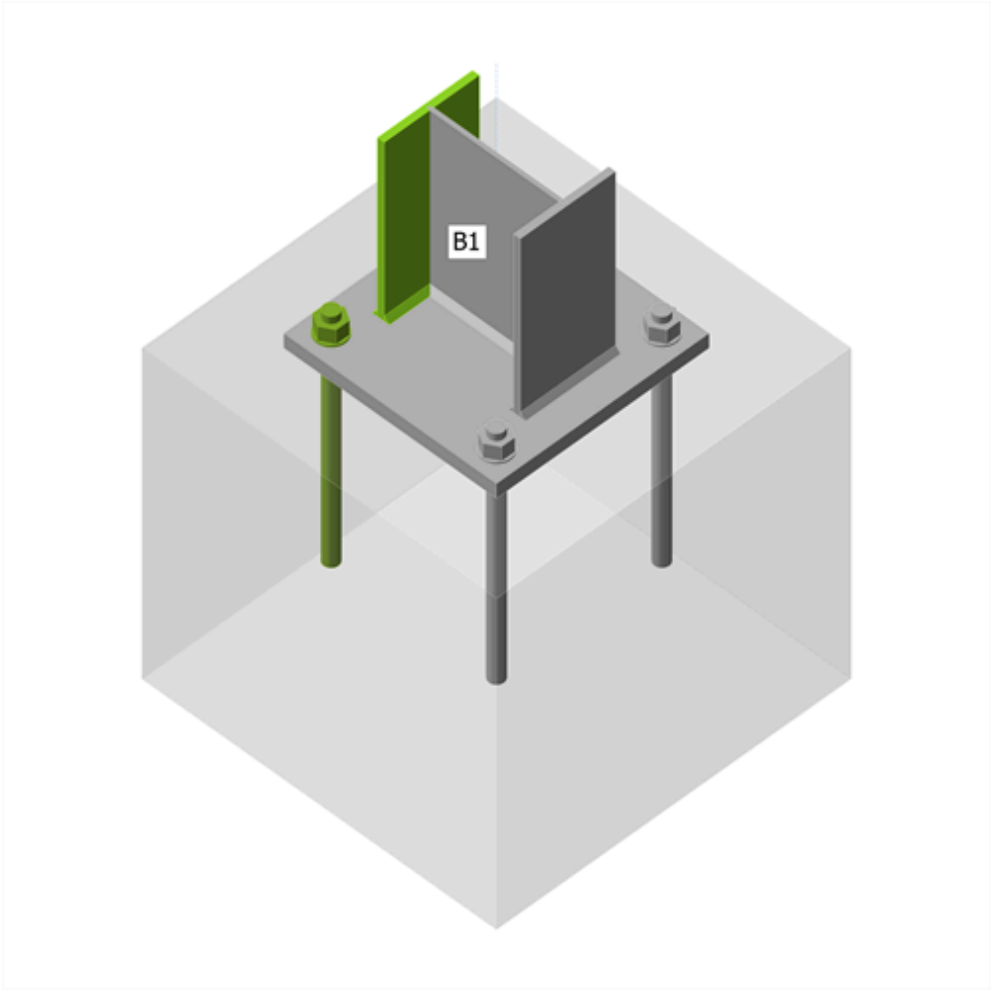
Design values used in the analysis

$\phi F_y =$ 45.0 ksi

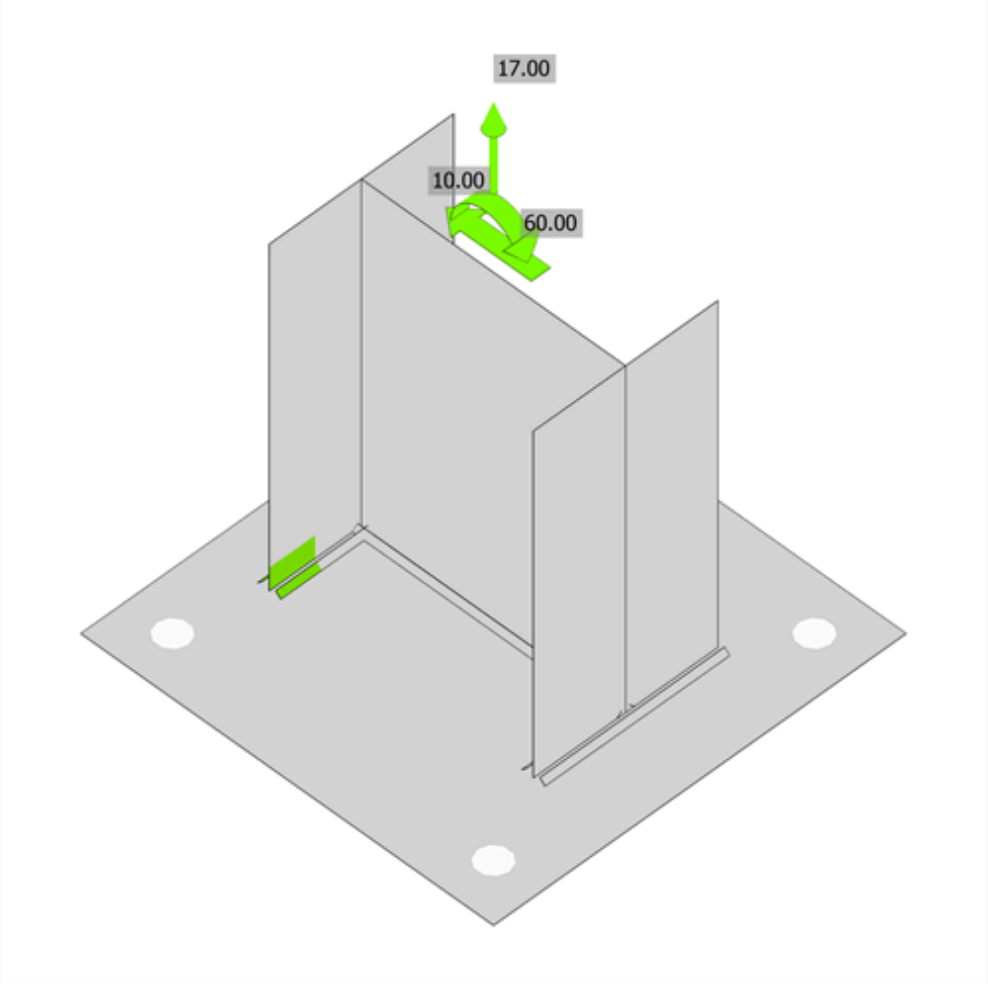
Where:

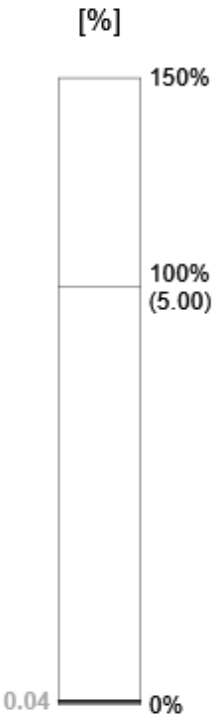
$F_y = 50.0$ ksi – characteristic yield strength

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

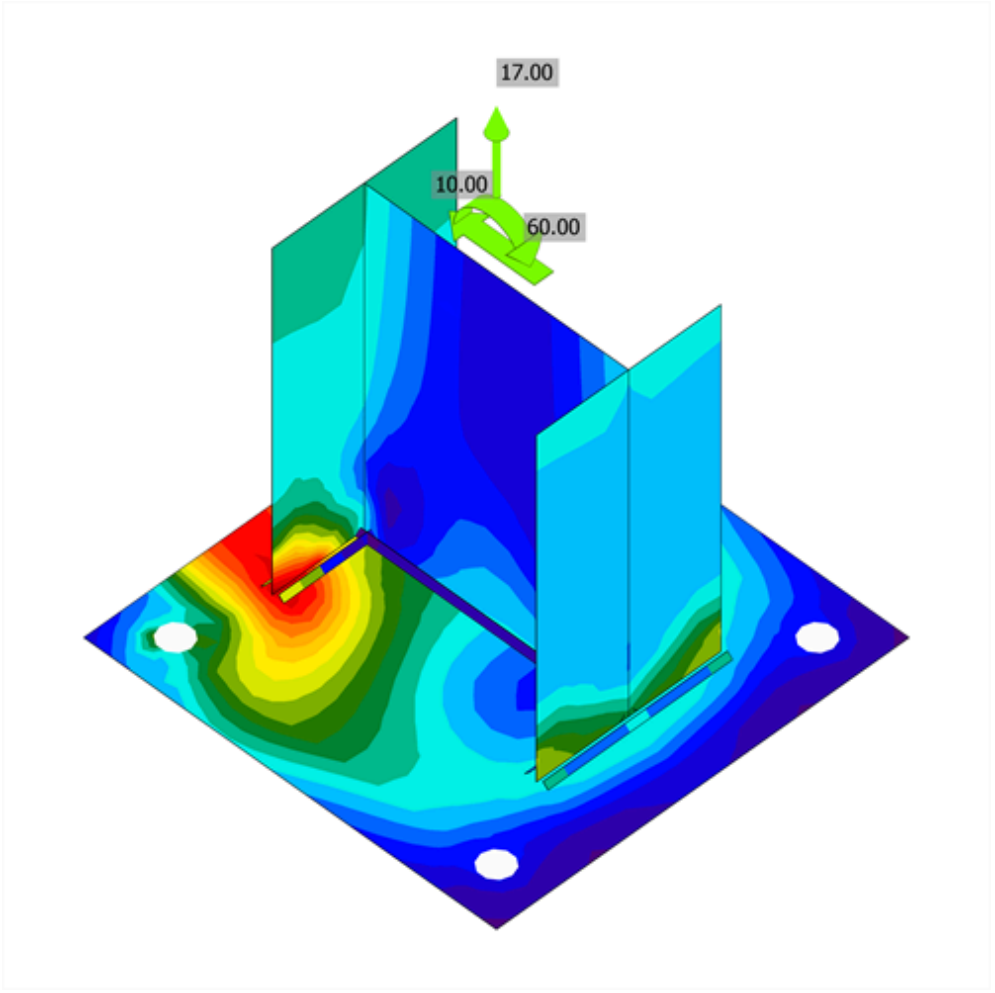


Overall check, N+Vz+My



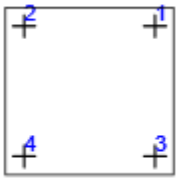


Strain check, N+Vz+My



Equivalent stress, N+Vz+My

Anchors

Shape	Item	Loads	N_f [kip]	V [kip]	Ut_t [%]	Ut_s [%]	Ut_{ts} [%]	Detailing	Status
	A1	Uplift+Vy	22.15	4.71	43.5	16.6	30.0	OK	OK
	A2	N+Vz+My	31.93	2.55	62.8	9.0	47.8	OK	OK
	A3	Uplift+Vz	22.11	5.01	43.5	17.7	30.5	OK	OK
	A4	N+Vz+My	31.94	2.55	62.8	9.0	47.8	OK	OK

Design data

Grade	ϕN_{sa} [kip]	ϕV_{sa} [kip]
1 1/4 F1554 Gr.55 - 1	50.87	28.34

Detailed result for A4

Following checks of anchors loaded in tension are not provided and should be checked using information in relevant Technical Product Specification (based on the 5 percent fractile of tests performed and evaluated according to ACI 355.2):

- *Pull-out failure of fastener (for post-installed mechanical anchors) - ACI 318-19 – 17.6.3*
- *Bond strength of adhesive anchor (for post-installed bonded anchors) - ACI 318-19 – 17.6.5*
- *Concrete splitting failure during installation should be evaluated by ACI 355.2 requirements*

Concrete blow-out failure is provided only for anchors with washer plates.

Anchor tensile resistance (ACI 318-19 – 17.6.1)

$\phi N_{sa} = \phi \cdot A_{se,N} \cdot f_{uta} =$ 50.87 kip ≥ $N_f =$ 31.94 kip

Where:

$\phi =$ 0.70 – resistance factor

$A_{se,N} =$ 0.9690 in^2 – tensile stress area

$f_{uta} =$ 75.0 ksi – specified tensile strength of anchor steel:

- $f_{uta} = \min(125 \text{ ksi}, 1.9 \cdot f_{ya},\ f_u)$, where:
  - $f_{ya} =$ 55.0 ksi – specified yield strength of anchor steel
  - $f_u =$ 75.0 ksi – specified ultimate strength of anchor steel

Shear resistance (ACI 318-19 – 17.7.1)

$\phi V_{sa} = \phi \cdot 0.6 \cdot A_{se,V} \cdot f_{uta} =$ 28.34 kip ≥ $V =$ 2.55 kip

Where:

$\phi =$ 0.65 – resistance factor

$A_{se,V} =$ 0.9690 in^2 – tensile stress area

$f_{uta} =$ 75.0 ksi – specified tensile strength of anchor steel:

- $f_{uta} = \min(125 \text{ ksi}, 1.9 \cdot f_{ya},\ f_u)$, where:
  - $f_{ya} =$ 55.0 ksi – specified yield strength of anchor steel
  - $f_u =$ 75.0 ksi – specified ultimate strength of anchor steel

Interaction of tensile and shear forces (ACI 318-19 – R17.8)

${U_{tt}}^{5/3} + {U_{ts}}^{5/3} =$ 0.48 ≤ 1.0

Where:

$U_{tt} =$ 0.63 – maximum ratio of factored tensile force and tensile resistance determined from all appropriate failure modes

$U_{ts} =$ 0.09 – maximum ratio of factored shear force and shear resistance determined from all appropriate failure modes

Supplementary reinforcement (ACI 318-19 – 17.5.2.1 ; ACI 318-19 – 17.5.2.1)

Supplementary reinforcement should resist force of 63.87 kip in tension and 10.00 kip in shear. Only current load effect considered.

Welds

Item	Edge	Xu	t_w [in]	w [in]	L [in]	L_c [in]	Loads	F_n [kip]	ϕR_n [kip]	Ut [%]	Ut_c [%]	Detailing	Status
BP1	B1-bfl 1	E70xx	◢ 5/16 ◣	◢ 7/16 ◣	8"1/16	7/8	Uplift+Vy	9.14	11.85	77.2	60.9	OK	OK
		E70xx	◢ 5/16 ◣	◢ 7/16 ◣	8"1/16	7/8	Uplift+Vy	9.19	11.85	77.5	63.0	OK	OK
BP1	B1-tfl 1	E70xx	◢ 5/16 ◣	◢ 7/16 ◣	8"1/16	7/8	N+Vz+My	9.96	12.33	80.8	72.5	OK	OK
		E70xx	◢ 5/16 ◣	◢ 7/16 ◣	8"1/16	7/8	N+Vz+My	9.79	12.27	79.8	72.1	OK	OK
BP1	B1-w 1	E70xx	◢ 5/16 ◣	◢ 7/16 ◣	11"1/2	7/8	Uplift+Vz	1.35	9.98	13.5	5.4	OK	OK
		E70xx	◢ 5/16 ◣	◢ 7/16 ◣	11"1/2	7/8	Uplift+Vz	1.39	9.95	14.0	5.6	OK	OK

Design data

Material	F_{exx} [ksi]
E70xx	70.0

Detailed result for BP1 / B1-tfl 1

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

$\phi R_n = \phi \cdot F_{nw} \cdot A_{we} =$ 12.33 kip ≥ $F_n =$ 9.96 kip

Where:

$F_{nw} =$ 58.9 ksi – nominal stress of weld material:

- $F_{nw} = 0.6 \cdot F_{EXX} \cdot (1 + 0.5 \cdot sin^{1.5}\theta)$, where:
  - $F_{EXX} =$ 70.0 ksi – electrode classification number, i.e. minimum specified tensile strength
  - $\theta =$ 60.1° – angle of loading measured from the weld longitudinal axis

$A_{we} =$ 0.2789 in^2 – effective area of weld critical element

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

Concrete block

Item	Loads	A_1 [in^2]	A_2 [in^2]	σ [ksi]	$\phi f_{p,max}$ [ksi]	Ut [%]	Status
CB 1	Uplift+Vz	14.8867	716.0784	0.6	4.4	14.6	OK

Detailed result for CB 1

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

$\phi_c f_{p,max} =$ 4.4 ksi ≥ $\sigma =$ 0.6 ksi

Where:

$f_{p,max} =$ 6.8 ksi – 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:
  - $f'_c =$ 4.0 ksi – concrete compressive strength
  - $A_1 =$ 14.8867 in^2 – base plate area in contact with concrete surface
  - $A_2 =$ 716.0784 in^2 – concrete supporting surface

$\phi_c =$ 0.65 – resistance factor for concrete

Buckling

Buckling analysis was not calculated.

Bill of material

Manufacturing operations

Name	Plates [in]	Shape	Nr.	Welds [in]	Length [in]	Bolts	Nr.
BP1	P1"1/4x1'-6"-1'-6" (A572 Gr.50)		1	Double fillet: 7/16	2'-3"5/8	1 1/4 F1554 Gr.55	4

Symbol explanation

Fillet weld	leg size of weld

Welds

Type	Material	Throat thickness [in]	Leg size [in]	Length [in]
Double fillet	E70xx	5/16	7/16	2'-3"5/8

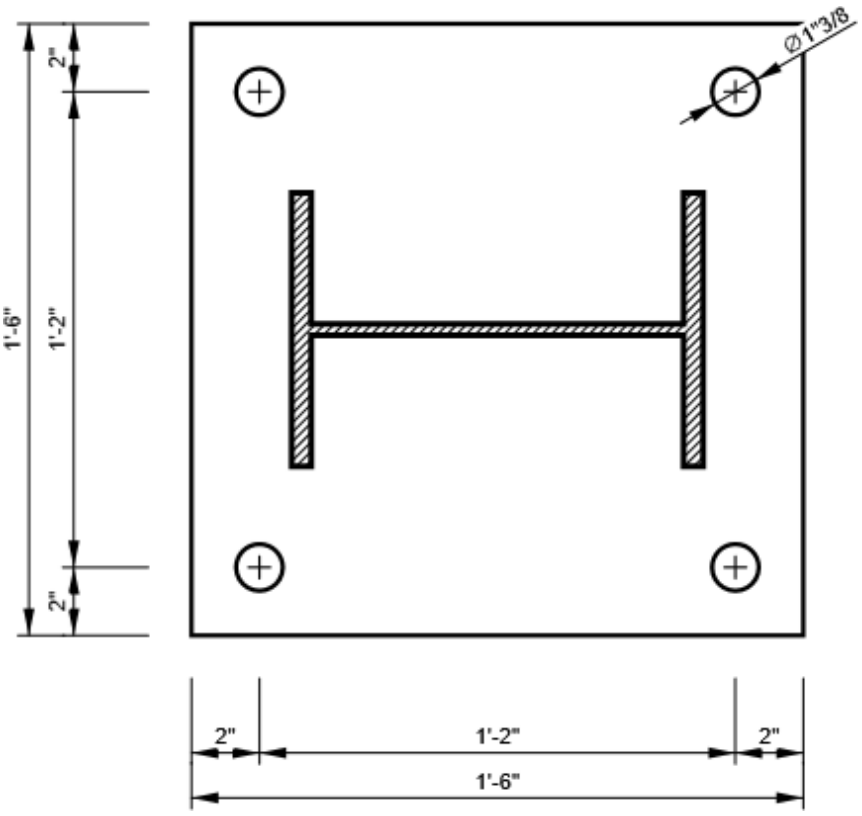
Anchors

Name	Length [in]	Drill length [in]	Count
1 1/4 F1554 Gr.55	1'-7"1/4	1'-6"	4

Drawing

BP1

P1"1/4x1'-6"-1'-6" (A572 Gr.50)



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
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 318-19 – 17.6.1
ϕV_{sa}	Steel strength of anchor in shear - ACI 318-19 – 17.7.1
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

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	No		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 318-19 – 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

Software info

Application	IDEA StatiCa Connection
Version	25.0.0.2048
Developed by	IDEA StatiCa