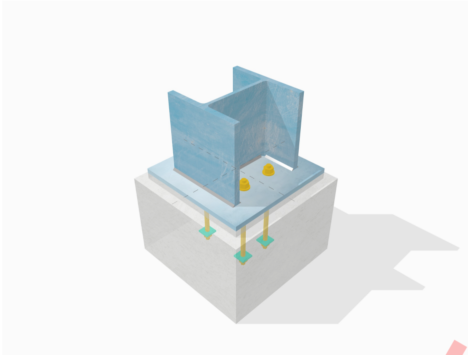
REFERENCES	CALCULATIONS	RESULTS

SkyCiv Base Plate and Anchor Rod Design

C - aisc sample 1

Project Information:
Design Code: AISC 360-22/360-16 (LRFD) and ACI 318-19

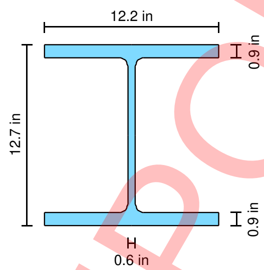


Load Combinations:

Load Combination	Axial Load, Nx (kip)	Strong-axis Shear, Vy (kip)	Weak-axis Shear, Vz (kip)
1	100.00	0.00	0.00

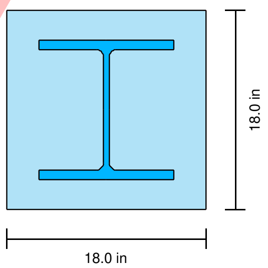
Note: Positive Nx (+) indicates compression; negative Nx (-) indicates tension.

Column Properties:



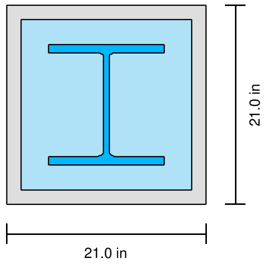
Symbol	Description	Value
d_{col}	Column depth	12.700 in
t_w	Column web thickness	0.550 in
b_f	Column flange width	12.200 in
t_f	Column flange thickness	0.900 in
A_{col}	Column area	28.200 in^2
r_{col}	Column root radius	0.600 in
F_{y_col}	Column yield stress (A992)	50.000 ksi
F_{u_col}	Column tensile stress (A992)	65.000 ksi

Base Plate Properties:



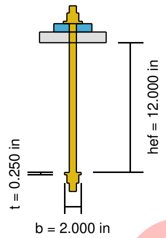
Symbol	Description	Value
B_{bp}	Base plate width	18.000 in
L_{bp}	Base plate length	18.000 in
t_{bp}	Base plate thickness	0.750 in
A_{bp}	Base plate plan area	324.000 in^2
F_{y_bp}	Base plate yield stress (A36)	36.000 ksi
F_{u_bp}	Base plate tensile stress (A36)	58.000 ksi

Concrete Properties:



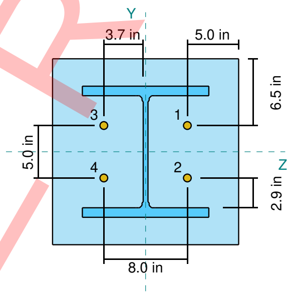
Symbol	Description	Value
B_{conc}	Concrete width	21.000 in
L_{conc}	Concrete length	21.000 in
t_{conc}	Concrete thickness	14.000 in
A_{conc}	Concrete plan area	441.000 in^2
$f_c^{'}$	Concrete compressive strength (3000)	3.000 ksi
λ	Factor for normal-weight concrete	1.000

Anchor Information:



Symbol	Description	Value
d_a	Anchor rod diameter	0.750 in
h_{ef}	Anchor rod effective embedment length	12.000 in
b_{embed_plate}	Anchor embed plate side dimension	2.000 in
t_{embed_plate}	Anchor embed plate thickness	0.250 in
F_{y_anc}	Anchor rod yield stress (A325)	92.000 ksi
F_{u_anc}	Anchor rod tensile stress (A325)	120.000 ksi
F_{y_ep}	Embed plate yield stress (A36)	36.000 ksi

Anchor Layout:



Symbol	Description	Value
n_a	Total number of anchor rods	4.000
s_z	Spacing of anchor rods along Z-axis	8.000 in
s_y	Spacing of anchor rods along Y-axis	5.000 in
$l_{edge,z}$	Base plate edge distance along Z-axis	5.000 in
$l_{edge,y}$	Base plate edge distance along Y-axis	6.500 in

Anchor Data Summary:

ID	Z (in)	Y (in)	Anchor in Tension Zone	Breakout (Tension)	Side-Face Blowout (Y-direction)	Side-Face Blowout (Z-direction)
1	4	2.5	✓	BO Group 1	N/A	N/A
2	4	-2.5	✓	BO Group 1	N/A	N/A
3	-4	2.5	✓	BO Group 1	N/A	N/A
4	-4	-2.5	✓	BO Group 1	N/A	N/A

Weld Properties:

Symbol	Description	Value
$Type$	Weld Type	Fillet
W_{top_flange}	Fillet weld size at Top Flange	0.313 in
$E_{w\_top\_flange}$	Weld throat at Top Flange	0.221 in
W_{bottom_flange}	Fillet weld size at Bottom Flange	0.313 in
$E_{w\_bottom\_flange}$	Weld throat at Bottom Flange	0.221 in
W_{web}	Fillet weld size at Web	0.313 in
E_{w_web}	Weld throat at Web	0.221 in
F_{exx}	Filler metal classification strength (E70xx)	70.000 ksi

Summary of Detailing Checks

Check Name	Dimensions (Min/Max/Actual)	Status
Weld Size Requirement (Flange)	Min: 0.25 in, Max: 0.75 in, Actual: 0.31 in	PASS
Weld Size Requirement (Web)	Min: 0.25 in, Max: 0.75 in, Actual: 0.31 in	PASS
Anchor Clearance	Min: 1.19 in in, Actual: 2.64 in	PASS
Base Plate Edge Distance	Min: 1.06 in in, Actual: 5.00 in	PASS
Minimum Number of Anchors	Min: 4.00, Actual: 4.00	PASS
Min. Anchor Spacing to Prevent Concrete Splitting	Min: 2.99 in in, Actual: 5.00 in	PASS
Min. Concrete Cover to Prevent Concrete Splitting	Min: 2.00 in in, Actual: 6.50 in	PASS

The design geometry meets requirements!

REFERENCES	CALCULATIONS	RESULTS

Load Combination No. 1: Compression Load Only

Check No. 1: Column Bearing Capacity
Calculate bearing load on column member

$N_x = 100$ kip - Compression load

R_u - Required column bearing strength

$$R_u = N_x = 100 \text{ kip}$$

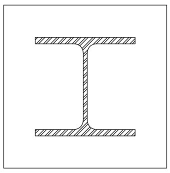


Fig. Bearing area of column.

Calculate bearing capacity of column member

$F_{y\_col} = 50$ ksi - Column yield stress (A992)

$A_{col} = 28.2 \text{ in}^2$ - Column area

$\phi = 0.75$ - Steel bearing resistance factor

AISC 360-22 Chapter J7 Eq. (J7-1), Finished bearing plate per AISC 360-22 Chapter M4.4

ϕR_n - Design bearing strength

$$\phi R_n = \phi 1.8 F_{y\_col} A_{col} = 0.75 \times 1.8 \times 50 \text{ ksi} \times 28.2 \text{ in}^2 = 1903.5 \text{ kip}$$

Result:

PASS = 0.05

DCR - Demand over capacity ratio:

$$DCR = \frac{R_u}{\phi R_n} = \frac{100 \text{ kip}}{1903.5 \text{ kip}} = 0.052535$$

Check No. 2: Weld Capacity

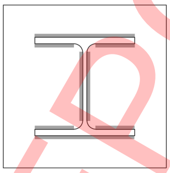


Fig. Effective welds on column to base plate.

Calculate total weld length on column flange and web

$d_{col} = 12.7$ in - Column depth

$b_f = 12.2$ in - Column flange width

$t_f = 0.9$ in - Column flange thickness

$t_w = 0.55$ in - Column web thickness

$r_{col} = 0.6$ in - Column root radius

L_{weld} - Total length of weld

$$L_{weld} = 2b_f + 2\left(d_{col} - 2t_f - 2r_{col}\right) + 2\left(b_f - t_w - 2r_{col}\right)$$

$$L_{weld} = 2 \times 12.2 \text{ in} + 2 \times (12.7 \text{ in} - 2 \times 0.9 \text{ in} - 2 \times 0.6 \text{ in}) + 2 \times (12.2 \text{ in} - 0.55 \text{ in} - 2 \times 0.6 \text{ in}) = 64.7 \text{ in}$$

Calculate load per unit length of weld

$N_x = 100$ kip - Compression load

$L_{weld} = 64.7$ in

r_u - Required weld strength per unit length

$$r_u = \frac{N_x}{L_{weld}} = \frac{100 \text{ kip}}{64.7 \text{ in}} = 1.5456 \text{ kip/in}$$

Calculate fillet weld capacity

$F_{exx} = 70$ ksi - Filler metal classification strength (E70xx)

$E_w = 0.221$ in - Design weld throat

$k_{ds} = 1$ - Directional strength increase factor

$\phi = 0.75$ - Weld resistance factor

AISC 360-22 Chapter J2.4 Eq. (J2-4)

ϕr_n - Design strength of fillet welds per unit length

$$\phi r_n = \phi 0.6 F_{exx} E_w k_{ds} = 0.75 \times 0.6 \times 70 \text{ ksi} \times 0.221 \text{ in} \times 1 = 6.9615 \text{ kip/in}$$

Result:

PASS = 0.22

DCR - Demand over capacity ratio:

$$DCR = \frac{r_u}{\phi r_n} = \frac{1.5456 \text{ kip/in}}{6.9615 \text{ kip/in}} = 0.22202$$

Check No. 3: Base Plate Yield Capacity (Compression Load)

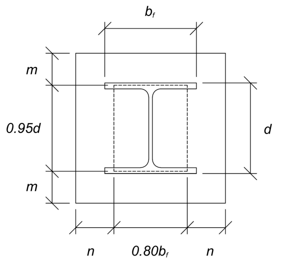


Fig. Cantilever lengths of base plate.

Calculate critical cantilever length for I-shaped column

$d_{col} = 12.7\ \text{in}$ - Column depth

$b_f = 12.2\ \text{in}$ - Column flange width

$L_{bp} = 18\ \text{in}$ - Base plate length

$B_{bp} = 18\ \text{in}$ - Base plate width

AISC Manual 15th Ed. Part 14 pg. 14-5, AISC Design Guide 01 3rd Ed. Section 4.3.1. Lambda conservatively taken as 1.0

l - Critical cantilever length of base plate

$$l = \max\left(\frac{\mathrm{L_{bp}} - 0.95\mathrm{d_{col}}}{2}, \frac{\mathrm{B_{bp}} - 0.8\mathrm{b_f}}{2}, \frac{\sqrt{\mathrm{d_{col}}\mathrm{b_f}}}{4}\right)$$

$$l = \max\left(\frac{18\ \text{in} - 0.95 \times 12.7\ \text{in}}{2}, \frac{18\ \text{in} - 0.8 \times 12.2\ \text{in}}{2}, \frac{\sqrt{12.7\ \text{in} \times 12.2\ \text{in}}}{4}\right)$$

$$l = 4.12\ \text{in}$$

Calculate applied moment load per unit length on critical section of base plate due to compression from concrete

$N_x = 100\ \text{kip}$ - Compression load

$B_{bp} = 18\ \text{in}$ - Base plate width

$L_{bp} = 18\ \text{in}$ - Base plate length

AISC Manual 15th Ed. Part 14 pg. 14-5, AISC Design Guide 01 3rd Ed. Section 4.3.1. Lambda conservatively taken as 1.0

$l = 4.12\ \text{in}$

AISC Design Guide 01 2nd Ed.

m_u - Required flexural yielding strength of base plate

$$m_u = \left(\frac{N_x}{B_{bp}L_{bp}}\right)\left(\frac{l^2}{2}\right)$$

$$m_u = \left(\frac{100\ \text{kip}}{18\ \text{in} \times 18\ \text{in}}\right) \times \left(\frac{4.12\ \text{in}^2}{2}\right) = 2.6195\ \text{kip}\cdot\text{in}/\text{in}$$

Calculate flexural yielding capacity of base plate per unit length due to compression from concrete

$F_{y\_bp} = 36\ \text{ksi}$ - Base plate yield stress (A36)

$t_{bp} = 0.75\ \text{in}$ - Base plate thickness

$\phi = 0.9$ - Flexural resistance factor

AISC Manual 15th Ed. Part 14 pg.14-6, AISC 360-22 Chapter F2 Eq. (F2-1)

ϕm_n - Design flexural yielding strength of base plate per unit length

$$\phi m_n = \phi F_{y\_bp}\left(\frac{(t_{bp})^2}{4}\right) = 0.9 \times 36\ \text{ksi} \times \left(\frac{(0.75\ \text{in})^2}{4}\right) = 4.5562\ \text{kip}\cdot\text{in}/\text{in}$$

Result:

PASS = 0.57

DCR - Demand over capacity ratio:

$$DCR = \frac{m_u}{\phi m_n} = \frac{2.6195\ \text{kip}\cdot\text{in}/\text{in}}{4.5562\ \text{kip}\cdot\text{in}/\text{in}} = 0.57493$$

Check No. 4: Concrete Bearing Capacity

Calculate bearing load on concrete

$N_x = 100\ \text{kip}$ - Compression load

P_u - Required concrete bearing strength

$$P_u = N_x = 100\ \text{kip}$$

The restraining side is equal along the concrete width and concrete length.

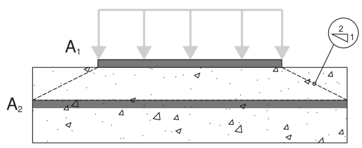


Fig. Bearing area on base plate (A1) and maximum support area on concrete (A2).

Calculate bearing area on base plate

$L_{bp} = 18\ \text{in}$ - Base plate length

$B_{bp} = 18\ \text{in}$ - Base plate width

AISC 360-22 Chapter J8, ACI

318-19 Sect. 22.8.3.2 and Fig. R22.8.3.2

A_1 - Area of bearing on base plate (assume full area)

$$A_1 = L_{bp} B_{bp} = 18 \text{ in} \times 18 \text{ in} = 324 \text{ in}^2$$

Calculate maximum bearing area on concrete foundation

$N_{A2} = 21 \text{ in}$ - Length of max bearing area on support (A2)

$B_{A2} = 21 \text{ in}$ - Width of max bearing area on support (A2)

AISC 360-22 Chapter J8, ACI 318-19 Sect. 22.8.3.2 and Fig. R22.8.3.2

A_2 - Maximum area of bearing on concrete (assume 1:2 slope)

$$A_2 = N_{A2} B_{A2} = 21 \text{ in} \times 21 \text{ in} = 441 \text{ in}^2$$

Calculate bearing capacity of concrete

$f_c^{'} = 3 \text{ ksi}$ - Concrete compressive strength (3000)

AISC 360-22 Chapter J8, ACI 318-19 Sect. 22.8.3.2 and Fig. R22.8.3.2

$A_1 = 324 \text{ in}^2$

AISC 360-22 Chapter J8, ACI 318-19 Sect. 22.8.3.2 and Fig. R22.8.3.2

$A_2 = 441 \text{ in}^2$

$\phi = 0.65$ - Concrete bearing resistance factor

AISC 360-22 Chapter J8 Eq. (J8-2)

ϕP_p - Design bearing strength of concrete crushing

$$\phi P_p = \phi \left(\min \left(0.85 \left(\mathrm{f_c^{'}} \right) \mathrm{A_1} \sqrt{\frac{\mathrm{A_2}}{\mathrm{A_1}}},\ 1.7 \left(\mathrm{f_c^{'}} \right) \mathrm{A_1} \right) \right)$$

$$\phi P_p = 0.65 \times \left(\min \left(0.85 \times (3 \text{ ksi}) \times 324 \text{ in}^2 \times \sqrt{\frac{441 \text{ in}^2}{324 \text{ in}^2}},\ 1.7 \times (3 \text{ ksi}) \times 324 \text{ in}^2 \right) \right)$$

$$\phi P_p = 626.54 \text{ kip}$$

Result:

PASS = 0.16

DCR - Demand over capacity ratio:

$$DCR = \frac{P_u}{\phi P_p} = \frac{100 \text{ kip}}{626.54 \text{ kip}} = 0.15961$$

REFERENCES	CALCULATIONS	RESULTS
	Summary of Design Checks	The governing combination is Load Combination 1.

Load Combination	Design Check	Demand	Capacity	DCR	Result
1	Column Bearing Capacity	100.00	1903.50	0.05	PASS
1	Weld Capacity	1.55	6.96	0.22	PASS
1	Base Plate Yield Capacity (Compression Load)	2.62	4.56	0.57	PASS
1	Concrete Bearing Capacity	100.00	626.54	0.16	PASS

The design is adequate!