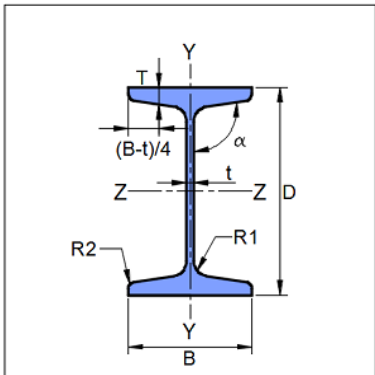




Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

## 1 Input Parameters

Main Module		Moment Connection		
Module		Base Plate Connection		
Connectivity		Moment Base Plate		
End Condition		Fixed		
Axial Compression (kN)		1600.0		
Axial Tension/Uplift (kN)		0.0		
Shear Force (kN)				
- Along major axis (z-z)		80.0		
- Along minor axis (y-y)		23.0		
Bending Moment (kNm)				
- Major axis ( $M_{z-z}$ )		180.0		
- Minor axis ( $M_{y-y}$ )		45.0		
Column Section - Mechanical Properties				
	Column Section		HB 450	
	Material		E 300 (Fe 440)	
	Ultimate Strength, $F_u$ (MPa)		440.0	
	Yield Strength, $F_y$ (MPa)		300.0	
	Mass, $m$ (kg/m)	87.22	$I_z$ (cm <sup>4</sup> )	39200.0
	Area, $A$ (cm <sup>2</sup> )	111.0	$I_y$ (cm <sup>4</sup> )	2980.0
	None	None	$r_z$ (cm)	18.7
	$D$ (mm)	450.0	$r_y$ (cm)	5.18
	$B$ (mm)	250.0	$Z_z$ (cm <sup>3</sup> )	1740.0
	$T$ (mm)	13.7	$Z_y$ (cm <sup>3</sup> )	238.0
	$t$ (mm)	9.8	$Z_{pz}$ (cm <sup>3</sup> )	1950.0
	Flange Slope	94	$Z_{py}$ (cm <sup>3</sup> )	394.0
	$R_1$ (mm)	15.0		
	$R_2$ (mm)	7.5		
Base Plate - Design Preference				
Material		E 300 (Fe 440)		
Ultimate Strength, $F_u$ (MPa)		440		
Yield Strength, $F_y$ (MPa)		300		



Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

Stiffener/Shear Key - Design Preference	
Material	E 300 (Fe 440)
Anchor Bolt Outside Column Flange - Input and Design Preference	
Diameter (mm)	['M30']
Property Class	['10.9']
Anchor Bolt Type	End Plate Type
Anchor Bolt Galvanized?	Yes
Designation	M30X532.7 IS5624 GALV
Hole Type	Over-sized
Total Length (mm)	525.7
Material Grade, $F_u$ (MPa)	1040.0
Anchor Bolt Inside Column Flange - Input and Design Preference	
Diameter (mm)	N/A
Property Class	N/A
Anchor Bolt Type	N/A
Anchor Bolt Galvanized?	N/A
Designation	N/A
Hole Type	N/A
Total Length (mm)	N/A
Material Grade, $F_u$ (MPa)	N/A
Friction Coefficient (between concrete and anchor bolt)	0.3
Weld - Design Preference	
Type of Weld Fabrication	Shop Weld
Material Grade Overwrite, $F_u$ (MPa)	600.0
Detailing - Design Preference	
Edge Preparation Method	b - Rolled, machine-flame cut, sawn and planed
Are the Members Exposed to Corrosive Influences?	No
Design - Design Preference	
Design Method	Limit State Design
Base Plate Analysis	Elastic Analysis Method



Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

## 2 Design Checks

Design Status	Pass
---------------	------

### 2.1 Design Parameters

Check	Required	Provided	Remarks
Bearing Strength of Concrete (N/mm <sup>2</sup> )		$\sigma_{br} = 0.45f_{ck}$ $= 0.45 \times 25$ $= 11.25$  [Ref. IS 456:2000, Cl.34.4]	OK
Grout Thickness (mm)		$t_g = 50$	OK
Modular Ratio		$E_s = 2 \times 10^5 \text{ (N/mm}^2\text{)}$ $E_c = 5000 \sqrt{f_{ck}} \text{ (N/mm}^2\text{)}$ $= 5000 \times \sqrt{25} = 25000.0$  $n = \frac{E_s}{E_c}$ $n = \frac{200000}{25000.0}$ $= 8.0$  [Ref. IS 800:2007, IS 456:2000]	OK
Epsilon - stiffener plate		$\epsilon_{st} = \sqrt{\frac{250}{f_{yst}}}$ $= \sqrt{\frac{250}{300}}$ $= 0.91$  [Ref. IS 800:2007, Table2]	OK



Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

## 2.2 Load Consideration

Check	Required	Provided	Remarks
Axial Compression (kN)	$P_x = 1600.0$	$P_u = \max(P_x, 0.3P_d), \text{ but, } \leq P_d$ $= \max(1600.0, 0.3 \times 3027.27)$ $= \max(1600.0, 908.18)$ $\leq 3027.27$ $= 1600.0$  [Ref. IS 800:2007, Cl.10.7]  Note: $P_d$ is the design axial capacity of the column	Pass
Axial Tension/Uplift (kN)		$P_{up} = 0.0$	OK
Shear Force - along major (z-z) axis (kN)	$V_d = 391.27$	$V_1 = 80.0$	Pass
Shear Force - along minor (y-y) axis (kN)	$V_d = 391.27$	$V_2 = 23.0$	Pass
Bending Moment - major (z-z) axis (kNm)	$M_z = 180.0$	$M_{zmin} = 0.5 * M_{dz}$ $= 0.5 \times 474.55$ $= 237.27$  $M_{uz} = \max(M_z, M_{zmin}), \text{ but, } \leq M_{dz}$ $= \max(180.0, 237.27)$ $\leq 474.55$ $= 223.66$  Note: The column is classified as semi-compact.  [Ref. IS 800:2007, Cl.8.2.1.2]	Pass
Bending Moment - minor (y-y) axis (kNm)	$M = 45.0$	$M_y = 45.0$	Pass



Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

Check	Required	Provided	Remarks
Interaction Ratio	I.R. < 1.0	$\begin{aligned} \text{I.R. axial} &= P_x/P_d \\ &= 1600.0/3027.27 \\ &= 0.529 \\ \\ \text{I.R. moment} &= M_z/M_{dz} \\ &= 180.0/474.55 \\ &= 0.379 \\ \\ \text{I.R. sum} &= \text{I.R. axial} + \text{I.R. moment} \\ &= 0.529 + 0.379 \\ &= 0.908 \end{aligned}$	Pass

### 2.3 Plate Washer and Nut Details - Anchor Bolt Outside Column Flange

Check	Required	Provided	Remarks
Plate Washer Size (mm)		Square – 58X58  [Ref. IS 6649:1985, Table 2]	Pass
Plate Washer Thickness (mm)		$t_w = 8.5$  [Ref. IS 6649:1985, Table 2]	Pass
Plate Washer Hole Diameter (mm)		$d_h = 33$  [Ref. IS 6649:1985, Table 2]	Pass
Nut (hexagon) Thickness (mm)		$t_n = 25.6$  [Ref. IS 1364-3:2002, Table 1]	Pass
End Plate Size (mm)		Square - 116 X 116	Pass
End Plate Thickness (mm)		14	Pass



Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

## 2.4 Plate Washer and Nut Details - Anchor Bolt Inside Column Flange

Check	Required	Provided	Remarks
Plate Washer Size (mm)		Square – 58X58 [Ref. IS 6649:1985, Table 2]	Pass
Plate Washer Thickness (mm)		$t_w = 8.5$ [Ref. IS 6649:1985, Table 2]	Pass
Plate Washer Hole Diameter (mm)		$d_h = 33$ [Ref. IS 6649:1985, Table 2]	Pass
Nut (hexagon) Thickness (mm)		$t_n = 18.0$ [Ref. IS 1364-3:2002, Table 1]	Pass
End Plate Size (mm)		Square - 116 X 116	Pass
End Plate Thickness (mm)		14	Pass

## 2.5 Anchor Bolt Summary - Outside Column Flange

Check	Required	Provided	Remarks
Diameter (mm)		30	Pass
Number of Bolts		$n_{out} = 4$	Pass
Property Class		10.9	Pass

## 2.6 Anchor Bolt Summary - Inside Column Flange

Check	Required	Provided	Remarks
Diameter (mm)		30	Pass
Number of Bolts		$n_{in} = 4$	Pass
Property Class		8.8	Pass



Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

## 2.7 Detailing Checks - Outside Column Flange

Check	Required	Provided	Remarks
Min. End Distance ( $mm$ )	$e_{\min} = 1.5d_0$ $= 1.5 \times 38.0$ $= 57.0$ <p>[Ref. IS 800:2007, Cl.10.2.4.2]</p>	90	Pass
Max. End Distance ( $mm$ )	$e_{\max} = 12t\varepsilon; \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 56 \times \sqrt{\frac{250}{280}} = 634.98$ $e_2 = 12 \times 56 \times \sqrt{\frac{250}{280}} = 634.98$ $e_{\max} = \min(e_1, e_2) = 634.98$ <p>[Ref. IS 800:2007, Cl.10.2.4.3]</p>	90	Pass
Min. Edge Distance ( $mm$ )	$e'_{\min} = 1.5d_0$ $= 1.5 \times 38.0$ $= 57.0$ <p>[Ref. IS 800:2007, Cl.10.2.4.2]</p>	90	Pass
Max. Edge Distance ( $mm$ )	$e'_{\max} = 12t\varepsilon; \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 56 \times \sqrt{\frac{250}{280}} = 634.98$ $e_2 = 12 \times 56 \times \sqrt{\frac{250}{280}} = 634.98$ $e'_{\max} = \min(e_1, e_2) = 634.98$ <p>[Ref. IS 800:2007, Cl.10.2.4.3]</p>	90	Pass
Min. Pitch Distance ( $mm$ )	N/A	0.0	N/A
Max. Pitch Distance ( $mm$ )	N/A	0.0	N/A



Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

## 2.8 Base Plate Dimension (L X W)

Check	Required	Provided	Remarks
Length (mm)	$L = D + 2(e + e)$ $= 450.0 + 2 \times (90 + 90)$ $= 810.0$ [Ref. based on detailing requirement]	810	Pass
Width (mm)	$W = (0.85B) + 2(e' + e')$ $= (0.85 \times 250.0) + 2 \times (90 + 90)$ $= 572.5$ [Ref. based on detailing requirement]	575	Pass

## 2.9 Base Plate Analysis

Check	Required	Provided	Remarks
Eccentricity - about major axis (mm)		$e_{zz} = \frac{M_{uz}}{P_u}$ $= \frac{223.66 \times 10^6}{1600.0 \times 10^3}$ $= 139.79$	OK
Base Plate Type	$\frac{L_{min}}{6} < e_{zz} < \frac{L_{min}}{3}$ $\frac{810.0}{6} < 139.79 < \frac{810.0}{3}$ $135.0 < 139.79 < 270.0$	Case 2: The base plate is mostly under compression/bearing while a small tension force being transferred through the anchor bolts outside column flange on the tension side	OK
k1	$k_1 = 3 \left( e_{zz} - \frac{L}{2} \right)$ $= 3 \left( 139.79 - \frac{810}{2} \right)$ $= -795.63$ [Ref. Design of Welded Structures, Omer W Blodgett, section 3.3.]		OK





Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

Check	Required	Provided	Remarks
Total Area of Anchor Bolt - under tension (mm <sup>2</sup> )	$A_s = n \times \left(\frac{\pi}{4}\right) d^2$ $= 2 \times \left(\frac{\pi}{4}\right) \times 30^2$ $= 1414.0$		OK
Lever Arm - distance between the centre of the column and the C.G of the bolt group under tension (mm)	$f = \left(\frac{L}{2} - e\right)$ $= \left(\frac{810}{2} - 90\right)$ $= 315.0$ <p>[Ref. Design of Welded Structures, Omer W Blodgett, section 3.3]</p>		OK
k <sub>2</sub>	$k_2 = \frac{6 n A_s}{W} \left(f + e_{zz}\right)$ $= \frac{6 \times 8.0 \times 1414.0}{575} \times (315.0 + 139.79)$ $= 53682.62$ <p>Note: <math>n</math> is the modular ratio.</p> <p>[Ref. Design of Welded Structures, Omer W Blodgett, section 3.3]</p>		OK
k <sub>3</sub>	$k_3 = -k_2 \left(\frac{L}{2} + f\right)$ $= -53682.62 \left(\frac{810}{2} + 315.0\right)$ $= -38651486.4$ <p>[Ref. Design of Welded Structures, Omer W Blodgett, section 3.3]</p>		OK
Effective Bearing Length (mm)	$y^3 + k_1 y^2 + k_2 y + k_3 = 0$ $y^3 - 795.63 \times y^2 + 53682.62 \times y - 38651486.4 = 0$ $y = 790.0$ <p>[Ref. Design of Welded Structures, Omer W Blodgett, section 3.3]</p>		OK



Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

Check	Required	Provided	Remarks
Total Tension Demand (kN)	$P_t = - P_u \left[ \frac{\frac{L}{2} - \frac{y}{3} - e_{zz}}{\frac{L}{2} - \frac{y}{3} + f} \right]$ $= - 1600.0 \times \left[ \frac{\frac{810}{2} - \frac{790.0}{3} - 139.79}{\frac{810}{2} - \frac{790.0}{3} + 315.0} \right]$ $= 6.58$ <p>[Ref. Design of Welded Structures, Omer W Blodgett, section 3.3]</p>		OK
Critical Section - compression side (mm)	$y_{critical} = \frac{L - 0.95D}{2}$ $= \frac{810 - (0.95 \times 450.0)}{2}$ $= 191.25$ <p><math>y &gt; y_{critical} \quad (790.0 &gt; 191.25)</math></p> <p>Therefore, <math>y_{critical} = 191.25</math></p> <p>Note: The critical section lies at <math>0.95D</math> of the column section.</p>		OK
Bending Moment - at critical section (due to bearing stress) (N - mm)	$M_{critical1} = 0.45 f_{ck} W y_{critical} \times \left( \frac{y_{critical}}{2} \right)$ $= 0.45 \times 25.0 \times 575 \times 191.25 \times \left( \frac{191.25}{2} \right)$ $= 118.3 \times 10^6$		OK
Lever Arm - distance between center of the flange and bolt group (tension side) (mm)	$l = \frac{L}{2} - \frac{D}{2} + \frac{T}{2} - e$ $= \frac{810}{2} - \frac{450.0}{2} + \frac{13.7}{2} - 90$ $= 96.85$		OK
Bending Moment - at critical section (due to tension in the anchor bolts) (N - mm)	$M_{critical2} = P_t l$ $= 6.58 \times 1000 \times 96.85$ $= 637.27 \times 10^3$		OK



Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

Check	Required	Provided	Remarks
Maximum Bending Moment ( $N - mm$ )	$M_{critical} = \max (M_{critical1}, M_{critical2})$ $= \max (118.3 \times 10^6, 637.27 \times 10^3)$ $= 118.3 \times 10^6$	Bending of the base plate is governed by the bearing stress caused by the footing	OK
Moment Capacity of Base Plate	$z_{eplate} = \frac{W t_p^2}{6}$ $M_{dplate} = 1.5 z_{eplate} f_{yp} / \gamma_{m0}$ $= \frac{1.5 \left( \frac{W \times t_p^2}{6} \right) f_{yp}}{\gamma_{m0}}$ [Ref. IS 800:2007, Cl.8.2.1.2]		OK
Thickness of Base Plate (mm)	$(T, t) < t_p \leq 120$ $(13.7, 9.8) < t_p \leq 120$	$M_{dplate} = M_{critical}$ $t_p = \left[ \frac{4 M_{critical}}{W (f_{yp} / \gamma_{m0})} \right]^{0.5}$ $t_p = \left[ \frac{4 \times 118.3 \times 10^6}{575 \times (300/1.1)} \right]^{0.5}$ $= 54.93$ $= 56$	Pass
Maximum Bearing Stress on Footing ( $N/mm^2$ )	$\sigma_{callowable} = \sigma_{br}$ $= 11.25$	$\sigma_{cmax} = \frac{P_t y}{A_s n \left( \frac{L}{2} - y + f \right)}$ $= \frac{6.58 \times 10^3 \times 790.0}{1414.0 \times 8.0 \times \left( \left( \frac{810}{2} - 790.0 + 315.0 \right) \right)}$ $= 6.56$	Pass

## 2.10 Anchor Bolt Design - Outside Column Flange

Check	Required	Provided	Remarks
Shear Capacity ( $kN$ )		$V_{dsb} = \frac{f_{ub} n_n A_{nb}}{\sqrt{3} \gamma_{mb}}$ $= \frac{1040.0 \times 1 \times 561}{1000 \times \sqrt{3} \times 1.25}$ $= 269.48$ [Ref. IS 800:2007, Cl.10.3.3]	OK



Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

Check	Required	Provided	Remarks
Kb		$k_b = \min \left( \frac{e}{3d_0}, \frac{f_{ub}}{f_u}, 1.0 \right)$ $= \min \left( \frac{90}{3 \times 38.0}, \frac{1040.0}{440.0}, 1.0 \right)$ $= \min(0.79, 2.36, 1.0)$ $= 0.79$ <p>[Ref. IS 800:2007, Cl.10.3.4]</p>	OK
Bearing Capacity ( $kN$ )		$V_{dpb} = \frac{2.5k_b d t f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 0.79 \times 30 \times 56 \times 440}{1000 \times 1.25}$ $= 1167.94$ $= 0.7 \times 1167.94$ $= 817.56$ <p>Note: The bearing capacity is reduced since the hole type is Over-sized or Short-slotted.</p> <p>[Ref. IS 800:2007, Cl.10.3.4]</p>	OK
Bolt Capacity ( $kN$ )		$V_{db} = \min (V_{dsb}, V_{dpb})$ $= \min (269.48, 817.56)$ $= 269.48$ <p>[Ref. IS 800:2007, Cl.10.3.2]</p>	OK
Tension Demand - per anchor bolt ( $kN$ )	$T_b = \frac{P_t}{n_{out}/2}$ $= \frac{6.58}{4/2}$ $= \frac{6.58}{2}$ $= 3.29$	$T_{db} = 0.90 f_{ub} A_n / \gamma_{mb}$ $< f_{yb} A_{sb} (\gamma_{mb} / \gamma_{m0})$ $= \min \left( 0.90 \times 1040.0 \times 561 / 1.25, \right.$ $\left. 940.0 \times 707 \times (1.25/1.1) \right)$ $= \min(420.08, 755.2)$ $= 420.08$ <p>[Ref. IS 800:2007, Cl.10.3.5]</p>	Pass



Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

Check	Required	Provided	Remarks
Anchor Length - above concrete footing (mm)		$l_1 = t_g + t_p + t_w + t_n + 20$ $= 50 + 56 + 8.5 + 25.6 + 20$ $= 160.1$	Pass
Anchor Length - below concrete footing (mm)		$l_2 = \left[ \frac{T_{db}}{15.5 \sqrt{f_{ck}}} \right]^{0.67}$ $= \left[ \frac{420.08 \times 10^3}{15.5 \times \sqrt{25.0}} \right]^{0.67}$ $= 317.54$ $= 320$ $= \max(320, 320)$ $= 320$ $= 320 + t_n + 20$ $= 320 + 25.6 + 20$ $= 365.6$ [Reference: Design of Steel Structures by N.Subramanian, (2019 edition).]	Pass
Anchor Length - total (mm)	$320 \leq l_a \leq 2000$ [Reference: IS 5624:1993, Table 1]	$l_a = l_1 + l_2$ $= 160.1 + 365.6$ $= 525.7$	Pass

## 2.11 Anchor Bolt Design - Inside Column Flange

Check	Required	Provided	Remarks
Shear Capacity ( $kN$ )	The bolts are not designed to carry shear force	N/A	N/A
Bearing Capacity ( $kN$ )	The bolts are not designed to carry shear force	N/A	N/A
Bolt Capacity ( $kN$ )	N/A	N/A	N/A
Tension Demand ( $kN$ )	$P_{uplift} = 0.0$		OK



Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

Check	Required	Provided	Remarks
Tension Capacity ( $kN$ )		$T_{db} = 0.90 f_{ub} A_n / \gamma_{mb}$ $< f_{yb} A_{sb} (\gamma_{mb} / \gamma_{m0})$ $= \min \left( 0.90 \times 830.0 \times 245 / 1.25, \right.$ $\left. 660.0 \times 314 \times (1.25/1.1) \right)$ $= \min(146.41, 235.5)$ $= 146.41$ [Ref. IS 800:2007, Cl.10.3.5]	OK
Anchor Bolts Required ( $kN$ )	$n_{in} = \frac{P_{uplift}}{T_{db}}$ $= \frac{0.0}{146.41}$ $= 0.0$	4	
Anchor Length - above concrete footing (mm)		$l_1 = t_g + t_p + t_w + t_n + 20$ $= 50 + 56 + 8.5 + 18.0 + 20$ $= 160.1$	Pass
Anchor Length - below concrete footing (mm)		$l_2 = \left[ \frac{T_{db}}{15.5 \sqrt{f_{ck}}} \right]^{0.67}$ $= \left[ \frac{146.41 \times 10^3}{15.5 \times \sqrt{25.0}} \right]^{0.67}$ $= 200$ $= 200$ $= \max(200, 200)$ $= 200$ $= 200 + t_n + 20$ $= 200 + 18.0 + 20$ $= 365.6$ [Reference: Design of Steel Structures by N.Subramanian, (2019 edition).]	Pass



Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

Check	Required	Provided	Remarks
Anchor Length - total (mm)	$200 \leq l_a \leq 800$ [Reference: IS 5624:1993, Table 1]	$l_a = l_1 + l_2$ $= 160.1 + 365.6$ $= 390.5$	Pass

## 2.12 Stiffener Design - Along Column Flange

Check	Required	Provided	Remarks
Length of Stiffener (mm)		$L_{stf} = \frac{W - B}{2}$ $= \frac{575 - 250.0}{2}$ $= 162.5$ [Ref. based on detailing requirement]	OK
Height of Stiffener (mm)		$H_{stf} = L_{stf} + 50$ $= 162.5 + 50$ $= 212.5$	OK
Thickness of Stiffener (mm)	$t_{stf} = \left( \frac{L_{stf}}{13.6 \times \epsilon_{st}} \right) \geq T$ $= \max \left( \left( \frac{162.5}{13.6 \times 0.91} \right), 13.7 \right)$ $= \max(13.13, 13.7)$ Note: The stiffener is assumed as semi-compact. [Ref. IS 800:2007, Table 2]	22	Pass
Stress (average) at Stiffener (N/mm <sup>2</sup> )	$= \sigma_{allowable}$ $= 11.25$	Since, $y > y_{critical}$ (790.0 > 191.25) $\sigma_{stf} = \frac{\sigma_{cmax}}{2}$ $= \frac{6.56}{2}$ $= 3.28$	Pass



Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

Check	Required	Provided	Remarks
Shear on Stiffener ( $kN$ )	$V_{stf} = \sigma_{stf} \left( y \times L_{stf} \right)$ $= 3.28 \times \left( 790.0 \times 162.5 \right) \times 10^{-3}$ $= 421.07$	$V_{df} = \frac{A_{vg} f_{yst}}{\sqrt{3} \gamma_{m0}}$ $= \frac{(H_{stf} \times t_{stf}) f_{yst}}{\sqrt{3} \gamma_{m0}}$ $= \frac{(212.5 \times 22) \times 300}{\sqrt{3} \times 1.1 \times 10^3}$ $= 736.122$ <p>Note: Stiffener is not restricted to low shear. [Ref. IS 800:2007 (Cl.8.4.1)]</p>	Pass
Section Modulus of the Stiffener ( $mm^3$ )		$z_{est} = 165.57 \times 10^3$	OK
Moment on Stiffener ( $kNm$ )	$M_{stf} = \sigma_{stf} \left( y \times \frac{L_{stf}^2}{2} \right)$ $= 3.28 \times \left( 790.0 \times \frac{162.5^2}{2} \right) \times 10^{-6}$ $= 34.212$	$M_{df} = \frac{\beta_b z_{est} f_{yst}}{\gamma_{m0}}$ $= \frac{1 \times z_{est} f_{yst}}{\gamma_{m0}} \quad (\beta_b = 1)$ $= \frac{1 \times 165.57 \times 10^3 \times 300}{1.1 \times 10^6}$ $= 45.156$ <p>[Ref. IS 800:2007 (Cl.8.2.1.2)]</p>	Pass
Weld Size (mm)	10	12	Pass

### 2.13 Stiffener Design - Along Column Web

Check	Required	Provided	Remarks
Length of Stiffener (mm)		$L_{stw} = \frac{L - D}{2}$ $= \frac{810 - 450.0}{2}$ $= 180.0$ <p>[Ref. based on detailing requirement.]</p>	OK
Height of Stiffener (mm)		$H_{stw} = L_{stw} + 50$ $= 180.0 + 50$ $= 230.0$	OK





Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

Check	Required	Provided	Remarks
Thickness of Stiffener (mm)	$t_{stw} = \left( \frac{L_{stw}}{13.6 \times \epsilon_{st}} \right) \geq t$ $= \max \left( \left( \frac{180.0}{13.6 \times 0.91} \right), 9.8 \right)$ $= \max(14.54, 9.8)$ <p>[Ref. IS 800:2007, Table 2.]</p>	16	Pass
Stress (average) at Stiffener (mm)	$= \sigma_{allowable}$ $= 11.25$	$\sigma_{stw} = \frac{\sigma_{cmax} + \sigma_{crt}}{2}$ $= \frac{6.56 + 4.98}{2}$ $= 5.77$	Pass
Shear on Stiffener (kN)	$V_{stw} = \sigma_{stw} (B L_{stw})$ $= 5.77 \times (250.0 \times 180.0) \times 10^{-3}$ $= 259.65$	$V_{dw} = \frac{A_{vg} f_{yst}}{\sqrt{3} \gamma_{m0}}$ $= \frac{(H_{stw} \times t_{stw}) f_{yst}}{\sqrt{3} \gamma_{m0}}$ $= \frac{(230.0 \times 16) \times 300}{\sqrt{3} \times 1.1 \times 10^3}$ $= 579.45$ <p>Note: Stiffener is not restricted to low shear. [Ref. IS 800:2007 (Cl.8.4.1)]</p>	Pass
Section Modulus of the Stiffener (mm <sup>3</sup> )		$z_{est} = 141.07 \times 10^3$	OK
Moment on Stiffener (kNm)	$M_{stw} = \left( \sigma_{crt} \times B \times \frac{L_{stw}^2}{2} \right) +$ $\left( \left( \sigma_{cmax} - \sigma_{crt} \right) \times B \times \frac{L_{stw}^2}{3} \right)$ $= \left[ \left( 4.98 \times 250.0 \times \frac{180.0^2}{2} \right) + \right.$ $\left. \left( \left( 6.56 - 4.98 \right) \times 250.0 \times \frac{180.0^2}{3} \right) \right] \times 10^{-6}$ $= 24.435$	$M_{dw} = \frac{\beta_b z_{est} f_{yst}}{\gamma_{m0}}$ $= \frac{1 \times z_{est} f_{yst}}{\gamma_{m0}} \quad (\beta_b = 1)$ $= \frac{1 \times 141.07 \times 10^3 \times 300}{1.1 \times 10^6}$ $= 38.473$ <p>[Ref. IS 800:2007 (Cl.8.2.1.2)]</p>	Pass
Weld Size (mm)	10	12	Pass



Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

## 2.14 Stiffener Design - Across Column Web

Check	Required	Provided	Remarks
Length of Stiffener (mm)		$L_{staw} = \max (L_{stf}, L_{stw})$ $\leq \frac{W - t}{2}$ $= \max (162.5, 180.0)$ $= 180.0$	Pass
Height of Stiffener (mm)		$H_{staw} = L_{staw} + 50$ $= 180.0 + 50$ $= 230.0$	Pass
Thickness of Stiffener (mm)	$t_{staw} = \left( \frac{L_{staw}}{13.6 \times \epsilon_{st}} \right) \geq t$ $= \max \left( \left( \frac{180.0}{13.6 \times 0.91} \right), 9.8 \right)$ $= \max(14.54, 9.8)$ [Ref. IS 800:2007, Table 2.]	16	Pass
Weld Size (mm)	10	8	Pass

## 2.15 Shear Design

Check	Required	Provided	Remarks
Shear Resistance (kN)		$V_r = P_u \times \mu$ $= 1600.0 \times 0.45$ $= 720.0$	OK
Shear Key Requirement - along column depth	$V_1 = 80.0 \text{ kN}$	$V_1 \leq V_r$ $80.0 \leq 720.0$	Shear key not required
Shear Key Requirement - along column width	$V_2 = 23.0 \text{ kN}$	$V_2 \leq V_r$ $23.0 \leq 720.0$	Shear key not required





Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

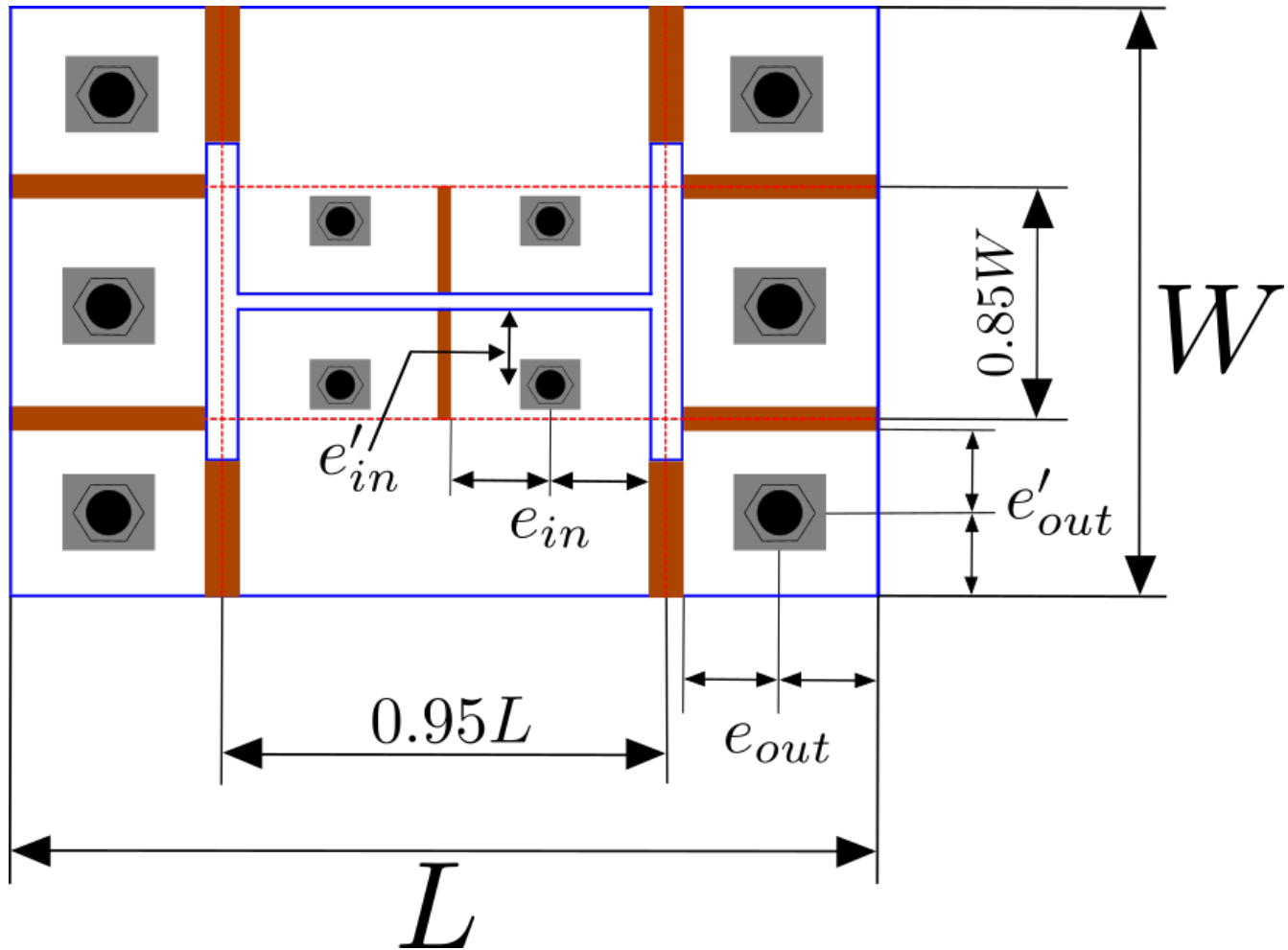


Figure 2: Typical Base Plate Detailing



Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

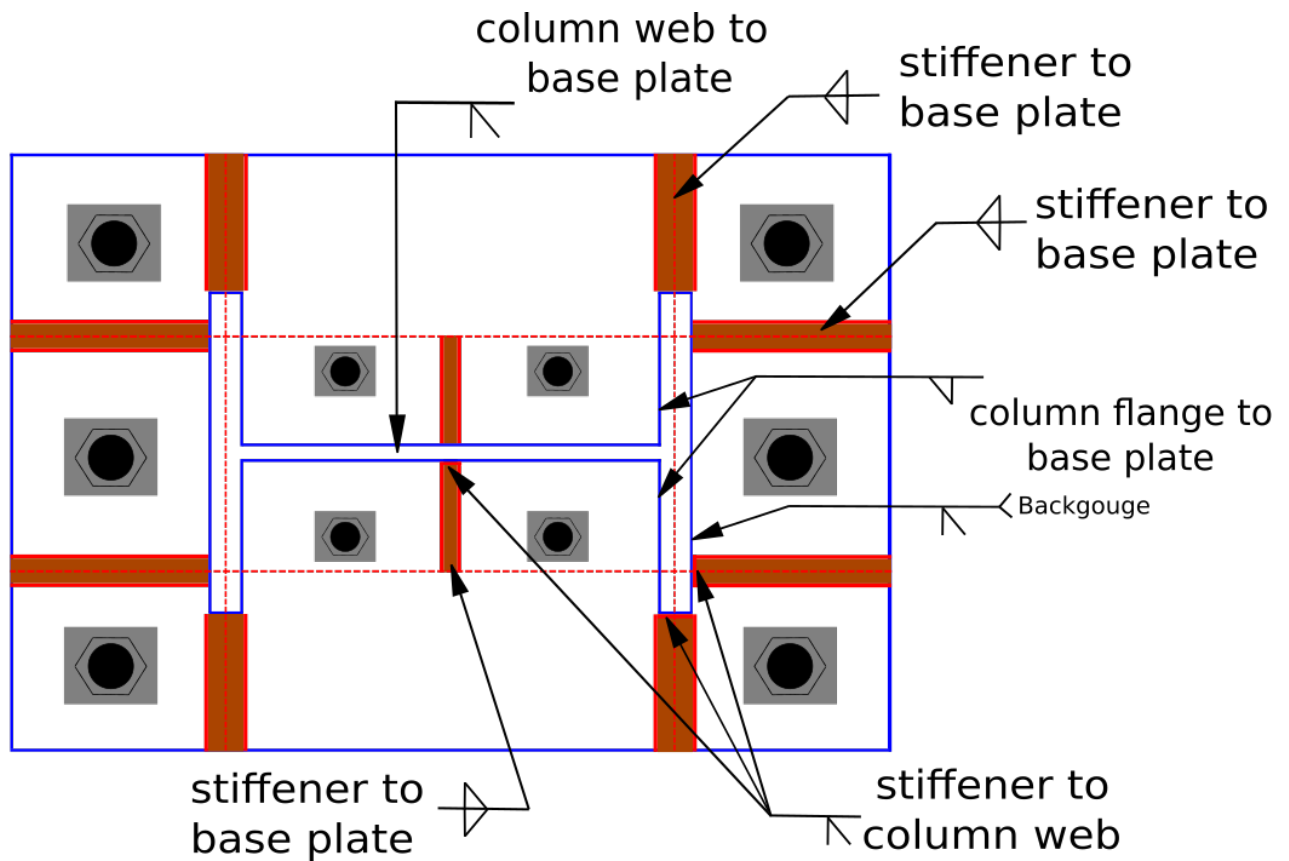
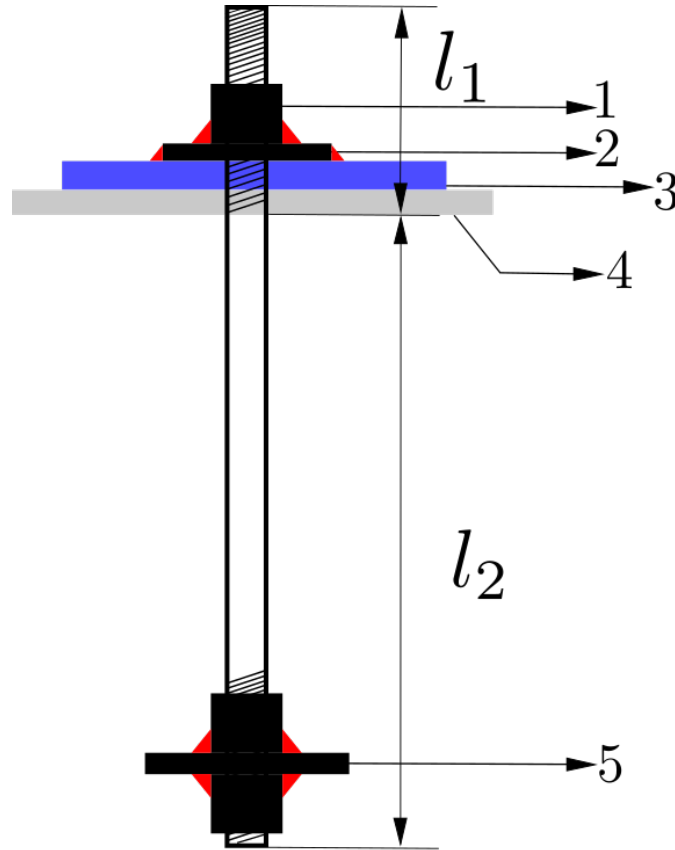


Figure 3: Typical Weld Details



Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay



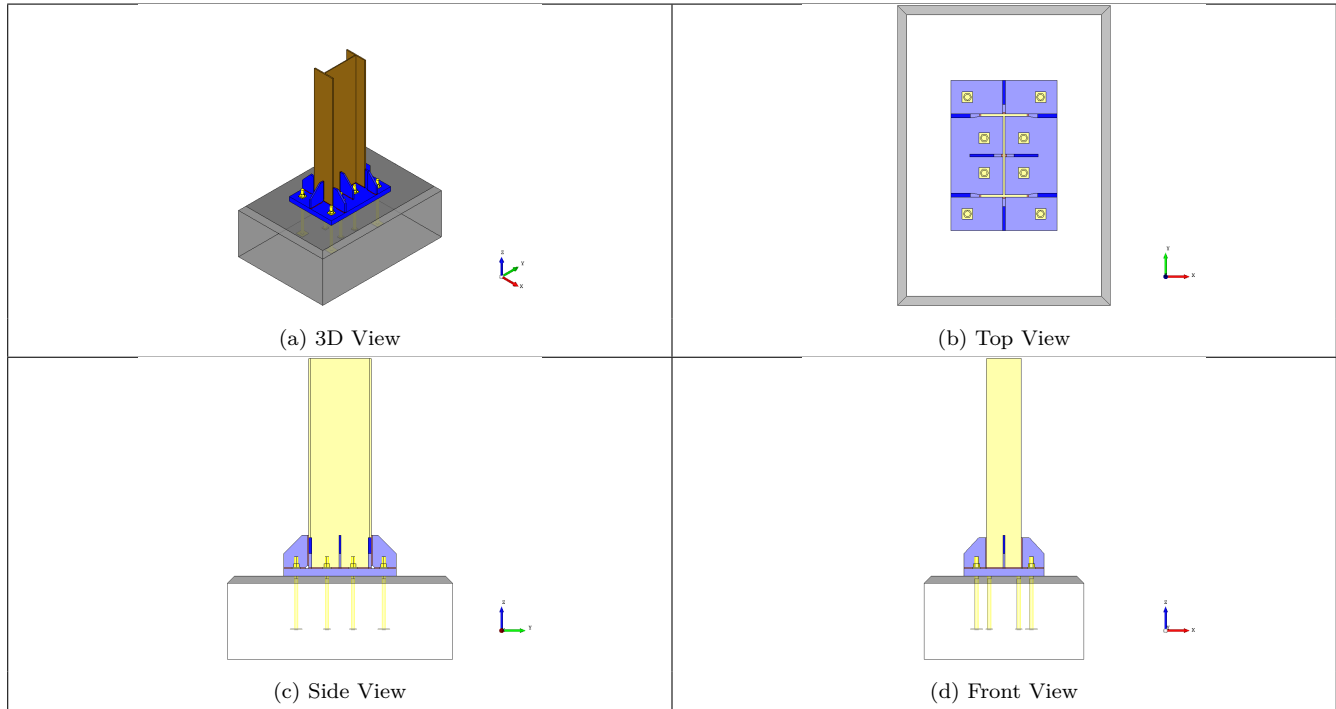
- $l_1$  = length above footing  
 $l_2$  = length below footing  
1 =  $t_n$ , nut thickness  
2 =  $t_w$ , washer thickness  
3 =  $t_p$ , plate thickness  
4 =  $t_g$ , grout thickness  
5 = end plate thickness

Figure 4: Typical Anchor Bolt Details



Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

## 4 3D Views



## 5 Design Log

2021-02-04 15:20:25 - Osdag - WARNING - The Load(s) defined is/are less than the minimum recommended value [Ref. IS 800:2007, Cl.10.7].

2021-02-04 15:20:25 - Osdag - WARNING - [Minimum Factored Load] The external factored bending moment (447.32 kNm) is less than 0.5 times the plastic moment capacity of the column (237.27 kNm)

2021-02-04 15:20:25 - Osdag - INFO - The minimum factored bending moment should be at least 0.5 times the plastic moment capacity of the beam to qualify the connection as rigid connection

2021-02-04 15:20:25 - Osdag - INFO - The value of load(s) is/are set at minimum recommended value as per Cl.10.7

2021-02-04 15:20:25 - Osdag - INFO - Designing the connection for a factored moment of 223.66 kNm

2021-02-04 15:20:25 - Osdag - INFO - [Base Plate Type] The value of eccentricity about the major axis is 138 mm



2021-02-04 15:20:25 - Osdag - INFO - Eccentricity is greater than 135.0 (L/6) mm but less than 270.0 (L/3) mm

2021-02-04 15:20:25 - Osdag - INFO - Case 2: A larger part of the base plate is under compression/bearing with a small to moderate tension/uplift force being transferred through the anchor bolts outside column flange on the tension side

2021-02-04 15:20:25 - Osdag - INFO - [Base Plate Type] The value of eccentricity about the major axis is 138 mm

2021-02-04 15:20:25 - Osdag - INFO - Eccentricity is greater than 135.0 (L/6) mm but less than 270.0 (L/3) mm

2021-02-04 15:20:25 - Osdag - INFO - Case 2: A larger part of the base plate is under compression/bearing with a small to moderate

			
Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.2.2
Date	04 /02 /2021	Client	Prof. Meera Raghunandan, IIT Bombay

tension/uplift force being transferred through the anchor bolts outside column flange on the tension side

2021-02-04 15:20:25 - Osdag - INFO - [Minor Axis Moment] The value of eccentricity about the minor axis is 28 mm

2021-02-04 15:20:25 - Osdag - INFO - Eccentricity is less than 95.83 mm (W/6)

2021-02-04 15:20:25 - Osdag - INFO - Case 1: The base plate is purely under compression/bearing over it's width, thus there is no requirement of anchor bolts along the width of the column section

2021-02-04 15:20:25 - Osdag - INFO - [Design for Shear] The shear resistance of the base plate assembly due to the friction between the base plate and the grout/concrete material is 720.0 kN

2021-02-04 15:20:25 - Osdag - INFO - The horizontal shear force - 80.0 kN, is less than the shear resistance of the base plate

2021-02-04 15:20:25 - Osdag - INFO - Shear key is not required

2021-02-04 15:20:25 - Osdag - INFO - [Design for Shear] The shear resistance of the base plate assembly due to the friction between the base plate and the grout/concrete material is 720.0 kN

2021-02-04 15:20:25 - Osdag - INFO - The horizontal shear force - 80.0 kN, is less than the shear resistance of the base plate

2021-02-04 15:20:25 - Osdag - INFO - Shear key is not required

2021-02-04 15:20:25 - Osdag - INFO - [Anchor Bolt Length] The length of the anchor bolt is computed assuming the anchor bolt is casted in-situ during the erection of the column.

2021-02-04 15:20:25 - Osdag - INFO - [Anchor Bolt Length] The recommended range for the length of the anchor bolt of thread size 30 mm is as follows:

2021-02-04 15:20:25 - Osdag - INFO - [Anchor Bolt Length] Minimum length = 320 mm, Maximum length = 2000 mm.

2021-02-04 15:20:25 - Osdag - INFO - [Anchor Bolt Length] The provided length of the anchor bolt is 525.7 mm

2021-02-04 15:20:25 - Osdag - INFO - [Anchor Bolt] Designer/Erector should provide adequate anchorage depending on the availability of standard lengths and sizes, satisfying the recommended range

2021-02-04 15:20:25 - Osdag - INFO - [Anchor Bolt Length] Reference: IS 5624:1993, Table 1

2021-02-04 15:20:25 - Osdag - INFO - [Anchor Bolt Length] The recommended range for the length of the anchor bolt of thread size 20 mm is as follows:

2021-02-04 15:20:25 - Osdag - INFO - [Anchor Bolt Length] Minimum length = 200 mm, Maximum length = 800 mm.

2021-02-04 15:20:25 - Osdag - INFO - [Anchor Bolt Length] The provided length of the anchor bolt is 390.5 mm

2021-02-04 15:20:25 - Osdag - INFO - [Anchor Bolt] Designer/Erector should provide adequate anchorage depending on the availability of standard lengths and sizes, satisfying the recommended range

2021-02-04 15:20:25 - Osdag - INFO - [Anchor Bolt Length] Reference: IS 5624:1993, Table 1

2021-02-04 15:20:25 - Osdag - WARNING - [Shear Check - Stiffener] The stiffener along the flange fails the shear check

2021-02-04 15:20:25 - Osdag - WARNING - The shear demand on the stiffener (421.07 kN) exceeds 60% of it's capacity (281.06 kN)

2021-02-04 15:20:25 - Osdag - INFO - Increasing the thickness of the stiffener and re-checking against shear demand

2021-02-04 15:20:25 - Osdag - INFO - : ===== Design Status =====

2021-02-04 15:20:25 - Osdag - INFO - : Overall base plate connection design is SAFE

2021-02-04 15:20:25 - Osdag - INFO - : ===== End Of Design =====