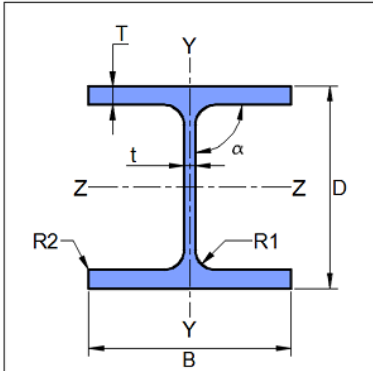




Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	Base Plate Connection
Designer	Engineer #1	Job Number	1.3.1.2
Date	18 /12 /2020	Client	V Kalyanaraman, Retd. Professor, IIT Madras

1 Input Parameters

Main Module		Moment Connection		
Module		Base Plate		
Connectivity		Welded Column Base		
End Condition		Pinned		
Axial Compression (kN)		880.0		
Axial Tension/Uplift (kN)		0.0		
Shear Force (kN)				
- Along major axis (z-z)		25.0		
- Along minor axis (y-y)		10.0		
Bending Moment (kNm)				
- Major axis (M_{z-z})		0.0		
- Minor axis (M_{y-y})		0.0		
Column Section - Mechanical Properties				
	Column Section		PBP 360 X 178.4	
	Material		E 300 (Fe 440)	
	Ultimate Strength, f_u (MPa)		440.0	
	Yield Strength, f_y (MPa)		290.0	
	Mass, m (kg/m)	178.4	I_z (cm ⁴)	52200.0
	Area, A (cm ²)	227.0	I_y (cm ⁴)	18900.0
	None	None	r_z (cm)	15.2
	D (mm)	362.0	r_y (cm)	9.1
	B (mm)	379.0	Z_z (cm ³)	2880.0
	T (mm)	20.9	Z_y (cm ³)	1000.0
	t (mm)	21.0	Z_{pz} (cm ³)	3260.0
	Flange Slope	90	Z_{py} (cm ³)	1530.0
	R_1 (mm)	15.0		
	R_2 (mm)	0.0		
Base Plate - Design Preference				
Material		E 250 (Fe 410 W)A		
Ultimate Strength, f_u (MPa)		410		
Yield Strength, f_y (MPa)		250		



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Stiffener/Shear Key - Design Preference	
Material	E 250 (Fe 410 W)A
Ultimate Strength, f_u (MPa)	410
Yield Strength, f_y (MPa)	250
Anchor Bolt Outside Column Flange - Input and Design Preference	
Diameter (mm)	['M20']
Property Class	['10.9']
Anchor Bolt Type	End Plate Type
Anchor Bolt Galvanized?	Yes
Designation	M20X356.5 IS5624 GALV
Hole Type	Over-sized
Total Length (mm)	356.5
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)	440.0
Detailing - Design Preference	
Edge Preparation Method	b - Rolled, machine-flame cut, sawn and planed
Are the Members Exposed to Corrosive Influences?	Yes
Design - Design Preference	
Design Method	Limit State Design
Base Plate Analysis	Effective Area Method



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2 Design Checks

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

2.1 Design Parameters

Check	Required	Provided	Remarks
Bearing Strength of Concrete (N/mm^2)		$\sigma_{br} = 0.45f_{ck}$ $= 0.45 \times 30$ $= 13.5$ [Ref. IS 456 : 2000, Cl. 34.4]	OK
Grout Thickness (mm)		$t_g = 50$	OK
Epsilon - stiffener plate		$\epsilon_{st} = \sqrt{\frac{250}{f_{yst}}}$ $= \sqrt{\frac{250}{250}}$ $= 1.0$ [Ref. IS 800 : 2007, Table 2]	OK

2.2 Load Consideration

Check	Required	Provided	Remarks
Axial Compression (kN)	$P_x = 880.0$	$P_u = \max(P_x, 0.3P_d), \text{ but, } \leq P_d$ $= \max(880.0, 0.3 \times 5984.55)$ $= \max(880.0, 1795.37)$ ≤ 5984.55 $= 1795.37$ [Ref. IS 800 : 2007, Cl. 10.7] Note : P_d is the design axial capacity of the column	Pass
Shear Force - along major (z-z) axis (kN)	$V_d = 614.1$	$V_1 = 25.0$	Pass
Shear Force - along minor (y-y) axis (kN)	$V_d = 614.1$	$V_2 = 10.0$	Pass



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Check	Required	Provided	Remarks
Interaction Ratio	IR < 1.0	$IR, axial = P_x/P_d$ $= 880.0/5984.55$ $= 0.15$ $IR, moment = M_z/M_{dzz}$ $= 0.0/0.0$ $= 0.0$ $IR, sum = IR, axial + IR, moment$ $= 0.15 + 0.0$ $= 0.15$	Pass

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

Check	Required	Provided	Remarks
Plate Washer Size (mm)		Square – 45X45 [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)		$d_h = 22$ [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 - 90 X 90	Pass
End Plate Thickness (mm)		14	Pass



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2.4 Anchor Bolt Summary - Outside Column Flange

Check	Required	Provided	Remarks
Diameter (mm)		20	Pass
Number of Bolts		$n_{out} = 4$	Pass
Property Class		10.9	Pass

2.5 Anchor Bolt Summary - Inside Column Flange

Check	Required	Provided	Remarks
Diameter (mm)	0	N/A	N/A
Number of Bolts	0	$n_{in} = 0$	N/A
Property Class	N/A	N/A	N/A

2.6 Detailing Checks - Outside Column Flange

Check	Required	Provided	Remarks
Min. End Distance (mm)	$e_{min} = 1.5 d_0$ $= 1.5 \times 24.0$ $= 36.0$ [Ref. IS 800 : 2007, Cl. 10.2.4.2]	55	Pass
Max. End Distance (mm)	$e_{max} = 40 + 4t$ Where, $t = \min(22, 22)$ $= 40 + (4 \times 22)$ $e_{max} = 128.0$ [Ref. IS 800 : 2007, Cl. 10.2.4.3]	55	Pass
Min. Edge Distance (mm)	$e'_{min} = 1.5 d_0$ $= 1.5 \times 24.0$ $= 36.0$ [Ref. IS 800 : 2007, Cl. 10.2.4.2]	55	Pass



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Date	18 /12 /2020	Client	V Kalyanaraman, Retd. Professor, IIT Madras

Check	Required	Provided	Remarks
Max. Edge Distance (mm)	$e'_{max} = 40 + 4t$ $\text{Where, } t = \min(22, 22)$ $= 40 + (4 \times 22)$ $e'_{max} = 128.0$ $[Ref. IS 800 : 2007, Cl. 10.2.4.3]$	55	Pass
Min. Pitch Distance (mm)	N/A	0.0	N/A
Max. Pitch Distance (mm)	N/A	0.0	N/A

2.7 Base Plate Dimension (L X W)

Check	Required	Provided	Remarks
Length (mm)	$L = D + 2(e + e')$ $= 362.0 + 2 \times (55 + 55)$ $= 582.0$ $[Ref. based on detailing requirement]$	582.0	Pass
Width (mm)	$W = (0.85B) + 2(e' + e')$ $= (0.85 \times 379.0) + 2 \times (55 + 55)$ $= 542.15$ $[Ref. based on detailing requirement]$	599.0	Pass

2.8 Base Plate Analysis

Check	Required	Provided	Remarks
Min. Area Required (mm^2)	$A_{req_{min}} = \frac{P_u}{\sigma_{br}}$ $= \frac{1795.365 \times 10^3}{13.5}$ $= 132.99 \times 10^3$	$A_{provided} = L \times W$ $= 582.0 \times 599.0$ $= 348.62 \times 10^3$	Pass



Company Name	IIT Bombay	Project Title	Sample Connection Design
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Designer	Engineer #1	Job Number	1.3.1.2
Date	18 /12 /2020	Client	V Kalyanaraman, Retd. Professor, IIT Madras

Check	Required	Provided	Remarks
Effective Bearing Area (mm^2)	$A_{br eff} = (D + 2c)(B + 2c) - \left[(D - 2(T + c))(B - t) \right]$ $= (362.0 + 2c)(379.0 + 2c) - \left[(362.0 - 2 \times (20.9 + c))(379.0 - 21.0) \right]$ <p><i>Note : c is the projection beyond the face of the column</i></p> <p>[Reference : Design of Steel Structures – N.Subramanian, (2019 edition) Chapter 15,]</p>		OK
Projection (mm)	$A_{br eff} = A_{req min}$ $= 132.99 \times 10^3$ <p>Therefore, $(362.0 + 2c)(379.0 + 2c) - \left[(362.0 - 2(20.9 + c))(379.0 - 21.0) \right]$</p> $= 132.99 \times 10^3$ $c = 2.86$ <p>$projection = \max(c, e)$</p> $= \max(2.86, 55)$ $= 55$ <p>[Reference : Design of Steel Structures – N.Subramanian, (2019 edition) Chapter 15,]</p>	55	Pass
Actual Bearing Stress (N/mm^2)	13.5	$\sigma_{br actual} = \frac{P_u}{A_{provided}}$ $= \frac{1795.365 \times 10^3}{348.62 \times 10^3}$ $= 5.15$	Pass



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Check	Required	Provided	Remarks
Thickness of Base Plate (mm)	$(T, t) < t_p \leq 120$ $(20.9, 21.0) < t_p \leq 120$	$t_p = c \left[\frac{2.5 \sigma_{bractual} \gamma_{m0}}{f_{yplate}} \right]^{0.5}$ $= 55 \times \left[\frac{2.5 \times 5.15 \times 1.1}{250} \right]^{0.5}$ $= 13.09$ $= 22$ <p>[Ref. IS 800 : 2007, Cl.7.4.3.1]</p>	Pass

2.9 Anchor Bolt Design - Outside Column Flange

Check	Required	Provided	Remarks
Shear Capacity (kN)		$V_{dsb} = \frac{f_{ub} n_n A_{nb}}{\sqrt{3} \gamma_{mb}}$ $= \frac{1040.0 \times 1 \times 245}{1000 \times \sqrt{3} \times 1.25}$ $= 117.69$ <p>[Ref. IS 800 : 2007, Cl. 10.3.3]</p>	OK
Kb		$k_b = \min \left(\frac{e}{3d_0}, \frac{f_{ub}}{f_u}, 1.0 \right)$ $= \min \left(\frac{55}{3 \times 24.0}, \frac{1040.0}{440.0}, 1.0 \right)$ $= \min(0.76, 2.36, 1.0)$ $= 0.76$ <p>[Ref IS 800 : 2007, Cl. 10.3.4]</p>	OK



Company Name	IIT Bombay	Project Title	Sample Connection Design
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Check	Required	Provided	Remarks
Bearing Capacity (kN)		$V_{dpb} = \frac{2.5 k_b d t f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 0.76 \times 20 \times 22 \times 410}{1000 \times 1.25}$ $= 274.21$ $= 0.7 \times 274.21$ $= 191.95$ <p><i>Note : The bearing capacity is reduced since the hole type is Over – sized or Short – slotted</i></p> <p>[Ref. IS 800 : 2007, Cl. 10.3.4]</p>	OK
Bolt Capacity (kN)		$V_{db} = \min (V_{dsb}, V_{dpb})$ $= \min (117.69, 191.95)$ $= 117.69$ <p>[Ref. IS 800 : 2007, Cl. 10.3.2]</p>	OK
Tension Demand - per anchor bolt (kN)	$T_b = \frac{P_t}{n_{out}/2}$ $= \frac{0}{4/2}$ $= \frac{0}{2}$ $= 0.0$	$T_{db} = 0.90 f_{ub} A_n / \gamma_{mb}$ $< f_{yb} A_{sb} (\gamma_{mb} / \gamma_{m0})$ $= \min \left(0.90 \times 1040.0 \times 245 / 1.25, \right.$ $\left. 940.0 \times 314 \times (1.25/1.1) \right)$ $= \min(183.46, 335.41)$ $= 183.46$ <p>[Ref. IS 800 : 2007, Cl. 10.3.5]</p>	
Anchor Length - above concrete footing (mm)		$l_1 = t_g + t_p + t_w + t_n + 20$ $= 50 + 22 + 8.5 + 18.0 + 20$ $= 118.5$	Pass
Anchor Length - below concrete footing (mm)		$l_2 = 238.0$ <p>[Reference : IS 5624 : 1993, Table 1]</p>	Pass



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Check	Required	Provided	Remarks
Anchor Length - total (mm)	$200 \leq l_a \leq 800$ <i>[Reference : IS 5624 : 1993, Table 1]</i>	$l_a = l_1 + l_2$ $= 118.5 + 238.0$ $= 356.5$	Pass

2.10 Shear Design

Check	Required	Provided	Remarks
Shear Resistance (kN)		$V_r = P_u \times \mu$ $= 1795.37 \times 0.45$ $= 807.91$	OK
Shear Key Requirement - along column depth	$V_1 = 25.0 \text{ kN}$	$V_1 \leq V_r$ $25.0 \leq 807.91$	Shear key not required
Shear Key Requirement - along column width	$V_2 = 10.0 \text{ kN}$	$V_2 \leq V_r$ $10.0 \leq 807.91$	Shear key not required

2.11 Weld Design - Column to Base Plate Connection

Check	Required	Provided	Remarks
Weld Strength (N/mm ²)	$f_{uw} = \min(f_w, f_u)$ $= \min(440.0, 440.0)$ <i>[Ref. IS 800 : 2007, Cl. 10.5.7.1.1]</i>	$f_{uw} = 440.0$	Pass
Total Weld Length - at flange (mm)		1394	Pass
Total Weld Length - at web (mm)		540	Pass
Weld Size (mm)	6	10	Pass



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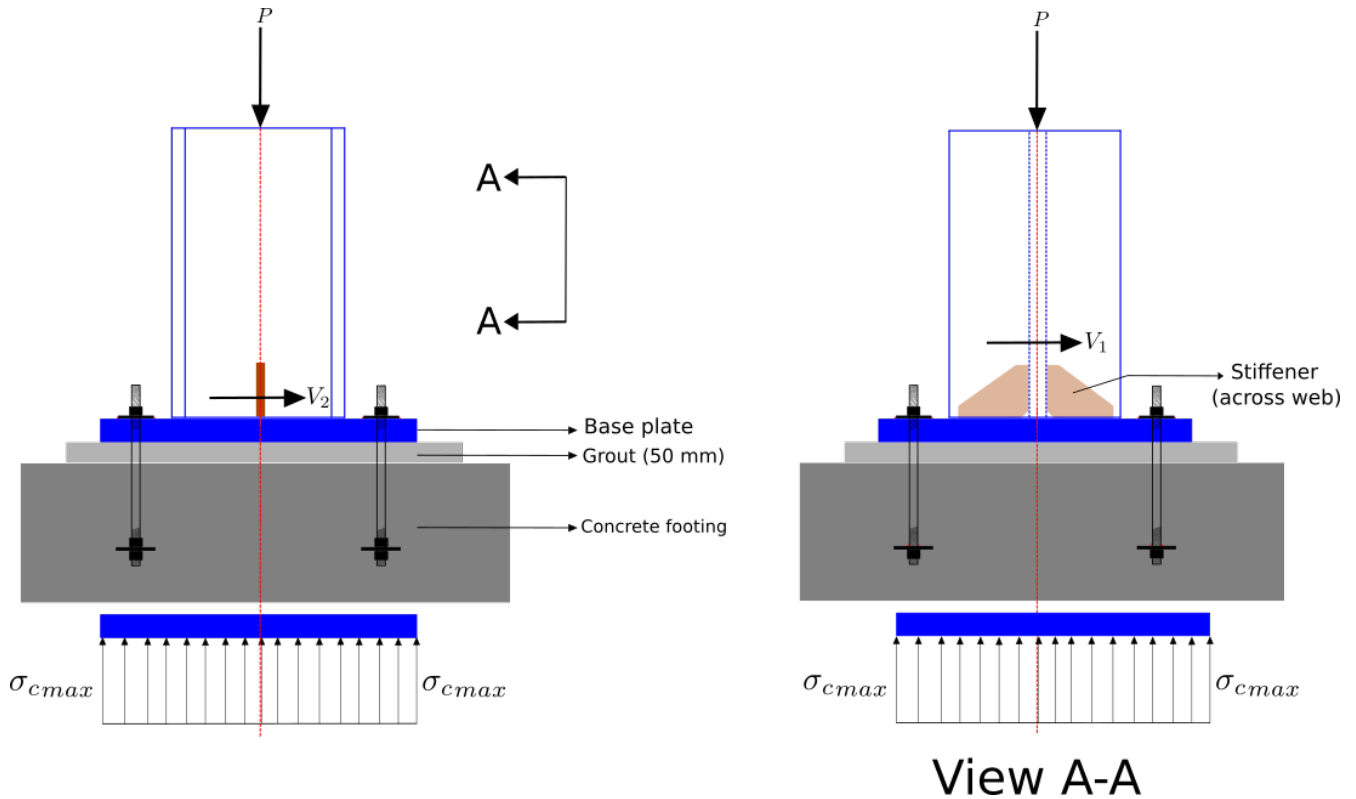


Figure 1: Typical Base Plate Details

3 2D Drawings (Typical)



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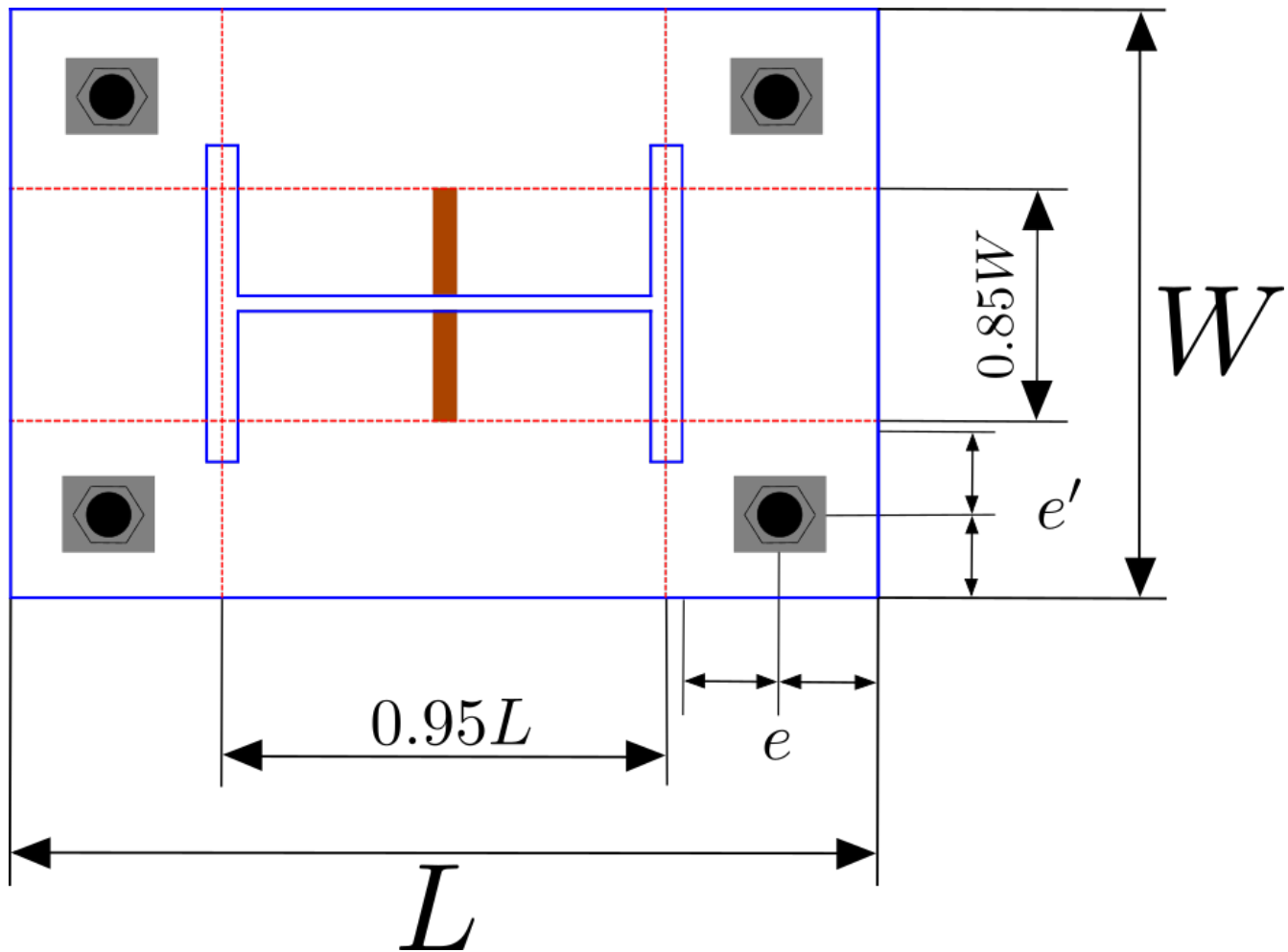


Figure 2: Typical Base Plate Detailing



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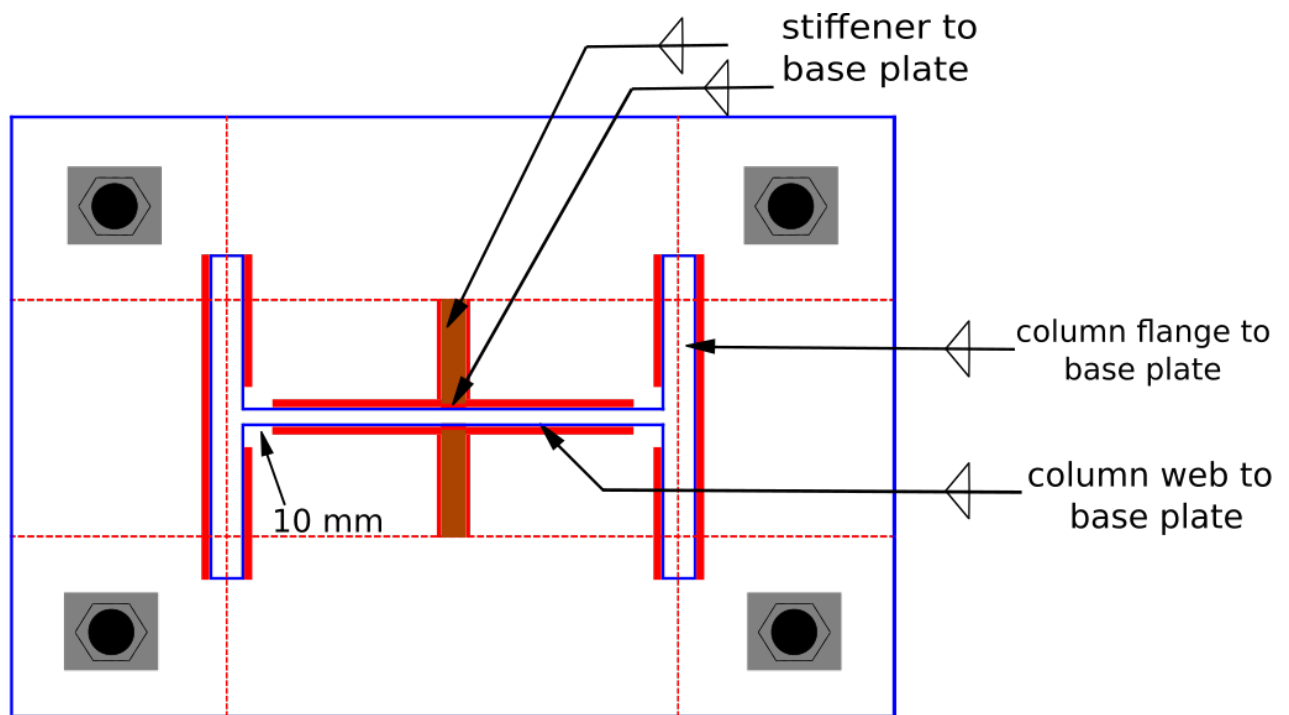
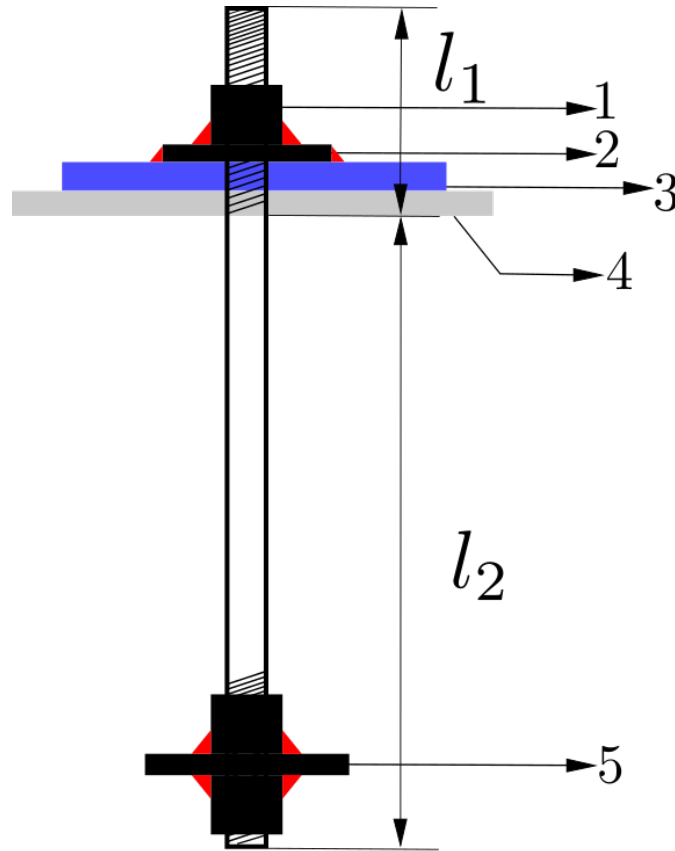


Figure 3: Typical Weld Details



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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

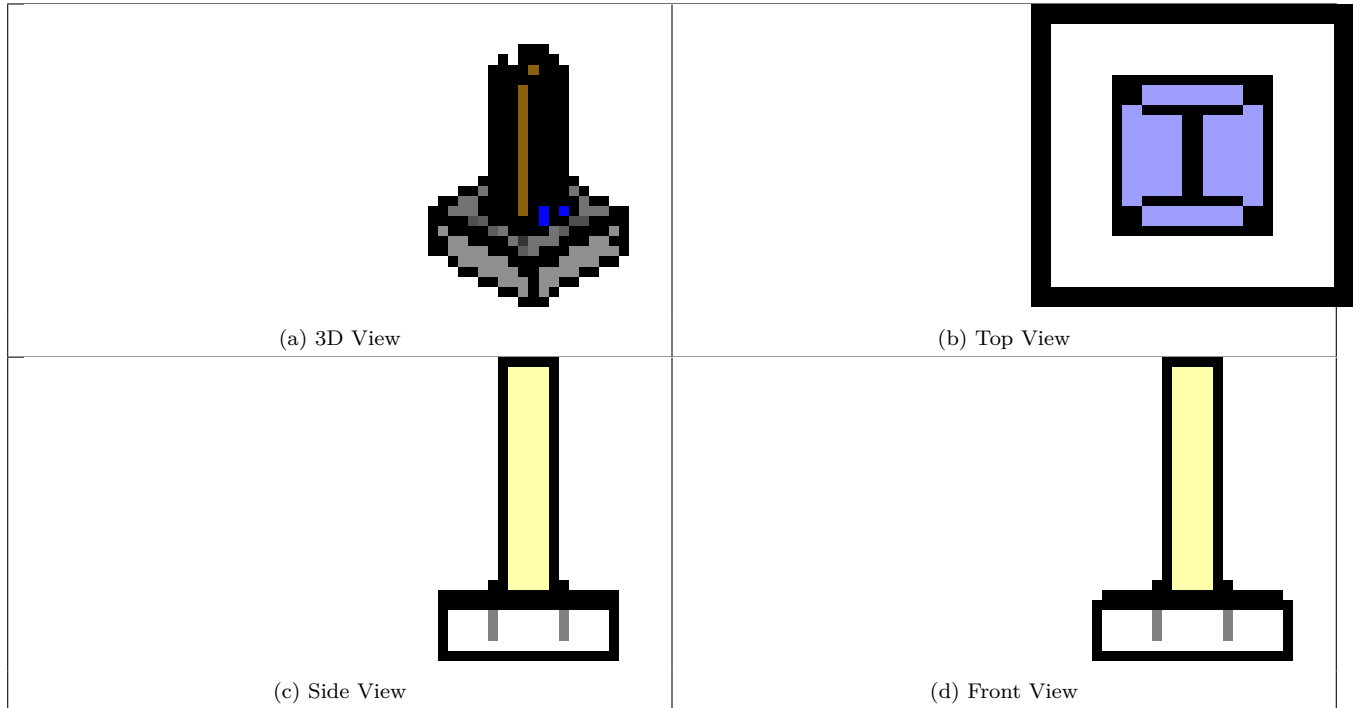
4 = t_g , grout thickness

5 = end plate thickness

Figure 4: Typical Anchor Bolt Details

		Created with  Osdag®	
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4 3D Views



5 Design Log

2020-12-18 01:42:21 - Osdag - WARNING - [Minimum Design Action] The defined value of axial compression (880.0 kN) is less than 0.3 times the capacity of the column section (1795.37 kN) [Ref. Cl. 10.7, IS 800:2007]

2020-12-18 01:42:21 - Osdag - INFO - Setting the value of axial compression equal to the minimum recommended value

2020-12-18 01:42:21 - Osdag - WARNING - : [Analysis Error] The value of the projection (c) as per the Effective Area Method is 5 mm [Reference: Clause 7.4.1.1, IS 800: 2007]

2020-12-18 01:42:21 - Osdag - WARNING - : [Analysis Error] The computed value of c should at least be equal to the end/edge distance

2020-12-18 01:42:21 - Osdag - INFO - : [Analysis Error] Setting the value of c equal to end/edge distance



2020-12-18 01:42:21 - 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 807.91425 kN

2020-12-18 01:42:21 - Osdag - INFO - The horizontal shear force - 25.0 kN, is less than the shear resistance of the base plate

2020-12-18 01:42:21 - Osdag - INFO - Shear key is not required

2020-12-18 01:42:21 - 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 807.91425 kN

2020-12-18 01:42:21 - Osdag - INFO - The horizontal shear force - 25.0 kN, is less than the shear resistance of the base plate

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Company Name	IIT Bombay	Project Title	Sample Connection Design
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2020-12-18 01:42:21 - Osdag - INFO - Shear key is not required

2020-12-18 01:42:21 - Osdag - INFO - [Anchor Bolt Length] The recommended range for the length of the anchor bolt of thread size 20 mm is as follows:

2020-12-18 01:42:21 - Osdag - INFO - [Anchor Bolt Length] Minimum length = 200 mm, Maximum length = 800 mm.

2020-12-18 01:42:21 - Osdag - INFO - [Anchor Bolt Length] The provided length of the anchor bolt is 356.5 mm

2020-12-18 01:42:21 - Osdag - INFO - [Anchor Bolt] Designer/Erector should provide adequate anchorage depending on the availability of standard lengths and sizes, satisfying the recommended range

2020-12-18 01:42:21 - Osdag - INFO - [Anchor Bolt Length] Reference: IS 5624:1993, Table 1