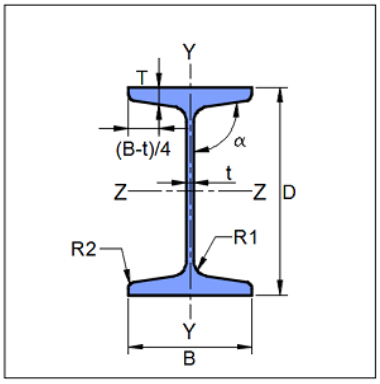
Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	Base Plate Connection
Designer	Engineer #1	Job Number	1.3.1.1
Date	18 /12 /2020	Client	Harshavardhan Subbarao, Construma Consultancy, Mumbai

1 Input Parameters

Main Module	Moment Connection
Module	Base Plate
Connectivity	Welded Column Base
End Condition	Pinned
Axial Compression (kN)	1100.0
Axial Tension/Uplift (kN)	0.0
Shear Force (kN)	
- Along major axis (z-z)	0.0
- Along minor axis (y-y)	0.0
Bending Moment (kNm)	
- Major axis (M_{z-z})	0.0
- Minor axis (M_{y-y})	0.0

Column Section - Mechanical Properties



Column Section		HB 450	
Material		E 250 (Fe 410 W)A	
Ultimate Strength, f_u (MPa)		410.0	
Yield Strength, f_y (MPa)		250.0	
Mass, m (kg/m)	87.22	I_z (cm^4)	39200.0
Area, A (cm^2)	111.0	I_y(cm^4)	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^3)	1740.0
T (mm)	13.7	Z_y (cm^3)	238.0
t (mm)	9.8	Z_{pz} (cm^3)	1950.0
Flange Slope	94	Z_{py} (cm^3)	394.0
R_1 (mm)	15.0		
R_2 (mm)	7.5		

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', 'M24', 'M30']
Property Class	['8.8', '9.8']
Anchor Bolt Type	End Plate Type
Anchor Bolt Galvanized?	Yes
Designation	M20X348.5 IS5624 GALV
Hole Type	Over-sized
Total Length (mm)	348.5
Material Grade, f_u (MPa)	900.0
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)	510.0
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

Company Name	IIT Bombay	Project Title	Sample Connection Design
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Designer	Engineer #1	Job Number	1.3.1.1
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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)		$\sigma_{br} = 0.45fck$ $= 0.45 \times 25$ $= 11.25$ $[Ref.\ IS\ 456 : 2000,\ Cl.\ 34.4]$	OK
Grout Thickness (mm)		t_g = 50	OK
Epsilon - stiffener plate		$\epsilon_{st} = \sqrt{\frac{250}{f_{y\,st}}}$ $= \sqrt{\frac{250}{250}}$ $= 1.0$ $[Ref.\ IS\ 800 : 2007,\ Table\ 2]$	OK

2.2 Load Consideration

Check	Required	Provided	Remarks
Axial Compression (kN)	$P_x = 1100.0$	$P_u = max(P_x,\ 0.3P_d),\ but,\ \leq P_d$ $= max(1100.0,\ 0.3 \times 2522.73)$ $= max(1100.0,\ 756.82)$ ≤ 2522.73 $= 1100.0$ $[Ref.IS\ 800 : 2007, Cl.\ 10.7]$ *Note : P_d is the design axial capacity of the column*	Pass
Shear Force - along major (z-z) axis (kN)	$V_d = 326.06$	$V_1 = 0.0$	
Shear Force - along minor (y-y) axis (kN)	$V_d = 326.06$	$V_2 = 0.0$	

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Check	Required	Provided	Remarks
Interaction Ratio	IR < 1.0	$IR,\ axial = P_x/P_d$ $= 1100.0/2522.73$ $= 0.44$ $IR,\ moment = M_z/M_{dzz}$ $= 0.0/0.0$ $= 0.0$ $IR,\ sum = IR,\ axial + IR,\ moment$ $= 0.44 + 0.0$ $= 0.44$	**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**

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		9.8	**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)	$e_{max} = 40 + 4t$ $Where, t = min(14, 14)$ $= 40 + (4 \times 14)$ $e_{max} = 96.0$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.3$]	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**

Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	Base Plate Connection
Designer	Engineer #1	Job Number	1.3.1.1
Date	18 /12 /2020	Client	Harshavardhan Subbarao, Construma Consultancy, Mumbai

Check	Required	Provided	Remarks
Max. Edge Distance (mm)	$e'_{max} = 40 + 4t$ $Where, t = min(14, 14)$ $= 40 + (4 \times 14)$ $e'_{max} = 96.0$ [$Ref.\ IS\ 800 : 2007,\ Cl.\ 10.2.4.3$]	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)	$L = D\ +\ 2\ (e\ +\ e)$ $= 450.0\ +\ 2 \times (55\ +\ 55)$ $= 670.0$ [$Ref.$ *based on detailing requirement*]	670.0	**Pass**
Width (mm)	$W = (0.85B)\ +\ 2\ (e'\ +\ e')$ $= (0.85 \times 250.0)\ +\ 2 \times (55\ +\ 55)$ $= 432.5$ [$Ref.$ *based on detailing requirement*]	470.0	**Pass**

2.8 Base Plate Analysis

Check	Required	Provided	Remarks
Min. Area Required (mm^2)	$A_{req_{min}} = \frac{P_u}{\sigma_{br}}$ $= \frac{1100.0 \times 10^3}{11.25}$ $= 97.78 \times 10^3$	$A_{provided} = L \times W$ $= 670.0 \times 470.0$ $= 314.9 \times 10^3$	**Pass**

Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	Base Plate Connection
Designer	Engineer #1	Job Number	1.3.1.1
Date	18 /12 /2020	Client	Harshavardhan Subbarao, Construma Consultancy, Mumbai

Check	Required	Provided	Remarks
Effective Bearing Area (mm^2)	$A_{breff} = (D + 2c)(B + 2c) - \Big[\big(D - 2(T + c)\big)\big(B - t\big)\Big]$ $= (450.0 + 2c)(250.0 + 2c) - \Big[\big(450.0 - 2 \times (13.7 + c)\big)\big(250.0 - 9.8\big)\Big]$ *Note : c is the projection beyond the face of the column* [*Reference : Design of Steel Structures – N.Subramanian, (2019 edition) Chapter* 15,]		**OK**
Projection (mm)	$A_{breff} = A_{req_{min}}$ $= 97.78 \times 10^3$ *Therefore*, $(450.0 + 2c)(250.0 + 2c) - \Big[\big(450.0 - 2(13.7 + c)\big)\big(250.0 - 9.8\big)\Big]$ $= 97.78 \times 10^3$ $c = 10.85$ $projection = max(c,\ e)$ $= max(10.85,\ 55)$ $= 55$ [*Reference : Design of Steel Structures – N.Subramanian, (2019 edition) Chapter* 15,]	55	**Pass**
Actual Bearing Stress (N/mm^2)	11.25	$\sigma_{br\,actual} = \frac{P_u}{A_{provided}}$ $= \frac{1100.0 \times 10^3}{314.9 \times 10^3}$ $= 3.49$	**Pass**

Check	Required	Provided	Remarks
Thickness of Base Plate (mm)	$(T,\ t) < t_p \leq 120$ $(13.7,\ 9.8) < t_p \leq 120$	$t_p = c\left[\frac{2.5\ \sigma_{br\,actual}\ \gamma_{m0}}{f_{y\,plate}}\right]^{0.5}$ $= 55 \times \left[\frac{2.5\ \times 3.49 \times\ 1.1}{250}\right]^{0.5}$ $= 10.78$ $= 14$ $[Ref.\ IS\ 800:2007,\ Cl.7.4.3.1]$	**Pass**

2.9 Anchor Bolt Design - Outside Column Flange

Check	Required	Provided	Remarks
Shear Capacity (kN)		$V_{dsb} = \frac{f_{ub}\ n_n\ A_{nb}}{\sqrt{3}\ \gamma_{mb}}$ $= \frac{900.0 \times 1 \times 245}{1000 \times \sqrt{3}\ \times\ 1.25}$ $= 101.84$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.3]$	**OK**
Kb		$k_b = min\left(\frac{e}{3d_0}, \frac{f_{ub}}{f_u}, 1.0\right)$ $= min\left(\frac{55}{3 \times 24.0}, \frac{900.0}{410.0}, 1.0\right)$ $= min(0.76, 2.2, 1.0)$ $= 0.76$ $[Ref\ IS\ 800:2007,\ Cl.\ 10.3.4]$	**OK**

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Date	18 /12 /2020	Client	Harshavardhan Subbarao, Construma Consultancy, Mumbai

Check	Required	Provided	Remarks
Bearing Capacity (kN)		$V_{dpb} = \frac{2.5\ k_b\ d\ t\ f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 0.76 \times 20 \times 14 \times 410}{1000 \times 1.25}$ $= 174.5$ $= 0.7 \times 174.5$ $= 122.15$ *Note : The bearing capacity is reduced since the hole type is Over − sized or Short − slotted* [*Ref. IS* 800 : 2007, *Cl.* 10.3.4]	**OK**
Bolt Capacity (kN)		$V_{db} = min\ (V_{dsb}, V_{dpb})$ $= min\ (101.84, 122.15)$ $= 101.84$ [*Ref. IS* 800 : 2007, *Cl.* 10.3.2]	**OK**
Tension Demand - per anchor bolt (kN)	$T_b = \frac{P_t}{n_{out}/2}$ $= \frac{0}{4/2}$ $= \frac{0}{2}$ $= 0.0$	$T_{db} = 0.90\ f_{ub}\ A_n\ /\ \gamma_{mb}$ $<\ f_{yb}\ A_{sb}\ (\gamma_{mb}\ /\ \gamma_{m0})$ $= min\Big(0.90\ \times 900.0 \times 245\ /\ 1.25,$ $720.0 \times 314 \times (1.25/1.1)\Big)$ $= min(158.76,\ 256.91)$ $= 158.76$ [*Ref. IS* 800 : 2007, *Cl.* 10.3.5]	
Anchor Length - above concrete footing (mm)		$l_1 = t_g\ +\ t_p\ +\ t_w\ +\ t_n\ +\ 20$ $= 50\ +\ 14\ +\ 8.5\ +\ 18.0\ +\ 20$ $= 110.5$	**Pass**
Anchor Length - below concrete footing (mm)		$l_2 = 238.0$ [*Reference : IS* 5624 : 1993, *Table* 1]	**Pass**

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Check	Required	Provided	Remarks
Anchor Length - total (mm)	$200 \leq\ l_a\ \leq 800$ $[Reference:\ IS\ 5624:1993,\ Table\ 1]$	$l_a = l_1\ +\ l_2$ $= 110.5\ +\ 238.0$ $= 348.5$	**Pass**

2.10 Stiffener Design - Across Column Web

Check	Required	Provided	Remarks
Length of Stiffener (mm)		$L_{staw} = 110.0$	**Pass**
Height of Stiffener (mm)		$H_{staw} = L_{staw}\ +\ 50$ $= 110.0\ +\ 50$ $= 160.0$	**Pass**
Thickness of Stiffener (mm)	$t_{staw} = \left(\frac{L_{staw}}{13.6 \times \epsilon_{st}}\right) \geq t$ $= max\left(\left(\frac{110.0}{13.6 \times 1.0}\right),\ 9.8\right)$ $= max(8.09, 9.8)$ $[Ref.\ IS\ 800:2007,\ Table\ 2]$	10	**Pass**
Weld Size (mm)	3	6	**Pass**

2.11 Weld Design - Column to Base Plate Connection

Check	Required	Provided	Remarks
Weld Strength (N/mm^2)	$f_{uw} = min(f_w,\ f_u)$ $= min(510.0,\ 410.0)$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.5.7.1.1]$	$f_{uw} = 410.0$	**Pass**
Total Weld Length - at flange (mm)		870	**Pass**
Total Weld Length - at web (mm)		745	**Pass**
Weld Size (mm)	5	8	**Pass**

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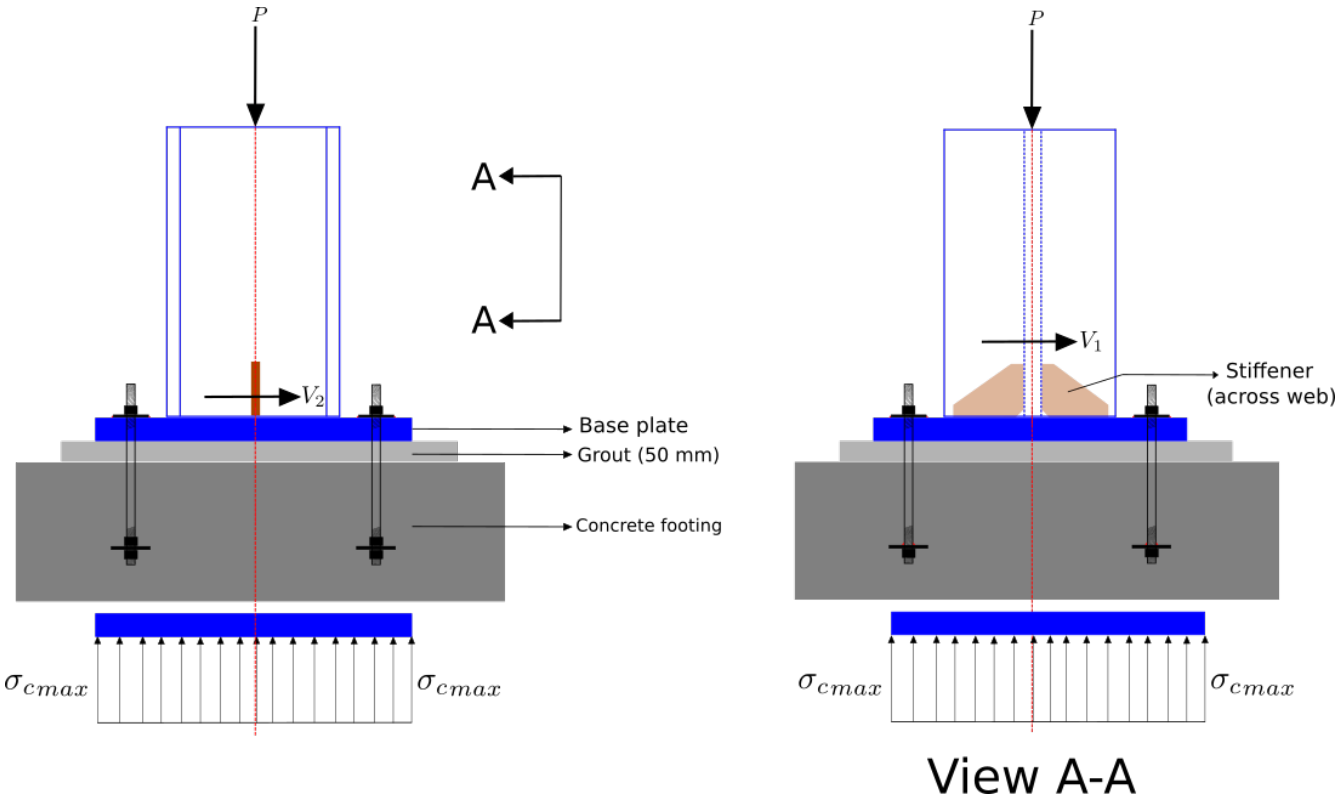

Figure 1: Typical Base Plate Details

3 2D Drawings (Typical)

Company Name	IIT Bombay	Project Title	Sample Connection Design
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Designer	Engineer #1	Job Number	1.3.1.1
Date	18 /12 /2020	Client	Harshavardhan Subbarao, Construma Consultancy, Mumbai

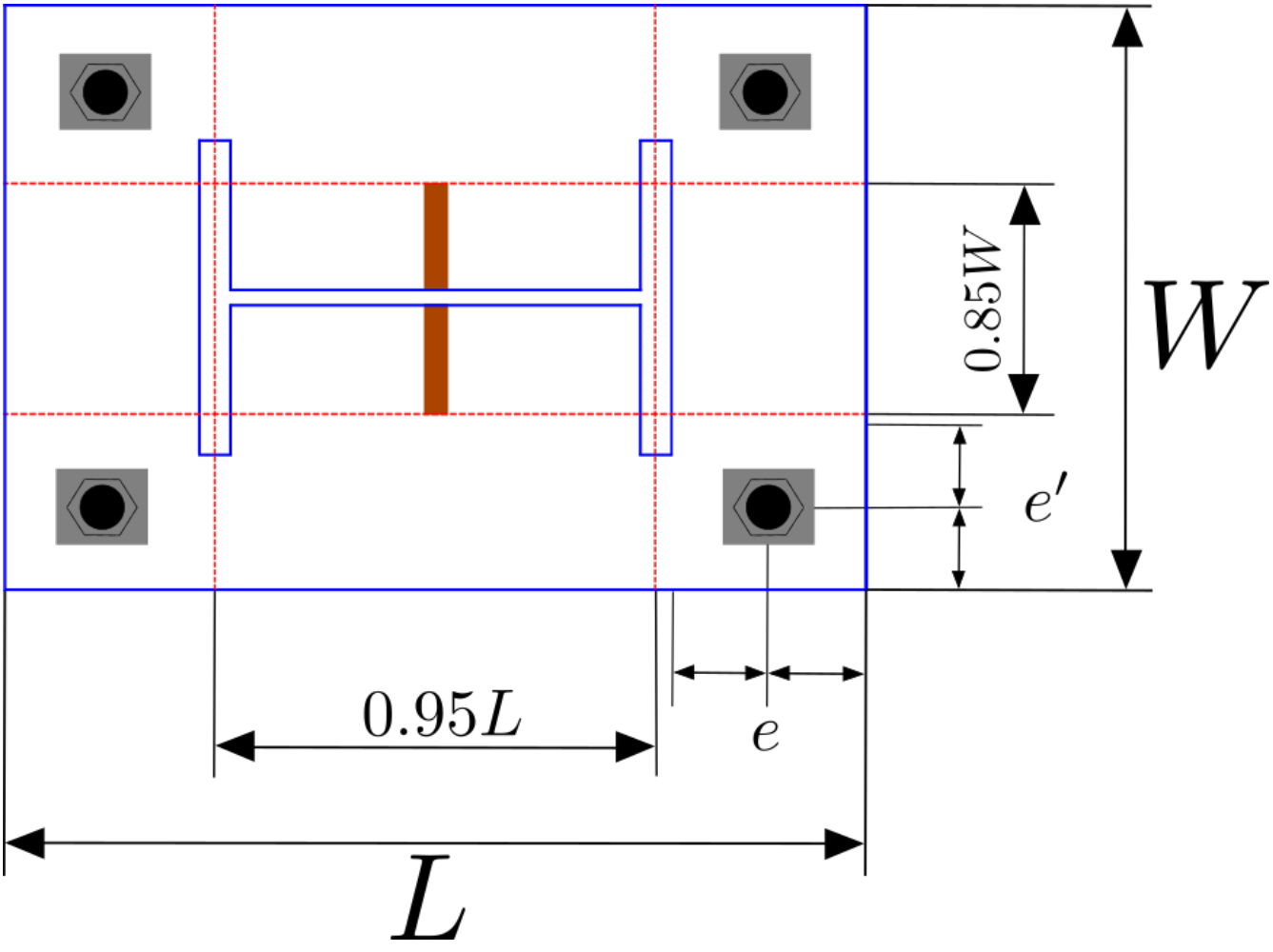


Figure 2: Typical Base Plate Detailing

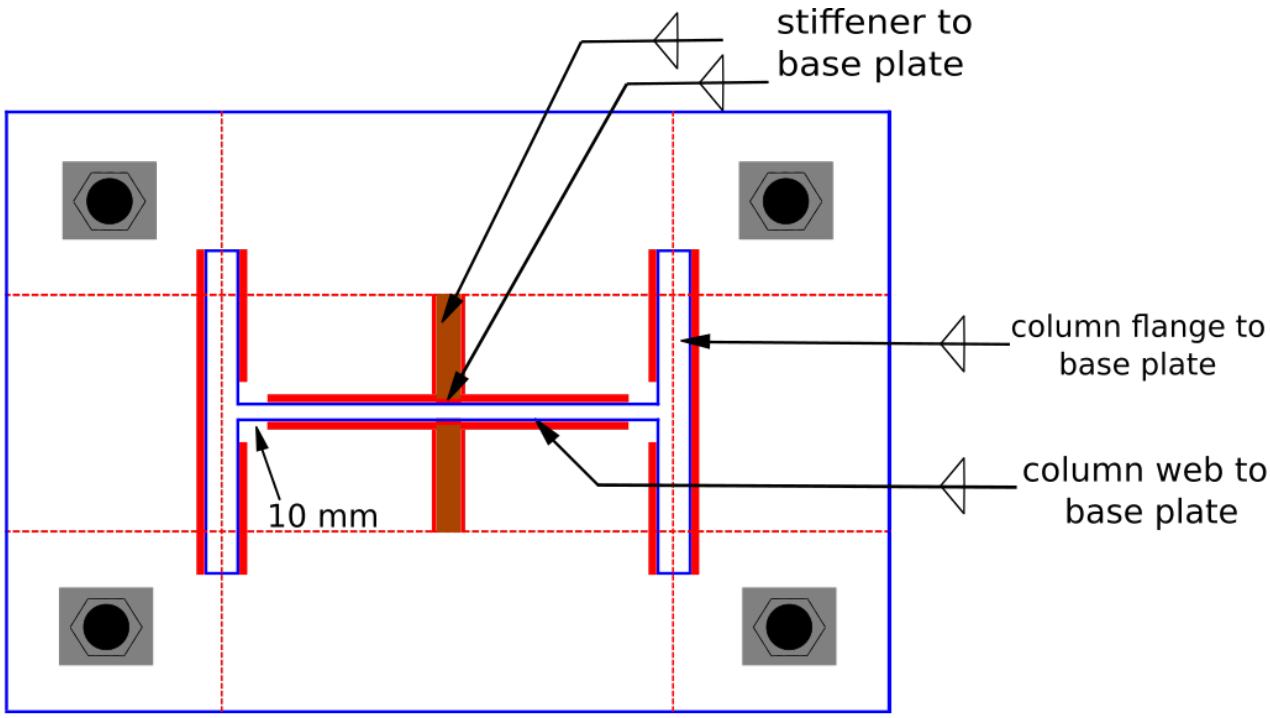
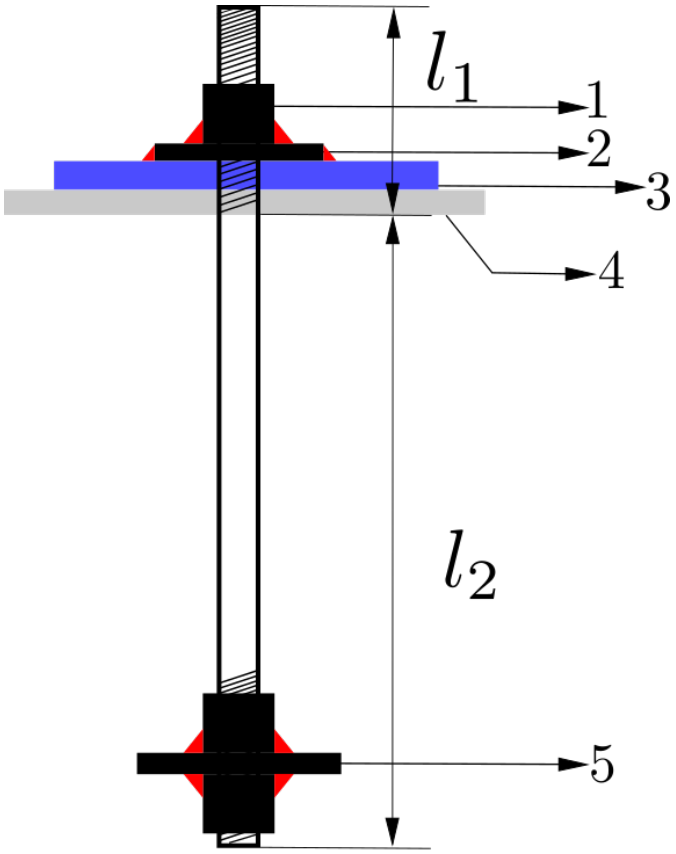


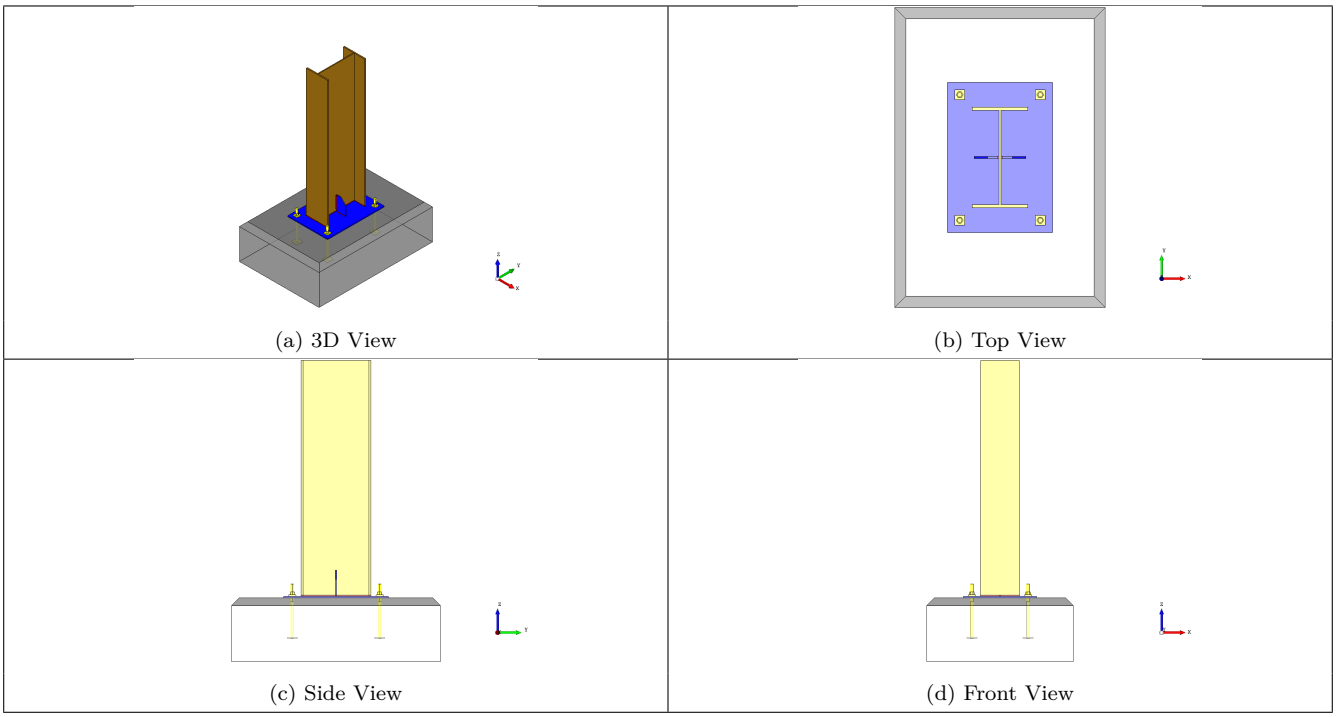
Figure 3: Typical Weld Details



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

Figure 4: Typical Anchor Bolt Details

4 3D Views



(a) 3D View

(b) Top View

(c) Side View

(d) Front View

5 Design Log

2020-12-18 01:37:15 - Osdag - WARNING - : [Analysis Error] The value of the projection (c) as per the Effective Area Method is 15 mm [Reference: Clause 7.4.1.1, IS 800: 2007]
2020-12-18 01:37:15 - Osdag - WARNING - : [Analysis Error] The computed value of c should at least be equal to the end/edge distance

2020-12-18 01:37:15 - Osdag - INFO - : [Analysis Error] Setting the value of c equal to end/edge distance
2020-12-18 01:37:15 - 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 01:37:15 - Osdag - INFO - [Anchor Bolt Length] Minimum length = 200 mm, Maximum length = 800 mm.
2020-12-18 01:37:15 - Osdag - INFO - [Anchor Bolt Length] The provided length of the anchor bolt is 348.5 mm
2020-12-18 01:37:15 - 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 01:37:15 - Osdag - INFO - [Anchor Bolt Length] Reference: IS 5624:1993, Table 1