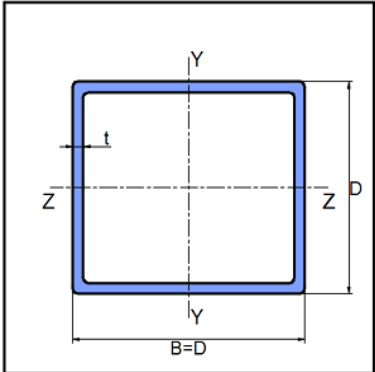




Company Name	IIT Bombay	Project Title	Base Plate
Group/Team Name	Osdag	Subtitle	Welded Base Plate
Designer	Engineer#1	Job Number	1.3.3.1
Date	04 /02 /2021	Client	Mr. Somnath Mukherjee, Kolkata

1 Input Parameters

Main Module		Moment Connection		
Module		Base Plate Connection		
Connectivity		Hollow/Tubular Column Base		
End Condition		Fixed		
Axial Compression (kN)		650.0		
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		SHS 180 x 180 x 8.0	
	Material		E 300 (Fe 440)	
	Ultimate Strength, F_u (MPa)		440.0	
	Yield Strength, F_y (MPa)		300.0	
	Mass, m (kg/m)	41.91	r_z (cm)	6.97
	Area, A (cm ²)	53.39	r_y (cm)	6.97
	None	None	Z_z (cm ³)	287.86
	D (mm)	180.0	Z_y (cm ³)	287.86
	B (mm)	180.0	Z_{pz} (cm ³)	340.68
	t (mm)	8.0	Z_{py} (cm ³)	340.68
	I_z (cm ⁴)	2590.73		
	I_y (cm ⁴)	2590.73		
Base Plate - Design Preference				
Material		E 250 (Fe 410 W)A		
Ultimate Strength, F_u (MPa)		410		
Yield Strength, F_y (MPa)		250		
Stiffener/Shear Key - Design Preference				
Material		E 250 (Fe 410 W)A		



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Anchor Bolt - Input and Design Preference	
Diameter (mm)	['M20', 'M24', 'M30']
Property Class	['8.8', '10.9']
Anchor Bolt Type	End Plate Type
Anchor Bolt Galvanized?	Yes
Designation	M20X346.5 IS5624 GALV
Hole Type	Over-sized
Total Length (mm)	346.5
Material Grade, F_u (MPa)	1040.0
None	
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?	No
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)		$\sigma_{br} = 0.45f_{ck}$ $= 0.45 \times 25$ $= 11.25$ [Ref. IS 456:2000, Cl.34.4]	OK
Grout Thickness (mm)		$t_g = 50$	OK
Epsilon - stiffener plate		$\epsilon_{st} = \sqrt{\frac{250}{f_{yst}}}$ $= \sqrt{\frac{250}{250}}$ $= 1.0$ [Ref. IS 800:2007, Table2]	OK

2.2 Load Consideration

Check	Required	Provided	Remarks
Axial Compression (kN)	$P_x = 650.0$	$P_u = \max(P_x, 0.3P_d), \text{ but, } \leq P_d$ $= \max(650.0, 0.3 \times 1456.09)$ $= \max(650.0, 436.83)$ ≤ 1456.09 $= 650.0$ [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)	$V_d = 123.95$	$V_1 = 0.0$	
Shear Force - along minor (y-y) axis (kN)	$V_d = 123.95$	$V_2 = 0.0$	



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Check	Required	Provided	Remarks
Interaction Ratio	I.R. < 1.0	$\begin{aligned} \text{I.R. axial} &= P_x/P_d \\ &= 650.0/1456.09 \\ &= 0.45 \\ \\ \text{I.R. moment} &= M_z/M_{dz} \\ &= 0.0/0.0 \\ &= 0.0 \\ \\ \text{I.R. sum} &= \text{I.R. axial} + \text{I.R. moment} \\ &= 0.45 + 0.0 \\ &= 0.45 \end{aligned}$	Pass

2.3 Plate Washer and Nut Details

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

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

2.5 Detailing Checks

Check	Required	Provided	Remarks
Min. End Distance (mm)	$e_{min} = 1.5d_0$ $= 1.5 \times 24.0$ $= 36.0$ <p>[Ref. IS 800:2007, Cl.10.2.4.2]</p>	55.0	Pass
Max. End Distance (mm)	$e_{max} = 12t\varepsilon; \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 12 \times \sqrt{\frac{250}{250}} = 144.0$ $e_2 = 12 \times 12 \times \sqrt{\frac{250}{250}} = 144.0$ $e_{max} = \min(e_1, e_2) = 144.0$ <p>[Ref. IS 800:2007, Cl.10.2.4.3]</p>	55.0	Pass
Min. Edge Distance (mm)	$e'_{min} = 1.5d_0$ $= 1.5 \times 24.0$ $= 36.0$ <p>[Ref. IS 800:2007, Cl.10.2.4.2]</p>	55.0	Pass



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Check	Required	Provided	Remarks
Max. Edge Distance (mm)	$e'_{\max} = 12t\varepsilon; \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 12 \times \sqrt{\frac{250}{250}} = 144.0$ $e_2 = 12 \times 12 \times \sqrt{\frac{250}{250}} = 144.0$ $e'_{\max} = \min(e_1, e_2) = 144.0$ <p>[Ref. IS 800:2007, Cl.10.2.4.3]</p>	55.0	Pass
Min. Pitch Distance (mm)	N/A	0.0	N/A
Max. Pitch Distance (mm)	N/A	0.0	N/A

2.6 Base Plate Dimension (L X W)

Check	Required	Provided	Remarks
Length (mm)	$L = D + 2(c + e)$ $= 180.0 + 2 \times (55 + 55.0)$ $= 400.0$ <p>[Ref. based on detailing requirement]</p>	400.0	Pass
Width (mm)	$W = B + 2(c + e')$ $= 180.0 + 2 \times (55 + 55.0)$ $= 400.0$ <p>[Ref. based on detailing requirement]</p>	400.0	Pass



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2.7 Base Plate Analysis

Check	Required	Provided	Remarks
Min. Area Required (mm ²)	$A_{\text{req min}} = \frac{P_u}{\sigma_{\text{br}}}$ $= \frac{650.0 \times 10^3}{11.25}$ $= 57.78 \times 10^3$	$A_{\text{provided}} = L \times W$ $= 400.0 \times 400.0$ $= 160.0 \times 10^3$	Pass
Effective Bearing Area (mm ²)	$A_{\text{breff}} = (D + 2c)(B + 2c)$ $= (180.0 + 2c)(180.0 + 2c)$ <p>Note: c is the projection beyond the face of the column.</p> <p>[Reference: Design of Steel Structures, by N.Subramanian, (2019 edition)]</p>		OK
Projection (mm)	$A_{\text{breff}} = A_{\text{req min}}$ $= 57.78 \times 10^3$ <p>Therefore, $(180.0 + 2c)(180.0 + 2c) = 57.78 \times 10^3$</p> $c = 30.19$ <p>projection = max(c, e)</p> $= \max(30.19, 55.0)$ $= 55.0$ <p>[Reference: Design of Steel Structures, by N.Subramanian, (2019 edition)]</p>	55	Pass
Actual Bearing Stress (N/mm ²)	11.25	$\sigma_{\text{br actual}} = \frac{P_u}{A_{\text{provided}}}$ $= \frac{650.0 \times 10^3}{160.0 \times 10^3}$ $= 4.06$	Pass



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Check	Required	Provided	Remarks
Thickness of Base Plate (mm)	$t < t_p \leq 120$ $8.0 < t_p \leq 120$	$t_p = c \left[\frac{2.5 \sigma_{bractual} \gamma_{m0}}{f_{y_{plate}}} \right]^{0.5}$ $= 55 \times \left[\frac{2.5 \times 4.06 \times 1.1}{250} \right]^{0.5}$ $= 11.62$ $= 12$ <p>[Ref. IS 800:2007, Cl.7.4.3.1]</p>	Pass

2.8 Anchor Bolt Design

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		$k_b = \min \left(\frac{e}{3d_0}, \frac{f_{ub}}{f_u}, 1.0 \right)$ $= \min \left(\frac{55.0}{3 \times 24.0}, \frac{1040.0}{440.0}, 1.0 \right)$ $= \min(0.76, 2.36, 1.0)$ $= 0.76$ <p>[Ref. IS 800:2007, Cl.10.3.4]</p>	OK



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Check	Required	Provided	Remarks
Bearing Capacity (kN)		$V_{dpb} = \frac{2.5k_b d t f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 0.76 \times 20 \times 12 \times 410}{1000 \times 1.25}$ $= 149.57$ $= 0.7 \times 149.57$ $= 104.7$ <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)		$V_{db} = \min (V_{dsb}, V_{dpb})$ $= \min (117.69, 104.7)$ $= 104.7$ <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)		$l_1 = t_g + t_p + t_w + t_n + 20$ $= 50 + 12 + 8.5 + 18.0 + 20$ $= 108.5$	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)	$200 \leq l_a \leq 800$ [Reference: IS 5624:1993, Table 1]	$l_a = l_1 + l_2$ $= 108.5 + 238.0$ $= 346.5$	Pass

2.9 Stiffener Design

Check	Required	Provided	Remarks
No. of Stiffeners		4	OK
Length of Stiffener (mm)		$L_{st1} = \frac{L - D}{2}$ along column D $= \frac{400.0 - 180.0}{2}$ $= 110.0$ $L_{st2} = \frac{W - B}{2}$ along column B $= \frac{400.0 - 180.0}{2}$ $= 110.0$	OK
Height of Stiffener (mm)		$H_{st1} = L_{st1} + 50$ $= 110.0 + 50$ $= 160.0$ $H_{st2} = L_{st2} + 50$ $= 110.0 + 50$ $= 160.0$	OK
Thickness of Stiffener (mm)	$t_{st} = \left(\frac{L_{st}}{13.6 \times \epsilon_{st}} \right) \geq T$ $= \left(\frac{110.0}{13.6 \times 1.0} \right) \geq 8.0$ $= \max(8.09, 8.0)$ [Ref. IS 800:2007, Table 2.]	16	Pass
Stress (average) at Stiffener (N/mm^2)	11.25	$\sigma_{st} = \sigma_{bractual}$ $= 4.06$	Pass



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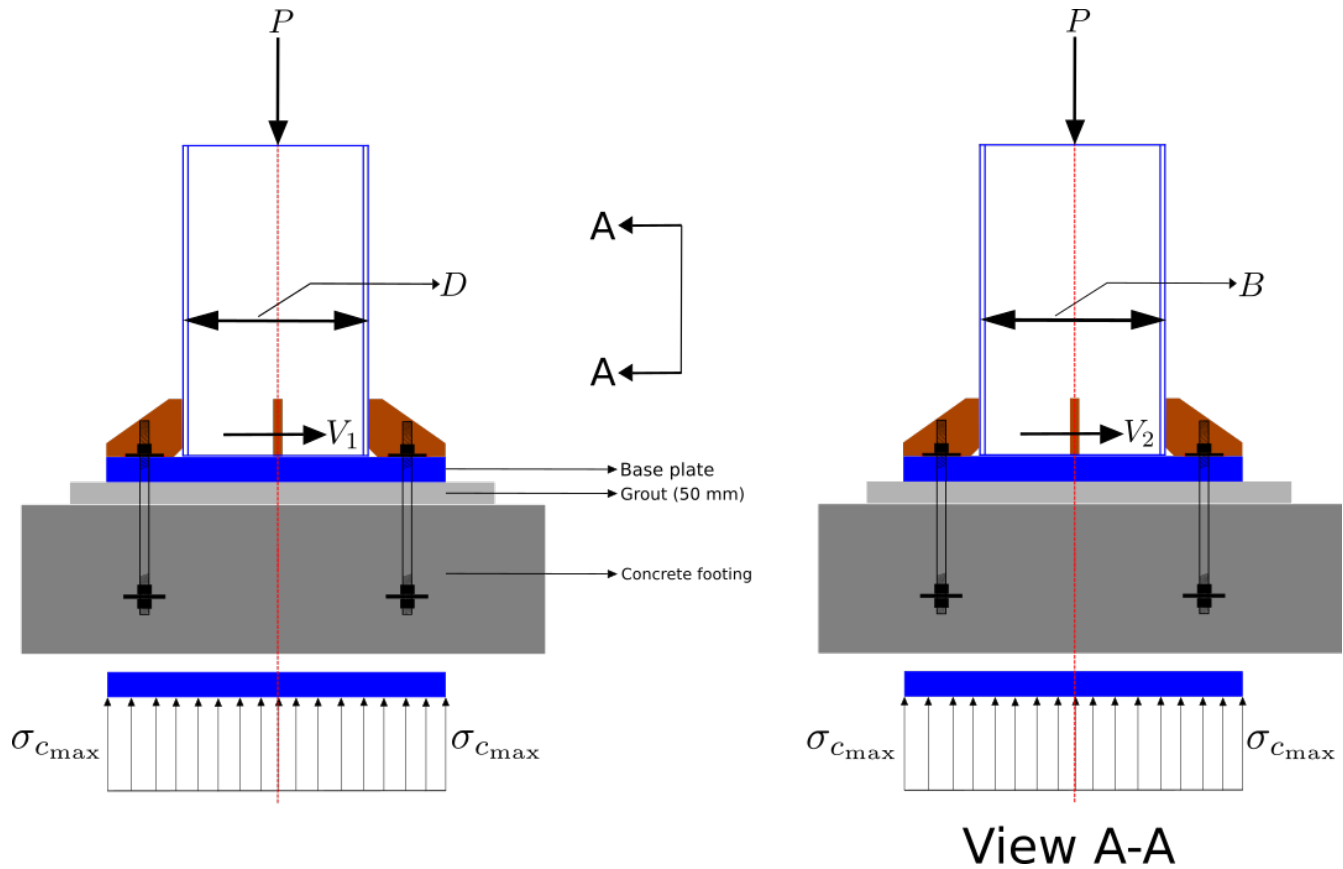
Check	Required	Provided	Remarks
Max. Shear on Stiffener (kN)	$V_{st} = \sigma_{st} (W L_{st})$ $= 4.06 \times (400.0 \times 110.0)$ $= 178.64$	$V_{dst} = \frac{A_{vg} f_{yst}}{\sqrt{3} \gamma_{m0}}$ $= \frac{(H_{st} \times t_{st}) \times f_{yst}}{\sqrt{3} \times \gamma_{m0}}$ $= \frac{(160.0 \times 16) \times 250}{\sqrt{3} \times 1.1 \times 10^3}$ $= 335.913$ Note: Stiffener is not restricted to low shear. [Ref. IS 800:2007 (Cl.8.4.1)]	Pass
High Shear Check	$V_{st} \leq 0.6 \times V_{dst}$ $\leq 0.6 \times 335.913$ ≤ 201.55	$V_{st} = 178.64$	Pass
Section Modulus of the Stiffener (mm^3)		$z_{est} = 68.27 \times 10^3$	OK
Max. Moment on Stiffener (kNm)	$M_{st} = V_{st} \times \frac{L_{st}}{2}$ $= 178.64 \times \frac{110.0}{2} \times 10^{-3}$ $= 9.825$	$M_{dst} = \frac{\beta_b z_{est} f_{yst}}{\gamma_{m0}}$ $= \frac{1 \times z_{est} f_{yst}}{\gamma_{m0}} \quad (\beta_b = 1)$ $= \frac{1 \times 68.27 \times 10^3 \times 250}{1.1 \times 10^6}$ $= 15.515$ [Ref. IS 800:2007 (Cl.8.2.1.2)]	Pass
Weld Size (mm)	5	6	Pass

2.10 Weld Design - Hollow CS to Base Plate Connection

Check	Required	Provided	Remarks
Weld Strength (N/mm^2)	$f_{uw} = \min(f_w, f_u)$ $= \min(510.0, 440.0)$ [Ref. IS 800:2007, Cl.10.5.7.1.1]	$f_{uw} = 440.0$	Pass
Total Weld Length (mm)		720	Pass
Weld Size (mm)	5	8	Pass



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3 2D Drawings (Typical)



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Designer	Engineer#1	Job Number	1.3.3.1
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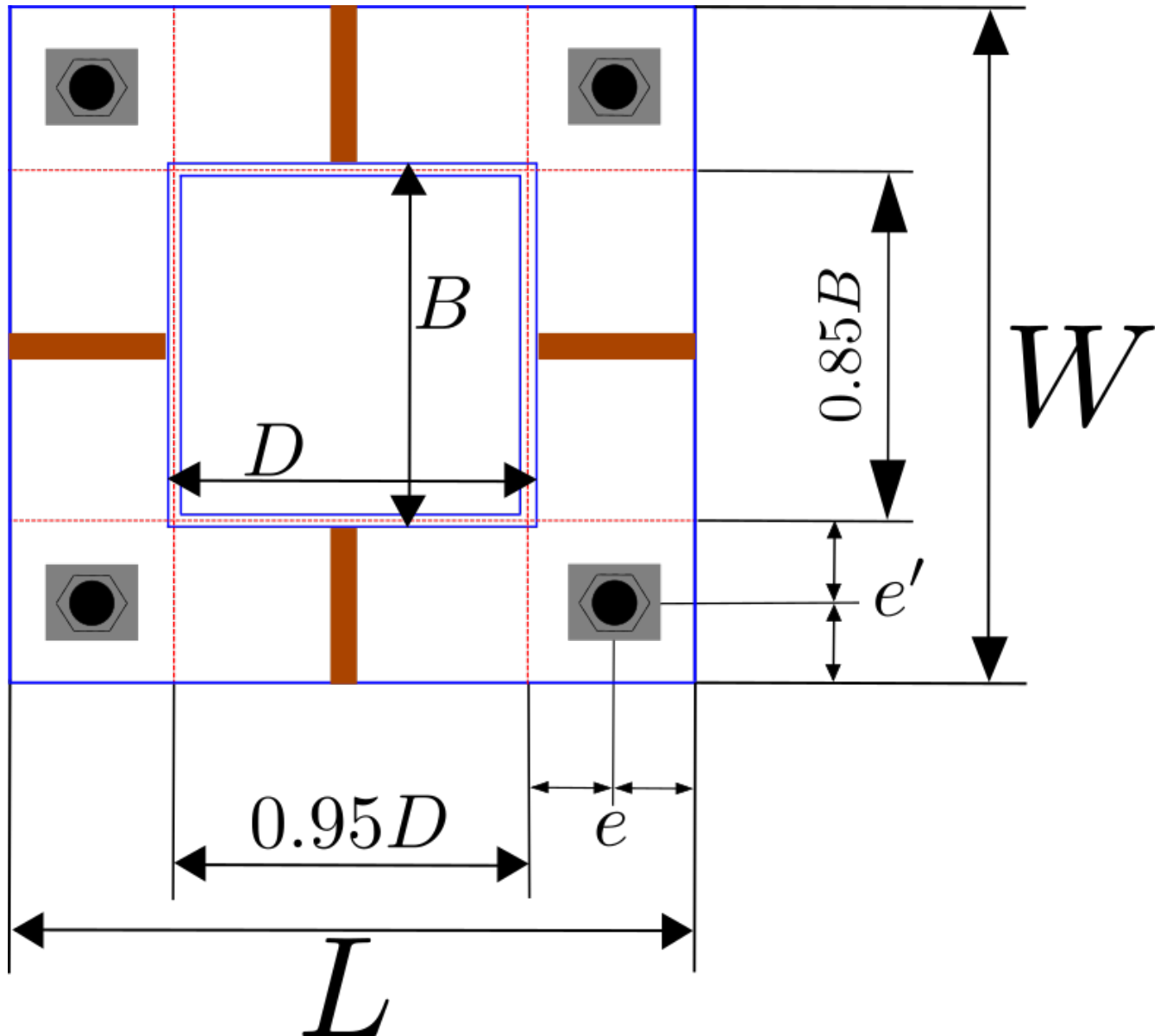


Figure 2: Typical Base Plate Detailing



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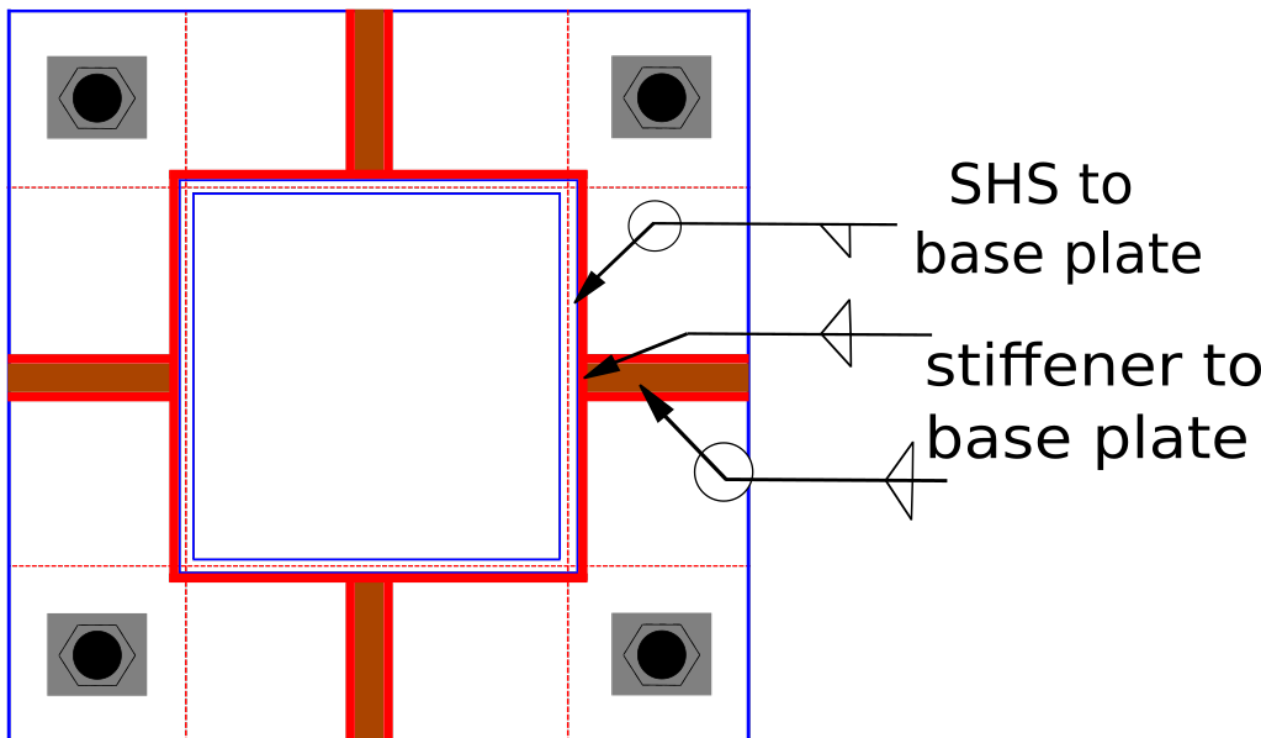
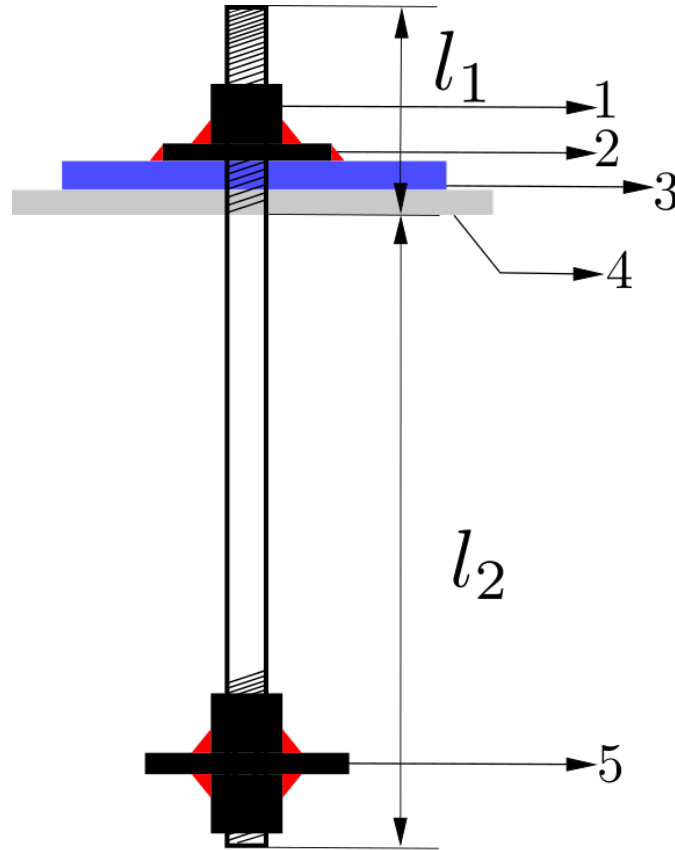


Figure 3: Typical Weld Details



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Designer	Engineer#1	Job Number	1.3.3.1
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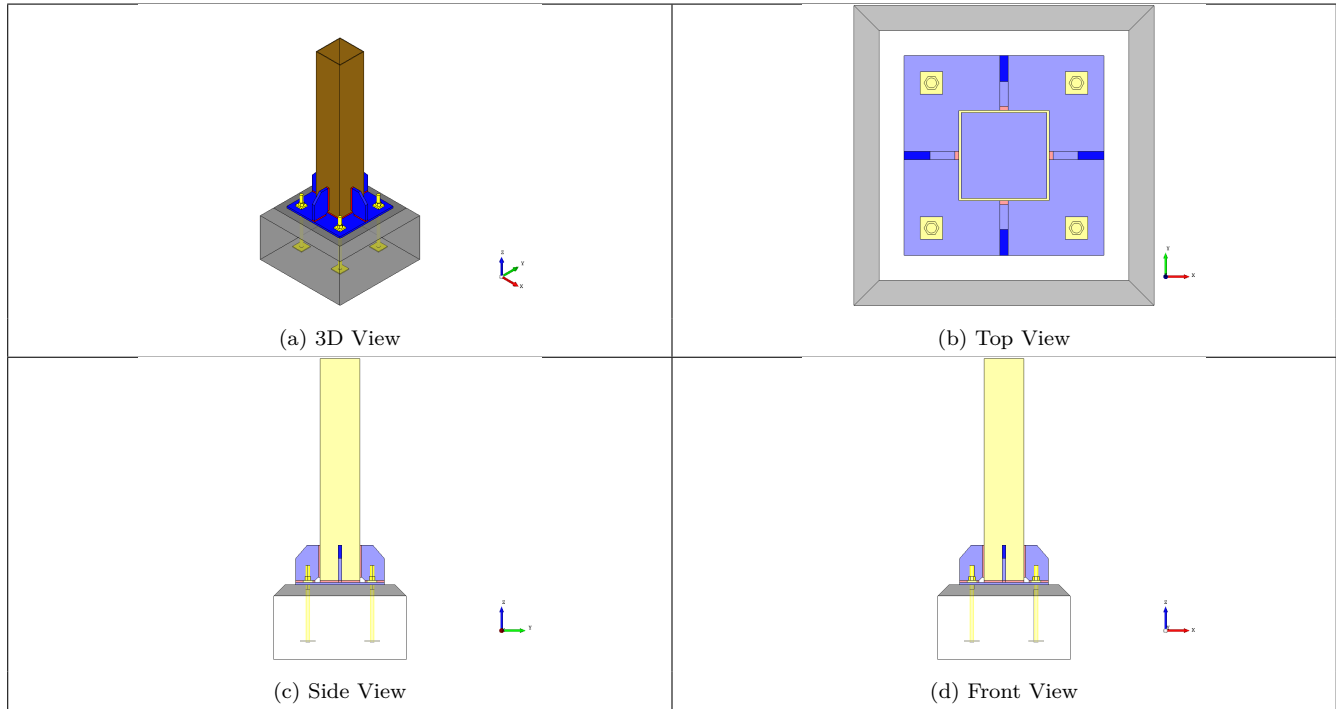
- l_1 = length above footing
 l_2 = length below footing
1 = t_n , nut thickness
2 = t_w , washer thickness
3 = t_p , plate thickness
4 = t_g , grout thickness
5 = end plate thickness

Figure 4: Typical Anchor Bolt Details



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4 3D Views



5 Design Log

2021-02-04 15:21:52 - Osdag - WARNING - : [Analysis Error] The value of the projection (c) as per the Effective Area Method is 35 mm [Reference: Clause 7.4.1.1, IS 800: 2007]

2021-02-04 15:21:52 - Osdag - WARNING - : [Analysis Error] The computed value of c should at least be equal to the end/edge distance

2021-02-04 15:21:52 - Osdag - INFO - : [Analysis Error] Setting the value of c equal to end/edge distance

2021-02-04 15:21:52 - 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 15:21:52 - Osdag - INFO - [Anchor Bolt Length] Minimum length = 200 mm, Maximum length = 800 mm.

2021-02-04 15:21:52 - Osdag - INFO - [Anchor Bolt Length] The provided length of the anchor bolt is 346.5 mm

2021-02-04 15:21:52 - 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 15:21:52 - Osdag - INFO - [Anchor Bolt Length] Reference: IS 5624:1993, Table 1

2021-02-04 15:21:52 - Osdag - WARNING - [Shear Check - Stiffener] The stiffener fails the shear check

2021-02-04 15:21:52 - Osdag - WARNING - The shear demand on the stiffener (178.64 kN) exceeds 60% of it's capacity (125.97 kN)

2021-02-04 15:21:52 - Osdag - INFO - Increasing the thickness of the stiffener and re-checking against shear demand



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2021-02-04 15:21:52 - Osdag - INFO - : ===== Design Status =====
2021-02-04 15:21:52 - Osdag - INFO - : Overall base plate connection design is SAFE
2021-02-04 15:21:52 - Osdag - INFO - : ===== End Of Design =====